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ORIGINAL PAPER

Aligning with Practice: Examining the Effects of a Practice-Based Educational Technology Course on Preservice Teachers' Potential to Teach with Technology

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Abstract
This study was conducted to examine the design of a face-to-face undergraduate educational technology course for preservice teachers. The design of the course used Grossman et al.'s (2009) pedagogies of practice to emphasize the blended teaching practices of teachers in the university's nine placement districts and designing instruction for technology-rich and blended environments. Using Schmidt et al.'s (2009) technological pedagogical content knowledge (TPACK) survey, Harris et al.'s (2010) Technology Integration Assessment Rubric, lesson plan reflections, and course reflections, this study investigates using the pedagogies of practice to design a course that prepares preservice teachers to teach with technology in technology-rich and blended environments. Results indicate statistically significant growth in preservice teachers' teaching and technology self-perceptions, technological pedagogical knowledge, and overall TPACK application after the completion of the course. Suggestions for research and practice are provided.

Keywords Practice-based teacher education · Teacher preparation · Pedagogies of practice · Blended learning · TPACK

As technology has become more ubiquitous across the country, the reality of teaching with technology in today's P-12 classrooms has changed. The U.S. Department of Education's National Education Technology Plan (2017) noted a "rapid change across the country in fundamental aspects of the educational technology landscape" (p. 1). More schools have access to reliable internet, a variety of devices available for reasonable prices, and web-based educational technology applications. School districts across the United States have consistently decreased their student-to-device ratios and increased the number of student devices they support (Consortium for School Networking, 2020; Project Tomorrow, 2021). As a result, teachers have found themselves teaching in blended environments that allow them to leverage online learning strategies in their face-to-face classrooms.

Despite these changes to technology access and instructional approaches in P-12 settings, teacher preparation programs have not prepared preservice teachers to teach in blended environments (Archambault, 2011; Archambault et al., 2014; Graham et al., 2019). Additionally, research suggests teacher preparation programs offer limited opportunities for students to master the skills necessary for understanding how to effectively teach with technology in their future classrooms (Buss et al., 2015; Foulger et al., 2012). Many standalone educational technology courses for preservice teachers teach students how to use technologies (Betrus, 2012; Kay, 2006; Ottenbreit-Leftwich et al., 2010) and use technology integration frameworks (Lee & Kim, 2014; Buss et al., 2015), yet teachers entering the field continue to be unprepared to teach with technology (Bakir, 2015; U.S. Department of Education, 2017).

There is a disconnect between what preservice teachers are taught in standalone educational technology courses and the realities of teaching with technology in today's classrooms. Few (if any) studies investigate the effects of an educational technology course designed to reflect the reality of local classrooms on preservice teachers' potential to teach with technology. Grossman et al.'s (2009) pedagogies of practice provide a framework in which standalone

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educational technology courses can represent how teachers teach with technology in today's classrooms, break down how teachers teach with technology in today's classrooms, and allow preservice teachers to practice components of teaching with technology in today's classrooms. The purpose of this study is to investigate how a standalone educational technology course designed using Grossman et al.'s (2009) pedagogies of practice to reflect the blended teaching practices of teachers in the university's nine placement school districts affects preservice teachers' potential to teach with technology. The questions guiding this study were:

1. To what extent does an educational technology course that reflects the blended practices of local classrooms impact preservice teachers' technological pedagogical content knowledge (TPACK) self-perceptions?
2. To what extent does an educational technology course that reflects the blended practices of local classrooms impact preservice teachers' application of TPACK in blended instruction?
3. What are preservice teachers' experiences in an educational technology course that reflects the blended practices of local classrooms?

Conceptual Considerations

Practice-Based Teacher Education

Practice-based teacher education is an approach that makes "teaching practice the central element of teacher education" (Zeichner, 2012, p. 376). Practice-based teacher education programs engage students in practicing real teaching practices to begin developing their teaching repertoires, which results in students learning about teaching practices in both conceptual and practical ways (Janssen et al., 2015). Janssen et al. (2015) described, "The emphasis in [practice-based teacher education]…is on helping novices learn how to use this knowledge in action" (p. 138). To guide professional education programs in using a practice-based approach, Grossman et al. (2009) developed the pedagogies of practice framework.

Pedagogies of Practice

Grossman et al. (2009) defined three pedagogies of practice: 1) representations, 2) decomposition, and 3) approximations. Collectively, these pedagogies of practice support preservice teachers' learning the practice of teaching.

Representations include how teaching practice is represented for teacher education students (Grossman et al., 2009). Representations typically are abundant in teacher preparation programs and can include instructors modelling strategies, observations, videos depicting scenarios or techniques, case studies, and more. Grossman et al. suggested, "Professional educators need to be mindful of the range of meanings that representations convey and provide opportunities to debrief these representations with students" (p. 2068).

Decomposition involves decomposing and explicating teaching practices (Grossman et al., 2009). When decomposing practice, teacher educators break down complex teaching practices into smaller parts, so students can understand the complexities and practice them (Grossman et al., 2009; Janssen et al., 2015). Students then begin practicing how to enact the parts of the complex practices and receive feedback specific to the skill they learned before they practice enacting the complex practice as a whole (Grossman et al., 2009). For instance, teacher educators may decompose the complexity of a whole lesson plan by dividing instruction into smaller sections about each lesson plan component to facilitate students' understanding of and practice with specific components before they design an entire lesson plan on their own (Grossman et al., 2009).

Approximations provide preservice teachers with opportunities to practice components of teaching practices (Grossman et al., 2009); this is when students recompose the complex teaching practices that were decomposed (Janssen et al., 2015). Approximations challenge students to engage in practices that are difficult for inexperienced teachers (Grossman et al., 2009). While approximations can vary in authenticity, they have the same goal: to provide students opportunities to experiment with the actual practices of teachers (Janssen et al., 2015). Grossman et al. (2009) noted that approximations allow students to learn from their experiences recomposing as well as the errors they make when recomposing.

