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The Role of a Virtual Internship in Developing Preservice Teachers' Technological Pedagogical Content Knowledge

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Abstract

Virtual internships are new areas of research in teacher education. They provide authentic contexts to foster complex professional thinking. Furthermore, they embody the essential elements of learning-technology-by-design approach, which is believed to be the most effective method to develop teachers' technological pedagogical content knowledge (TPACK). This study, conducted in 2018, examined the effectiveness of a virtual internship to develop preservice teachers' TPACK employing a quasi-experimental research design aided by qualitative data. The participants were seventy-four preservice teachers from a variety of majors. Data were collected using a self-report survey adapted from the Survey of Preservice Teachers' Knowledge of Teaching and Technology and the reflections written by the participants. The results indicated no statistically significant differences in the TPACK survey scores between the experimental and the control group participants. However, the experimental group significantly increased their TPACK scores in all TPACK sub-domains, except the content knowledge. The qualitative analysis based on participants' reflections supported the findings from the quantitative analysis by providing confirming evidence for the effectiveness of virtual internships in preservice teacher education.

Keywords: Technological pedagogical content knowledge (TPACK), technology integration, virtual internships, epistemic games, preservice teachers

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Introduction

Technological Pedagogical Content Knowledge (TPACK) is a conceptual framework describing the types of knowledge teachers need for technology integration (Mishra & Koehler, 2006). It builds on Shulman's (1986, 1987) conception of pedagogical content knowledge (PCK), underlying the idea that the relationship between content and pedagogy is as important as they are separate. Effective teachers need to be occupied with both content and pedagogy by making the aspects of subject matter more teachable (Shulman, 1986).

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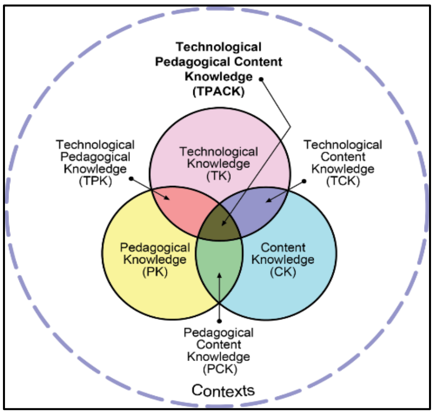
According to Mishra and Koehler (2006), the prominence of new technologies in educational practice is a big change. They are candidates for playing an essential role in changing the nature of classrooms by offering a variety of representations, analogies, examples, explanations, and demonstrations assisting to make content more understandable to learners as mentioned by Shulman in 1986. Mishra and Koehler introduced the TPACK framework putting the knowledge of content, pedagogy, technology at the center of teaching. The focus of the TPACK framework is on the connections, interactions, affordances, and constraints between and among these knowledge bases rather than considering them as separate bodies of knowledge. This way of thinking resulted in the following types of knowledge: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and finally the interplay between all of them, technological pedagogical content knowledge (TPACK) (Figure 1).

Figure 1

TPACK Framework Categories (reproduced by permission of the publisher, © 2012 by tpack.org)



Content knowledge (CK) can be explained as the quantity and organization of the actual subject matter that is to be learned or taught. It is the knowledge assumed to be known and understood by teachers such as key facts, conceptions, theoretical information, and methodologies in a particular field; knowledge of explanatory frameworks organizing and connecting ideas; and knowledge of the rules of evidence and proving (Mishra & Koehler 2006; Shulman, 1986). Pedagogical knowledge (PK) represents the knowledge of procedures and methodologies that one uses during the teaching and learning processes. PK is related to all matters of how students learn, managing a classroom, developing and implementing lesson plans, and assessing students. PCK was described by Shulman (1986) as the knowledge that is the most germane in a particular subject matter for teaching. Technological knowledge (TK) can be explained as knowing how to utilize standard technologies like books, black, and chalkboards, as well as more advanced technologies such as the Internet and interactive whiteboards. TCK is the knowledge of how to compose representations in a subject area by making use of technologies. TPK is about the knowledge of various technologies teachers benefit for pedagogical purposes during learning and teaching processes. It includes knowing the presence, elements, and potentials of these technologies and also knowing how their use might have potential influences on the teaching process. And finally, TPACK is a type of knowledge that "requires an understanding of the representation of concepts using technologies, pedagogical techniques that use technologies in constructive ways to teach content, knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face, knowledge of students' prior knowledge and theories of epistemology, and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones" (Mishra & Koehler, 2006, p. 1029). TPACK requires fully understanding the interweaving and complex relationships between the three major sources of teacher knowledge.

Researchers have suggested several ways to help teachers develop TPACK. These methods involved the use of TPACK-based courses (Albion, 2012; Niess et al., 2010; Tanak, 2020; Tyarakanita et al., 2020) or technology courses as part of cultural exchange programs (Dalal et al., 2021), courses specifically focusing on lesson plan designs (Chai et al., 2010; Guzey & Roehrig, 2009; Harris & Hofer, 2011; Koh & Chai, 2014; Njiku et al., 2021; Polly, 2011), intervention programs providing teachers technology integration opportunities in their classes (Jaipal-Kamani & Figg, 2015; Koh & Divaharan, 2011), and strategies combining more than one method (Jang, 2010; Mouza et al., 2014).

Most notably, however, Koehler et al. (2007) advocated the use of design-based activities in order to develop TPACK. In this learning-technology-by-design approach, the general guideline is to have teachers enact on an authentic professional action, such as designing materials or activities for their own classrooms, to develop their TPACK. While some researchers state that it is not clear what makes this strategy successful, there is a general agreement among researchers on its effectiveness (Voogt et al., 2016). Therefore, it is important to focus on the critical elements of this approach to suggest effective learning environments for TPACK development.

