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Evaluation of pre-service Science and Math teachers' online teaching experiences within the TPACK framework

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Highlights

- Pre-service teachers struggle with the pedagogical and technological knowledge components of TPACK.
- Pre-service teachers need to improve their conceptualization of TPK and TCK.
- Pre-service math teachers achieved more TPACK-OTC indicators.
- Pre-service teachers' preferences for technology tools are not at desired levels.
- Pre-service teachers need to improve student-teacher interactions with interactive learning materials.

Article Info: Research Article

Keywords: *Online teaching, Technological pedagogical content knowledge, Pre-service teachers*

Abstract

The purpose of this study is to identify the factors that shape pre-service teachers' (PSTs) online teaching practices within the technological pedagogical content knowledge (TPACK) framework. Ten science PSTs and nine mathematics PSTs who experienced the practical part face-to-face and the theoretical part online of the Teaching Practice 2 course participated in this study based on a multiple case study design. The researchers collected data through online lesson videos and the TPACK in Online Teaching Survey. Descriptive statistics were used for the survey analysis, while the document analysis technique was through TPACK in Online Teaching Checklist for online lesson videos. The results show that PSTs have some problems, especially in the technological and pedagogical knowledge components of TPACK. Both groups do not have adequate knowledge of the technological tools of assessment, because they give it the least importance. They generally use standard technologies such as presentations or office programs. Their use of the same technologies to identify and teach the subject indicates their limited conceptualizations of technological pedagogical knowledge (TPK) and technological content knowledge (TCK). PSTs need improvement in promoting teacher-student interaction through interactive learning and assessment tools. Some recommendations for teacher education programs are offered.

1. Introduction

The first attempts to use technology in education were rooted in the Project 2061 Technology Panel nearly 35 years ago (Johnson, 1989), and its role in K-12 has become more visible with America's National Science Education Standards (National Research Council [NRC], 1996). In this context, Mishra and Koehler (2006) proposed the Technological Pedagogical Content Knowledge (TPACK) framework to identify the knowledge and skills teachers need to effectively integrate technology into learning environments.

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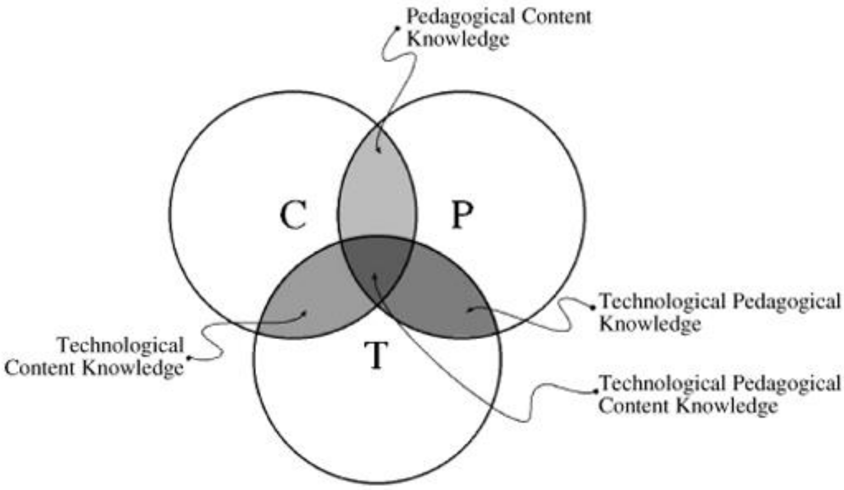

Fig. 1. Technological Pedagogical Content Knowledge Model (Mishra & Koehler, 2006).
Note. C: Content knowledge; P: Pedagogical knowledge; T: Technological knowledge

The TPACK model is an educational model that emerged as a result of integrating technology as a new field of knowledge into Shulman's (1986) Pedagogical Content Knowledge model, which reveals the teacher's understanding of how subjects should be taught. Thus, unlike PCK, TPACK focuses on how to provide effective technology integration for teaching a subject rather than how to teach a subject. Figure 1 illustrates the seven components of the TPACK framework. According to this framework, effective technology integration requires that teachers have knowledge of the subject matter being taught (content knowledge [CK]); teaching methods, processes, and practices (pedagogical knowledge [PK]); the best way to teach the subject matter (pedagogical content knowledge [PCK]); common technologies and their uses (technological knowledge [TK]); which technologies are related to which subject matter (technological content knowledge [TCK]); and the learning and teaching technologies (technological pedagogical knowledge [TPK]).

The online web-based instructional settings have been widely used recently. The practice based on it is called Web Pedagogical Content Knowledge (WPCK) (Lee et al., 2008). WPCK is a specific version of TPACK and is not independent of the TPACK concept. The W in WPCK stands for web-based tools, web-based communication, or web-based interaction (Lee & Tsai, 2010). According to Curtain (2002), online teaching is a type of web-based education that uses the Internet to increase interaction between students and teachers by using asynchronous or synchronous tools. Although this study is based on teaching through web-based tools, it also has open to the participants' choice of different technological applications (mobile, web-based, etc.). Therefore, the authors decided to use the term TPACK as it has a broad definition that includes all. The Covid-19 pandemic has greatly accelerated studies of online education, which began in the 1980s. Online instruction is a type of distance education that provides flexible and varied interactions where educational opportunities are accessed through various technologies (Benson, 2002; Conrad, 2002). The standard terms used in the definitions, such as technology use and interaction, emphasize the role of the instructor. However, it is reported that instructors struggle with pedagogical deficiencies (Ozdamli & Karagozlu, 2022) and lack of training (Hamad, 2022) in online teaching.

Skills such as the teacher's ability to provide active student engagement, in-class communication, and technology use competence are reported as common among the skills needed for successful and effective online teaching in various frameworks (Bigatel et al., 2012; Husna et al., 2022; Martin et al., 2019). These common skills demonstrate the relationship between online teaching and TPACK (Archambault & Crippen, 2019; Bilgin et al., 2012). Similarly, content, pedagogical competence, and technology use competence, which are three of the eight components of the Readiness Model for Teachers in Online Teaching proposed by Demir and Yurdugul (2015), directly emphasize TPACK components. The more technology is integrated into the learning environment, the more TPACK is required for educators. All communication and media depend on technology in online education. TPACK is an appropriate model to guide the effectiveness of online teaching environments (Mailizar et al., 2021). In this regard, it is essential for pre-service and in-service teachers and is considered an important issue for teacher education programs (Tondeur et al., 2012).

2. Literature

2.1. Studies on Pre-service Teachers' TPACK in Traditional Classroom Settings

Self-report questionnaires, open-ended questions, interviews, observations, and performance evaluations were mainly used in the TPACK studies of PSTs (Wang et al., 2018). However, the results of the studies showed a low correlation between the responses to self-report questionnaires and their actual practices (Karakaya, 2017). In this regard, self-report questionnaires, open-ended questions, and performance evaluation methods are used to identify the TPACK of PSTs in classroom teaching.