TPACK

In an effort to understand the knowledge teachers need to effectively teach with technology in their classrooms, Mishra and Koehler (2006) built upon Shulman's (1986) pedagogical content knowledge (PCK) to develop the technological pedagogical content knowledge (TPACK) framework, adding technology as a third main knowledge domain (Mishra & Koehler, 2006; Koehler et al., 2013). The TPACK model depicts the framework's seven overlapping domains and the interactions between knowledge of instructional technology, pedagogy, and content (see Fig. 1). Notably, the framework suggests the need for teachers to have all three types of knowledge (i.e., content, pedagogical, technological) and the importance of learning them in an integrated manner rather than in isolation (Koehler et al., 2014). The seven TPACK domains include:

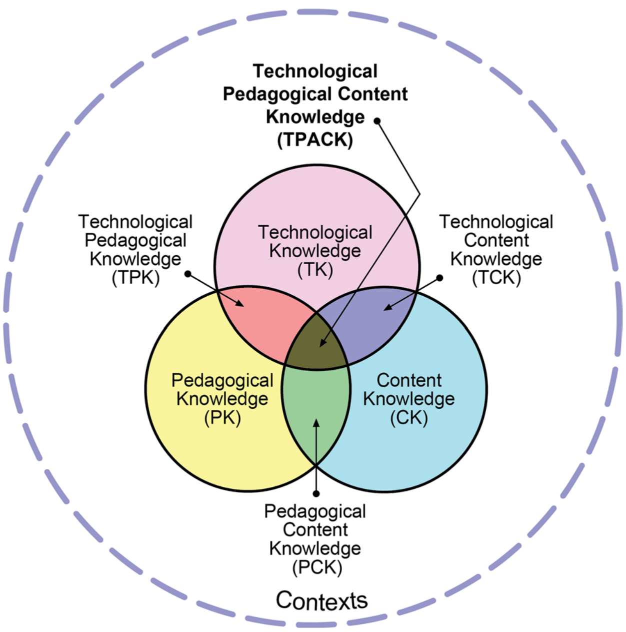

Fig. 1 Technological Pedagogical Content Knowledge Model (TPACK). The TPACK model. Reproduced with permission of the publisher © 2012 by tpack.org

1. **Content Knowledge (CK):** The domain-specific or subject matter (e.g., English, math) comprehension that a teacher must have (Mishra & Koehler, 2006; Koehler et al., 2013).
2. **Pedagogical Knowledge (PK):** The overall understanding of teaching pedagogies, including processes, strategies, and practices that support learning.
3. **Technological Knowledge (TK):** The expertise of using emerging digital technologies.
4. **Pedagogical Content Knowledge (PCK):** The understanding of the best teaching practices for a specific domain. It shows the interaction between CK and PK.
5. **Technological Content Knowledge (TCK):** The awareness of the technology tools available to support learning in specific subject matters.
6. **Technological Pedagogical Knowledge (TPK):** The expertise in using technology to create meaningful learning experiences.
7. **Technological Pedagogical Content Knowledge (TPACK):** The interaction of all domains, demonstrating the mastery of teachers using educational technologies to support teaching pedagogies in specific subject matters.

To measure these domains, TPACK has been assessed in a number of ways. Schmidt et al. (2009) created a survey instrument to assess TPACK, which uses self-reported data to measure the seven TPACK domains described above. The instrument has been widely used and adapted by researchers in different contexts (e.g., Abbitt, 2011; Chai et al., 2011; Hall, 2018; Hall et al., 2020; Kopcha et al., 2014; Nelson & Hawk, 2020). Because Schmidt et al.'s (2009) TPACK survey instrument only provides self-reported data, Harris et al. (2010) modified Britten and Cassady's (2005) Technology Integration Assessment Instrument to develop the Technology Integration Assessment Rubric (TIAR) as a performance assessment of teaching artifacts to evaluate the TPACK domains. Others have developed additional surveys (e.g., Archambault & Crippen, 2009), open-ended questionnaires (e.g., So & Kim, 2009), and performance assessments (e.g., Koh, 2013; Graham et al., 2012).

Scholars have conducted empirical studies using TPACK to understand preservice teachers' technology integration development (Wang et al., 2018). Most studies with preservice teachers employ survey instruments to investigate self-reported TPACK perception data and/or performance-based instruments to analyze lesson plans (Wang et al., 2018). For instance, Abbitt (2011) studied 45 preservice teachers' self-efficacy in the context of TPACK and found a significant positive correlation between self-efficacy and the TPACK scale. More recently, Hall et al. (2020) investigated 32 preservice teachers' TPACK self-perceptions and application in a flipped course and a face-to-face course that was designed using Merrill's (2002) first principles of instruction; the authors found that preservice teachers' TPACK self-perceptions and application both increased significantly.

While TPACK's popularity promulgated research on preservice and inservice teachers' teaching with technology self-efficacy and growth, a number of scholars have critiqued its vague and differing definitions of domains (e.g., Graham, 2011; Kopcha et al., 2014), confounding domain boundaries (e.g., Archambault & Barnett, 2010), and usefulness for practical application (e.g., Brantley-Dias & Ertmer, 2013). Graham (2011) described the definitions of domains as "lacking sufficient clarity to give a reader confidence in what the constructs represent" (p. 1955). Likewise, Kopcha et al. (2014) found it was difficult to use Mishra and Koehler's (2006) definitions of TPACK to distinguish TCK without considering aspects of TPK and TPACK. Archambault and Barnett (2010) explained the difficulties of measuring the domains separately and questioned their existence as independent constructs. Using both the definitions of domains and domain boundaries to support their rationale, Brantley-Dias and Ertmer (2013) argued, "The TPACK framework is 'too big' and its constructs 'too small'" (p. 123), making it difficult to use in practical ways that help prepare teachers to teach in today's classrooms.

Despite some of the criticisms, TPACK has been used to make significant contributions to research in the field of educational technology. Specifically, research has suggested modelling, designing lessons for technology-rich environments, and increased knowledge of technology can facilitate preservice teachers' TPACK development (e.g., Ozgun-Koca, 2009; Voogt et al., 2013; Wang et al., 2018). To examine the design of an undergraduate educational technology course, the current study used two validated instruments to measure TPACK for the purpose of understanding if the course affected preservice teachers' potential to teach with technology in technology-rich and blended environments.

Blended Learning

Blended learning holds various meanings and conceptualizations in the literature (Graham, 2019; Hrastinski, 2019; Osguthorpe & Graham, 2003), and the variety of definitions of blended learning make it difficult to measure its prevalence (Graham, 2019). Hrastinski (2019) noted that failing to adopt a specific definition of blended learning might lead to a misconception of what a scholar or practitioner means by blended learning. For the context of this study, blended learning combines online and face-to-face instruction and activities (Graham et al., 2019). The ways in which online and face-to-face instruction or activities are combined can vary. Some use online and face-to-face elements simultaneously, while others distinctly separate the online and face-to-face instruction or activities (Graham, 2006).

