International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

Pre-Service Teachers' Technological Pedagogical Knowledge: A Continuum of Views on Effective Technology Integration

Kathryn S. Lee, Texas State University
Shaunna Smith, Texas State University
Beth Bos, Texas State University

Abstract

This article reports a heuristic case study that explored how components of Technological Pedagogical Knowledge (TPK) manifested in the artifacts of post-Baccalaureate pre-service teachers. Self-reported perceptions of their technology integration competencies were high. End-of-semester presentations reflected three distinct views of technology integration: trendy, pragmatic, and pedagogical. The quality of TPK connections in lesson plans was mixed. Higher TPK scores were apparent in lesson plans associated with models of teaching with which they had the most familiarity as learners themselves. The appropriateness of their choice of technology to enhance student learning was related to the depth of their conceptual understanding of the pedagogy. This article concludes by echoing Shulman's (1987) advice that teacher education courses and programs need to be structured in a way that explicitly address pedagogical reasoning.

Résumé

Cet article rapporte une étude de cas heuristique qui a exploré de quelle façon les composantes des connaissances technologiques pédagogiques (TPK) se manifestent dans les artéfacts des enseignants en formation initiale post-baccalauréat. Les perceptions auto déclarées de leurs compétences d'intégration de la technologie étaient élevées. Les présentations de fin de semestre ont fait ressortir trois vues distinctes de l'intégration de la technologie : en vogue, pragmatique et pédagogique. La qualité des connexions TPK dans les plans de cours était mixte. Des scores plus élevés de TPK étaient visibles dans les plans de cours associés à des modèles d'enseignement avec lesquels ils avaient eu le plus de familiarité comme apprenants eux-mêmes. La pertinence de leur choix de la technologie pour améliorer l'apprentissage des élèves était liée à la profondeur de leur compréhension conceptuelle de la pédagogie. Cet article conclut en faisant écho à l'avis de Shulman (1987) à savoir que les cours et les programmes de formation des enseignants doivent être structurés de manière à aborder explicitement le raisonnement pédagogique.

INTRODUCTION

Technology integration is arguably a relevant topic in teacher education, because numerous state, national, and international educational standards indicate the importance of educators integrating

Suggested Citation:
Lee, K.S., Smith, S., & Bos, B. (2014). Pre-service teachers' technological pedagogical knowledge: A continuum of views on effective technology integration. *International Journal of E-Learning & Distance Education, 29*(2), 1-18. Available online at: http://ijede.ca/index.php/jde/article/view/887/1540.

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

technology to support their own instruction as well as providing hands-on opportunities for students to actively use technology throughout their learning experiences. Therefore, teacher educators are charged with promoting teacher candidates' integration of technology in their teaching and design of authentic and engaging learning experiences for their students. This case study investigates teacher candidates' development of technology integration in their instructional planning as well as their perceptions of technology integration in teaching and learning after having completed an online teaching methods course. The course emphasized technology integration in instructional planning.

RELEVANT LITERATURE AND THEORETICAL FRAMEWORK

The International Society for Technology in Education (ISTE) outlines specific standards for students, teachers, and administrators to endorse the technological skills and knowledge individuals need to function productively in our global and digital society (2014). The ISTE Standards for Teachers (2008) are summarized according to the organization's following categories:

1. Facilitate and inspire student learning and creativity.
2. Design and develop digital age learning experiences and assessments.
3. Model digital age work and learning.
4. Promote and model digital citizenship and responsibility.
5. Engage in professional growth and leadership.

Even though technology integration in teaching and learning has been promoted for many years, beginning teachers and pre-service teachers continue to feel inadequately prepared to effectively integrate technology into instruction (Funkhouser & Mouza, 2013; Lei, 2009; Tondeur, van Braak, Sang, Voogt, Fisser, & Ottenbreit-Leftwich, 2012). Lei (2009) explained the complex process required to prepare pre-service teachers to integrate technology in teaching and learning:

> To help pre-service teachers integrate technology into teaching in meaningful ways, technology cannot be taught as a separate and independent domain. Instead, teacher education programs need to help pre-service teachers understand how technology intersects with content and with pedagogy and make connections between technology, content, and pedagogy. (p. 93)