So and Kim's (2009) study, which used self-report questionnaires and lesson plans, found that PSTs understood the importance of technological and pedagogical knowledge. However, they could not integrate it in the context of the TPACK framework. Similarly, Basaran (2020) reported that science and mathematics PSTs with low TPACK-21 scores also had low levels of TPK. The most common challenges reported by PSTs in technology integration were developing new knowledge, lack of pedagogical experience, and lack of PCK knowledge (Pamuk, 2012). Detailed analyses revealed that PSTs struggled with time management, maintaining students' interest, assessment, and supporting students' learning process in PK; dealing with students' different levels of content knowledge and maintaining their interest in PCK; using standard technologies such as smartboards and Office 365, supporting students' learning with ICT, and focusing on their learning while using ICT in TPK; and dealing with technical problems in the TK component (Valtonen et al., 2020). However, in another study, it was reported that pre-service teachers were most confident in pedagogical knowledge, especially in supporting students' learning processes and discussions. Moreover, in terms of technological pedagogical knowledge, pre-service teachers were most confident in integrating ICT into lessons and supporting students to work with ICT throughout the lesson. Time management, maintaining students' interest and assessment in the context of pedagogical knowledge, and maintaining focus on learning while using ICT in the context of technological pedagogical knowledge were ranked as the most challenging factors for pre-service teachers (Valtonen et al., 2020). Tyarakanita et al. (2020), who evaluated pre-service teachers' TPACK through lesson plans, found that although pre-service teachers' lesson plans included several domains of TPACK, there were some problems especially in TPK and PCK.

Although studies reported that evaluating the development of TCK and TPK was complex (Hosseini & Tee, 2012; Kopcha et al., 2014), they pointed out some problematic issues regarding the TPACK components. However, it was stated that the relationship between PK-TPK and TPK-TPACK becomes stronger as the connection between technological knowledge and pedagogical knowledge is established (Chai et al., 2011).

2.2. Studies on Pre-service Teachers' TPACK in Online Teaching

Studies on PSTs' TPACK in online teaching became more popular during the global lockdown in the Covid-19 pandemic. In one of the studies, it was found that PSTs scored high on CK and low on TCK in the use of digital technologies in lesson plans. It was also found that 37 out of 173 lesson plans used no technology and 90 used the technology only for teachers (Schmid et al., 2021). Similarly, another study reported that PSTs' TCK was positively correlated with their readiness to teach online. The results of both studies underscore the importance of TPACK components for online teaching (Rafiq et al., 2022).

Tanik Onal and Onal (2023) reported that PSTs had some difficulties in classroom management, and they felt anxious in online teaching practices. The results of another study showed that preparing technology-enhanced, inquiry-based lesson plans for online instruction significantly affected PSTs' TPACK self-efficacy; however, they were at the moderate level in the proper use of technological tools and naive in technology integration (Kapici & Akcay, 2023). In addition, Bonafini and Lee (2021) found that although mathematics PSTs showed strong TK, TPK, and TCK in their instructional videos, their TCK practices were heavily focused on standard purposes such as creating a symbol or shape. Kartal and Dilek (2021), in another study, reported that pre-service science teachers who learned about instructional technologies and designed a technology-enhanced lesson showed positive developments in how to integrate technologies into science instruction, indicating that teaching science is more than just having technological knowledge. Similarly, Mangundu (2023) reported that the skills of pre-service STEM teachers needed for multimodal online instruction were not aligned with their technological skills. Although many studies have been conducted on pre-service teachers' TPACKs, Stinken-Rösner et al. (2023) study was an important trigger for the emergence of this study. Stinken-Rösner et. al (2023) reported that there was a significant increase in the TPACK action and behavioral orientations of pre-service teachers as a result of the TPACK training they received and also reported that pre-service teachers were able to use high quality technology in the lessons they planned. From this point of view, it is thought that it is important to identify the factors that PSTs need improvement by evaluating their online teaching experiences in the context of TPACK framework.

2.3. The Rationale and Purpose of the Present Study

The results of PSTs' TPACK in traditional classroom settings appear to be compatible with the results of TPACK in online teaching studies. The main difference is in the methods of data collection. PSTs' TPACK was evaluated through self-report questionnaires or lesson plan outputs in traditional classroom settings, while performance evaluation was used in online teaching. Based on this, there is a need to examine PSTs' TPACK in detail and reveal the possible reasons for their performance in online teaching. In this regard, this study aims to reveal the factors that shape PSTs' online teaching practices within the TPACK framework by examining which indicators are essential for each TPACK component, which factors are considered in course design, and their actual performances.

This study contributes to the gap in online teaching and TPACK by measuring PSTs' perceived importance of TPACK components, factors they considered when designing the online lesson, and online teaching skills through developed data collection and analysis tools. The study provides essential information for teacher educators and new measurement tools to determine the quality of online teaching practices. In addition, the results of this study would promote the support needed to redesign online teaching practices.

The study addresses the following research problems:

- What is the perceived importance of each TPACK component to science and math PSTs?
- What are science and math PSTs' self-evaluations of their online teaching experiences within TPACK?
- How are science and math PSTs' online teaching performances?

3. Methodology

3.1. Research Model/Design

Since the aim was to investigate a holistic case in the context of more than one case in a constrained system, the study used a holistic multiple case study design. In this design, more than one case related to a particular problem is selected, data is collected from multiple sources of information, and the researcher explores and explains the cases (Creswell, 2007). This design was preferred because the researchers wanted to examine the factors that shape the online teaching experiences of science and math PSTs. Because this study aims to describe "the cases" in detail and is not a survey study, one of the limitations of this study may be the lack of generalizable findings.

3.2. Participants

Nineteen PSTs enrolled in the 4th year of the Faculty of Education at a state university in the Aegean region during the spring semester of the 2022-23 academic year participated in the study. The demographic information of the participants is presented in Table 1.

Table 1.

The cross-tabulation of participants' gender and subjects

	Mathematics teaching	Science teaching
Female	8	6
Male	1	4

According to Table 1, 73.68% of the PSTs were female and 53.62% were science PSTs. All PSTs have completed the Teaching Practice 1 course and are taking the Teaching Practice 2 course during the data collection period.

The practical part of the Teaching Practice 2 course was based on face-to-face practicum, while the theoretical part was based on designing online teaching practices. In addition, due to the global lockdown in the Covid-19 pandemic and the major earthquakes in Turkey in February 2023, the participants have experienced most of the undergraduate courses through online education. Due to this fact, the participants implemented their lesson plans in the theoretical part of the Teaching Practice 2 course online.

3.3. Data Collection Tools

3.3.1. TPACK in Online Teaching Survey (TPACK-OTS): This survey was developed by the authors within the scope of this study. It consists of three sections. The first section includes demographic questions about the participants. In the second part, pre-service teachers were asked to consider the context of the online course they teach and accordingly rank the TPACK components in terms of importance. In the development process of this section, at least three indicators were determined in the context of each component by reviewing the literature on the characteristics of TPACK components. The participants were asked to rank the indicators in the context of each component in order of importance. In addition, the "Other" option was added to identify other factors that the pre-service teachers deemed important in the context of the relevant component other than the indicators already written. In the third part of the survey, pre-service teachers' self-evaluations of their TPACK in the context of online teaching were questioned through open-ended questions. Since online teaching was a limitation here, open-ended questions focused on the self-evaluations of pre-service teachers in the context of technology knowledge, technological content knowledge and technological pedagogical knowledge components. The survey was validated through expert views. TPACK-OTS can be found in Appendix A.