Virtual Internships/ Epistemic Games

One novel approach that can effectively support TPACK development of preservice teachers is virtual internships. This is because they also embody the elements of authenticity, small group collaboration, and design task - the three essential characteristics of the learning-technology-by-design-approach (Oner, 2020). Virtual internships in general aim to provide authentic contexts to foster complex professional thinking. In a virtual internship, learners collaboratively work on authentic tasks in small teams, and interact with mentors in a simulated online environment. In this environment, they are given the identity of actual interns of a specific profession.

Virtual internships are based on the epistemic frame theory, and thus, also called epistemic games (Shaffer, 2004, 2006, 2007, 2012). Epistemic frame theory argues that it is not just the amount of knowledge that makes up expertise in any given profession. It is the connections and configurations among different knowledge bases, which make up the epistemic frame of a profession –a construct similar to TPACK (Oner, 2020). Thus, virtual internships can be defined as computer-based practicum simulations designed to support the development of the epistemic frame of professional practice. More specifically, they aim to use the theory to transform the actions taken by the learner into a practicum experience within a digital learning environment. Therefore, they link the resulting game activities to the desired outcomes of an epistemic frame, which combines knowledge, skills, identity, values, and epistemology of a profession (Shaffer, 2006). Normally, this process advances gradually through a professional practicum in which a student takes part in a controlled environment and makes reflections on the consequences with mentors and peers (Shaffer et al., 2009).

Within the last decade, several virtual internships have been developed and assessed, such as the Pandora Project, Land Science, Escher's World, and Nephrotex, at the Epistemic Analytics Lab. These proved to be successful in developing complex thinking in areas such as mathematics, engineering, and urban planning (Arastoopour et al., 2014; Hatfield & Shaffer, 2006; Nash & Shaffer, 2012). However, they mostly addressed the STEM professions and used by high school students and engineering freshmen (Oner, 2020). Thus, the use of virtual internships in higher education is a new area of research.

More recently, a new virtual internship was designed by Oner (2020), namely the School of the Future (STF), for preservice teachers to develop their TPACK. Oner (2020) further analyzed preservice teachers' TPACK development using a network analytics method, namely the epistemic network analysis (Shaffer et al., 2016). Her analysis showed that at the end of the STF experience, preservice teachers' TPACK representations became more complex in terms of the number of pedagogical considerations and the strength of connections between technological, pedagogical, and content knowledge.

The present study tries to complement this line of work by investigating the effectiveness of virtual internships in preservice teacher education by using a self-report TPACK survey and participant reflections. More specifically, this study aims to support TPACK development with the implementation of a new virtual internship into an educational technology course offered as part of teacher education programs.

The research questions of the study are specified as:

(1) Do the preservice teachers who participate in a virtual internship (the STF group) differ from those who do not participate (control group) in their CK, PK, TK, PCK, TCK, TPK and TPACK scores over time?

(2) Is there a statistically significant difference between the pre- and post-TK, CK, PK, PCK, TCK, TPK and TPACK scores of the preservice teachers who participate in the virtual internship?

(3) How do preservice teachers' opinions on integrating technology into educational settings change as they participate in a virtual internship?

Method

This study employed a pre- and post-test quasi-experimental research design aided by qualitative data that were obtained from the participants' responses to a set of reflection questions. The qualitative data (reflections are written by the participants both at the beginning and at the end of the STF intervention) were used to complement and expand on the quantitative findings. Using qualitative data as an addition to quantitative data is accepted as a way to externalize the complex and multifaceted situations in learning and teaching practice (Chang et al., 2015).

Code of Ethics

This study has been reviewed and approved by Bogazici University SBB-EAK with the date and meeting number 04.04.2018, SBB-EAK 2018/39. Necessary permissions from the participants before data collection have been obtained.

Context and Participants

The study took place in the context of an educational technology course aiming to support preservice teachers' technology integration into their teaching at an English-medium university in 2018. The participants were preservice teachers who were in their junior or senior year from a variety of majors (see Table 1). Two sections of the course, taught by the same instructor, were randomly assigned as the experimental (STF) and the control groups. For the participants of the experimental group, participation in the virtual internship was a requirement of the course. However, participation in the study was voluntary and before data collection, ethical approval was granted by the institutional ethics committee.

Seventy-four participants, who gave informed consent, were involved in the study (see Table 1). A group of 26 participants from the STF group was randomly selected to answer the reflection questions.

Table 1

Number of Participants

Department	STF Group	Control Group	Total
Foreign Language Education	14	16	30
Mathematics Education	11	5	16
Science Education	6	8	14
Guidance and Psychological Counselling	7	7	14
Total	38	36	74

Intervention: School of Future Virtual Internship

The virtual internship 'School of the Future' (STF) was the primary intervention of the study. STF is a virtual internship program developed by Oner (2020) with the particular purpose of developing preservice teachers' TPACK. The intervention included an eight-week-long program that required students to participate in online STF sessions. The participation in the STF took place via two-hour-long online meetings during the class hours at a computer lab.