The skill to choose technological tools that support pedagogical instructional methods is what Mishra and Koehler (2006) refer to as Technological Pedagogical Knowledge (TPK). Teachers need to feel confident in their ability to integrate technology effectively in their instruction in order to meet the challenges of teaching and learning in this technological age (Buabeng-Andoh, 2012; Jamieson-Proctor, Finger, & Albion, 2010). Kereluik, Mishra, Fahnoe, and Terry (2013) elaborated on the components of TPK by stating the following:

> Knowing when to use a particular technology for activities such as collaboration, or why to use a certain technology for acquiring specific disciplinary knowledge, is a vastly, more important,

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

transferable, infinitely relevant type of knowledge, one that will not quickly become antiquated with ever-changing technological trends. (p. 133)

Theoretical Framework

This investigation was by Mishra and Koehler's (2006) Technology, Pedagogy, and Content Knowledge (TPACK) framework. This popular framework provides educators a way to think about and articulate the complex relationships among various types of knowledge required of effective teachers. Mishra and Koehler (2006) added a technology dimension to Shulman's (1986) framework in which effective teacher knowledge was defined as the integration of pedagogical and content knowledge (PCK) within a teacher's specific discipline. The framework supports the idea that today's teachers require technological pedagogical content knowledge (TPACK), a composite of technological, pedagogical, and content knowledge as illustrated in Figure 1. Capable teachers not only possess strong content knowledge (CK) in their disciplines, but also have robust pedagogical knowledge (PK)—a repertoire of instructional strategies to maximize student learning. Proficient teachers also possess technological knowledge (TK), the ability to incorporate technology tools and resources to support and enhance their students' learning. Today's finest teachers have that complex technological pedagogical content knowledge (TPACK) that enables them to harness appropriate technologies (TK) to facilitate student learning within an engaging and stimulating learning environment (PK) suited to their subject-matter expertise—their discipline (CK).

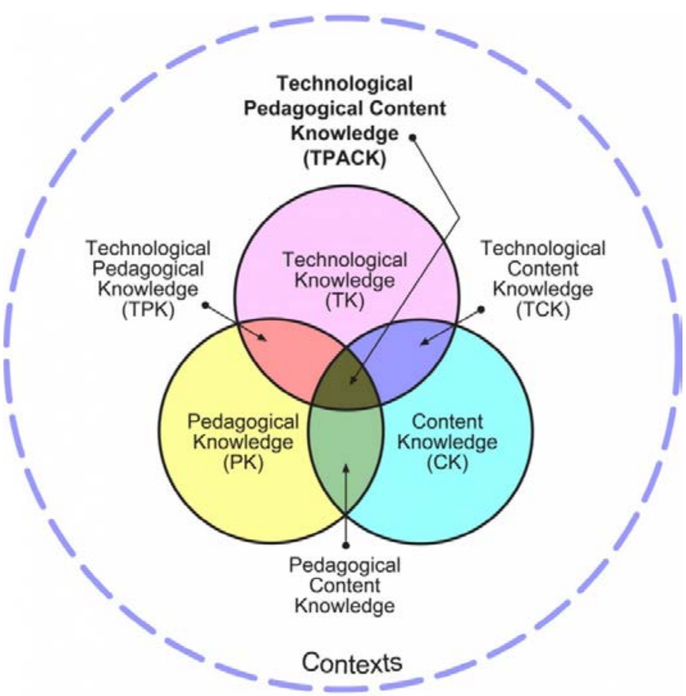

Figure 1. Components of TPACK from Mishra and Koehler (2006)

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

Intentional Development of TPACK

Several researchers have investigated numerous approaches in facilitating the purposeful development of TPACK in teacher education. Approaches have included microteaching lessons (Cavin, 2008) and design projects (Angeli & Valanides, 2009; Brupbacher & Wilson, 2009; Koehler & Mishra, 2005) that promote technology integration into teaching.

Some researchers have studied the development of TPACK in pre-service teachers after completion of a course with emphasis on TPACK development. Chai, Koh, and Tsai (2010) found significant gains in TPACK development with pre-service teachers after participating in a technology integration course. The course curriculum was sequenced in such a way that the distinct constructs of TPACK were separated and studied in succession. Similarly, Jang and Chen (2010) found that a restructured science teacher education program positively impacted pre-service teachers' development of TPACK. The curriculum focused on TPACK comprehension, observation, practice, and reflection.