3.3.2. Online Lesson Videos: The theoretical part of the Teaching Practice 2 course was conducted online throughout the semester. The online course platform of the relevant university was used as the online teaching platform. Before starting the online teaching process, the instructors explained to the pre-service teachers how to use the system (how participant students can write on the screen, how to share presentations, screen sharing, etc.). In each theoretical course during the semester, a pre-service teacher performed an online teaching course in line with the relevant learning outcome to be taught in the face-to-face part of the Teaching Practice 2 course (in internship). This process was conducted using role-playing technique. Accordingly, the pre-service teachers acted as a teacher with all the authority and responsibility, and the other students participating in the lesson and the instructor of the course acted as the students at the grade level of the relevant learning outcome. In the process of performing the online teaching practice with the role-playing technique, all pre-service teachers participated in the online lessons every week. At the beginning of the course, the instructor authorized the use of the online course platform to the pre-service teacher who was going to perform online teaching practice that week. The pre-service teachers presented the online course materials they prepared according to the 5E model through this platform. In this process, for example, if the pre-service teacher was conducting an online assessment using the Kahoot program, other pre-service teachers and the instructor participated in this application as students. At the end of the course, the pre-service teacher who performed online teaching practice was given various feedbacks by other pre-service teachers and the instructor about the aspects of the course that needed improvement.

3.4. Data Analysis

The data obtained from the second part of the TPACK-OTS were analyzed using descriptive statistics. Accordingly, frequency values regarding the importance level of indicators were counted and percentage frequencies were calculated. The data from the third section were analyzed through content analysis. In this regard, the researchers created codes; when possible, categories and frequency values were counted for each code or category.

The researchers used document analysis technique for online lesson videos and developed Technological Pedagogical Content Knowledge in Online Teaching Checklist (TPACK-OTC). In the process of developing TPACK-OTC, the researchers searched the literature based on content analysis to determine the characteristics of online teaching, the ways to develop TK, TCK, and TPK components of TPACK, and the leading indicators specifically for online teaching. At the end of the literature review, the common items identified by both researchers were selected and arranged as question phrases. Then, each researcher grouped the items into some categories. In the next step, the researchers discussed the categorization process and made some revisions based on the views they agreed upon. As a result, the checklist questions were categorized under three themes: teacher support, technological pedagogical content knowledge, and assessment. Content validity was ensured by expert opinions suggesting the elimination of some items and the revision of others. For example, the experts suggested that an example should be given next to the statement "Selects and uses appropriate technology for subject teaching" in TPACK-OTC and in this context, the relevant statement was revised as "Selects and uses appropriate technology for subject teaching (e.g. using animation/simulation instead of photographs in subjects requiring process/demonstration, etc.)". As part of the reliability study, three preservice teachers who taught online lessons were scored by four different raters using TPACK-OTC, and the agreement between them was calculated. "Yes" codes were scored as 1 and "No" codes were scored as 0. The Cochran Q test was used for analysis. This test calculates the consistency for multiple raters in binary scoring (Karagoz, 2017). The reliability results showed agreement among four raters for each pre-service teacher (p_1=.912; p_2=.200 and p_3=.305). These scores provided evidence of the reliability of the checklist. All data were presented separately and comparatively for science and math PSTs to describe their online teaching experiences in detail within the scope of TPACK framework. The final version of the TPACK-OTC can be found in Appendix B.

3.5. Validity and Reliability

According to Creswell (2007), validation in qualitative research refers to assessing the accuracy of the findings. Three strategies were used to validate the study. The first is triangulation. In this regard, closed-ended questions were used for PSTs' perceived importance of indicators for each TPACK component, while open-ended questions were used for their perceived effectiveness and factors considered when designing an online lesson. In addition, a performance assessment was used to evaluate their online teaching practices. The second strategy is the presentation of detailed information about participants and settings. The final strategy is external review. In this regard, the results of the study were shared with three colleagues who have studies on the topic, and they were asked to verify whether the data supported the findings, interpretations, and results.

According to Creswell (2007), reliability in qualitative research refers to the consistency between coders. The responses of three randomly selected PSTs were coded by the researchers to ensure the reliability of the content analysis process. At the end of the coding process, the researchers discussed the codes they used, reached consensus on the codes, and made some revisions accordingly. The researchers then re-coded the responses from three different PSTs. At the end of the second coding process, the researchers checked the consistency of the codes using Miles and Huberman's (1994) formula and found it to be 83%. This value provided evidence for the reliability process of open-ended questions. Furthermore, the interrater reliability was calculated again for the reliability of the performance analysis using TPACK-OTC. The same rater rated three randomly selected online lesson videos of PSTs with an interval of 20 days. Cohen's kappa was used to calculate interrater reliability. This statistic calculates the consistency between two raters in binary scoring by eliminating chance factors (Cohen, 1960). The results showed that the consistency coefficients were .79, .82, and .64 for each pre-service teacher. According to Landis and Koch (1977), these values indicate that consistency is significant and high.

4. Findings and Discussion

In this section, findings from each data collection tool are presented first, and then all findings are synthesized for science and mathematics PSTs.

4.1. Science and Math PSTs Perceived Importance of Each TPACK Component

The perceived importance of the indicators for each TPACK component by science and math PSTs is shown in Figure 2 and Figure 3.

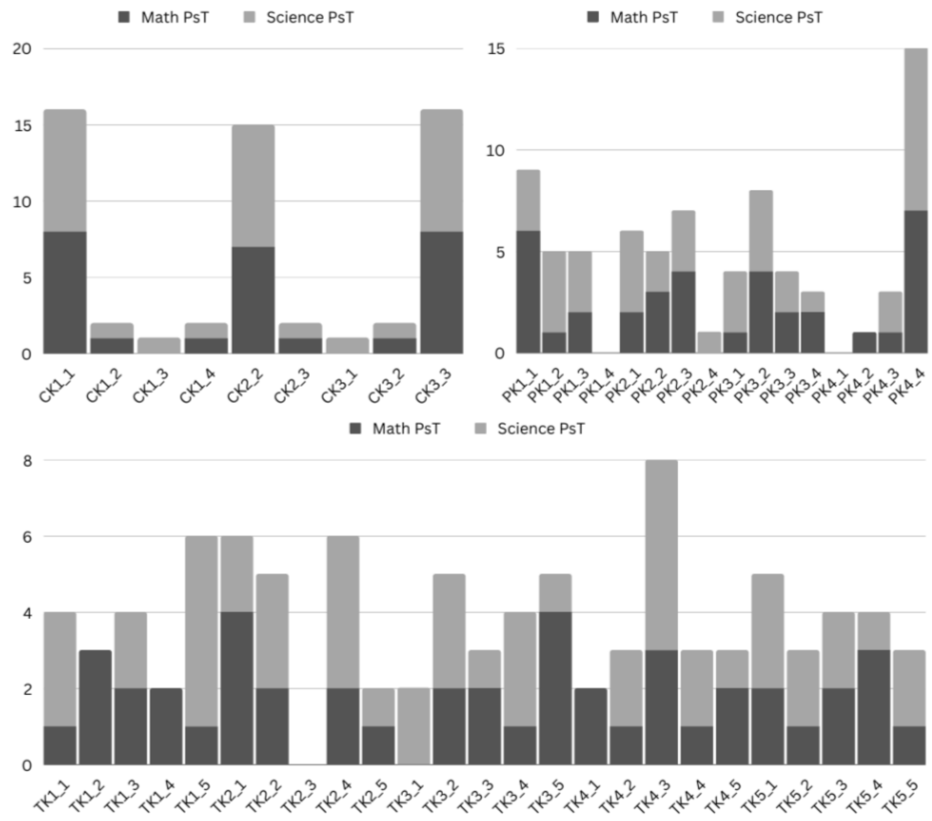

Fig. 2. Perceived importance level of TPACK's single components
Note. CK: Content knowledge; PK: Pedagogical knowledge; TK: Technological knowledge
CK1_1 represents that the 1st item of CK is ranked in the 1st number. Similarly, TK3_2 represents that the 3rd item of TK is ranked in the 2nd number.

