Infusing Educational Technology in Teaching Methods Courses: Successes and Dilemmas

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Abstract

In this action research study, we describe the implementation of a program to infuse technology in general methods courses as a requirement of a teacher preparation program. Results from teacher candidate focus groups revealed successes and dilemmas of infusing technology into the courses. Candidates ably described prospective use of elements of the Technological Pedagogical Content Knowledge (TPACK) model (Mishra & Koehler, 2006), but were less confident of their ability to develop and implement content-based lessons in which P–12 students employed technology to meet content and technology standards. Recommendations include continuing to fine-tune the new courses, providing more resources for professional development (PD), and encouraging instructors to participate in more PD leading to greater modeling of hands-on learning with a focus on content and pedagogical uses of technology.

"Most of education should be testing a hypothesis; we don’t know how to do it. We should be studying our program with disciplined inquiry leading to mindful reform and change." (Shulman, 2013)

We chose this epigraph because it reflects our efforts to use a disciplined inquiry approach to assess the effectiveness of a reform we instituted in our teacher preparation program. In this article, we report on the second phase of a five-phase project, a longitudinal study designed to describe and measure the effectiveness of a traditional, stand-alone approach for teaching technology to teacher education candidates (hereafter candidates) as compared to a newly implemented integrative approach in which learning to use technology is infused into methods courses.

The Technological Pedagogical Content Knowledge (TPACK) model holds great promise as a guide for teacher educators to prepare new teachers (Polly & Brantley-Dias, 2009), but research is needed to determine how teacher educators can design new courses and activities to better prepare beginning teachers to develop their teaching skills while implementing a TPACK framework. The problem we are addressing is the need for further study of what TPACK looks like in practice (Cox & Graham, 2009). In this case, the practice is preparing preservice teacher candidates to effectively integrate technology into their future classrooms. We seek to describe the early implementation of a series of methods courses designed to prepare preservice teachers to teach and learn within a program that emphasizes the integration of technology, pedagogy, and content.

Since the beginning of the 21st century, there has been an emerging sense that stand-alone technology courses were ineffective in providing teacher education candidates with appropriate preparation to successfully integrate technology into their instruction (Bielefeldt, 2001). Increasingly, educational technology leaders have discussed the value of integrating technology into methods and content courses to foster technology skills more strongly connected to use in PK–12 instruction and cognitive development of candidates (Niess, 2008; Pierson & Thompson, 2005; Tonduer, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2012). For example, the Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators includes various chapters advocating the importance of technology in teaching literacy, social studies, mathematics, and so on (American Association of Colleges of Teacher Education [AACTE] Committee, 2008).

Nevertheless, due to the historic contexts in which educational technology courses were initially offered in desktop labs, stand-alone courses have continued to be a critical element in many initial teacher preparation programs (Gronseth et al., 2010; Kleiner, Thomas, & Lewis, 2007). Today with the advent of mobile devices the earlier reasons for teaching a technology-across-the-curriculum course in a lab are no longer compelling. In fact, one could make the argument that teacher preparation students bring at least one mobile device, for example, a smartphone, and have these readily available in all of their teacher preparation methods courses. We suggest that it may be time to reconsider Bielefeldt’s (2001) notion that stand-alone courses in computer labs may not provide optimal preparation. Further, careful consideration of the TPACK framework provides a compelling rationale and a sound model by which technology infusion ought to be situated in methods courses because technology, pedagogy, and content can be brought together and taught in meaningful ways in these courses.
Perspective/Theoretical Framework

TPACK
As educational technology leaders, we are studying the results of a transition, from the stand-alone technology course in the first semester of a teacher preparation program, to the infusion of technology into two technology-intensive methods courses. Research on adult learning tells us adults grow their professional knowledge through “a continuously ongoing reciprocal process of interaction with his or her environment” (Rogers, 2002, p. 69). In our context of teacher education, this means that learning to teach with technology is not perfected in one semester, but takes place over time in coursework and field experiences, and with strong support.

With this perspective in mind, we applied an educational lens known as Technological Pedagogical Content Knowledge (TPACK). The TPACK framework was originally designed to illuminate the complexities that P–12 teachers and teacher candidates encounter as they learn to integrate technology (Koehler & Mishra, 2008, 2009; Mishra & Koehler, 2006; Pierson, 1999). The framework stems from the idea that good teaching involves the complementary knowledge bases of content and pedagogy as originally explicated by Shulman (1986), combined with technology knowledge, in a way that requires understanding and negotiation of all three knowledge bases concurrently.

As illustrated in Figure 1 according to Mishra and Koehler (2006), content knowledge, pedagogical knowledge, and technology knowledge (TPACK) are all important subdomains as teachers learn to leverage the power of technology in their teaching.

Development of TPACK in Preservice Teacher Candidates
Initially research about TPACK was focused on defining the construct and its components and how the components worked together in the TPACK framework (Koehler & Mishra, 2008, 2009; Mishra & Koehler, 2006; Pierson, 1999). Subsequently, research work moved forward on examining TPACK and its components by measuring TPACK in preservice teacher candidates (Chai, Koh, & Tsai, 2010; Schmidt, Baran, Thompson, Mishra, Koehler, & Shinn, 2009). Most recently, investigators have been exploring the development of TPACK among teachers and teacher candidates (Chai et al., 2010; Hofer & Grandgenett, 2012; Mouza & Karchmer-Klein, 2013; Niess, 2011; Niess et al., 2009; Özgün-Koca, Meagher, & Edwards, 2010; Pamuk, 2011).

Before reviewing the literature on development of TPACK in preservice teachers, we briefly review the work of Niess and her colleagues (Niess, 2011; Niess et al., 2009). Niess and her colleagues examined the development of TPACK among inservice teachers. They suggested the development of TPACK took place when technology was introduced alongside of content to enhance content instruction, which resulted in a thoughtful, measured integration of technology with content that included five steps: (a) recognizing (knowing about) the alignment of technology with content, but not yet integrating technology into teaching content; (b) accepting (being persuaded about) the use of technology for teaching specific content; (c) adapting (making a decision about) technology to assist in teaching a content area; (d) exploring (implementing), that is, actively integrating technology into teaching; and (e) advancing (confirming) by evaluating the results of the instructional technology integration efforts. Additional research evidence suggested inservice teachers attained TPACK through unique pathways where they focused on one area more than others (Krauskopf, Williams, & Foulger, 2013).