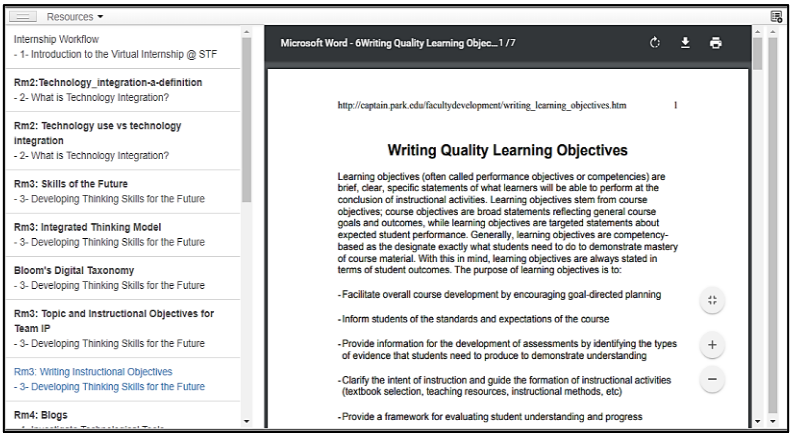
In STF, participants were addressed as intern teachers at a fictitious school (called the School of the Future) and asked to work on a major assignment throughout eight sessions: a collaborative instructional plan that integrates technology and that could be used by the STF teachers in the upcoming semesters. The participants from the same department were assigned to teams of four or five. Every week, teams worked on tasks that were designed to scaffold the final instructional plan project. During the online meetings, two graduate students (one of them being the first author), portrayed as mentor teachers at STF, facilitated the sessions by asking pre-prepared thought-provoking questions, providing explanations about that week's assignment, and technical help while maintaining team collaboration.

Weekly tasks required students to read assigned readings before and during the online meetings, prepare reports before meeting online, discuss questions posted by mentors synchronously during the online meetings, and submit notebooks (artefacts and reflections) during the online meeting or later -- all of which required them to consider and reconsider the connections between technology, pedagogy, and content that they needed to teach. An ordinary flow of STF participation is further explained below.

After login, interns see a pop-up screen indicating a new message from the STF coordinator about that week's assignment. The message informs the interns about the specific assignment, necessary resources, and notebook content they need to submit. The interns can access the resources by following the links in the message or using the resources tab on their screen (see Figure 2).

Figure 2

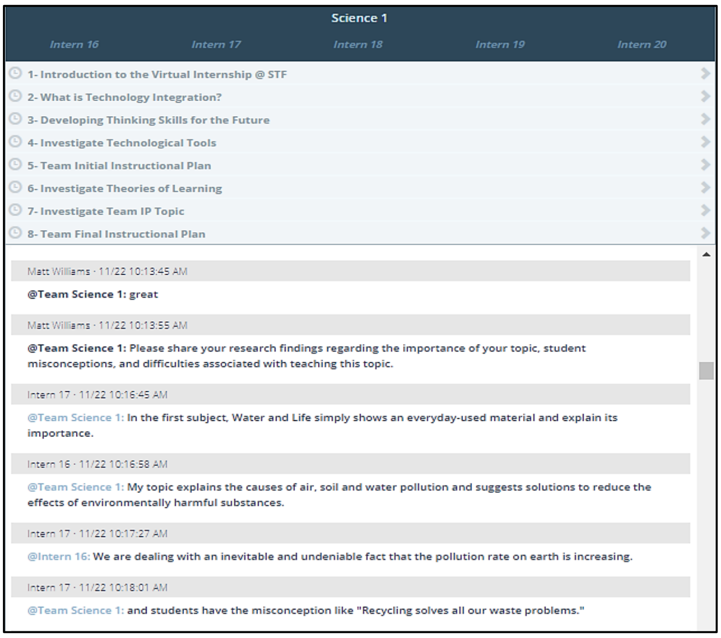
Resources Screen



Mentors interact with the team members during all online meetings via an integrated chat window (see Figure 3).

Figure 3

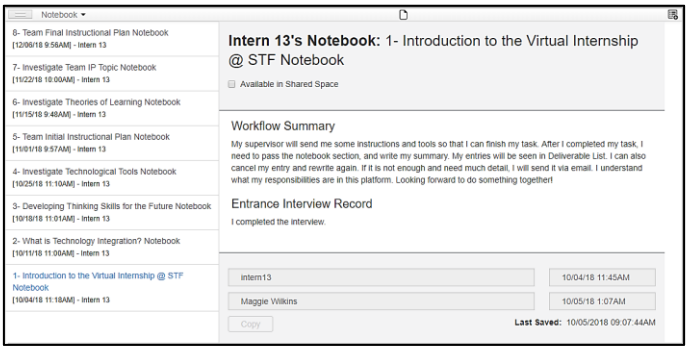
Online Chat Page of Teams



After each online meeting, team members need to individually submit a notebook, which includes deliverables showing their work on the tasks. An example of a notebook entry is the summary of the team discussion of a particular week (see Figure 4).

Figure 4

Notebook Screen of an Intern



The research team can display deliverables (notebook entries) on the STF mentor interface, evaluate them, and send feedback messages back to the interns on behalf of the STF program coordinator (see Figure 5). Example feedback messages are shown in Figures 6 and 7.

Figure 5

Mentor Screen for Viewing Deliverables (Notebooks)