Despite the difficulties associated with accurately assessing the adoption of blended learning, informal evidence from P-12 contexts suggests more and more schools are adopting blended learning approaches as technology becomes more ubiquitous in the classroom. For example, Prescott et al. (2018) conducted a study to examine the implementation of a blended learning literacy program from kindergarten to fifth grade. Their study demonstrated significant growth on standardized reading tests "even when controlling for student grade level, initial student skill level, and EL status, showing that benefits of the blended learning program were found to be similar across various types of students" (p. 504). To investigate math achievement differences in 6th grade students in a traditional, face-to-face setting versus a blended learning setting, Fazal and Bryant (2019) found statistically higher Measure of Academic Progress scores in students instructed through blended learning than those in the face-to-face environment. They concluded, "Schools could benefit from implementing the station-rotation blended learning practices within math classes, particularly for students who are behind academically and need additional learning growth in one school year" (p. 61).

Because of the increasing adoption of blended learning approaches in P-12 contexts, it is important for teacher educators to prepare preservice teachers to teach in blended environments. Graham et al. (2019) noted, "Teachers must develop specialized skills for teaching in blended environments" (p. 239). Archambault et al. (2014) recommended that teacher preparation programs comprehensively adopt online and blended teaching approaches to prepare all students for their future classrooms. Some teacher educators have taken up the call to prepare preservice teachers for teaching in blended environments. For instance, Shand and Farrelly (2017) designed and implemented a blended social studies course for preservice teachers to study the principles of blended courses that preservice teachers identify as beneficial to their own learning and are willing to use in their future classrooms. Students in their study valued the course's organization, clear expectations, instructor presence (online and face-to-face), and personalized learning, and they indicated a desire to implement these four strategies in their future blended classrooms. In a course designed to teach students about blended learning and help them develop blended teaching competencies, Arnesen et al. (2019) found students not only were more positive about blended learning by the end of the course, but also they felt they knew how they could personalize learning in their future classrooms.

While the course being examined in the current study did not solely teach students about blended teaching and learning, it modelled blended teaching and learning at the activity level, where learning activities contained both distinctly separate and simultaneous online and face-to-face components (Graham, 2006). The course's learning activities and projects emphasized students applying their technological, pedagogical, and content knowledge when approximating classroom management, instructional design, and blended instructional strategies. Specific details about the course's design are described below.

Course Design

A project-based educational technology course for undergraduate preservice teachers at a public university in the Midwest United States was designed using Grossman et al.'s (2009) pedagogies of practice to emphasize 1) blended teaching in the local context (i.e., nine placement school districts), 2) teaching and learning with technology, and 3) designing blended instruction.

Representations

Preservice teachers at our institution are required to experience diverse school placements, including at least one rural, urban, and suburban school placement setting; these placements, which are for observations, pre-internships, and student teaching, typically occur in one of nine school districts. An analysis of the nine placement school districts revealed that six districts have completed their 1:1 technology rollout, and one is just starting its rollout. Two districts currently do not have published plans for a 1:1 technology initiative or increasing the amount of technology available for students and teachers at school. Additionally, 100% of the nine placement districts use Google for Education. None of the districts have a formal blended teaching and learning initiative, which is consistent with almost all K-12 schools across the state; however, the seven districts with a 1:1 initiative provide instructional technology professional development that promotes blended teaching at the activity level, where online and face-to-face components primarily occur simultaneously. As a result of the school placement settings requirements, students are likely to complete at least one field placement experience in a blended environment.

To reflect the realities of blended teaching practices in local classrooms (i.e., the nine placement districts), Google Classroom was chosen to deliver and organize the course, allowing instructors to model effective use of the tool in a blended environment and students to experience the student side without explicit instruction. As students learned about educational technology topics and teaching with technology practices, course instructors modelled blended teaching competencies (i.e., online integration, data practices, personalization, online interaction) to support learning in any discipline (Graham et al., 2021). Key characteristics of the course included activities that blended online and face-to-face activities and projects that students could personalize in the context of the discipline(s) they will eventually teach. Major topics covered in the course were informed by both educational technology topics and instructional technology coaches from around the state where this research was conducted. The first author met with instructional technology coaches from around the state quarterly, and at each meeting, she inquired about the teaching with technology skills they hope first-year teachers in their district have. The instructional technology coaches frequently highlighted the importance of first-year teachers knowing how to manage technology in the classroom, use Google tools, and design blended instruction. Topics covered in the course include meaningful learning with technology; technology integration and blended teaching and learning; classroom management of technology; universal design for learning and differentiation with technology; instructional design for blended environments; makerspaces; gamification; and responsible uses of technology. Throughout the course, preservice teachers submitted six major projects – a classroom technology management plan, two formal lesson plans, a Maker's Workshop (Sanders et al., 2019) plan, a digital escape room activity, and an inquiry project about a P-12 educational technology topic of their choice. The project, topics covered, and our chosen delivery method allowed us to design a course that represents expectations of schools and districts in the local context.

Each class session began with the agenda document projected at the front of the room, which linked to all of the materials and activities that would be used for class that day. Upon arriving to class, students opened their devices (or used one in the classroom), logged into Google Classroom, and opened the agenda. Each day was designed to engage students in meeting the course objectives and to scaffold their progress on major course projects (for more details, see Decomposition below). The instructors modelled how to use all aspects of Google Classroom from the teacher side and modelled the use of a variety of instructional strategies and tools that students could use with their future students. Examples from real classrooms anchored new concepts students were learning about, and the instructors aimed to bring in the voices of current P-12 teachers (synchronously or asynchronously) to illustrate the connection between the coursework and its application in today's classrooms.

Decomposition

While modelling best practices of blended learning and teaching with technology during class, instructors engaged students in breaking down teaching practices (e.g., classroom management of technology, designing instruction for blended environments) into smaller components that students practiced, often collaboratively. Students received feedback on the components they practiced during these decomposition activities before they recomposed the components to complete course projects.