Technological Pedagogical Knowledge (TPK)

Jaipal and Figg (2010) examined the development of TPACK in pre-service teachers who planned and implemented technology-integrated lessons while participating in a seven-week field-based block of study. The investigators focused on technological knowledge elements of TPACK. They found that, although all three elements of technology knowledge (TK, TCK, and TPK) are required for successful implementation of technology-enhanced instruction, "TPK characteristics played the most significant role in successful planning and implementation" (p. 432). Their study investigated both planning and implementation of technology-enhanced instruction within the context of a field-based block, whereas, the study described in this paper focused solely on the planning aspect—identifying appropriate technological tools to enhance student learning within lesson plans designed to illustrate a variety of teaching models that were being studied.

Context of the Study

Immersing teacher candidates in a technology-rich course in which they co-design a series of lessons illustrating various models of teaching using information and communications technology as tools for learning, collaborating, and teaching may foster the likelihood that they will, in turn, design and facilitate similar student-centered and authentic learning activities for their own students. This premise underlies the design of an online course required for graduate students pursuing a Master of Arts in Secondary Education, a Master of Education in Secondary Education with Teacher Certification, or a Master of Education in Secondary Education with a Specialization in Educational Technology in a large south central university in the United States. The state university serves 35,600 students; 1,800 of whom are enrolled in the university's teacher preparation program. Approximately 100 graduate students are enrolled in the Secondary Education graduate program. All core courses required for certification are offered online to accommodate the needs of these adult graduate students. Both practicing teachers and teacher candidates enroll in the secondary strategies course and are assigned to interdisciplinary

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

virtual design teams to co-create a series of lesson plans and instructional materials illustrating different models of teaching with an emphasis on integrating student use of technology into their lessons. Adding to the uniqueness of this study, most of the graduate students enrolled in the course are post-Baccalaureate students from various disciplines who are pursuing initial teacher certification. Most students have had no training themselves in pedagogy or experience in learning with technology as cognitive tools, while a few have some experience in learning with technology used in teacher-centered ways to transmit information from teacher to students. Given the composition of the student group, understanding these teacher candidates' perceptions of technology integration is critical in informing the facilitation of this online course and increasing the likelihood of the students integrating technology as tools for student learning in their future classrooms.

Like the previously referenced studies, this study was designed to analyze the effects of intentional development of TPACK in teacher education students. Specifically, the aim was to closely examine the TPK construct in teacher education students. The pre-service teachers completed a survey about their perceptions of technology integration in the classroom at the end of the fifteen-week project-based course that was designed to promote TPK. They were surveyed at the end of the course after they had synthesized their learning over the semester and highlighted their best team illustrations of technology-enhanced lesson designs and artifacts via an end-of-semester wiki showcase presentation. Additionally, the appropriateness of each virtual design team's choices of student technology tools was analyzed within the context of each of the pedagogical models that were studied.

Research Aims and Questions

In this case study, featuring 10 teacher candidates, the aim was to investigate the notion of technology integration that supports instructional effectiveness by exploring the following questions after the participants' completion of an online teaching methods course required for teacher certification:

1. What are teacher candidates' perceptions of technology integration in the classroom in relation to their perceived individual technology competencies and views on technology integration for student-centered instruction?
2. How well are teacher candidates applying TPK to develop supplemental instructional materials that illustrate student-centered technologies for specific teaching models?

METHODOLOGY

This heuristic case study (Merriam, 1998) examined the bounded system of one online course during the Spring 2013 semester, consisting of 15 weeks of instruction and collaborative interactions within their virtual design teams. A heuristic case study design was employed because the design "focuses on holistic description and explanation" and "illuminates the reader's understanding of the phenomenon under study" (Merriam, 1998, p. 29). The convenience sample consisted of 10 graduate students enrolled in a Master's of Education program who were seeking initial teacher certification at a large urban university.

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

The students voluntarily participated in the research and signed consent forms at the beginning of the academic semester in compliance with the university's Institutional Review Board requirements. They agreed to allow analysis of data generated from their natural participation in the course including surveys, discussion forums, completed assignments, etc.

Data Sources and Analysis Procedures

Data were derived from three sources. The two quantitative instruments used in the study were Almekhlafi and Almeqdadi's (2010) Technology in the Classroom survey, and Harris, Grandgenett, and Hofer's (2010) Technology Integration Assessment rubric. Qualitative analysis of the end-of-semester final team presentations also occurred. Table 1 summarizes the data sources in relation to the previously stated research questions.