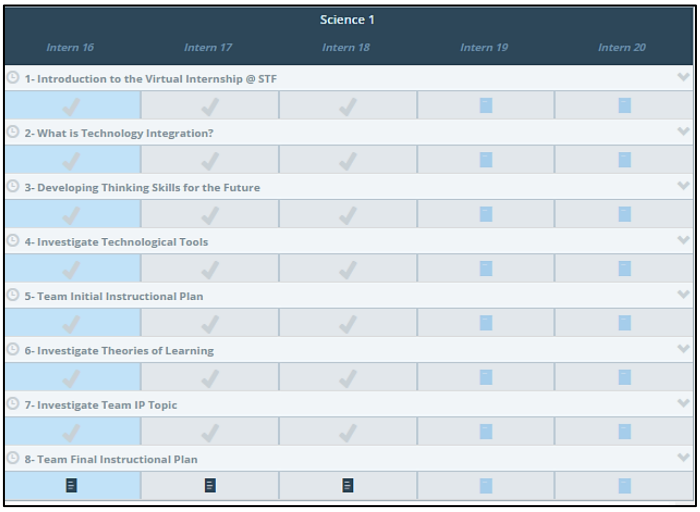
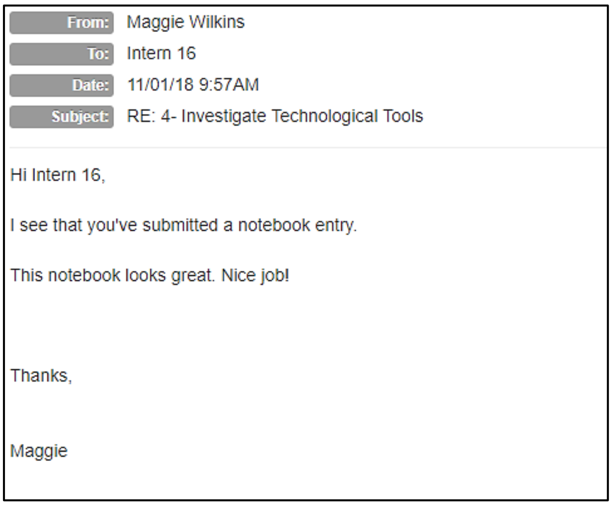


Figure 6

Feedback Screen 1


From: Maggie Wilkins
To: Intern 16
Date: 11/01/18 9:57AM
Subject: RE: 4- Investigate Technological Tools

Hi Intern 16,

I see that you've submitted a notebook entry.

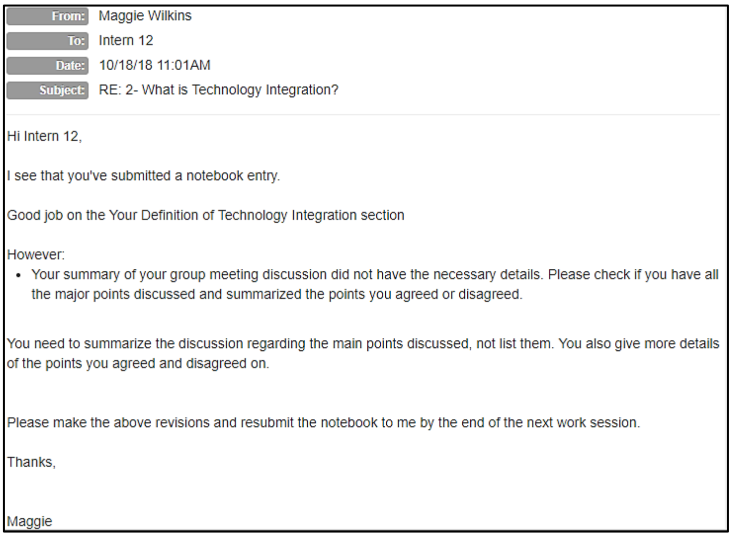
This notebook looks great. Nice job!

Thanks,

Maggie

Figure 7

Feedback Screen 2


From: Maggie Wilkins
To: Intern 12
Date: 10/18/18 11:01AM
Subject: RE: 2- What is Technology Integration?

Hi Intern 12,

I see that you've submitted a notebook entry.

Good job on the Your Definition of Technology Integration section

However:

- Your summary of your group meeting discussion did not have the necessary details. Please check if you have all the major points discussed and summarized the points you agreed or disagreed.

You need to summarize the discussion regarding the main points discussed, not list them. You also give more details of the points you agreed and disagreed on.

Please make the above revisions and resubmit the notebook to me by the end of the next work session.

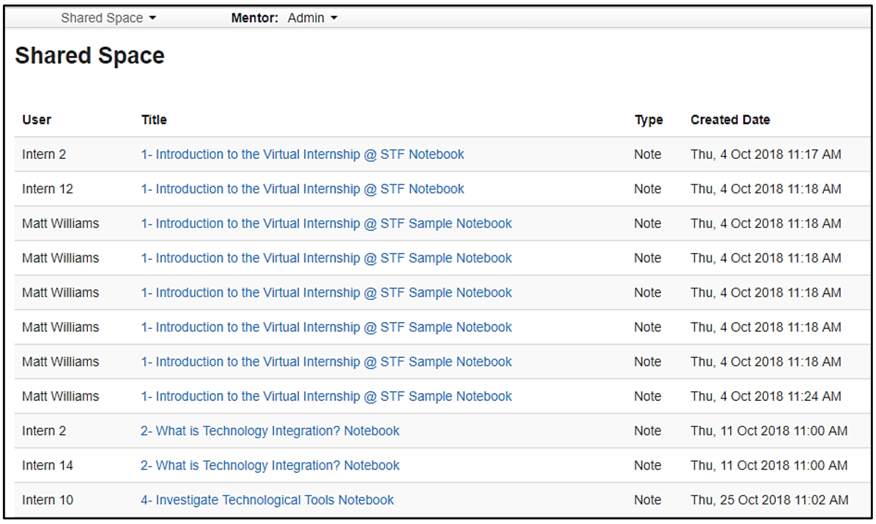
Thanks,

Maggie

The interns can also share their deliverables on a shared space accessible to all STF participants (see Figure 8).