For example, after reading about and viewing examples of the variety of classroom technology environments they might experience in the future (e.g., computer lab, technology stations, mobile laptop/tablet cart, one-to-one, bring your own device), students were randomly assigned to one of the environments to collaboratively create a list of pros and cons for teaching in their assigned technology environment. The instructor checked in with students as they were discussing their environments, and groups presented their list to the rest of the class. During the presentations, the instructor facilitated a discussion that linked the pros and cons to technology integration and blended teaching concepts as well as to the other environments. After the discussion, students worked together to connect the pros and cons of a computer lab environment to an example classroom technology management plan created for a computer lab, which included classroom technology rules, a common language for using technology, and technology care expectations. By thinking through pros and cons of teaching in specific environments, linking them to technology integration and blended teaching, and connecting the pros and cons to a management plan for a computer lab, students practiced how to approach designing their own classroom technology management plan.

After learning about the variety of different technology environments they might teach in and creating a classroom technology management plan for an environment of their choice, students began focusing on how to design blended instructional activities that used online and face-to-face elements simultaneously. Prior to writing their first lesson plan, the lesson plan components were decomposed to ensure students understood the lesson plan expectations before the first lesson plan. For instance, to master writing learning objectives that aligned with the standards, activities, assessments, and identified technology environment, students collaboratively wrote learning objectives for one of six different scenarios, which provided a summary of the instructional plan (i.e., instructional activities, technology tools, assessments, technology environment) and indicated the grade level, subject area, and standards. The instructors explicated a completed example to model how students would use the provided information to write learning objectives for their scenario. During the activity, the instructor walked around the classroom to assist groups as needed before students presented their scenario and objectives to the class. Instructors provided constructive feedback about each objective by discussing the alignment between the learning objectives, standards, and components of the instructional plan summary. Additionally, the instructor noted whether students used a strong verb and identified the condition in which the learners would demonstrate their knowledge or skills (i.e., by the end of this lesson, students will be able to). Through these think-aloud evaluations, the entire class was able to learn more about writing strong learning objectives that aligned with the rest of the instructional plan before they wrote their own.

Approximations

Once students had the opportunity to decompose the teaching practices that are relevant to course projects, they had the opportunity to recompose (Janssen et al., 2015) those teaching practices when completing course projects. Each of the six course projects engaged students in the practices of teaching with technology – from classroom management to designing instruction to accommodating a variety of learners – while also requiring students to reflect on their experiences and connect their completed work to the International Society for Technology in Education's (ISTE) Educator Standards (2017).

For example, after evaluating the pros and cons of the variety of classroom technology environments they might experience in the future, connecting them to the concepts of technology integration and blended teaching, and decomposing classroom technology management policies, students designed a classroom technology management plan for a blended environment of their choice. The classroom technology management plan project required preservice teachers to develop three posters they could hang in their future classroom to explain their classroom technology policies and procedures to their students. Preservice teachers created one poster for each of the following topics: 1) classroom technology rules, 2) a common language for using technology in the classroom, and 3) expectations for how students care for technology in the classroom. Classroom management is a difficult practice for inexperienced teachers to master (Wolff et al., 2015), and management of technology in classrooms can be difficult for experienced teachers (Bolick & Cooper, 2015). Through approximations of managing classroom technology, preservice teachers were able to experiment creating the policies and procedures they will need to manage the physical classroom space when students are simultaneously working in the physical and online classroom spaces.

After demonstrating their understanding of classroom management of technology, preservice teachers built on that knowledge as they learned to design blended instruction. For example, after decomposing how to write learning objectives, evaluate technological tools for instructional purposes, and design an aligned lesson plan, preservice teachers designed and developed their first lesson plan in the course that intentionally used technology to blend online and face-to-face instructional activities for a grade level and content area of their choice. They were expected to begin with the standards and learning objectives before moving on to their instructional plan and selecting technology that would assist learners in meeting the standards and objectives. In the lesson plans, preservice teachers were required to identify the state standards, write learning objectives, describe their instructional plan, identify formative and/or summative assessments, identify the technology environment they were writing the lesson for (i.e., 1:1 with Windows, MacBook, or Chromebook laptops; laptop or iPad cart; laptop or iPad stations), identify the ISTE Standards for Students (2016) addressed by their lesson, and design and develop all of the materials they would need to carry out the lesson. We required students to identify a technology environment in their lesson plans for two reasons, so 1) students were forced to consider contextual factors that may have implications for their instructional plan, instructional strategies, and the technological tools they decided to use and 2) instructors could assess the overall alignment of their instructional plan within a specific context. For instance, it would be problematic for a student to write a lesson plan for a classroom that is 1:1 with laptops when the lesson leverages an application that is only available on iPads. In this way, the lesson plan projects allowed preservice teachers to begin envisioning what was possible with technology in ways that are representative of what they will be expected to do once they enter the field.

Prior to the first lesson plan project, most students had previous experience writing lesson plans in other undergraduate education courses; however, this was the first time they were required to fully design and develop the instructional materials they would need to carry out the lesson. Additionally, it was the first time some of them were required to write a lesson plan that intentionally used technology for teaching and learning purposes. While challenging many of them, the lesson plans gave students the opportunity to practice what it means to develop instructional materials that leveraged technological tools and plan for how students would engage with those materials, which they achieved by testing all of their materials and thoroughly explaining their instructional procedures.

Methods

This study used a case study design that incorporated mixed methods to evaluate the effects of the course on preservice teachers' potential to teach with technology in technology-rich and blended environments.

Participants

The participants included 33 preservice teachers who completed the redesigned 16-week undergraduate educational technology course described above. Two participants identified as male, and 31 participants identified as female. The participants were enrolled in nine different majors: Elementary Education (19 participants), Early Childhood Education (6 participants), Secondary Social Studies Education (2 participants), Secondary English Education (1 participant), Art Education (1 participant), Physical Education (1 participant), Agricultural Education (1 participant), English (1 participant), and Multidisciplinary Studies: American Sign Language and Elementary Education (1 participant). Additionally, students were at different places in their teacher preparation programs; two participants were freshman, 11 participants were sophomores, 16 participants were juniors, and two participants were seniors.

Data Collection

Both quantitative and qualitative data were collected from all preservice teachers participating in the study.

Quantitative Data

Quantitative data consisted of survey responses from the beginning and end of the semester and rubric scores on two lesson plans.