Others have explored the development of TPACK in preservice teacher candidates. Pamuk (2011) studied TPACK growth in 78 preservice teachers who were taking an information and communication technologies (ICT) course in which they designed “educational materials for teaching subject matter to learners who are either distant-located or are using computers independently” (Pamuk, 2011, p. 427). These students would become technology teachers at the middle or high school level or work in other technology positions. Results showed participants struggled in terms of developing new TPACK knowledge. Further, Pamuk suggested that limited pedagogical knowledge inhibited technology integration. In a quantitative study, Chai et al. (2010) also examined TPACK development in an ICT course for which 365 secondary, preservice teachers completed both a pre- and post-course TPACK survey from the work of Schmidt et al. (2009). The adaptations included use of only TK, PK, CK, and TPACK subscales; a 7-point Likert format rather than a 5-point format; and revision of CK to make them appropriate to teaching of secondary content rather than elementary content areas in the original instrument. Results indicated there were gains in TK, PK, CK, and TPACK. Further, regression analyses indicated TK, PK, and CK all predicted secondary preservice teachers’ TPACK, with PK having the greatest influence.

In another study where preservice, secondary mathematics teachers were taking a mathematics methods course, Özgün-Koca et al. (2010) examined the development of TPACK by using participant surveys and assignments. Data indicated preservice teacher TPACK development was related to a shift in identity from learners to teachers of mathematics, but they remained skeptical about using technology in the development of mathematical concepts. Additionally, Hofer and Grandgenett (2012) investigated TPACK development among eight secondary, preservice teachers who participated in an 11-month MA in education program. Results from self-report surveys, structured reflections, and instructional plans over the course of the program indicated substantial development of TPK and TPACK, but limited growth of TCK.

Finally, in a study that examined the development of TPACK among 74 primary, preservice teachers, Koh and Divaharan (2011) explored TPACK development using an instructional model they formulated, which was called
the TPACK-developing instructional model (TPACK-DIM). TPACK-DIM was based on the five developmental TPACK stages observed by Niess (2011; Niess et al. 2009), and it was composed of three instructional stages: (a) fostering acceptance, (b) technological proficiency and pedagogical modeling, and (c) pedagogical application. The TPACK-DIM model was applied in a 7-week ICT course focused on instruction on the use of the interactive whiteboard. Participants’ course reflection data revealed they primarily developed TK, how to use the technical capabilities of the whiteboard, and TPK. To develop other TPACK areas, Koh and Divaharan recommended, “More emphasis on subject-focused pedagogical modeling, product critique, and peer sharing may better develop their Technological Content Knowledge and TPACK” (p. 35).

Research on the development of TPACK and its related components is an emerging area, as attested to by the literature just reviewed. Nevertheless, two critical gaps continue to exist in that emerging literature. First, most studies have been focused at the secondary level. For example, the work of Chai et al. (2010), Hofer and Grandgenett (2012), Özgün-Koca et al. (2010), and Pamuk (2011) have all been conducted with secondary education majors serving as the sample from which data were gathered. Second, many of the studies that have been conducted to examine the development of TPACK have been carried out in single-semester, ICT courses (Chai et al., 2010; Koh & Divaharan, 2011; Pamuk, 2011) rather than in technology-infused methods courses, which are offered over time throughout the program rather than being a one-semester course offering.

When considering the body of literature related to the TPACK framework and its utility in teacher preparation, we questioned whether the one-semester stand-alone technology course that had been the tradition in our college, taught in the first semester of students’ junior year, was the most effective method for helping our students develop their TPACK knowledge. Would a different type of educational technology curriculum that spanned multiple contexts, was iterative and developmental in nature, and was not isolated to one semester be better? Further, infusing technology into the methods courses is consistent with

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Figure 1. Graphic representation of technical pedagogical content knowledge (TPACK). Adapted from http://tpack.org Web site and used with permission.
Niess’s (2008) conceptualization, in which she suggested that “guiding pre-service teachers in developing TPCK” could best be accomplished by incorporating technological knowledge into methods courses where teacher education candidates would be concurrently developing pedagogical knowledge and content knowledge. Specifically, Niess (2008) advised that the preparation of teachers must be focused on preparing preservice teachers to teach in ways that help them to guide their students in learning with appropriate technologies . . . teacher preparation methodology courses must assume the task of guiding preservice teachers toward the abilities, strategies, and ways of thinking for teaching today and tomorrow. (p. 224, emphasis in original)

In this study we share initial results about our attempts to design and implement two technology-infused methods courses based on the TPACK framework with objectives and activities aligned with the ISTE Standards for Teachers (ISTE Standards•T, formally NETS•T). To achieve this goal, the professional development technology coordinator worked with general methods instructors to redesign parts of two courses to infuse technology and conduct professional development to enable instructors to teach the technology-infused courses. We examined the views of students to gain insights into the initial implementation process, course activities, and outcomes.

The research question guiding this study is: How well and in what ways were candidates prepared to teach P–12 students to use and integrate technology to meet content standards or pedagogical standards?

**Method**

In this study, we employed an action research approach that defines action research as being "actively engaged in helping organizations to implement a new idea" (Kaplan, 1998, p. 90). Innovation action research assists practitioners in engaging their educational communities in intentional, systematic study that provides them with deep understandings that solve problems and directly improve their lives and the lives of others' (Stringer, 2007). Working as practitioners in our college, we identified an area of concern, implemented an innovation to address the concern, infused technology into methods courses, and conducted formative data collection and analysis to refine the innovation as it was being implemented and to revise program components for subsequent semesters (Table 1).