Figure 2 shows the number of PSTs in relation to their perceived level of importance of each TPACK component. According to Figure 2, science and math PSTs considered subject matter knowledge essential. At the same time, they considered linking the subject to other courses to be less important in terms of content knowledge. In the pedagogical knowledge component, mathematics PSTs considered engaging students in the lesson to be important, while science PSTs considered knowledge of teaching methods to be important. In the context of technology knowledge, the most important perceived indicator was keeping up with current educational technologies for science PSTs and using learning management systems for math PSTs, while the least important perceived indicator was using Office 365 for science PSTs and solving potential technical problems for math PSTs.

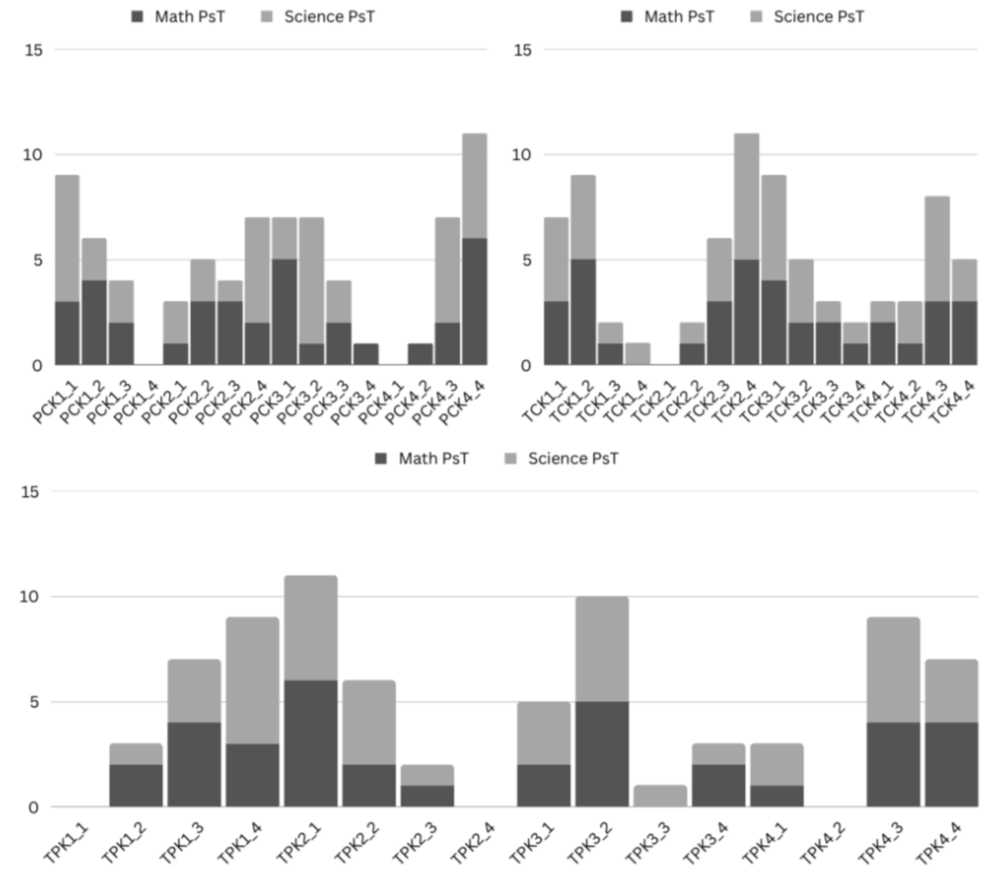

Fig. 3. Perceived importance level of TPACK's dual components
Note. PCK: Pedagogical content knowledge; TPK: Technological pedagogical knowledge; TCK: Technological content knowledge
PCK1_1 represents that the 1st item of PCK is ranked in the 1st number. Similarly, TCK3_2 represents that the 3rd item of TCK is ranked in the 2nd number.

Figure 3 shows the number of PSTs regarding their perceived level of importance of the two TPACK components. According to Figure 3, science PSTs considered knowing effective instructional approaches to be important. In contrast, mathematics PSTs considered presenting appropriate activities related to learning gains to be significant in the context of pedagogical content knowledge. In addition, both groups considered providing appropriate context for reinforcement to be the least important. In the technological content knowledge component, visualizing abstract concepts was perceived as the most important indicator, while asking questions that can only be answered using technology was perceived as least important for both groups. In the technological pedagogical knowledge component, creating interactive learning materials was considered important by both groups. However, creating online assessments was perceived as the least important indicator for science PSTs, while using web-based platforms was perceived as important for math PSTs.

4.2. Science and Math PSTs' Self-Evaluations of Online Teaching Experiences through TPACK

PSTs' efficacy, justifications, and preferences for the TK, TPK, and TCK components of TPACK were examined after their online teaching experiences. According to the results, 68.4% of pre-service science PSTs and 58% of mathematics PSTs felt adequate in technological knowledge. However, 42% of mathematics PSTs needed some development in pedagogical factors, such as getting instant feedback, engaging students in the lesson, and creating interactive learning/assessment activities, while 12.4% of science PSTs needed development in personal factors, such as learning new applications and solving technical problems. 47.3% of math PSTs and 50.2% of science PSTs preferred using presentation software in online lessons.

60% of mathematics PSTs and 78.4% of science PSTs felt adequate in the technological content knowledge component. The basis of this efficacy was pedagogical factors, such as creating interactive materials and getting students' attention for science PSTs, while personal factors, such as dealing with technical problems and positive feedback from the lecturer for mathematics PSTs. However, both groups stated that they needed some developments regarding pedagogical factors. Both groups preferred using presentation and Office 365 programs for technological content knowledge practices with justifications such as effective visual presentation and feeling confident. Only 17.7% of mathematics PSTs with similar justifications preferred educational software programs.

Half of the science PSTs and 83.2% of the math PSTs indicated that they needed some development in technological pedagogical knowledge. They associated their perceived efficacy with pedagogical factors such as interacting with students and providing immediate feedback. In addition, both groups preferred to use Office 365 and presentation programs for technological pedagogical knowledge practices, with justifications such as interest and beliefs in dealing with technical problems. However, it was found that interactive learning materials, such as educational software and web-based or mobile applications suitable for online teaching, were used for assessment or effective visual presentation.

4.3. Science and Math PSTs' Online Teaching Performances

The findings of science and math PSTs' online teaching practices are shown in Figure 4.