Figure 8

Shared Space


Shared Space ▾ Mentor: Admin ▾

Shared Space

User	Title	Type	Created Date
Intern 2	1- Introduction to the Virtual Internship @ STF Notebook	Note	Thu, 4 Oct 2018 11:17 AM
Intern 12	1- Introduction to the Virtual Internship @ STF Notebook	Note	Thu, 4 Oct 2018 11:18 AM
Matt Williams	1- Introduction to the Virtual Internship @ STF Sample Notebook	Note	Thu, 4 Oct 2018 11:18 AM
Matt Williams	1- Introduction to the Virtual Internship @ STF Sample Notebook	Note	Thu, 4 Oct 2018 11:18 AM
Matt Williams	1- Introduction to the Virtual Internship @ STF Sample Notebook	Note	Thu, 4 Oct 2018 11:18 AM
Matt Williams	1- Introduction to the Virtual Internship @ STF Sample Notebook	Note	Thu, 4 Oct 2018 11:18 AM
Matt Williams	1- Introduction to the Virtual Internship @ STF Sample Notebook	Note	Thu, 4 Oct 2018 11:18 AM
Matt Williams	1- Introduction to the Virtual Internship @ STF Sample Notebook	Note	Thu, 4 Oct 2018 11:24 AM
Intern 2	2- What is Technology Integration? Notebook	Note	Thu, 11 Oct 2018 11:00 AM
Intern 14	2- What is Technology Integration? Notebook	Note	Thu, 11 Oct 2018 11:00 AM
Intern 10	4- Investigate Technological Tools Notebook	Note	Thu, 25 Oct 2018 11:02 AM

Data Sources

The TPACK Survey

The quantitative data were gathered using an adapted version of the Survey of Preservice Teachers' Knowledge of Teaching and Technology (the TPACK survey in short) (Schmidt et al., 2009), which was presented to the participants as the entrance and exit interviews required by STF. The TPACK survey was adapted by adding parallel items for the foreign language education and psychological counselling and guidance departments by taking expert opinions (two faculty members from the foreign language education and psychological counselling and guidance departments) and excluding the items for the social sciences department. For example, item 17 was constructed as “I can use a scientific way of thinking” for the participants from the science department, whereas it was “I can use a way of thinking used by counsellors” for the participants from the guidance and psychological counselling department.

The adopted TPACK survey included six items for TK, three questions for CK (arranged for each department- Mathematics, EFL, Science/ Physics/ Chemistry, Guidance, and Psychological Counselling), seven items for PK, four items for PCK, four items for TCK, nine items for TPK, and four items for TPACK. The final version of the survey included 55 items, nine of them asking demographic information. It has a 5-point Likert-scale ranging from strongly disagree to strongly agree as to the original survey.

To assure reliability, Cronbach's alpha values were calculated based on the data of 62 preservice teachers, different from the study participants, who took the adopted TPACK survey. The results indicated that the Technological Knowledge (TK) subscale had a Cronbach's alpha of .85, the Content Knowledge (CK) subscale had a Cronbach's alpha of .96 for mathematics, .96 for science, .92 for guidance and psychological counselling, and .83 for EFL group. The Pedagogical Knowledge (PK) subscale had a Cronbach's alpha of .86 and the Technological Pedagogical Content Knowledge (TPK) subscale had a Cronbach's alpha of .92. A Cronbach's alpha value could not be calculated for the PCK, TCK, and TPACK since these subscales involved single items.

Reflection Questions

To collect qualitative data, participants were given some reflection questions before and after the STF treatment. In this study, we particularly analyzed the answers given to the following reflection questions: (1) How could technology be effectively integrated into a lesson plan in your field? Please exemplify. (2) Could you state the cases that integration of technology into the instruction would be appropriate and not appropriate? Please exemplify.

Data Collection

The data were collected throughout two semesters following the same procedures. The participants, as intact groups of two sessions of the course, were randomly assigned to the experimental (STF) and control groups. Both groups were administered the adopted TPACK survey at the beginning of the semester. Pre-intervention reflection questions were also given to 26 STF participants, which were determined randomly. The experimental group followed the STF procedures online for eight weeks (see above), while the control group covered similar content in a regular class environment.

The typical lesson activities of the control group involved completing and discussing weekly assigned readings (same as in the STF group), sharing their personal opinions on the use of technology in K12 education, and posting reflections on their web-based portfolio. They also worked on developing technology-integrated lesson plans to provide meaningful learning with technology.

At the end of the intervention, both groups were administered the same TPACK survey. Additionally, the same group of the 26 STF group participants, who also had replied to the pre-intervention reflection questions, responded to the same reflection questions.

Data Analysis

The survey data were analyzed through quantitative methods. For each participant, the mean scores for each of the TPACK components as pre- and post-intervention scores were calculated. To answer the first research question, a two-way mixed design MANOVA test was used. Before conducting the test, nine assumptions of the two-way

MANOVA were checked to satisfy the requirements of the test (i.e., the dependent variables measured at interval level, the independent variables consisting of two categorical groups, the independence of observations, adequate sample size, no univariate or multivariate outliers, multivariate normality, a positive linear correlation between each pair of dependent variables for all combinations of the two independent variables, homogeneity of variance-covariance matrices, no multicollinearity).

To answer the second research question, a separate one-way repeated measure MANOVA test was used to examine the differences between the TPACK sub-scores of the STF group over time. Before conducting the MANOVA test, the assumptions were checked again on the STF data. Determining the main effect (time) on the dependent variables, univariate follow-up ANOVA tests were performed to determine which TPACK sub-scores differed in time, using the Bonferroni adjustment. As the time factor involved only two levels (pre and post), further t-tests were not performed.