**Innovation**

For the current study we use the definition of an innovation proposed by Cohen and Loewenberg Ball (2006), when they maintained:

> It is a departure from current practice—deliberate or not, originating in or outside of practice, which is novel. Innovations include novel practices, tools or technologies, and knowledge and ideas. In some cases there are clear distinctions between "designers" and "users" of innovations, as when a textbook publisher markets a new text to a state, and teachers and students use the books. . . . These innovators often are associated with different sorts of innovations, but all have two things in common: they urge a departure from conventional practice, and both design and use require accommodation with the environment. (pp. 19–20)

In this case the innovation includes the design, instructor training, and implementation of newly designed methods courses within a large teacher preparation program. Due to the removal of the required stand-alone educational technology course in our teacher preparation program, a new approach was implemented to effectively prepare teacher candidates to teach with technology. The innovation is the infusion of technology into methods courses such that technology, pedagogy, and content are taught in tandem. Courses within the program were systematically selected for technology infusion in such a way that all students would have two well-designed technology-intensive courses throughout their program, taught by faculty members who had access to professional development and support.

The syllabi for these courses were revised to include technology-rich lessons and assignments. These revisions were made through collaboration between the technology infusion coordinator and a "lead instructor" for each course who possessed strong content and pedagogy skills with respect to the course. Instructors assigned to teach the courses were offered various professional development opportunities, including workshops, individual coaching, just-in-time training, and co-teaching experiences. In addition, the instructors and the technology infusion coordinator used

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**Table 1. Overview of Research Design, Data Collection and Analysis Procedures**

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<th>Research Question</th>
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<td>How well and in what ways were candidates prepared to teach P–12 students to use and integrate technology to meet content standards or pedagogical standards?</td>
<td>Action research employing qualitative methods</td>
<td>Design and implementation of professional development and new technology infused courses</td>
<td>Five focus groups of students representing both courses</td>
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<td>Professional development occurred during the summer and continued throughout the fall 2012 semester when implementation was conducted</td>
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social media to discuss technology-infused lessons, share new resources, and provide support for one another as they commenced teaching the technology-infused version of the course.

**Professional Development Specific to Teacher Educators**

Two tenets of professional development (PD) are particularly relevant to this study. First, the complexity of the tasks expected of participants and their prior backgrounds provide insight into the amount and type of PD needed. Second, successful PD leaders offer a variety of modes of delivery of training as well as different levels of training (Speck & Knipe, 2005). In this project, the professional development technology coordinator and the course instructors communicated openly about the support needed for implementation of the new courses. The instructors assigned to teach the technology-infused courses displayed a range of expertise. Some were enthusiastic and knew quite a bit about technology infusion, whereas others lacked confidence in their ability. Given the diverse instructor needs, a variety of professional development was offered to instructors, but not required. Professional development opportunities included just-in-time training such as e-mail exchange, phone contact, face-to-face planning, in-class presence, and co-teaching, as well as face-to-face workshops and the use of a social media site for ongoing support and communication. Instructor participation in professional development was somewhat lower than expected. Eight of the 12 instructors of the technology-infused methods courses participated either in a workshop session or in at least one coaching session; nine of 12 joined the social media group. However, all instructors used the standard syllabi with technology-infused objectives and assignments.

Our approach to infusing technology had two components: (a) assisting instructors to infuse technology throughout two designated courses and (b) providing stand-alone modules on specific topics for use in these or other courses. The first component, based on the TPACK framework, focused on technology integration into teaching and learning experiences. To achieve this, we identified two courses. The first, EED 433, Language Arts Methods, Management, and Assessment, was a three-credit course required of all candidates in elementary and special education programs. Full-time faculty members taught nine sections and part-time faculty associates taught two sections. The second, SED 464, Middle School Curriculum and Organization, was a three-credit course required of all teacher candidates in the secondary education program. In the fall 2012 semester, six sections of the course were offered, two of which were taught by full-time faculty members, three by faculty associates, and one by a graduate teaching assistant. The second component, self-contained short modules, addressed “digital media” including skills associated with conducting research such as identifying and evaluating web-based resources, fair use, plagiarism, and proper citation of sources. Data collection occurred during the fall 2012 semester across all 17 sections of the two courses.

**Context and Data Sources**

In all, 17 sections of the two courses were offered in fall 2012 with approximately 500 students; 21% were male and 79% female; 70% were Caucasian, 20% Hispanic/Latino, and 10% other. For this study, we employed a purposeful sample, which was also a sample of convenience. Nine of 17 sections representing both courses were selected at random. Of the nine, five instructors were able to accommodate the focus groups into their end of semester schedules. Three instructors taught the same Middle School Curriculum and Organization course (SED 464), which is required of all secondary education candidates, and two taught Elementary Writing Methods (EED 433), which is required of elementary and special education candidates. Three of the instructors were part-time instructors and had never taught a university-level course previously; two were experienced full-time faculty members. We asked instructors to solicit volunteers and from the volunteers select students who represented a range of abilities to create technology-rich projects.

Instructors selected four to eight candidates from their course sections to participate in a focus-group conversation during which they responded to nine focus-group questions. See the Instrument section, next, for the specific questions. All student participants were juniors in their first semester of the teacher preparation program and agreed to take time from a class meeting near the end of the semester to participate in a 40- to 60-minute conversation about their experience. Educational technology experts in the college who were not the candidates’ instructors facilitated each focus group.

**Instrument**

To help answer the research question of how well and in what ways candidates were prepared to teach P–12 students to use and integrate technology to meet content standards or pedagogical standards, we asked candidates a series of focus-group questions. The questions were:

1. How well do you feel prepared to teach elementary students to use technology to work toward content standards?
2. What factors account for your level of preparation in being able to integrate technology into your instruction?
3. What would prepare you better to integrate technology into your instruction?
4. Do you think you are representative of other students in being able to integrate technology?
5. How important is it to teach elementary students to be critical viewers of digital media?
6. How important is it to teach students to use technology to problem solve and become critical thinkers?
7. What are your thoughts about how elementary students should document sources for their work and work to summarize rather than plagiarize the work of others?
8. Provide an example of how you would teach a [elementary or
secondary] lesson with student use of technology. What would the students learn? Why would this approach be better than an approach without technology?

9. What technology integration procedures have you seen modeled in your education courses? What technologies? What activities? What assignments?

The question protocol had been employed with an earlier cohort of students in the teacher preparation program. An analysis of the data from that work indicated the questions were useful in probing about the implementation of elements of the TPACK framework in their courses. Each focus group session lasted 40–60 minutes.