Survey Schmidt et al.'s (2009) TPACK survey was administered twice – at the beginning and end of semester – to measure preservice teachers' self-perceptions of the seven TPACK domains. The survey items were measured on a 5-point Likert Scale ranging from strongly disagree (1) to strongly agree (5). The authors validated the survey, which had an internal consistency ranging from .78 to .93 using Cronbach's alpha. Because students were from a wide range of teacher education disciplines, discipline-specific survey items were revised to encompass all disciplines. For example, in the Content Knowledge (CK) domain, "I can use a mathematical way of thinking," "I can use a historical way of thinking," "I can use a scientific way of thinking," and "I can use a literary way of thinking" became "I can use a way of thinking that is appropriate to the content area(s) I will be teaching (e.g., mathematical, historical, scientific, literary, etc.)." The modifications resulted in 28 survey items.

Rubric Scores Two lesson plans from each preservice teacher were evaluated using Harris et al.'s (2010) Technology Integration Assessment Rubric (TIAR), which assesses TPACK by analyzing teaching artifacts. It should be noted that preservice teachers were not evaluated using the TIAR during the semester; the rubrics used during the semester were specific to the projects, which included both the lesson plans and reflection questions. As a result, the TIAR was used to evaluate preservice teachers' application of TPACK in the blended instruction they designed after the completion of the course and for research purposes only. The lesson plans were submitted five weeks apart. Lesson Plan #1 was submitted during week seven and required students to design an original lesson plan, develop all of their own materials, and blend online and face-to-face instructional activities. Lesson Plan #2 was submitted during week 12 and required students to transform a teacher edition lesson plan, develop the materials they would need, and blend online and face-to-face instructional activities. To ensure students understood each component of the lesson plan prior to writing one independently, the lesson plan components were decomposed during each in-class session to provide students opportunities for distributed practice (Willingham, 2002). Additionally, alternate forms of instructional planning, design, and development (i.e., Maker's Workshop, digital escape rooms) were assigned between the lesson plans. The TIAR addresses three TPACK domains: technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). The TIAR contains four rubric criteria: Curriculum Goals and Technologies (measures TCK), Instructional Strategies and Technologies (measures TPK), Technology Selection(s) (measures TPACK), and Fit (measures TPACK). Each rubric criteria rates teaching artifacts on a four-point scale, resulting in a total score that ranges from four to 16 points. The TIAR was validated and used Cronbach's alpha to establish an internal consistency of .91 (Harris et al., 2010).

Qualitative Data

Qualitative data consisted of open-ended project reflections and open-ended course reflections.

Lesson Reflections Each lesson plan posed four reflection questions, which asked students to reflect on their experiences with specific aspects of the project. The first lesson plan required students to describe their experiences designing a lesson, describe their experiences developing their own materials, and explain how they believed their lesson would assist students in mastering the content standards. The second lesson plan required students to explain why they thought the lesson they chose needed a makeover; describe their experiences transforming the lesson; and describe how their transformed lesson was more innovative, differentiated, and engaging. For both lesson plans, students used specific details from their project to explain how their work on the lesson plan helped them demonstrate their mastery of an ISTE Standard for Educators (2017).

Course Reflections At the end of the semester, students responded to five open-ended questions about the course: 1) What was the most important thing learned? 2) What was your favorite project this semester? Explain why this was your favorite project. 3) What was your least favorite project? Explain why this was your least favorite project. 4) Please describe the strengths of the course. 5) Please describe suggestions you have for modifying and improving future sections of [the course].

Data Analysis

To answer research question 1 (impact on TPACK self-perceptions), the 28 knowledge about teaching and technology survey items were analyzed according to each of the seven TPACK domains (Schmidt et al., 2009). Mean scores for each domain were averaged for each participant, creating a construct score; descriptive statistics and paired t-tests were calculated on the seven construct scores. To answer research question 2 (impact on application of TPACK in blended instruction), rubric scores were created using Harris et al.'s (2010) TIAR to evaluate two lesson plans for each student. Prior to evaluating the lesson plans, the authors met to discuss each rubric criterion, review two randomly chosen lesson plans, and discuss the rationale behind our ratings as a group. Once a level of comfort on using the rubric and agreement on how to apply it was achieved, the second and third author, who both have taught the course, evaluated all of the lesson plans independently and took notes to record the rationale behind their decisions before engaging in a consensus-building process. Consensus building can improve the trustworthiness and dependability of findings (Lincoln & Guba, 2000). The consensus-building process consisted of the authors reviewing each lesson plan to review their independent ratings. When there was a disagreement on scores, the authors compared their notes and discussed the lesson plan to reach consensus. Descriptive statistics and paired t-tests were calculated on overall rubric scores and the rubric scores for each criterion.

Finally, to answer research question 3 (preservice teachers' experiences), the project and course reflections each underwent thematic analyses using Braun and Clarke's (2006) six-phase process. The analyses were conducted separately, resulting in three thematic analyses: Lesson Plan #1, Lesson Plan #2, and course reflections. Phase 1 consisted of reading the data and recording memos, and Phase 2 included initial coding. During Phases 3 and 4, we met as a team to identify patterns and categorize codes (Auerbach & Silverstein, 2003), which is when we realized the patterns and codes emerging from the lesson plan reflections were similar. As a result, we categorized the lesson plan reflection codes collectively before naming and defining themes in Phase 5. Once our themes were defined, we identified representative examples of each theme to report in Phase 6.

Results

Impact on TPACK Perceptions (Research Question 1)

On average, students reported higher scores on all seven TPACK domains at the end of the course, and the differences were statistically significant ($p =. 000$) and represented a large effect (see Table 1). Students reported the largest difference in the TCK domain from the beginning of the course ($M = 3.00$, $SD = 1.00$) to the end of the course ($M = 4.49$, $SD = 0.51$), $t(32) = 8.015$, $p = .000$, $d = 1.40$. The second largest difference was in TPACK from the beginning of the course ($M = 3.36$, $SD = 0.78$) to the end of the course ($M = 4.49$, $SD = 0.57$), $t(32) = 6.71$, $p = .000$, $d = 1.18$, which was followed by the difference in TPK from the beginning of the course ($M = 3.49$, $SD = 0.63$) to the end of the course ($M = 4.60$, $SD = 0.40$), $t(32) = 10.193$, $p = .000$, $d = 1.77$.