To answer the third research question, the reflection data were organized using an Excel sheet. After a preliminary exploratory analysis of the pre- and post-intervention reflection data to obtain a general sense of the whole data, the data were coded qualitatively. This involved dividing the reflection data into meaningful units, which involved one particular issue (Merriam, 1998), and using the constant comparative data analysis method (Glaser & Strauss, 1967). The major themes underlying participants' responses to the reflection questions were determined. The most prominent themes and the number of the participants who highlighted these themes were compared and contrasted in two reflection data sets (pre- and post-intervention) to provide a complementary understanding of participants' TPACK development. While the first author coded the qualitative data, the second author (the thesis advisor) constantly checked the validity of the codes. Furthermore, the qualitative findings were triangulated with quantitative data.

Results

Difference between STF and Control Groups

Descriptive statistics for the STF and the control groups indicated that there were increases at the post mean scores for all the seven TPACK domains, without exception, in comparison with the pre mean scores of both groups. The gain scores (mean score differences) for all of the TPACK components, except for the CK, were higher in the STF group (see Table 2).

Table 2

Mean Score Differences (Post-Pre) of the Experimental and Control Groups

	STF			Control		
	Pre	Post	Gain Score	Pre	Post	Gain Score
TK	3.43	3.98	0.55	3.26	3.70	0.44
CK	4.31	4.39	0.08	4.23	4.38	0.15
PK	3.83	4.13	0.30	3.76	3.99	0.23
PCK	4.18	4.53	0.35	4.19	4.42	0.23
TCK	3.53	4.24	0.71	3.72	4.31	0.59
TPK	3.78	4.32	0.54	3.80	4.20	0.40

A two-way mixed design MANOVA, using Wilk's Lambda, revealed that there was not a significant interaction effect of time and group, Wilk's $\Lambda = .965$, $F(7, 66) = .344$, $p > .05$. Again, using Wilk's Lambda, there was not a significant main effect of group, Wilk's $\Lambda = .868$, $F(7, 66) = 1.432$, $p > .05$. However, the multivariate result was significant for time, Wilk's $\Lambda = .426$, $F(7, 66) = 12.684$, $p < .05$, partial $\eta 2 = .574$, indicating a meaningful difference in the pre and post TPACK domain scores with a large effect size (see Table 3).

Table 3

Multivariate Test Results for Wilk's Lambda[a]

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Between Subjects	Intercept	.005	1772.947[b]	7.000	66.000	.000	.995
	Group	.868	1.432[b]	7.000	66.000	.208	.132
Within Subjects	Time	.426	12.684[b]	7.000	66.000	.000	.574
	Time* Group	.965	.344[b]	7.000	66.000	.931	.035

a. Design: Intercept + Group
Within Subjects Design: Time
b. Exact statistic

To summarize, the multivariate test result indicated that there was not a statistically significant difference in the TPACK domain scores between the STF and control groups. The analysis, however, revealed a statistically significant increase in the TPACK domain scores in time regardless of the group affiliation.

STF Group and TPACK Improvement

Using Wilk's Lambda, one-way repeated measures MANOVA test result revealed a significant time effect over the TPACK domain scores of the STF group, Wilk's $\Lambda = .346$, $F(7, 31) = 8.370$, $p < .01$, partial $\eta2 = .654$, indicating a large effect size (see Table 4). That is, there is a statistically significant difference in the seven combined TPACK domains (TK, CK, PK, PCK, TCK, TPK, and TPACK) over time (after participating in the virtual internship).

Table 4

Tests of Within-subjects Effects [a, b]

Within-Subjects Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Time	Wilk's Lambda	.346	8.370[c]	7.000	31.000	.000	.654

a. Design: Intercept
Within Subjects Design: time
b. Tests are based on averaged variables.
c. Exact statistic

Since the MANOVA test was significant for time, the univariate test results were used to determine which dependent variables (TPACK domain scores) differed. A more conservative alpha level was applied using the Bonferroni adjustment ($\alpha = .007$), a divided α value by the number of dependent variables (seven in this case) to counteract the potential of an inflated Type I error rate due to multiple ANOVAs (Tabachnick & Fidell, 1996). The univariate ANOVA test results revealed that the pre and post TPACK scores of the STF group differed significantly for all the TPACK domains, except for the CK domain $F(1, 37) = .664$, $p > .007$ (see Table 5). As the time factor involved only two levels (pre and post), further t-tests were not performed.

To summarize, the STF participants significantly increased all of their TPACK scores, except the CK domain, in time. The qualitative analysis based on the written reflections presented below also supported the findings from the quantitative analysis by providing complementary evidence for the TPACK development of the STF group.

Table 5

Univariate Tests

Source	Measure	Type III Sum of Squares	*df*	Mean square	*F*	Sig.	Partial Eta Squared
	TK	5.825	1	5.825	45.800	.000	.553
	PK	1.823	1	1.823	13.723	.001	.271
	CK	.118	1	.118	.664	.421	.018
	PCK	2.224	1	2.224	9.941	.003	.212
	TCK	9.592	1	9.592	18.770	.000	.337
	TPK	5.470	1	5.470	54.964	.000	.598
	TPACK	4.750	1	4.750	16.349	.000	.306
Error (time)	TK	4.706	37	.127			
	PK	4.915	37	.133			
	CK	6.603	37	.178			
	PCK	8.276	37	.224			
	TCK	18.908	37	.511			
	TPK	3.683	37	.100			
	TPACK	10.750	37	.291			

Change in Preservice Teachers' Opinions about Technology Integration

Before the STF experience, the participants had more tendencies to benefit from technology as a source for teaching materials. As seen in Table 6, they generally perceived videos as easy-to-access materials to provide means when necessary teaching resources are not available, such as laboratory kits. One student stated that

> Most of the concepts of physics are observable and experimental. To make these concepts more understandable, if possible, it is best to conduct experiments in the classroom or laboratory, if not, the videos of these experiments can be viewed at the classroom. (Student 37, pre-intervention reflection)