**Data Analysis**

Responses for all focus groups were audiotaped, transcribed, entered into HyperRESEARCH Qualitative Analysis Tool, coded, and then analyzed using predetermined and emerging codes (Creswell, 2009). Predetermined codes arose naturally from the literature review and our understanding of the TPACK framework and the ISTE Standards for Teachers and Students (ISTE, 2011). Examples of predetermined codes included: understand various tech tools, understand digital literacy, students use technology in research, and students use technology for communication and collaboration. Based on our analysis, examples of emerging codes included: faculty exposed candidates to tools, faculty embedded tech into assignments, critical thinking emphasis, and faculty should provide more instruction on pedagogy with technology. Emerging codes were based on grounded theory and were developed using the constant comparative method (Strauss & Corbin, 1998).

To ensure credibility, specific steps were taken as outlined in what follows. First, two of the authors read and reread transcriptions of the interviews and then began to code the candidate focus-group data. They met multiple times to compare and refine the nascent codes. Each coded the same transcript individually and then they met to discuss codes and their application of the codes. They repeated this process for portions of each transcript. After reaching substantial agreement on the coding of transcripts, they individually coded the remaining transcripts. Second, they met and worked to combine the codes into larger categories. Subsequently, theme-related components, themes, and finally assertions were developed. At each step of the process, the data were revisited and carefully reflected on to ensure they continued to support the higher level interpretations of the data. Thus, the data analysis was performed in an analytical, dependable, and careful way. The processes are credible because reflective efforts were employed, detailed processes were followed, and a comprehensive audit trail was developed. Finally, consistent with interpretive methods, we do not claim nor should the reader infer that our accounts are the only way to interpret the data.

**Results**

In the following sections, we present results that are organized around four assertions that are based on six distinct themes that emerged from our analysis of the candidate focus group data. To aid the reader’s understanding of our analysis of the qualitative data and the results we obtained, we provide the assertions, themes, theme-related components, and examples of codes in Table 2. The results are organized and presented based on the four assertions.

**Assertion 1**

Candidates suggested they had a range of TPACK abilities to integrate technology into their instruction and that these abilities were influenced by course instructional (a) activities, (b) technologies, (c) strategies provided by the instructors, and (d) other experiences. To address candidates’ preparation to infuse technology into instruction, we asked, “What specifically have you learned to do with technology?” Responses suggested a continuum of learning of TPACK skills depending on the candidates, the technology tool(s), and strategies provided by the instructor.

**Theme 1**

With respect to technology integration (TI), candidates’ views of their preparation to carry out TI ranged from little to well-prepared; they appreciated opportunities to actively engage in learning about TPACK and TI; and they viewed instructors as being critical to providing strategies that fostered development of TPACK and learning TI. Several different aspects of theme 1 are enumerated in the next sections of the article.

Candidates expressed a range of responses regarding their preparation to integrate technology into their teaching. With respect to the focus-group question “How well do you feel prepared to teach elementary/secondary students to use technology to work toward content standards?”, candidates expressed a range of positions regarding their preparation to integrate technology in their future classrooms. First, there were those who felt less to somewhat prepared, such as one candidate who said, “In our class, I noticed . . . a lot of us don’t know how to exactly use technology extremely well either.”

Importantly, candidates also set a higher bar for being prepared, as evidenced by this comment:

I would have thought that I was a little under the average for being technologically savvy, just because I feel like someone said earlier, [I feel] pretty good with things that have to do with Microsoft or Word or those kinds of documents. When it comes to sound and video, I really don’t know what I’m doing.

Moreover, candidates differentiated between personal use of technology and teaching it to P–12 students, as demonstrated by one candidate who maintained, “I feel sort of prepared to use it. I feel more comfortable using it myself than I would be trying to explain it to a child.” Candidates typically expressed
the sense that they knew how to use common technologies like Microsoft Office applications, but were not convinced they could create multimedia applications or teach students to use the technology for addressing content standards.

On the other hand, approximately an equal number of respondents expressed confidence that they were somewhat to quite prepared. An example illustrates this perspective when one candidate offered, “I feel confident, but I want more practice in using technology found at schools, like the SMART Boards.” Often candidates expressed confidence that they were capable of figuring out how to use a technology in their classrooms once they knew what they wanted to accomplish. For example, one candidate asserted:

The way I see it, is I’m pretty tech-savvy in general, and I don’t really worry about learning how to use technology once I know it’s there. I can just dink with it, and I will figure out eventually how it works.

Candidates in this latter category had learned how to learn or applied earlier knowledge to help them figure out new technologies as they appear.

About half of the candidates indicated they had some skills using technology, but they were not comfortable with teaching P–12 students to use it. Others indicated they felt comfortable using technology and they could learn new technologies on their own and could teach children to use it too. Nevertheless, a closer analysis of all responses showed candidates answered this question primarily with respect to technology skills, and to a lesser extent with regard to pedagogical or content and the use of technologies.

In the following section, we report what we learned from exploring what candidates learned in their technology infused classes and from other experiences. The authors explore students’ perceptions of the strategies instructors employed to prepare candidates to use technology to meet P–12 content and pedagogical goals.

Candidates maintained they learned to use technology tools. Candidates said that they most often learned to use technology tools (e.g., Microsoft Office, iMovie, iPhoto) communication tools (e.g., e-mail and pen-pal programs) and content-area websites. A candidate in a language arts methods course provided a

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<th>Table 2. Theme-Related Components* With Examples of Codes, Themes, and Assertions for the Focus-Group Data</th>
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<td><strong>Theme-Related Components</strong></td>
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<td>Indications of using TPACK for technology integration</td>
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Note: Theme-related components are listed, and examples of codes are indented under the theme-related components.
typical response: “We’ve used like iMovie and iPhone and the SMART Board, educational sites to play games. In our writing course, we’re making a digital story using iMovie. That was a cool technology—infused assignment.”