Table 1. Relationship between Data Sources and Research Questions

Data Sources	Collection Procedures	Analysis Procedures	Connection To Research Questions
Technology in the Classroom Survey (Almekhlafi & Almeqdadi, 2010)	Collected through online survey form at the end of the semester	Averages and percentages derived for quantitative items and narrative analysis and coding procedures used for qualitative items	1
Technology Integration Assessment Rubric (Harris, Grandgenett, & Hofer, 2010)	Collected from each team for each of the six lesson plan assignments	Averages and percentages	2
End of semester reflections and showcase presentations	Collected through discussion forum and team showcase slide presentations	Narrative analysis and coding procedures used for qualitative items	1

The Survey: The investigators administered Almekhlafi and Almeqdadi's (2010) Technology in the Classroom survey to the pre-service teacher participants. The 50-item survey employed a 5-point Likert scale to measure the participants' responses, ranging from strongly disagree to strongly agree. In addition to face validity of the questions, the instrument had been reviewed by a panel of university professors considered experts in their fields; alpha reliability was 0.94 and the instrument was deemed highly reliable (Fraenkel & Wallen, 2006). The survey addressed several important factors impacting technology integration in the classroom such as teachers' perceptions of (a) their competency with technology, (b) student usage of technology, and (c) incentives and obstacles to integrating technology in the classroom. Due to the limitations of the speculative nature of the pre-service teacher perceptions of (b) and (c), these data were not included within the reported results of this study. Examples of the survey statements are as follows:

- I can use technology tools and information resources to increase productivity, promote creativity, and facilitate academic learning
- I can use technology tools to locate, evaluate, and collect information from a variety of sources.
- I understand the legal, ethical, cultural, and societal issues related to technology.

The Rubric: Harris, Grandgenett, and Hofer's (2010) Technology Integration Assessment rubric was used to assess the levels of technology integration within the six lesson plans that the student teams created to illustrate six different models of teaching. The developers of this assessment tool designed it to measure the quality of technology integration in lesson plans developed by pre-service teachers. The tool was analyzed for validity and reliability. According to the authors of the instrument, it was "tested by experienced technology-using educators who were evaluating pre-service teachers' lesson plan documents, and has been found to be both reliable and valid as a result (Harris, Grandgenett, & Hofer, 2010, p. 3838). Unlike other instruments to assess technology integration, such as the TPACK survey, this tool does not rely on self-reports but provides an external analysis by reviewers.

End of Semester Reflections and Showcase Presentations: During the last weeks of the semester, the students were asked to debrief and document their team experience in a discussion forum. They were prompted to reflect upon their collaborative processes and co-construct a slide presentation that showcased their work and shared their insights. The graded slide presentation showcased the team's best work and provided a synthesis of their learning over the course of the semester. Reflective prompts included the following:

- Document your team's choice of strongest (a) lesson plan, (b) visual advance organizer, (c) graphic organizer, and (d) student use of technology. Be sure each team member is represented in at least one of these 4 categories.
- You have studied 6 classic and contemporary models of teaching. Which models are you mostly likely to use and why? As a team, list the models in the priority of which you feel you would use them the most with justifications for each.
- What were your team's strengths in working together?
- What problems or obstacles did your team experience? How would you address these challenges in the future? What suggestions would you have for next semester's virtual teams?

- Which of the technology tools that you and your team investigated or used this semester will you likely use in your classroom and why? As a team, list the tools in the priority of which you feel you would use them and include a justification for each tool.
- In looking at your team's overall learning artifacts, do you feel that your collaborative products were of higher quality than if you had been working alone, or do you feel that your learning artifacts would have been of higher quality if you had been working individually? Please explain.
- List the tools you and your team used to collaborate with each other? List the tools according to the frequency of use, with the most frequently used tool listed first.

Each team arranged a time to present their slide presentation to the class, using a synchronous web conferencing tool.

Data Analysis Procedures

After the completion of the semester, the course professor, one of the researchers, invited a quantitative methodologist and a qualitative methodologist to jointly analyze the data. As a research team, the three researchers analyzed the variances in the survey data, scored the lesson plans using the rubric, and qualitatively analyzed the end-of-semester presentations. Qualitative procedures included first- and second-cycle coding that utilized Saldaña's (2009) techniques, including in vivo coding (first cycle) and pattern coding (second cycle). Using constant comparative methods (Bogdan & Biklen, 2003; Glaser, 2001), the multiple data sources were used to explore the variables contributing to participant development of TPK. The use of three data sources allowed for triangulation of data to increase validity of the study.