One of the most notable changes in the written reflections regarding question 1 is that the number of the participants who declared online platforms as an effective technology integration method increased from two to 11 after the STF experience (Table 6). At the pre-intervention reflections, they described an online platform as an area that the teacher could share course materials and the students can share their homework and explorations about a subject. At the post-intervention reflections, however, they explained an online platform more of a medium that the students can share their ideas, make discussions, prepare portfolios (Student 25), make comments to each other's ideas by getting feedback from teachers (Student 27, Student 34, Student 35, Student 38), working on cooperative projects (Student 18), working on a problem via brainstorming studies (Student 38), creating discussion groups that would be time-consuming and hard to compose in the classroom (Student 30). Thus, the post-intervention ideas included more emphasis on the learning methods, either individually or as a group.

Similarly, at pre-intervention, they mentioned computer-based simulations as an alternative in case of the absence of a laboratory and visuals as a way of representing abstract materials. On the other hand, at the post reflections, their statements were more mostly associated with integrating technology as a tool. The number of participants who considered different technologies simply as containers of knowledge notably decreased in the post reflection data. In addition to an increase in the number of the ideas about the effective ways of technology integration in a lesson plan, the computer-based tools became more diversified with the addition of using slide shows, implementing technologies that support multiple learning approaches and assessment that can be performed with the help of the Internet.

Table 6

Preferred Technological Tools for Teaching

	Pre STF	Post STF
Themes	# of the Participants	# of the Participants
Video	10	3
The Internet	7	1
Visualization	6	3
Educational games	5	1
Simulations	4	4
Applications	4	9
Online platforms	2	11
Online courses	2	-
Slide shows	-	7
Multiple learning approaches	-	3
Internet evaluation	-	2
Total	40	44

One of the most notable differences between the pre- and post-intervention reflection statements is related to teacher control when using technology in the classroom. The number of participants who thought that technology integration should have been under the teacher's control decreased from 6 to 1 at the post-intervention reflections (see Table 7). At the pre-intervention, participants' concern about technology integration was mostly about the possible challenges technology could bring along such as difficulties in classroom management (Student 25, Student 33, Student 35) and distraction of students at young ages (Student 18, Student 38). This concern of the participants indicates that they were overly stressed about the use of technological devices, without considering their potential for pedagogical purposes. However, at the post-intervention, more references were made to using technology as a tool instead of using it for its own sake (see Table 8). One student (Student 27) stated that "The goal should not be learning the technology itself. It can distract students from the lesson." Also, another (Student 18) said that "Learning technology is not a goal for us, we should benefit from it as a tool when we want to present a material or make some applications otherwise we would not be able to do."

Table 7

Reflection Themes before STF

Technology integration is appropriate		Technology integration is not appropriate	
Themes	# of the Participants	Themes	# of the Participants
Under teacher's control	6	Not used for its own purposes	4
Provided training for its use	5	Used for its own sake	4
Used as a tool	4	Not applicable to certain lessons	3
In any case	4	Equal access to technology is an issue	2
Supports multiple learning styles	2	Takes the place of a teacher	1
For saving of time	2	Students not familiar with technology	1
For distance learning	1	Students bring their own technology	1
Total	23		16

Table 8

Reflection Themes after STF

Technology integration is appropriate		Technology integration is not appropriate	
Themes	# of the Participants	Themes	# of the Participants
Used as a tool	6	Used for its own sake	6
In any case	4	Students not familiar with technology	5
To enhance student motivation	2	Teachers not familiar with technology	3
As an assistance to reach objectives	1	Distracting attention	3
Under teacher's control	1	Equal access to technology is an issue	1
For saving of time	1	Not applicable to certain lessons	1
Total	1		19

The analysis of the reflection data suggests that, after the STF experience, the participants started to think about technology as a tool for meeting instructional objectives with appropriate pedagogical methods rather than simply as a source of lesson materials and content. They became more articulate about the notion of technology integration as evident with more diversified ideas, by putting emphasis on meeting instructional objectives and using diverse pedagogical strategies rather than using technology for its own sake.

Discussion

The findings of the present study showed that the STF group had higher TPACK and TK, CK, PK, PCK, TCK, TPK score gains compared to the control group; however, the differences were not statistically significant. Further analyses indicated that the STF group significantly increased six of their TPACK scores (TK, PK, PCK, TCK, TPK, and TPACK), except one (CK), after the STF intervention. Also, the analysis of the pre and post reflections showed that the participants enhanced their understanding and conceptualization of technology integration, focusing more on the content-related learning outcomes with the use of diverse pedagogical strategies when using technology in classrooms.

Previous research on virtual internships typically relied on the analyses of large qualitative data sets (chat data of participants working in a virtual internship) and used a specific type of network analytics method, namely epistemic network analysis (Shaffer, 2017). This body of research manifested the effectiveness of virtual internships in knowledge development, content learning, making justifications and positive attitude development toward a subject (Arastoopour et al., 2014; Bagley & Shaffer, 2009; Bagley & Shaffer, 2011; Beckett & Shaffer, 2005; Chesler et al., 2013; Hatfield, 2011; Nash et al., 2012; Nash & Shaffer, 2012; Nulty & Shaffer, 2008; Shaffer, 1997; Svarovsky & Shaffer, 2006). However, our findings showed that, in the context of a quasi-experimental study, there were no statistically significant differences between the self-report based TPACK scores of preservice teachers who participated in a virtual internship and those who were in the control group.