Others discussed online tools. For instance, “I feel like all those things we’re doing right now, Google Docs for studying, and also the Wiki pages.” Content specific websites were also viewed as being important. One candidate’s comments reflected this perspective: “We were introduced to a lot of different web sites.” Technology applications that included content or pedagogy were evident, too. Another candidate explained:

The pens . . . I thought that was really cool. I feel like I could probably do that with an elementary school class. Yeah, for the digital storytelling. If you were to be able to bring in computers, or use computers and have the chance to manipulate the different programs, or . . . even if you were to do some kind of thing where two students pair up and one student tries to learn this program and another student tries to learn another program and then they teach it to each other . . . would be great.

Finally, some candidates were convinced that the programs they learned earlier would be those they would use and not the programs to which they were exposed in the technology-infused course. For example, one candidate asserted, “It’d probably be just, be limited to PowerPoints and Word documents and things that I feel like I’ve had a lot of practice with and not so much that I’ve had practice with through this class.” In some cases, candidates indicated that they had been exposed to but had not really mastered the technology, as noted by one candidate who said, “We had a couple lesson plans with Movie Maker, but that was kind of just trial and error.”

Candidates discussed a variety of technologies they had learned about and used. Some reminded us that they had been exposed to a certain technologies, such as websites for pen pals, and that they could probably implement these technologies for their classes; others remained a bit uncertain about their ability to implement them in their future classrooms. This finding is further addressed in subsequent sections on “candidate recommendations” and “instructor’s approaches.”

Candidates affirmed that instructors provided strategies that prepared them to integrate technology into instruction. In response to the question “What factors account for your level of preparation in being able to integrate technology into your instruction?”, candidates reported four types of instructor-provided strategies that helped to prepare them to integrate technology in their future classrooms: exposing candidates to a variety of tools; embedding technology by asking candidates to create something with technology for required assignments and online modules; employing project-based learning; and encouraging candidates to share with each other.

Exposure to technology tools. Between one-third and one-half of the candidates thought they were prepared by seeing technologies. In one exemplar, a candidate maintained, “I feel like being exposed to those different types of technology was useful because I mean if we want to implement something like that into our classroom, then at least we know that it’s out there.” Although most candidates were positive about instructors providing them with exposure to technology, many also commented on the lack of preparation to apply tools to their future classrooms.

Embed technology in assignments. Some candidates said that when an instructor’s assignments required technology use they learned to use it, for example, “I believe that the assignments that we have been given . . . have helped to prepare me to the level I am now as far as transferring that into my teaching later.”

Project-based learning and sharing with others. One instructor organized instruction around project-based learning projects during class time.

Candidates found this to be effective because technology use was inherent within the project activity; for example,

He does a good job of like letting us explore what technology we can use, because he might be like, “Okay, use any aspect of technology you want to explain your lesson or whatever.” That gives us the opportunity to kind of go out and see what is out there, and then share with each other. I learned more from my peers, than I did necessarily from him. It’s because of the way he designed—the way he taught the class.

However, another candidate commented on the limited number of technologies explored in the projects: “In this class we’ve done projects and she says, ‘Go pick a technology. Here’s a bunch of them, go explore.’ That’s been the only thing other than PowerPoint that I’ve seen integrated in this [course].”

Theme 2: Candidates Developed Technology Skills in Other Education Courses and General Education Courses

Candidates brought technology experiences to the technology infused methods courses from prior university courses. For example, in an Educational Psychology class, students reported learning to create a class wiki. “I have seen a lot. In our educational psychology class we’re actually making Wiki pages with motivational techniques, which is something new.” Others reported learning to use a variety of computer applications in a computer literacy course meeting a university general requirement. One candidate offered, “I had to take a 100 level course either my freshman or sophomore year where I had to go through and learn the ins and outs of Word, Excel, [and] PowerPoint.” Another added: “We had to make a newsletter to send home to parents. We had to make a grade book, so we were making things that we could actually use in class, and that was a computer literacy class for—not even everyone in there was an education
major.” Finally, specific content courses also provided a technology background:

For one of my physics classes . . . we wrote a complete program and then we could hit the run key, and then we would have masses flying around and they’d have arrows pointing like the directions of forces, the direction of velocities.

Typically, students reported gaining a variety of technology experiences from general studies and education related courses.

**Assertion 2**

Candidates had a strong conceptual understanding of digital media and they should be required to incorporate it into their lesson plans.

**Theme 3: Candidates Expressed Enthusiasm About Teaching Research Skills that Included Evaluation of Resources, Fair Use, Plagiarism, and Grade-Level Appropriate Citation of Sources**

They declared teaching digital media research skills is important, as evidenced in the following. Candidates were asked two questions specific to digital literacy, “How important is it to teach [P-12] students to be critical viewers of digital media?” and “What are your thoughts about how [P-12] students should document sources for their work and work to summarize rather than plagiarize the work of others?” The consensus of candidates is represented by these views illustrating the importance of teaching media skills. First, students should become critical consumers of digital media:

[Teaching students to be critical media consumers] is incredibly important because there is so much information available to us. It is called the information age for a reason. Not all of it is true, or even necessarily necessary.

One candidate who completed an online module about digital media literacy as part of course requirements said, “I think that [for] one of the assignments . . . you had to go in and research a website. Find out who wrote it, and what their background was, and I think that was super.” Overall, candidates expressed the need to teach P-12 students about copyright and fair use, in relation to technology use. For example, one candidate advised:

I think it’s extremely important to show them ways to document their source and to summarize. I know [for] a lot of students it would be easier . . . just to copy everything, especially the younger kids that still copy everything because they don’t know any better.

The majority of candidates were able to articulate sophisticated positions on digital literacy, copyright, and fair use. Overall, they expressed that it was important to teach digital media topics to P-12 students as they prepare to conduct research for project reports.

**Assertion 3**

Course instructors should become more proactive in the teaching and modeling of TPACK to enhance instruction.

**Theme 4**

Candidates suggested technology-infused courses could be improved by limiting the number of technology tools, providing more hands-on experiences, and providing more instruction modeling of technology. In the following paragraphs, results on limitations and suggestions for improving the courses are described.

Some candidates noted limitations in the technology-infused model. Some candidates noted the following limitations of the technology infusion model: (a) time constraints within a methods course and (b) instructors’ limited levels of working knowledge. A small group requested a stand-alone “technology in education” course.