Impact on Application of TPACK in Blended Instruction (Research Question 2)

Table 2 presents participants' mean TIAR scores. On average, students' second lesson plan ($M = 3.49$, $SD = 0.51$) exhibited technology use that supported instructional strategies (Instructional Strategies & Technologies criterion) more than was found in the first lesson plan ($M = 3.15$, $SD = 0.51$); this difference was significant, $t(32) = 2.77$, $p = .009$, $d = 0.48$. Evaluators perceived that students' instructional plans and developed materials were more detailed and

Table 1 TPACK Self-Perceptions

TPACK Domain	Beginning of Course		End of Course		p	d
	M	SD	M	SD		
Technology Knowledge (TK) [a]	3.30	0.68	4.11	0.72	.000	1.21
Content Knowledge (CK) [a]	3.76	0.64	4.47	0.52	.000	1.19
Pedagogy Knowledge (PK) [a]	3.72	0.66	4.54	0.40	.000	1.13
Pedagogical Content Knowledge (PCK) [a]	3.67	0.97	4.49	0.57	.000	0.75
Technological Content Knowledge (TCK) [a]	3.00	1.00	4.49	0.51	.000	1.42
Technological Pedagogical Knowledge (TPK) [a]	3.49	0.63	4.60	0.40	.000	1.80
Technological Pedagogical Content Knowledge (TPACK) [a]	3.36	0.78	4.49	0.57	.000	1.19

[a]Statistically significant differences from beginning of the course to the end of the course, $p = .000$

Table 2 Mean TIAR Scores

TIAR Criterion	Lesson Plan #1		Lesson Plan #2		p	d
	M	SD	M	SD		
Curriculum Goals & Technologies (TCK)	3.58	0.56	3.73	0.45	.201	0.23
Instructional Strategies & Technologies[a] (TPK)	3.15	0.51	3.49	0.51	.009	0.48
Technology Selection(s) (TPACK)	3.15	0.62	3.36	0.49	.109	0.29
Fit (TPACK)	3.36	0.55	3.55	0.51	.206	0.23
Total [b]	**13.24**	**1.84**	**14.12**	**1.62**	**.038**	**0.38**

[a]Statistically significant differences from Lesson Plan #1 to Lesson Plan #2, $p < .01$

[b]Statistically significant differences from Lesson Plan #1 to Lesson Plan #2, $p < .05$

precise in how the technology supported the instructional strategies. Additionally, the activities mediated by technology were more active from the students' perspective. For example, on Lesson Plan #2, Evaluator 2 observed, "The activities are engaging and mostly student-centered. The instruction is well-detailed, and the instructions are clear and informative." In addition to the Instructional Strategies and Technologies criterion, students' average total rubric scores on the second lesson plan ($M = 14.12$, $SD = 1.62$) had higher overall TIAR scores than the first lesson plan ($M = 13.24$, $SD = 1.84$); this difference was significant $t(32) = 2.17$, $p = .038$, $d = 0.38$.

While students' average scores in all other TIAR criteria (i.e., Curriculum Goals and Technologies, Technology Selection, Fit) were higher on the second lesson than the first, the differences were not statistically significant. Students scored highest in the Curriculum Goals & Technologies criterion on both lesson plans, and the scores increased 0.15 points from Lesson Plan #1 ($M = 3.58$, $SD = 0.56$) to Lesson Plan #2 ($M = 3.73$, $SD = 0.45$) on average; the evaluators found a mix of lesson plans where curriculum goals and technologies were aligned and some that needed more development in technology selections or alignment. The mean Technology Selections scores increased 0.21 points from Lesson Plan #1 ($M = 3.15$, $SD = 0.62$) to Lesson Plan #2 ($M = 3.36$, $SD = 0.49$). In both sets of lesson plans, when the Technology Selection was not assessed as appropriate (i.e., rated as a 3 out of 4), evaluators perceived the use of technology to be forced, age-inappropriate, or that another tool would be more appropriate for the learning objectives and instructional plan. Finally, students' Fit scores increased 0.19 points on average from Lesson Plan #1 ($M = 3.36$, $SD = 0.55$) to Lesson Plan #2 ($M = 3.55$, $SD = 0.51$). Most of the lesson plans provided an appropriate combination among content, pedagogies, and technologies; however, in the majority of lesson plans, students' instructional strategies could be improved to fit strongly together with the technology and instructional plan.

Preservice Teachers' Experiences (Research Question 3)

To understand preservice teachers' experiences in the course, thematic analyses were conducted on the Lesson Plan #1 reflections, Lesson Plan #2 reflections, and course reflections. The themes from the lesson plan reflections are presented concurrently.

Lesson Plan Reflections

Each student completed two lesson plan reflections – one for Lesson Plan #1 and one for Lesson Plan #2. Three themes emerged from the thematic analyses of the two lesson plans (see Table 3). Each theme is defined, indicates the number

Table 3 Themes from Lesson Plan Reflections

Theme (#)[a]	Definition
Designing lessons is difficult (15)	Students experienced difficulties designing lessons where the standards, learning objectives, instructional plan, and technology use were aligned.
Developing materials is time consuming but necessary (18)	By being required to fully develop all of the materials need to carry out a lesson, students learned that developing materials is time consuming but necessary for understanding how the technology works and how to implement activities with students.
Leveraging accessible and versatile digital tools (28)	Students described the importance of leveraging digital tools that are accessible on any type of device and versatile in their scope, ability to differentiate, and ability to monitor student progress.

[a]The number of students associated with the theme

of students whose reflections were included in the theme, and provides examples of reflections included in the theme.

Designing Lessons Is Difficult Almost half (15) of the students described experiencing difficulties as they designed lessons where the standards, learning objectives, instructional plan, technology use(s), and identified blended environment were aligned. One student explained, "I thought this project was hard from the very beginning because it was hard to decide which standards to start with. I have a hard time choosing where to begin, but once I began, I think that the lesson started to come together and my plan made sense with the standards, my objectives, and the activities I designed for students." Another student described her strategy for overcoming the difficulties she experienced: "In developing the material, I realized I needed to keep referencing the standards so my lesson didn't stray from the intended goal. Overall being mindful of what the end goal helps to stay on track." Of the 15 students who were included in this theme, four students made two comments that were grouped into the "Designing lessons is difficult" theme. While 15 students experienced difficulties creating aligned lesson plans, five students expressed having few or no difficulties. For instance, one student explained, "I thought that the lesson would be much more difficult to build than it was. I was overthinking it at first but once I started writing it out it started to flow. To my surprise it was easier than I thought and I enjoyed making the materials. I am proud of the work that I did in my lesson plan."