The reason for this finding might be attributed to the similar course content and equally effective methods used in both groups. During the course, the control group also worked on collaborative class projects, producing instructional multimedia, and developing technology-integrated lesson plans. Thus, the control group also had several opportunities to develop their TPACK skills throughout the semester. Thus, it is reasonable to argue that the reason that the two groups did not differ significantly in their TPACK development is that both groups comparably improved their TPACK scores during the study. Further research including additional control groups based on more traditional instruction (if possible) could be suggested to examine the effects of virtual internships in teacher education from a quantitative standpoint.

The analysis also showed that the preservice teachers who participated in the virtual internship significantly improved their TPACK scores over time. That is, their self-report evaluations corresponding to all of the TPACK domains (except the CK) improved as a result of participating in a virtual internship. These findings of the present study provided complementary evidence on virtual internships being effective means of developing preservice teachers' TPACK (Oner, 2020). Oner's analysis showed that preservice teachers' TPACK network representations became more complex in terms of the strength of connections between technological, pedagogical, and content knowledge after using the STF. This study corroborates these findings by showing that preservice teachers' self-evaluations regarding their TPACK development also significantly improved with a virtual internship.

One of the issues that should be addressed is the non-significant CK development of the STF group while making statistically significant improvements in the other TPACK domains. The reason for no significant development in the CK domain might be due to the fact that the mean score (M = 4.31) for the CK domain was already high in the pre-test results. Indeed, the highest pre-test mean score of the STF group was the CK domain. Therefore, even if the participants benefited from the STF experience, it might not have shown up in the results in terms of CK development. Indeed, there is an increase in the CK mean score at the post-test (M = 4.39), while not being a statistically significant development. Further research could examine ways of increasing CK in the design of learning environments for TPACK development.

Furthermore, it should be noted that the STF is not designed to develop general content knowledge per se. Mishra and Koehler (2006) also argue that an educational program should not be intended to teach a particular content, pedagogy, or technology separately; rather, the interplay between them should be taken into consideration. STF provides a setting to study the content knowledge in the context of pedagogical and technological knowledge; therefore, it does not provide explicit opportunities for content knowledge development separately. To elaborate, in one of the STF assignments, teams were asked to discuss their final project topic (content) concerning its importance (why is it important for students to learn this topic) and possible misconceptions or learning difficulties connected with it. This assignment also required students to think about the teaching strategies that can be used to support student learning and to address the difficulties (make use of PCK) and how technology can help to support student learning and in addressing the difficulties associated with teaching this topic (make use of TCK and TPK). Thus, STF is not designed to provide opportunities for developing TPACK domains separately; rather, it aimed to provide opportunities for developing TPACK domains in an integrated manner.

This study differs from the most virtual internship-related studies by a sampling of college students. The majority of the previous studies sampled high school or middle school students (Bagley & Shaffer, 2009; Bagley & Shaffer, 2011; Beckett & Shaffer, 2005; Hatfield, 2011; Nash et al., 2012; Nash & Shaffer, 2012; Nulty & Shaffer, 2008; Shaffer, 1997; Svarovsky & Shaffer, 2006) to study virtual internships. In one of the studies that sampled college students, researchers worked with the engineering students and demonstrated a significant increase in learning engineering content (Arastoopour et al., 2014; Chesler et al., 2013).

The TPACK improvement of the participants based on the survey data was additionally supported by the participants' reflection data. We found that preservice teachers started to bring in more ideas about the use of technology in relation to the teaching of certain content in terms of learning outcomes and various pedagogical methods. This finding provided further evidence for the effectiveness of virtual internships to develop preservice teachers' TPACK. However, further studies can be conducted to examine the effect of virtual internships in different university settings. In addition, researchers could investigate and compare the TPACK development of preservice teachers from different departments.

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Öğretmen Adaylarının Teknolojik Pedagojik Alan Bilgilerini Geliştirmede Sanal Stajın Rolü

Öz

Sanal stajyerlik uygulamaları, karmaşık profesyonel düşünceyi teşvik etmek için otantik bağlamlar sağlayan öğretmen eğitiminde yeni bir araştırma alanıdır. Ayrıca, öğretmenlerin teknolojik pedagojik alan bilgilerini (TPAB) geliştirmek için en etkili yöntem olduğuna inanılan tasarım yoluyla öğrenme yaklaşımının temel unsurlarını içerirler. 2018 yılında gerçekleştirilen bu çalışma, nitel verilerle desteklenen yarı deneysel bir araştırma desenini kullanarak öğretmen adaylarının TPAB'sini geliştirmek için sanal bir stajyerlik uygulamasının etkinliğini incelemiştir. Çalışmaya çeşitli bölümlerden yetmiş dört öğretmen adayı katılmıştır. Veriler, Öğretmen Adayları için Öğretim ve Teknoloji Bilgisi Anketi'nden uyarlanan bir öz bildirim anketi ve katılımcılar tarafından yazılan yansımalar kullanılarak toplanmıştır. Sonuçlar, deney ve kontrol grubu katılımcılarının TPAB anket puanlarında istatistiksel olarak anlamlı bir fark olmadığını göstermiştir. Ancak deney grubu, alan bilgisi dışındaki tüm TPAB alt alanlarında puanlarını önemli ölçüde artırmıştır. Katılımcıların yansımalarına dayalı nitel analiz, nicel analizden elde edilen bulguları destekleyerek, hizmet öncesi öğretmen eğitiminde sanal stajyerlik uygulamalarının etkililiğine dair doğrulayıcı kanıtlar sağlamıştır.

Anahtar Kelimeler: Teknolojik Pedagojik Alan Bilgisi (TPAB), teknoloji entegrasyonu, sanal stajyerlik, epistemik oyunlar, öğretmen adayları