In contrast to the consensus of candidates regarding more hands on experiences, a smaller group of candidates thought their instructors were not prepared to integrate technology into the technology-infused methods course. This concern was illustrated when one candidate commented:

I think it was, like what we were saying how she wasn’t fully prepared. She was kind of thrown into integrate all the technology. I think that’s why we were just introduced to certain things instead of going into each thing, or at least some of them. I don’t think she was fully comfortable with teaching it.

A few thought there was too much content in the course and including technology integration material exacerbated the matter:

I really don’t think [this . . . ] has anything to do with [the instructor, it’s about] time . . . the reasons why she wasn’t able to do so much was because of time, that’s probably why we did [look at them] briefly, just were shown the things as resources to have and then look into yourself [sic].

Another asserted a similar perspective when she affirmed, “It seemed like it was trying to fit two classes into one.” For some of these reasons, students recommended a separate class. Candidates knew that we had previously offered a standalone technology course for prior cohorts, and a small group (less than one-tenth of the focus-group participants) thought that a separate course would have better met their needs:

I think there should be a full class just to go over certain technologies. This class right now is great, however I think there should be some form of—even like a workshop that you could go to and just like, “This is—today we’re going to cover this topic or this program.”

These candidates thought that a separate class might allow them to better learn specific technologies.

Candidates offered advice for instructors and program leaders. We also asked,
“What would prepare you better to integrate technology into your instruction?” Candidates provided advice for improving the effectiveness of technology infusion in three areas: (a) expand the range of tools especially age-appropriate ones, (b) provide more instructor modeling of technology infusion, and (c) offer more instructional applications of tools and more pedagogical approaches for using tools.

Expand the range of tools and provide more hands-on opportunities. The view of one candidate resonated with approximately one-half of her peers: “Yeah, more of a variety of different kinds of technology—some things I did see.” Another offered, “[We could be] doing a little bit more hands-on. . . . There could’ve been more variety, because most of them did consist of a presentation that was focused on using the projector and the computer.”

Creating the activity together was another strategy candidates recommended:

I mean, if we were teaching a lesson on, let’s just say how to make a Wiki, instead of having something premade [sic] to show as an example, a simple activity of making a Wiki in class would easily facilitate the goal, and translate better with the class who is watching.

More modeling. In addition to the recommendation of more hands-on time, more than one-half of the candidates were equally expressive in their discussion of the importance of instructor modeling. In addition to theory and telling candidates what to do, they also suggested modeling:

I think to really wrap up all this; we’re learning a lot of theory in our block [set of courses in a semester], but we really aren’t applying anything that we’ve learned. We have teachers that are telling us, “Oh, you should have your students make a YouTube video.” Why can’t we do something like that in our class, so we have practical application of what it is we’re trying to learn? We are essentially learning theory.

Other candidates explained that instructors had disapproving views about the frequent use of PowerPoint, but candidates failed to see the above view modeled in class; for example,

I’m going to agree with that because she’s been discouraging use of PowerPoint . . . every single day, so have our other instructors. “Don’t use PowerPoint for every single thing you do,” but all we ever see is PowerPoint in any of our classes.

More pedagogical and content instruction that integrates technology. About three-quarters of the focus-group participants recommended more instruction on and experiences with technology with respect to content and pedagogical uses. They contrasted being shown a technology with actually seeing it implemented in a content area with a pedagogical plan—for example, “We are shown, ‘Here is this and this,’ but we don’t know necessarily how to put it in our content, in our lessons.” Another affirmed, “I feel that [the instructor] definitely shared with us several resources. While . . . he didn’t necessarily teach us how to implement them in our content areas . . . he did provide to us several types.” With respect to content-area integration, a third averred, “We didn’t really go over ways to implement that in this class, specifically for a certain content area.”

Clearly, the ISTE StandardsS (formally the NETSS) can help candidates write objectives of a lesson plan. Candidates explained that they needed more focused attention on the standards and how to use them as noted when one candidate testified:

But I would like to learn how to use [the NETSs] in the classroom, so like the pedagogy of using these technologies. We kind of glanced at it a couple times, but we haven’t really gone into it really deep[ly], which I feel like that would be more useful to me than learning—necessarily learning how to use them.

Candidates would also like to have had experiences that prepared them to teach by integrating technology into their future classrooms. This perspective was exemplified when one candidate maintained:

I feel like when I go my first year of teaching, I want to be able to have run through these things with a master teacher with me. I think it would be better to learn them now when we’re in the early stages of our teaching program, like just how to integrate them versus just kind of waiting until the end when we’re in the six-month period where we’re student teaching full time.

The advice that instructors feature more hands-on opportunities, modeling, and pedagogical content knowledge was commonly expressed across focus groups.

Assertion 4
Candidates articulated visions for technology integration (TI) consistent with the TPACK framework, but perceptions of their abilities to implement TI were not commensurate with their intentions to integrate technology.

Theme 5: Candidates Communicated Visions for Technology Integration (TI) in Their Future Classrooms
Candidates were asked, “How do you see yourself integrating technology in your future classrooms?” In the following we provide illustrative examples in science, but candidates provided similar examples in mathematics, language arts, and social studies.

The responses shown next from future high school, middle school, and elementary teachers were typical of responses of various groups of candidates. For example, future high school
teachers discussed the use of probe-ware to collect and graph science data, as illustrated when one candidate declared:

There’s a lot of different things you can do with science . . . in lab . . . we used temperature probes that are connected to something that will record the temperature for you every five seconds for 10 minutes. That is a lot easier than recording the temperature by hand every five seconds . . . and then you can graph it. That way, students can see the effect that adding this chemical has on the temperature. Something like that, that technology has made classrooms so that you can learn so much more, because you can see it first-hand.

A future middle school teacher discussed using a mind-mapping tool to teach science processes when she asserted:

I want to teach middle school science . . . I would actually use photosynthesis, and have them create a computer diagram of how it goes through the process . . . I think that is a big motivator . . . in order to make the model, and they’ll be forced to analyze the information that they have, to understand it and make it.