Developing Materials Is Time Consuming but Necessary After designing their lesson plans and developing all of the materials needed to carry out the lesson in a classroom, over half (18) of the students described learning that developing original instructional materials is a time-consuming but necessary process. For instance, one student reflected, "When creating the mini lesson, I ran into problems with the technology I was using as it was not capable of what I had hoped. This was a good reminder that technology does not always go as planned." Another student explained how he previously had not experienced the teacher side of some of the tools his lesson plan leveraged, "so I wasn't sure how to do some things. It gives me the knowledge to help my students if they have questions for me. They will probably run through the same problems I ran into." Finally, a third student described her process and the changes she made:

> Actually developing the materials needed for this lesson took longer than I expected. It is one thing to plan the activity, but it is another to actually do it yourself. For the activity I wanted the students to do during their work period, I changed the instructions about four times. The first time, I had way too many required materials for them to do. It took me around an hour to do and had to think logically that they would not have this long to physically do it in the classroom. So, I ended up changing the instructions to where the students could find the pictures online instead of in the school so they were able to do everything in our room.

Eight of the 18 students included in this theme made more than one reflection comment that was categorized into this theme. No students described the process of developing their own instructional materials as quick and/or unnecessary.

Leveraging Accessible and Versatile Digital Tools Almost all (28) students discussed the importance of leveraging digital tools, like Google tools, that are accessible on any type of device and versatile in their scope, ability to differentiate, and ability to monitor student progress. For instance, one student explained:

> Google technologies are very useful and beneficial in a classroom. It is an interconnected domain where many various resources can be linked together. It creates a cohesive and connected atmosphere of the material, as well as being easily accessible. Each student can have access to each assignment. Students can work collaboratively or independently. Teachers can also assess students through various forms and know where each student is at in understanding the material without it being made public to the rest of the class. Teachers can

also assign students different assignments individually to help their understanding.

Of the 28 students included in this theme, six made two reflection comments that were included, and one student had three reflection comments included. About two-thirds (19) of the students included in this theme additionally explained how the importance of leveraging accessible and versatile tools was informed by their experience learning about the limitations of some educational technologies through the process of designing and developing their own materials. One of these students reflected, “Creating the materials took time and some tinkering with. Even if I was not able to use the materials I created with one resource, I learned tips and tricks of settings to look for and in what ways that resource could be applicable in other lessons.”

Course Reflections

At the end of the semester, students responded to five open-ended reflection questions about the course, which asked them to describe and explain the most important lesson learned, their favorite project, their least favorite project, course strengths, and suggestions for modifications. Three themes emerged from the thematic analysis of the reflection responses (see Table 4).

Evaluating for Alignment Almost half (13) of the students described one of the most important things they learned in the course was how to evaluate and select digital tools that align with the intended learning objectives and instructional plan. For instance, one student wrote, “I think the most important thing I have learned in this course is how to appropriately choose technology based on the content being taught and how to use it most effectively.” Another student explained, “[Lesson Plan #1] was the first lesson that we really tried to incorporate technology. It taught me how important it is to start by thinking about the standards and learning objectives before choosing technology that would help my students master the standards. With all of the different options it’s easy to see a new tool and want to design a lesson around it, but that’s not the point and it might not result in students actually meeting the objectives.”

Understanding how Technology Can Support Instruction Two-thirds (22) of students indicated that the course and its projects required them to learn how technology can be used to support learning in a variety of environments. One student explained, “I think the general concept of the class - teaching with technology - is the most important thing I have explored. Each of the new ways to implement technology into the classroom to support all students’ learning is important and I think the general course was vital to my education and my future classroom.” Another student described using technology to meet the needs of all learners: “The most important thing I’ve learned was how technology can help teachers modify lessons for those who need [it] while still helping other students increase their content interaction.”

Valuing Usefulness of Coursework for Future Classrooms Over half (18) of students described valuing coursework when they believed it could be useful in their future classrooms. One student described, “I was most excited about creating [a Maker’s Workshop] and I really enjoyed what I came up with and think I would use it in the classroom.” Another student how what she learned by completing a project could be useful in the future: “I found [Lesson #1] to be the most beneficial when thinking long-term use. I learned a lot of new methods and tools that I can continue to use. It’s something that will most likely be available for a very long time and will continue to grow and get new tools and features. Now that I know how it all works, I will be able to easily stay up-to-date with it.” Three of the 18 students made two separate comments that were categorized into this theme. While it was not enough to constitute a theme, two students noted not valuing projects because they could not envision how they would use the concepts in their future classrooms. One of these students explained, “It was harder for me to understand how I would be able to apply [affinity spaces and YouTube playlists] to my classroom.”

Table 4 Themes from Course Reflections

Theme (#)[a]	Definition
Evaluating for alignment (13)	Students learned how to evaluate and select digital tools that align with the intended learning objectives and instructional plan.
Understanding how technology can support instruction (22)	Students learned how technology can be used to support instruction for all learners in a variety of contexts.
Valuing usefulness of coursework for future classrooms (18)	Students saw value in coursework when they believed it could be useful in their future classrooms.

[a]The number of students associated with the theme

Discussion

The purpose of this study was to examine how an educational technology course designed using the pedagogies of practice impacted preservice teachers' TPACK self-perceptions, application of TPACK in blended instruction, and course experiences. Overall, students' perception of their TPACK increased by the end of the course; the difference in mean TPACK survey scores was statistically significant in all seven TPACK domains, and each domain represented a large effect size. By design, the course engaged students in applying their knowledge of technology, pedagogy, and content; however, students' participation in the course alone may not account for the statistically significant gains and large effect sizes in their CK, PK, and CPK self-perceptions. Some (e.g., Hall, 2018; Mouza et al., 2014) have suggested self-perception growth in non-technological TPACK domains may be a result of preservice teachers' simultaneous enrollment in other education courses or participation in field experiences.