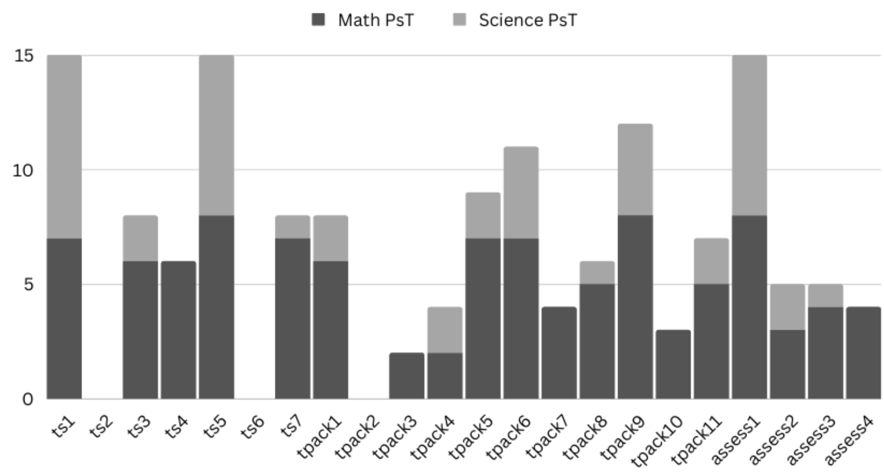

Fig. 4. The number of pre-service teachers who achieved TPACK-OTC indicators
Note. ts: teacher support; tpack: technological pedagogical content knowledge; assess: assessment

According to Figure 4, both groups were good at showing interest in students (ts1), acting like a friend (ts5), and giving immediate feedback (assess1). However, Figure 4 also showed that the math PSTs achieved better online teaching practices than the science PSTs. Math PSTs designed a more appropriate online lesson for the TPACK indicators. Similarly, they created appropriate assessments for online instructional practices and were able to support students in this process.

4.4. Underlying Key Factors of TPACK in Science and Math PSTs' Online Teaching Practices

Both groups considered subject matter knowledge to be the most important indicator in the content knowledge component (Figure 2). This finding may be related to undergraduate teacher education programs. Their undergraduate courses focus heavily on developing content knowledge. This may lead them to consider content knowledge as important. In this regard, it was reported that the most considered factors by PSTs were reflection and modeling by teacher educators in TPACK practices (Baran et al., 2019). However, both groups gave less importance to the association of the subject with other courses (Figure 2). Again, this may be due to the undergraduate teacher education programs. Deficiencies in PSTs' knowledge about integrating multiple disciplines into a course may be the cause of this finding. Various studies have found that a lack of knowledge about different disciplines is a barrier to multidisciplinary teaching (Dickson & Ampofo, 2020; Guerra & An, 2016).

Math PSTs considered engaging students in class as the most important indicator of pedagogical knowledge (Figure 2). Therefore, they showed more teacher-supportive behaviors such as showing interest in students, interacting with students during the lesson, giving equal access to participation, acting like a friend, keeping students engaged throughout the lesson, and giving immediate feedback to students' answers. In addition, science PSTs considered knowledge of teaching methods to be the most important component of pedagogical knowledge (Figure 2). These findings may be due to PSTs' online learning experiences. Participants experienced most of their undergraduate courses online due to the Covid-19 pandemic and the major earthquake in Turkey in February 2023. This experience may make them realize the importance of student involvement and preferred teaching methods. Similarly, in another study, PSTs stated that the instructor's teaching style, interaction, and lack of interest were the determinants of academic engagement in online classes (Arslan et al., 2023). However, science PSTs failed to create a learning environment appropriate for different ways of learning, although they considered knowledge of teaching methods as important. This may be due to their preference for teacher-centered pedagogical approaches. As the qualitative findings showed, their primary use of Office 365 and presentation programs in online teaching practices may support this likelihood. Tomte et al. (2015) found that most teacher educators used teacher-centered pedagogies in online teaching. This finding is not surprising considering that PSTs mostly modeled teacher educators, as stated by Baran et al. (2019). Similarly, PSTs were found to use technological tools mostly for teachers in online education (Schmidt et al., 2021). Another finding regarding the pedagogical knowledge component was that both groups considered knowledge of assessment methods to be the least important (Figure 3). As a result, only a few of the math PSTs used multiple-choice online assessments and allowed students to reflect on their learning. In contrast, only two of the science PSTs allowed students to reflect. This finding may be due to their lack of knowledge and experience with online assessment tools. Although PSTs had taken courses on integrating technology into learning environments, these courses may not have focused on online assessment tools. McVey (2016) found that PSTs primarily used traditional assessment tools, such as reports or quizzes. He linked their use of traditional assessment tools to their feelings of confidence. In addition, the fact that the most experienced online assessment strategy was multiple choice tests (Council of Higher Education [CoHE], 2021) may lead them to use it.

Mathematics PSTs considered the use of learning management systems to be the most important indicator (Figure 2), although only 15.8% of them associated it with their effectiveness in using technology. Solving technical problems was perceived as the least important indicator. In addition, they associated their technology use efficacy with solving potential technical problems. Qualitative findings indicated that they considered factors such as solving technical problems (10.5%), ease of use (26.2%), and feeling confident (21.1%) in technology preferences. On the other hand, science PSTs considered keeping up with current educational technologies as the most important indicator of technology knowledge. They also associated it with their effectiveness. However, none of them used contemporary educational or digital technologies in online teaching practices. Although they considered the use of the Office 365 program to be the least important, 33.4% preferred it in online teaching practices because of its ease of use, beliefs about dealing with possible technical problems, and mastery of its use. According to qualitative findings, half of them also used presentation programs such as PowerPoint. The difference between the perceived importance of the indicators and their actual practice may be related to their technological literacy. Many studies have found that competence in using technology and skills predict technological competence (Pozas & Letzel, 2023; Watson & Rockinson-Szapkiw, 2021). It can also be inferred that PSTs prefer to shape their online teaching practices with the factors they consider unimportant because they do not have sufficient knowledge and experience with the factors, they consider important.

The most significant indicator in the pedagogical content knowledge component was presenting appropriate activities for learning gains for mathematics PSTs. Considering that the primary pedagogy is the use of technology in online teaching, it is expected that appropriate activities for learning gains would be based on technology (Figure 2). However, it was found that they usually presented hands-on activities rather than using online learning activities. On the other hand, although science PSTs considered knowing effective teaching approaches as the most important indicator, only 20% preferred using online learning activities. Qualitative findings showed that they mainly preferred using presentation and Office 365 programs for teaching, with justifications such as mastering their use and appropriateness. It can be inferred that they have some problems in using technology for teaching. They may not know the technological or digital tools, or they may not feel confident in using them. Studies have reported that the technopedagogical competence of PSTs is positively and highly correlated with technology integration (Birisci & Kul, 2019). However, as the qualitative data showed, the finding that 40% of them needed improvement in the use of technology-based tools indicated that they were aware of these shortcomings. The least significant indicator was the presentation of context appropriate for reinforcement. As a result, both groups could not integrate the presentation of authentic problems into online instruction. When this finding is combined with the finding that PSTs considered knowledge of assessment methods to be insignificant, a remarkable situation emerges. Thus, PSTs considered the instructional dimension of online teaching as significant and neglected student learning. The study that reported that teachers' intention to engage in online teaching behaviors is predicted by student-independent factors such as TPACK competence and perceptions of the usefulness of the preferred technology (Khong et al., 2023) supports this conclusion.