FINDINGS & DISCUSSION

Perceptions of Technology Integration

Perceptions of technology integration were explored through analyzing results of the Technology in the Classroom Survey (Almekhlafi & Almeqdadi, 2010) in addition to a qualitative analysis of the end-of-semester showcase presentations. The results are organized to present the pre-service teachers' views of technology through their self-perceptions of their own technology competencies (survey) and how those perceptions ultimately informed the ways they defined effective technology integration (end-of-course presentations).

Technology competencies are arguably important for teacher candidates since effective integration cannot occur without skill to use the chosen tool. Participants were overwhelmingly positive in their perceptions of their own technology use. Thirty percent (30%) had neutral perceptions about their abilities to perform more abstract competencies, including "using technology for real world problem solving," "discussing ethical issues," and "discussing technology diversity issues." Figure 2 provides a visual comparison of the participant responses for each competency item.

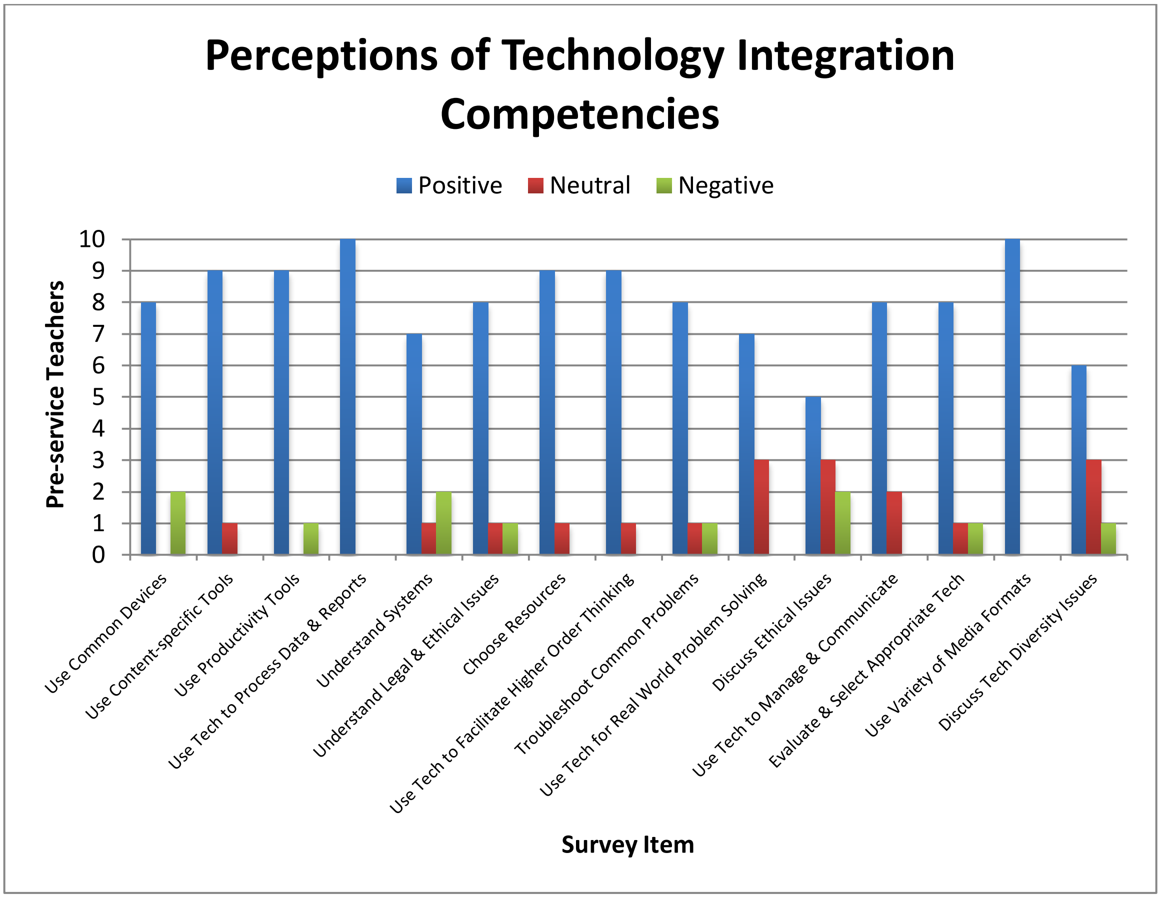

Figure 2. Perceptions of Technology Integration Competencies

Self-Perceptions of Ability to Integrate Technology

Adding to the participants' self-reported perceptions of technology competencies, the qualitative analysis of the end-of-semester presentations provided further insight into how the participants' self-perceptions informed an overall opinion of how they viewed technology and its role in education. The following themes emerged from the qualitative data and illuminate understanding of participants' personal definitions of technology integration. The final outcome of the analysis process included three views of technology integration: trendy, pragmatic, and pedagogical.