A future elementary teacher indicated she would use simulations in science when she offered:

If you wanted to teach about the weather cycles . . . find a simulator that they could see how the water evaporates, then it goes into the clouds, and then it rains, and then it condensation and things like that. I think it would be really cool because it’s an active visual. It’s not just pictures. You see it in action. I think that would be really cool to have as part of one of those lessons.

Most candidates provided similar rich responses of future uses of technology in mathematics, social studies, and language arts. Technologies specifically mentioned were SMART Boards, personal response devices, video editing, pen pal programs, and QR codes for accessing information resources. Future uses usually included addressing specific content areas or pedagogical knowledge as well as technology integration. In summary, as a whole, participants in focus groups were able to articulate future intentions to use technology in content areas.

Theme 6: Candidates’ Expressed Concerns About Their Abilities to Address Issues About the Practical Classroom Uses of Technology with P–12 Students to Meet Content Objectives

Candidates “talked a good game” regarding what they planned to do in their future classes, but appeared less able to stipulate explicit lesson plans, methods of teaching technology skills, alignment of specific objectives based on the ISTE Standards• with content objectives, and planning for classroom implementation. They felt that there was too much instruction at the exposure level, and insufficient instructor modeling during class and attention to content and pedagogical applications of technology. We note that this was the candidates’ first of four semesters in the teacher education program and depth of lesson planning was limited at this point, yet the students expected to do much more in their future classrooms. Concerns about their abilities were reflected in the following comments offered during the focus groups. One candidate suggested:

I feel like I would have a really limited range of programs that I feel like I could use to implement lesson plans or . . . to have students create something. It’d probably just be limited to PowerPoints and Word documents and things that I feel like I’ve had a lot of practice with and not so much that I’ve had practice with through this class.

Another maintained, “I could use the same techniques that I saw in high school like PowerPoint and Word and everything like that, but I don’t know if I’ve integrated a whole lot of new [technology] information from my classes.” A third respondent affirmed, “I’m aware of the different technology, but I don’t know if I could, per se, make sure that I know exactly how to teach them how to use it.”

Discussion

The discussion is organized into two major sections. In the first section, we provide an explanation of the results by connecting the results to the extant literature and offer a preliminary model that describes the development of TPACK knowledge among preservice teacher education candidates. We offer recommendations for future technology-infusion work based on the results of the study in the second section of the discussion.

Koehler and Mishra (2008) contend that learning to apply technology integration (TI) approaches to teaching through TPACK is a complex, multifaceted, and “wicked” problem. Specifically, Koehler and Mishra advise:

Technology integration has often been considered a kind of problem-solving, the goal of which is to fine the appropriate technological solutions to pedagogical problems. However, matters are not this clear cut. Integrating technology in the classroom is a complex and ill-structured problem involving the convoluted interaction of multiple factors, with few hard and fast rules that apply across contexts and cases. (p. 10)

Further, Niess (2008, 2011) suggests learning TPACK is wicked because teacher candidates have not learned the content by using technology. Nevertheless, we believe the learning of TPACK by teacher candidates may be more wicked than initially considered, especially in light of the complexity of TPACK and the limited knowledge of
PK that teacher candidates possess. Consistent with Koehler and Mishra’s (2008) arguments, teaching with technology, hereafter technology integration, involves multiple complex factors.

For example, when we start to unpack TPACK, the complex nature of the construct becomes more evident when we consider its development in teacher candidates. Thus, TPACK, the interaction of technological pedagogical content knowledge, which is represented by the intersection of three circles, is infinitely more complex for several reasons. First, teacher candidates are learning PCK, PTK, TCK, and TPACK simultaneously. Thus, for example, they are learning PCK, which consists of four components: (a) conceptions of purposes for teaching subject matter; (b) knowledge of students’ understanding; (c) knowledge of instructional strategies; and (d) curricular knowledge (Grossman, 1989, 1990). Simultaneously, they must also consider TPK, TCK, and the formidable matter of TPACK. The description of these interactions illustrates how concurrently drawing upon knowledge from multiple domains influences TI (Niess, 2011). Importantly, evidence from our study indicates students struggle with the complexity of integrating the TPACK domains when they express their limitations in learning and using TPACK.

Further, the instructional approach and the results are consistent with the work of Koh and Divaharan (2011). Our own efforts with respect to instructional matters in the technology-infused courses were aligned with their three instructional stages: fostering acceptance, technological proficiency and pedagogical modeling, and pedagogical application. The outcomes are consistent with Koh and Divaharan’s approach as revealed in the candidates’ responses when they indicate they are willing to employ technology in their teaching. Moreover, candidates clearly express that they increase their proficiency in using technology that can be applied to instruction in their future classrooms. Moreover, they appreciate the pedagogical modeling to which they were exposed in their courses. Finally, candidates report that they engage in pedagogical application of their learning as they develop products that are appropriate for classroom instruction and that were required in the courses.

Nevertheless, these applications are limited in scope and do not reflect the full range of potential uses of technology. This outcome reflects two issues: (a) limited knowledge of pedagogy and restricted TPK and (b) limited examples of technology modeling within the courses. With respect to the second matter, participants, especially secondary education candidates, suggested that they would like to see more modeling of subject matter–appropriate technology, which is aligned with a recommendation made by Koh and Divaharan (2011). We expand our thinking on this matter and other issues with regard to technology-infused course preparation and delivery in the final section on recommendations.

Taken together, the results demonstrate the “wickedness” of infusing technology into methods courses (Koehler & Mishra, 2008; Niess, 2008). As Niess (2008) suggested:

Incorporating TPCK as a way of thinking strategically into the curriculum of the preservice methods courses exposes the “wickedness” . . . of the preservice teacher preparation problem because preservice teachers have not traditionally experienced learning their subjects with these new and emerging technologies. They have not learned how to learn their content with these technologies as tools for learning. (p. 224)

Nevertheless, we are encouraged by the progress we have made in implementing technology-infused methods courses. For example, consistent with Niess’s (2011; Niess et al., 2009) model, our candidates readily exhibit steps 1–3 in which they recognize, accept, and adapt the TPACK model and its tenets about technology integration into classroom instruction. Nevertheless, they are much less certain about how they will integrate technology, which may be developmentally controlled and to which we now turn our attention.