Both groups considered the visualization of abstract concepts as the most important indicator in the technological content knowledge component (Figure 3). In this regard, mathematics PSTs indicated that they considered this indicator in their technological tool preferences, using Office 365 and presentation programs predominantly. In contrast, science PSTs associated this indicator with technological content knowledge literacy and considered it when choosing technological tools. PSTs' technological content knowledge practices were for standard purposes such as creating a shape, as Bonafini and Lee (2021) said. However, for both groups, asking questions that can only be answered by using technology was the least significant indicator (Figure 3). Two reasons have been suggested for this finding. One is that PSTs are unfamiliar with or unable to use digital resources or educational software that promote active student engagement and can be used to identify content. In addition, Ertmer et al. (2003) found that undergraduate teacher education courses have focused mainly on the technical aspects of technology, neglecting its integration into learning. The second reason may be related to their preferences for teacher-centered pedagogies. Duncan and Young (2009) found that the most challenging factors for college instructors were facilitating teacher-student and student-student collaboration and creating a productive learning environment in which all students could be engaged. Given that even experienced teachers have difficulty using student-centered pedagogies, it seems acceptable that PSTs with less experience tend to use teacher-centered pedagogies.

Both groups considered the creation/use of interactive learning materials important in the technological pedagogical knowledge component (Figure 3). Correspondingly, both associated technological pedagogical competence with creating/using interactive learning materials and Web 2.0 tools. However, most math PSTs and none of the science PSTs used interactive learning materials. Qualitative findings showed that they mainly preferred Office 365 (35.4%) and presentation programs (23.5%). The first reason might be their low digital literacy, especially in relation to teaching and learning. Improving digital literacy predicted the use of digital learning materials (Paetsch & Drechsel, 2021). However, Reisoglu and Cebi (2020) found that PSTs needed training in digital content creation, digital sources, teaching and learning, assessment, and learner empowerment in the DigCompEdu framework. The second reason may be related to technical issues. For example, Demirkan (2019) reported that although PSTs found digital learning materials exciting and effective, they could not use them due to weak internet connection or extra payment for more features. However, since mathematics PSTs considered the use of web-based platforms as insignificant (Figure 3), they could use them in the assessment process with justifications such as being game-based or promoting students' active engagement. Because web-based platforms encourage active student engagement, PSTs may perceive them as complicating classroom management. The results of other studies seem to support this likelihood (Boyacı, 2010; Tanik Onal & Onal, 2023). In addition to this, ease of use, perceived usefulness, and attitudes were found to predict the use of web-based tools (Horzum & Canan Gungoren, 2012). On the other hand, science PSTs did not consider the use of online assessment in TPK as significant. Qualitative findings showed that although they associated technological pedagogical knowledge competence with online assessment tools, only two used them in online teaching practices (Figure 4). This finding may be due to their lack of knowledge about online assessment tools or personal beliefs. Chien et al (2014) reported that teachers avoided using technology-based assessment tools due to negative beliefs about time management, infrastructure, and difficulty of use.

5. Conclusion and Suggestions

It can be concluded that mathematics PSTs have some problems mainly with the pedagogical and technological knowledge components of TPACK. Although they were good at demonstrating behaviors such as using different teaching methods and providing student-teacher interactions, there were some problems regarding assessment. This issue seems to stem from their perceived importance of knowledge about assessment methods and lack of technological knowledge. They predominantly used Office 365 and presentation programs in their online teaching practices. Their knowledge seemed to be limited, although they could occasionally use educational software and programs related to their subjects. Qualitative findings and online instructional videos revealed that they used similar technological tools to identify and teach the topic. This case suggests that PSTs have difficulty conceptualizing TCK and TPK. It can also be concluded that mathematics PSTs need some improvement in interacting with students using interactive learning or assessment tools, although they have achieved this verbally.

Like the math PSTs, the science PSTs have some difficulty with the pedagogical and technological knowledge components of TPACK. It can be understood that they do not have sufficient knowledge about online teaching and assessment methods. They predominantly used Office 365 and presentation programs in online teaching practices. Online teaching videos showed that none of them used technological tools specific to their subjects. This case suggests that science PSTs do not have adequate knowledge of educational software, web-based tools, and mobile applications related to their subjects. Qualitative findings and online lesson videos revealed that they use similar technological tools to identify and teach the subject. Therefore, they have some problems in conceptualizing TCK and TPK. They also need to improve teacher-student interaction with interactive learning or assessment tools.

Based on the results, it can be suggested that technology training programs for specific departments should be prepared in teacher education programs. This should be structured within a broader program that goes beyond the effective use of Office 365 programs, as in the Basic Information Technologies course, or the introduction of limited Web 2.0 tools, as in field education courses such as the Teaching Mathematics course or the Science Teaching course. PSTs should be informed about what technological tools can be used for what purposes in the courses, including the integration of technology into learning. Furthermore, the conceptualization of TPK and TCK should be improved and supported, especially in teaching contexts that require a multidisciplinary perspective, such as STEM (Science-Technology-Engineering-Mathematics) practices. In this regard, how the teaching methods presented in the field education courses can be used in a technology-supported or technology-embedded learning environment should be exemplified and PSTs should be encouraged to practice more.

References

Archambault, L., & Crippen, K. (2009). Examining TPACK among K–12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*(1), 71–88.

Arslan, B. Z., Bulut, E., Ozcan, B., Ural, F. & Barutcu Yildirim, F. (2023). Academic engagement experiences of pre-service teachers during the Covid-19 online education process. *Journal of Educational Technology & Online Learning, 6*(2), 315-328. http://doi.org/10.31681/jetol.1261006

Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A. & Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Educational Technology, 50*(1), 357-370. https://doi.org/10.1111/bjet.12565

Basaran, B. (2020). Examining preservice teachers' TPACK-21 efficacies with clustering analysis in terms of certain variables. *Malaysian Online Journal of Educational Technology, 8*(3), 84-99.

Benson, A. (2002). Using online learning to meet workforce demand: A case study of stakeholder influence. *Quarterly Review of Distance Education, 3*(4), 443−452.

Bigatel, P. M., Ragan, L. C., Kennan, S., May, J., & Redmond, B. F. (2012). The identification of competencies for online teaching success. *Journal of Asynchronous Learning Networks, 16*(1), 59–78.

Bilgin, İ., Tatar, E. & Ay, Y. (2012, June 27-30). *Sınıf öğretmeni adaylarının teknolojiye karşı tutumlarının teknolojik pedagojik alan bilgisi (TPAB)'ne katkısının incelenmesi* [Investigation of the contribution of primary school pre-service teachers' attitudes towards technology to technological pedagogical content knowledge (TPACK)] [Paper presentation]. X. National Science and Mathematics Congress, Niğde, Turkey.

Birisci, S. & Kul, U. (2019). Predictors of technology integration self-efficacy beliefs of preservice teachers. *Contemporary Educational Technology, 10*(1), 75-93. https://doi.org/10.30935/cet.512537

Bonafini, F. C., & Lee, Y. (2021). Portraying mathematics pre-service teachers' experience of creating video lessons with portable interactive whiteboards through the TPACK. *The New Educator, 17*(4), 327-352. https://doi.org/10.1080/1547688X.2021.1980167

Boyacı, A. (2010). Pre-service teachers' views on web-based classroom management. *Turkish Online Journal of Distance Education (TOJDE), 11*(2), 208-234.

Chai, C. S., Koh, J. H. L., Tsai, C. C. & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' technological pedagogical content knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education, 57*, 1184-1193. https://doi.org/10.1016/j.compedu.2011.01.007

Chien, S. P., Wu, H. K. & Hsu, Y. S. (2014). An investigation of teachers' beliefs and their use of technology-based assessments. *Computers in Human Behavior, 31*, 198-210. http://dx.doi.org/10.1016/j.chb.2013.10.037

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20*(1), 37-46.