While students' TPACK self-perceptions revealed statistically significant growth in all seven domains, their self-perception gains were the largest in three of the four technological domains: TCK, TPACK, and TPK, yet their application of TPACK in the blended instruction they designed revealed statistically significant growth in only one domain: TPK (i.e., Instructional Strategies and Technologies). The differing results of students' TPACK self-perceptions and application were to be expected. Prior research also found differences between students' perceptions and application of TPACK (e.g., Hall, 2018; Kopcha et al., 2014). Kopcha et al. (2014) described how the scores on the "Schmidt et al. survey better reflect what teachers think they know about TPACK rather than what they actually know or can do with that knowledge" (p. 94). However, statistically significant differences in students' self-perceptions of TCK, TPACK, and TPK as well as application of TPK were not surprising. During each class session of the 16-week course, the instructors modelled using blended instructional strategies that leveraged different tools preservice teachers could use in their future classrooms and engaged students in decomposition activities. By the time Lesson Plan #2 was submitted, students had been exposed to five additional weeks of new tools, representations of blended teaching strategies, and decomposition of teaching with technology practices, which could explain their TPK application growth. These TPACK application findings are consistent with Hofer and Grandgenett (2012), who used the TIAR and found in-class scaffolding of lesson plan components resulted in students demonstrating TPK growth. Wang et al.'s (2018) literature review on preservice teachers and TPACK development explained how effective modelling of teaching with technology was reported in all of the articles reviewed. In addition to supporting TPACK application, the representations, decomposition activities, and approximations in the course were all grounded in educational technology practice and topics, which could explain students' perceived growth in TCK, TPACK, and TPK.

Despite the differences in self-perceptions and applications, students improved their application of TPACK from the first to the second lesson plan. Students' mean scores increased in all four rubric criteria, and the difference in means for the overall rubric score was statistically significant. Through the lesson plan approximations, preservice teachers demonstrated that they were able to recompose this complex practice for novice teachers with a high degree of success, suggesting that the course prepared them to design instruction for technology-rich and blended environments. The lack of statistically significant growth in three of the four TIAR criteria (i.e., Curriculum and Technologies, TCK; Technology Selections, TPACK; Fit, TPACK) could be a result of the distributed decomposition practices intentionally used to support preservice teachers' understanding of the lesson plan components prior to Lesson Plan #1. While lesson plan alignment is a complex task for novice teachers that should be taught to and practiced by preservice teachers (Darling-Hammond et al., 2005; Shambaugh & Magliaro, 2006), the decomposition and collaborative practice prior to the first lesson plan meant we had no baseline TPACK application data to capture what students understood prior to completing Lesson Plan #1. Other educational technology courses designed using the pedagogies of practice should consider requiring students to complete a baseline lesson plan activity to assess the effects of decomposition practices on students' approximations.

In addition to engaging students in authentic activities and projects they saw as valuable for their future classrooms, the course's decomposition and approximation activities engaged students in teaching with technology practices they described as important, such as evaluation and selection of technological tools and developing and testing their technology-enhanced instructional materials. While some explained how the design and development process was time consuming, they revealed it was necessary because it helped them understand how they would implement the activities they designed in a P-12 classroom. Not only do these findings correspond to descriptions of TCK, TPK, and TPACK, but also they suggest the importance of the decomposition and approximation processes on students' potential to teach with technology in technology-rich and blended environments. Grossman et al. (2009) explained how authentic approximations can engage students in more complete representations of practice that allow them to fully participate in a way that is consistent with actual teaching.

Just as decomposition activities and approximations affected students' perceptions of what they valued and learned in the course, representations of teaching with technology practice intentionally included in the design of the course (e.g., blended teaching strategies, use of Google Classroom, use of a variety of tools) affected what tools and strategies students found worthwhile as they envisioned teaching with technology in their future classrooms. This is an interesting result, because the settings in which people experience representations can affect what they do with them (Hatch & Grossman, 2009), and what people take away from representations depends on their prior knowledge and ability to explain the significance of what is represented (Bransford et al., 2000). While representations can vary in how accurately they reflect the realities of classrooms, they provide students opportunities of seeing and understanding teaching practices in new ways (Grossman et al., 2009). In addition to modelling blended teaching and learning strategies, educational technology courses should consider including representations of the local context. The representations included in our course not only allowed preservice teachers to see, experience, and understand blended teaching practices in ways that reflect the realities of today's classrooms, but also they resulted in them applying their understanding in their lesson plan approximations and describing the importance of this newfound knowledge in their reflections.

Limitations

One limitation of this study is that it did not explicitly assess preservice teachers' readiness to teach in blended environments. While the instructors taught, modelled, and decomposed blended teaching practices and preservice teachers designed blended instruction, formal measures of blended readiness (e.g., Graham et al., 2019) should be included in future iterations of research on this course. A limitation of the participant population was the consistency among the progress of students in their teacher preparation programs. Only six of the 13 underclassmen (freshmen and sophomores) completed the course in sequence with their degree plan, and all six of those students were early childhood majors. All other majors requiring students to complete the course suggest students complete the course during their junior year after they have completed other foundational education and discipline-specific courses. As a result, the underclassmen may not have had the amount of content and/or pedagogical knowledge of their upperclassmen peers. Likewise, the course is situated in the context of a teacher preparation program, where it would be difficult to account for the gains students experienced in the TPACK domains as a result of other education courses they are enrolled in. A final limitation related to the participants in this study is the use of a modified TPACK survey. Schmidt et al.'s (2009) original survey included CK, PCK, TCK, and TPACK items that specifically align with mathematics, literacy, science, and social studies; however, students in this educational technology course span all grade levels and content areas, making the use of the original survey incompatible with the content knowledge of about a third of this study's participants and many students enrolled in the course.

Conclusions

Preservice teachers continue to enter the field feeling unprepared to teach with technology in today's technology-rich and blended environments (U.S. Department of Education, 2017). Moreover, many standalone educational technology courses fail to reflect the realities of teaching with technology in today's P-12 classrooms. The results of this study suggest that using the pedagogies of practice and the technology practices of local classrooms to inform the design of undergraduate educational technology courses for preservice teachers can positively impact preservice teachers' TPACK self-perceptions and application. Additionally, designing an educational technology course with local classrooms in mind can result in preservice teachers leaving their teacher preparation programs feeling confident and prepared to teach with technology in technology-rich and blended environments. Future research should investigate how students' teaching with technology growth after completing educational technology courses designed with the pedagogies of practice transfers into classroom teaching practice. It also should intentionally measure preservice teachers' readiness to teach in blended learning environments and the effects of requiring students to design and develop all of the instructional materials needed for their lesson plans. The results of such research will fill a significant gap in the literature and could provide design recommendations for leveraging the pedagogies of practice when designing educational technology courses that prepare preservice teachers to teach in technology-rich and blended environments.

Declarations

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the researchers' institutional review board and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. It was approved by the researchers' institutional review board.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent to Publish Participants signed informed consent regarding publishing their data.

Conflicts of Interest/Competing Interests The authors have no relevant financial or non-financial interests to disclose.

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