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

Trendy View: Technology Integration is "Exciting." Keeping in line with the societal view that technology is exciting due to its prevalence within everyday life, this view focused on the "fun" characteristics of technology and its overall inevitability and appeal. Participants whose comments generated the trendy view tended to use "buzz words" to support claims about technology and teaching (i.e., essential because "the world is becoming more technology-driven," "for lifelong learning"). Though technology integration does have potential for these outcomes, this view does not provide deeper background or connections to support the claim in terms of connecting technology to pedagogy or content. This trendy approach can be attributed to the adventurous risk-taking spirit that today's modern teacher needs to have in order to attempt technology integration; however, the researchers point out the dangers of similarly superficial viewpoints because they focus on the "flash" rather than the "substance," thereby missing the connections between pedagogy, content, and technology (Kereluik, Mishra, Fahnoe, & Terry, 2013; Mishra & Koehler, 2006).

Participants who held the trendy view of teaching with technology appeared to be centered on the attractive features of technology and not transparently focused on content or learning goals. As one participant stated in an open-ended survey response, "students get excited and are more willing to learn when they are using different technology." In the trendy view the focus was on the tool rather than the pedagogical method being employed to support learning the content. Coincidentally, this same participant was a member of one of the collaborative teams that remarked that the course focused "too much on content."

Pragmatic View: Technology Integration is "Challenging." Participants categorized within the pragmatic view tended to conduct deeper inspections into what was really taking place within learning environments. For instance, one participant noted from his/her school-based observations/fieldwork that some "students did not have much access" to technology which affected his/her view that technology integration is "challenging." Through their observations, the participants acknowledged that it isn't easy to find a balance between the time commitment required for using technology and addressing the academic demands of the curriculum. In addition to seeing the potential barriers, participants could also see the possibilities and understood the idea of connecting engaging technology with practical considerations by "taking advantage of the resources that are available to help with student and teacher success." Based on their willingness to locate resources on their own means, these teachers acknowledge the challenges and accept that nothing will be easy, nor will all solutions be simply handed to them - they must go in search of what will work in their classroom and find ways to amplify/transform. While this optimism reflects the participants' ability to see the pedagogical models that are suitable for the context of the classroom, they are admittedly unsure of how to fully achieve technological connections (TPK).

Pedagogical View: Technology Integration is "An Accompaniment to Content Learning." A very deep awareness of the need to connect theory and practice was the central focus of participants who generated the pedagogical view category. With content and learning outcomes at the forefront, one participant noted that "there is a great deal of prior knowledge and skills in the content area that a student must have in order to effectively use technology within these subjects." Seeing the connection between content and pedagogy, this participant acknowledged that proper instructional scaffolding with technology integration is necessary in order to achieve higher-level learning goals such as meaning-making and transference. The idea that "practice makes perfect" was used to describe the positive attitude that a teacher needs to feel confident enough to take risks in the face of potential challenges. A key component of the pedagogical view of technology integration is the ability to see the instructional affordances of the technology tool(s). With awareness of the practical connections that must be made between the content, pedagogy, and chosen technology tool, these participants acknowledged the potential of technology integration to "promote broader and more innovative teaching methods."

The qualitative data suggests that these pre-service teachers' views of technology dictated the ways they integrated technology into their lesson plans. Some viewed technology integration as exciting because of its engaging qualities. Several considered integration as challenging because of the difficulties of access and need for resources. Others viewed technology as an accompaniment to content learning because of its inherent connections to pedagogy and content. These results are in line with Pierson's (2001) assertion that "the ways technology was used determined the teachers' personal definitions of technology integration" (p. 419).