**Thoughts on a Preliminary Model of the Development of TPACK in Preservice Teachers**

Next, we offer some thoughts on a preliminary model of the development of TPACK in preservice teachers. First, as we consider the model, imagine three circles representing TK, PK, and CK. Recall Figure 1, which represents the TPACK framework and the interaction of the three knowledge domains. We suspect the circles representing these three TPACK domains might be better represented by circles of varying sizes depending on a candidate’s knowledge of the respective area. For example, based on data from our work, older students suggested they may possess lesser amounts of TK. Additionally, as preservice candidates, their pedagogical knowledge may be limited. Thus, the circle representing PK may be smaller as well. Representing different degrees of understanding of TK, PK, and CK with different sized circles is consistent with other recent research on TPACK (Krauskopf, Williams, & Foulger, 2013).

Second, we suspect the interactions among the TPACK domains such as TCK, TPK, PCK, and TPACK are limited, as well. Based on our data, candidates indicated they needed to see more modeling of TPK and TCK areas, which was especially prevalent in their responses about how to strengthen the technology-infused courses to make the courses more effective for them. Thus, as you imagine a figure composed of the three kinds of TPACK knowledge, the overlap of the three knowledge domains would be very incomplete for preservice teachers and it would increase over time. These ideas about limited interaction of the TPACK domains in preservice teacher candidates is consistent with the findings of Hofer and Grandgenett (2012) and Koh and Divaharan (2011), who suggest there was a need for greater emphasis in teaching/modeling of TCK.

Third, consistent with Niess’s (2008, 2011) research on the development of TPACK, preservice candidates are
developing TPACK strategic knowledge—“knowing when, where, and how to use domain-specific knowledge and strategies” (Niess, 2011, p. 307). As pre-service candidates are exposed to TPACK, they reflect on the knowledge domains individually and jointly. Over time, exposure and reflection foster TCK, TPK, PCK, and TPACK growth, with the result being a more integrated whole. In the final section, we provide some thoughts about next steps as we continue our efforts to infuse technology instruction into methods courses so that candidates will see, understand, and be better prepared to implement technology into their own teaching.

**Recommendations and Next Steps**

We offer three caveats and then make our recommendations. First, although we have little patience for waiting for the ocean liner (our teacher preparation program) to turn, we realize the implementation of change takes time. The easy part is often conceiving and designing the innovation including an initial implementation plan (Fullan, 2007). The difficult part is staying the course, improving faculty preparation one instructor and one step at a time, refining syllabi and assignments, finding more resources, and developing faculty and administrative leaders. Second, this is the first iteration of offering the course by general education faculty who possess varying technology backgrounds. Our program is a work in progress. We need to provide the time and support for them to gear up for this endeavor. Third, we have been describing student views of our efforts to accomplish technology infusion to meet content and pedagogical outcomes within general methods courses. Fullan (2001) points out that the views of administrators and instructors are important, but if we ignore the voices of students, all is lost. With these caveats, we make the following recommendations for program improvement based on the voices of the students.

1. Stay the course while modifying and adjusting program components using study data, because implementing change of this complexity requires 3–5 years (Fullan, 2001; Hall & Hord, 2010).

2. Provide more resources and involve more instructors in professional development activities stressing active engagement, modeling, and attention to fleshing out teaching and learning within a TPACK framework. This recommendation is consistent with the complexity of the tasks (described by Speck & Knipe, 2005) expected of instructors new to teaching technology-infused courses. We also recommend that leaders consider mandating participation in PD (see Recommendation 7 for a strategy) and/or offering incentives to participate.

3. Revise course syllabi to emphasize the integration of technology in objectives and assignments so that technology is viewed less as an add-on and more as an integral part of the course. Although candidates expressed the view that technology-infused objectives and assignments appeared to be an “add-on,” that may be a function of instructor preparation as well as the design of the activities and assignments. Both need attention.

4. Enlist the “early adoption” methods instructors who have made the transition to technology infusion as illustrative examples and allies in new PD ventures. Continue to develop a community among the instructors of the same course to support each other in furthering technology infusion. This recommendation is in line with the communities of practice work by Wenger (1998), which promotes that we embrace the organic nature of participation, from legitimate participants to peripheral participants, to improve the technology infusion skills of all instructors.

5. Where the tech-infused methods courses are situated in site-based professional development schools (PDS), pair P–12 teachers with ASU instructors. This would provide allies in planning for classroom implementation, as well as providing P–12 classrooms where future teachers can experience technology integrated lessons, with safe places to practice with P–12 students and their teachers, who can serve as mentors. This move is consistent with Hollins (2011), who suggests there is a need for programs to adopt such practice-based teacher preparation formulas to develop teacher candidates’ “discursive processes, reasoning, and actions taken in interpreting and translating the experiences and responses of learners in authentic situations within and outside of classrooms as a way to construct understanding of the substantive relationship between learners, learning, pedagogy, and learning outcomes” (p. 403).

6. Develop faculty leadership. Each course has a faculty member who is the designated course coordinator, an experienced full-time instructor who meets regularly with the course instructors and attempts to insure course fidelity. Stipends or release time might be provided to incentivize the course coordinator to work with the technology infusion coordinator to fully embrace the infusion. Once again, this aligns with Fullan’s (2008) conclusion that leaders play a key role in change.

7. Work with department administrators to revise the terms of hire for part-time faculty to include professional development opportunities so they are able to implement the goals expressed in the technology-infused syllabus. Without careful planning before the semester begins it is difficult to schedule time for PD with part-time faculty members because they often teach during the day or have other full-time responsibilities.

Where do we go from here? We will continue to study our practice (Shulman, 2013). This is the second phase of a five-phase longitudinal study of the (Arizona State University) migration from a stand-alone required educational technology course to a technology infusion in methods courses approach. In fall 2012, we implemented technology infusion in the first two methods courses, the
subject of this article. In the next phase, we will address the implementation of this approach for the second time, incorporating the preceding recommendations and featuring the changes that instructors and candidates learn in revised courses taught by instructors who have developed additional TPACK-based competencies.

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