Conrad, D. (2002). Deep in the hearts of learners: Insights into the nature of online community. *Journal of Distance Education, 17*(1), 1−19.

Council of Higher Education (CoHE) (2023, July 20). *Faculty staff survey report regarding the efficiency of online education in the pandemic process*. https://covid19.yok.gov.tr/Documents/anketler/ogretim-elemani-anket-sonuclari.pdf

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd Ed.). Sage Publications.

Curtain, R. (2002). *Online delivery in the vocational education and training sector*. https://www.ncver.edu.au/__data/assets/file/0027/9648/online-delivery-in-vet-sector-782.pdf

Demir, O. & Yurdugul, H. (2015). The exploration of models regarding e-learning readiness: Reference model suggestions. *International Journal of Progressive Education, 11*(1), 173-194.

Demirkan, O. (2019). Pre-service teachers' views about digital teaching materials. *Educational Policy Analysis and Strategic Research, 14*(1), 40-60. https://doi.org/10.29329/epasr.2019.186.3

Dickson, A. H. & Ampofo, R. E. (2020). Challenges of implementing integrated social studies curriculum in basic schools: A study of Cape Coast metropolis. *International Journal of Innovative Research & Development, 9*(11), 67-73. https://doi.org/10.24940/ijird/2020/v9/i11/NOV20032

Duncan, H. E., & Young, S. (2009). Online pedagogy and practice: Challenges and strategies. *The Researcher, 22*(1), 17--32.

Ertmer, P. A., Conklin, D., Lewandowski, J., Osika, E., Selo, M., & Wignall, E. (2003). Increasing preservice teachers' capacity for technology integration through use of electronic models. *Teacher Education Quarterly, 30*(1), 95–112.

Guerra, P. P. & An, S. (2016). Possibilities and challenges of teaching integrated math and social studies for social justice: Two teacher educators' collaborative self-study. *Georgia Educational Researcher*, *13*(2), 1-32. https://doi.org/10.20429/ger.2016.130201

Hamad, W. B. (2022). Understanding the foremost challenges in the transition to online teaching and learning during Covid-19 pandemic: A systematic literature review. *Journal of Educational Technology & Online Learning, 5*(2), 393-410. http://doi.org/10.31681/jetol.1055695

Horzum, M. B. & Canan Gungoren, O. (2012). A model for beliefs, tool acceptance levels and web pedagogical content knowledge of science and technology preservice teachers towards web based instruction. *Turkish Online Journal of Distance Education (TOJDE), 13*(3), 50-69.

Hosseini, Z., & Tee, M. Y. (2012). Conditions influencing development of teachers' knowledge for techology integration in teaching. *International Magazine on Advances in Computer Science and Telecommunications (IMACST), 3*(1), 91-101.

Husna, S. H., Shahrinaz, I., Siti, H. S. A., Ummul, F. A. R. (2022). Conceptual framework of factors affecting online teaching. *International Journal of Innovative Research and Scientific Studies, 5*(4), 354-362. https://doi.org/10.53894/ijirss.v5i4.874

Johnson, J. R. (1989). *Technology: Report of the Project 2061 phase I technology panel*. AAAS Books.

Kapici, H. O. & Akcay, H. (2023) Improving student teachers' TPACK self-efficacy through lesson planning practice in the virtual platform, *Educational Studies, 49*(1), 76-98. https://doi.org/10.1080/03055698.2020.1835610

Karagoz, Y. (2017). *SPSS ve AMOS uygulamalı nitel, nicel, karma bilimsel araştırma yöntemleri ve yayın etiği* [Qualitative, quantitative, mixed scientific research methods with SPSS and AMOS practices and publication ethics]. Nobel Yayınevi.

Karakaya, O. (2017). *Investigating preservice teachers' TPACK integration into lesson planning* [Master's thesis, Iowa State University]. Iowa State University Digital Repository.

Kartal, T. & Dilek, I. (2021). Preservice science teachers' TPACK development in a technology-enhanced science teaching method course. *Journal of Education in Science Environment and Health, 7*(4), 339-353. https://doi.org/10.21891/jeseh.994458

Khong, H., Celik, I., Le, T .T. T., Lai, V. T. T., Nguyen, A. & Bul, H. (2023). Examining teachers' behavioural intention for online teaching after Covid-19 pandemic: A large-scale survey. *Education and Information Technologies, 28*, 5999-6026. https://doi.org/10.1007/s10639-022-11417-6

Kopcha, T. J., Ottenbreit-Leftwich, A., Jung, J. & Baser, D. (2014). Examining the TPACK framework through the convergent and discriminant validity of two measures. *Computers & Education, 78*, 87-96.

Landis, J, R., & Koch, G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159-174.

Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web. *Instructional Science, 38*(1), 1–21. https://doi.org/10.1007/s11251-008-9075-4

Lee, M.H., Tsai, C.C. & Chang, C.Y. (2008, March). *Exploring teachers' self-efficacy toward the web pedagogical content knowledge in Taiwan* [Paper presentation]. Annual Meeting of the American Educational Research Association, New York.

Mangundu, J. (2023). STEM preservice teachers' e-readiness for online multimodal teaching methods usage in Pietermaritzburg, South Africa: Analysis through the adapted TPACK FRANEWORK. *African Journal of Research in Mathematics, Science and Technology Education*. https://doi.org/10.1080/18117295.2023.2232667

Mailizar, M., Hidayat, M., & Al-Manthari, A. (2021). Examining the impact of mathematics teachers' TPACK on their acceptance of online professional development. *Journal of Digital Learning in Teacher Education, 37*(3), 196-212. https://doi.org/10.1080/21532974.2021.1934613

Martin, F., Budhrani, K. & Wang, C. (2019). Examining faculty perception of their readiness to teach online. *Online Learning, 23*(3), 97–119. https://doi.org/10.24059/olj.v23i3.1555

McVey, M. (2016). Preservice teachers' perception of assessment strategies in online teaching. *Journal of Digital Learning in Teacher Education, 32*(4), 119-127, https://doi.org/10.1080/21532974.2016.1205460

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: A sourcebook of new methods* (2nd ed.). Sage Publications.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

National Research Council. (1996). *National science education standards*. The National Academies Press.

Ozdamli, F. & Karagozlu, D. (2022). Online education during the pandemic: A systematic literature review. *International Journal of Emerging Technologies in Learning, 17*(16), 167-193.

Paetsch, J. & Drechsel, B. (2021). Factors influencing pre-service teachers' intention to use digital learning materials: A study conducted during the Covid-19 pandemic in Germany. *Frontiers in Psychology, 12*, 1-12. https://doi.org/10.3389/fpsyg.2021.733830

Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning, 28*, 425-439. https://doi.org/10.1111/j.1365-2729.2011.00447.x

Pozas, M. & Letzel, V. (2023). Do you think you have what is takes? Exploring predictors of pre-service teachers' prospective ICT use. *Technology, Knowledge and Learning, 28*, 823-841. https://doi.org/10.1007/s10758-021-09551-0

Rafiq, K. R. M., Yunus, M. M. & Susiati. (2022). Re-envisioning technological pedagogical content knowledge and online teaching readiness of English for foreign language pre-service teachers in language teacher education. *Frontiers in Psychology, 13*, 1-6. https://doi.org/10.3389/fpsyg.2022.927835

Reisoglu, I. & Cebi, A. (2020). How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu. *Computers & Education, 156*, 1-16. https://doi.org/10.1016/j.compedu.2020.103940

Schmid, M., Brianza, E. & Petko, D. (2021). Self-reported technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to digital technology use in lesson plans. *Computers in Human Behavior, 115*, 1-12. https://doi.org/10.1016/j.chb.2020.106586

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14

So, H., & Kim, B. (2009). Learning about problem-based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australian Journal of Educational Technology, 25*(1), 101-116.

Stinken-Rösner, L., Hofer, E., Rodenhauser, A. & Abels, S. (2023). Technology implementation in pre-service science teacher education based on the transformative view of TPACK: Effects on pre-service teachers' TPACK, behavioral orientations and actions in practice. *Education Sciences, 13*(7), 1-26. https://doi.org/10.3390/educsci13070732

Tanik Onal, N. & Onal, N. (2023). Online learming and teaching experiences of preservice science teachers during Covid-19 pandemic. Journal of Educational Technology and Online Learning, 6(2), 295-314. https://doi.org/10.31681/jetol.1078486

Tomte, C., Enochsson, A. B., Buskqvist, U., & Karstein, A. (2015). Educating online student teachers to master professional digital competence: The TPACK-framework goes online. *Computers & Education, 84*, 26-35. http://dx.doi.org/10.1016/j.compedu.2015.01.005

Tondeur, J. Van Braak, J., Sang, G., Voogt, J., Fisser, P. & Ottenbreit-Leftwich, A. (2012). Preparing preservice teachers to integrate technology in education: In search of a new curriculum. *Educational Studies, 39*(2), 239-243.

Valtonen, T., Leppanen, U., Hyypia, M., Sointu, E., Smits, A. & Tondeur, J. (2020). Fresh perspectives on TPACK: Pre-service teachers' own appraisal of their challenging and confident TPACK areas. *Education and Information Technologies, 25*, 2823-2842. https://doi.org/10.1007/s10639-019-10092-4

Wang, W., Schmidt-Crawford, D. & Jin, Y. (2018). Preservice teachers' TPACK development: A review of literature, *Journal of Digital Learning in Teacher Education, 34*(4), 234-258, https://doi.org/10.1080/21532974.2018.1498039

Watson, J. H. & Rockinson Szapkiw, A. (2021). Predicting preservice teachers' intention to use technology-enabled learning. *Computers & Education, 168*, 1-10. https://doi.org/10.1016/j.compedu.2021.104207

Appendix A. TPACK in Online Teaching Survey (TPACK-OTS)

Section 1.

Gender	(……) Female	(……) Male
Department	(……) Science Education	(……) Mathematics Education

Section 2.

Instruction: There are a total of 24 items under each title. Please rank the items in order of importance in each specific title. You must put the item you consider most important in the first order. You can also add other items that should be included in the specific title in the "Other" choice.

Content Knowledge	(……) Having subject knowledge (……) Ask questions that help you explore the content. (……) Connect the content to other concepts in the lesson or to other lessons. Other (*Please specify*):	**Technological Content Knowledge**	(……) Select and use appropriate technology to support understanding of the topic. (……) Asking questions that can only be answered with technology (……) Visualize the abstract concepts (……) Keep up with current technologies as they relate to the subject you teach. Other (*Please specify*):
Pedagogical Knowledge	(……) Engage students in the lesson (……) Having the knowledge of teaching methods (……) Having the knowledge of classroom management (……) Having the knowledge of assessment methods Other (*Please specify*):	**Pedagogical Content Knowledge**	(……) Having knowledge of the effective teaching methods for a specific content domain (……) Use different teaching approaches (……) Present appropriate activities aligned with learning outcomes for students to engage in (……) Provide appropriate context in which to reinforce learning Other (*Please specify*):
Technological Pedagogical Knowledge	(……) Conduct online assessments (……) Preparing/using interactive learning materials (simulations, software, etc.) (……) Preparation of digital learning materials (video, presentation, etc.) (……) Use of web-based platforms (forum, blog, etc.) Other (*Please specify*):	**Technology Knowledge**	(……) Effective use of Office Programs (……) Effective use of online education platform (……) Dealing with possible technical problems (……) Use of various programs and software (……) Follow current educational technologies Other (*Please specify*):

Section 3.

Instruction: You have taught an online lesson using the Live Lesson System as part of the Teaching Practice 2 course. Please answer the following questions based on your experience. The writing area can be expanded as needed.

1. **a.** How would you rate your use of technology in general (*web applications, technical problems, virtual environments, etc*.) in the context of online teaching?

   b. What applications have you used for online teaching? Please list all applications by name.

   c. How did you choose the applications you listed in the previous question?

2. a. How would you rate your use of technology (*multimedia, visual presentations, educational software, etc.*) in online teaching?

   b. What applications have you used to describe the subject in online teaching? Please list all applications by name.

   c. How did you choose the applications you listed in the previous question?

3. a. How would you rate yourself in the use of technology for teaching and assessing the subject (*interactive learning materials, digital learning activities, teacher-student interaction, etc.*) in online teaching?

   b. What applications have you used to teach and assess the course online? Please list all applications by name.

   c. How did you choose the applications you listed in the previous question?

Appendix B. Technological Pedagogical Content Knowledge in Online Teaching Checklist (TPACK-OTC)

Instruction: Please answer the following questions to assess the appropriateness of pre-service teachers' online teaching practices. Put an X in the box of the answer you have selected as Yes or No. If you would like to make notes about the questions presented here or about other online teaching practices, you can fill in the "Comments" section at the end of the page.

Questions	**Answer**	
Teacher Support		
Does he/she show interest in his/her students?	Yes	No
Does he/she encourage communication between students?	Yes	No
Does he/she interact with the students during the lesson?	Yes	No
Does he/she give equal participation rights to his/her students?	Yes	No
Does he/she act like a friend to the students?	Yes	No
Does he/she enable students to make decisions about their own learning?	Yes	No
Does he/she keep students' interest throughout the lesson?	Yes	No
Technological Pedagogical Content Knowledge		
Does he/she provide a learning environment suitable for different ways of learning (verbal, visual, auditory, etc.)?	Yes	No
Does he/she use the technologies that he/she can direct his/her students to collaborative work?	Yes	No
Does he/she use interactive learning materials (software, simulations, etc.)?	Yes	No
Does he/she use online learning activities?	Yes	No
Does he/she ask questions that lead his/her students to think?	Yes	No
Does he/she use various technologies (video, presentation, software, etc.) together?	Yes	No
Does he/she associate learning outcomes with daily life situations?	Yes	No
Does he/she select and use appropriate technology for teaching the subject (e.g. using animation/simulation instead of photographs in subjects requiring process/demonstration, etc.)?	Yes	No
Does he/she select and use technology appropriate to the subject content?	Yes	No
Can he/she solve technical problems encountered during the course?	Yes	No
Does he/she use current technology/digital tools?	Yes	No
Does he/she use presentation programs effectively?	Yes	No
Assessment		
Does he/she give immediate feedback to the answers he/she receives from the students?	Yes	No
Does he/she use online assessment methods (online exams, etc.)?	Yes	No
Does he/she enable students to reflect on what they have learned?	Yes	No
Does he/she present real life problems to his/her students?	Yes	No