Appropriateness of Technology Tools Integrated into Lesson Plans

To further illuminate the pre-service teachers' pedagogical reasoning processes, the justifications for their choices of student-centered technology tools that were infused in their lesson plans were reviewed. The Instructional Strategies and Technologies (TPK) section of Harris, Grandgenett, and Hofer's (2010) Technology Integration Assessment Rubric was used to assess the appropriateness of the selected student-centered tool in relation to the model of teaching under study. The TPK scores range from 1-4, with 1 being low and 4 being high. A 4 is awarded when "technology use optimally supports instructional strategies" (Harris, Grandgenett, & Hofer, 2010). Figure 3 shows the Quality of Technology Integration scores in the co-constructed lesson plans developed for each of the models of teaching that were studied.

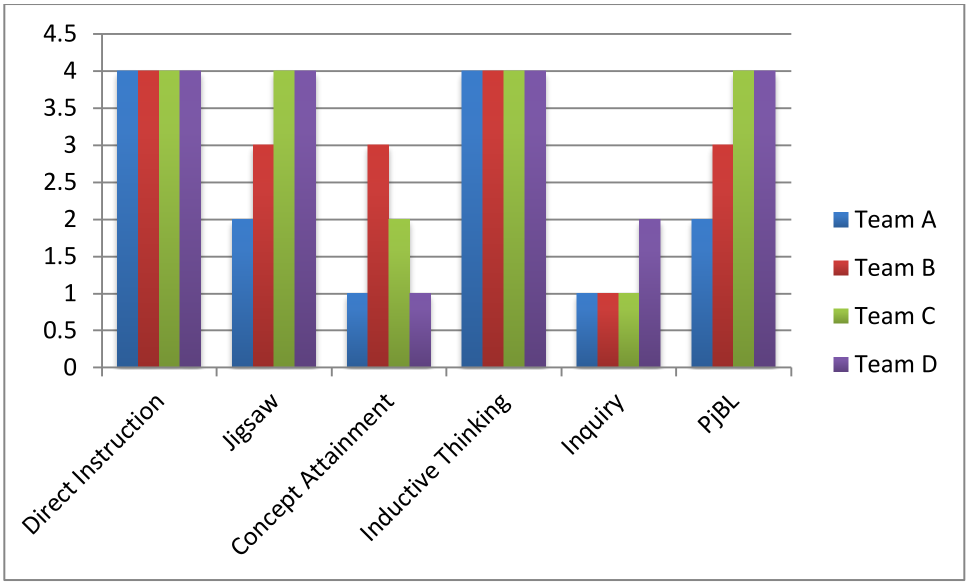

Figure 3. The Quality of Technology Interactions

Highest TPK Scores: As shown in Figure 3, TPK scores for the pre-service teams were highest for the Direct Instruction and Inductive Thinking teaching models. Students were able to accurately identify appropriate tools for these two models. Choices of web-based tools for students to use within the Direct Instruction model of teaching included online bookmarking tools such as Diigo (https://www.diigo.com/) and interactive timelines, such as Dipity (http://www.dipity.com/) to support students' organization of the information presented in the instruction. Other tools included web-based interactive poster creation applications, such as Glogster (http://edu.glogster.com/) for the students to demonstrate their learning by reproducing what they had learned. The high TPK scores for the Direct Instruction model may be attributed to pre-service teachers' familiarity with learning via direct instruction themselves.

The pre-service teachers also accurately identified and illustrated student use of technology for Taba's Inductive Model of teaching (1962). All teams chose popular web-based concept mapping tools, such as Bubbl.us (https://bubbl.us/) for their students to brainstorm, categorize, and cross-categorize the concepts that would be generated in response to the teacher's prompt. The high TPK scores for the Inductive Model of teaching are likely attributed to students' familiarity with concept mapping tools, directly connecting the mapping technology with the classifying processes inherent in the Inductive Model (pedagogy).

Lowest TPK Scores: Lower TPK scores were evident in technology-enhanced lessons illustrating the Inquiry-Based Learning model of teaching and Concept Attainment. Both Inquiry and Concept

Attainment are often challenging pedagogies for pre-service teachers to conceptualize and to apply instructional design principles due to their own lack of learning via inquiry processes. The pre-service teachers seemed to have had difficulty identifying student-centered technology tools that would support the actual inquiry processes that would be required of students. Most of the technology tools chosen for these inquiry models were ones that emphasized the activity of students presenting their results through an end product, such as presentation software tools like Prezi (http://prezi.com/index/9/).

Middle TPK Scores: The Jigsaw and Project-Based Learning (PjBL) technology-enhanced lesson plans had TPK scores that fell in the middle of the scores continuum. Many pre-service teachers tend to be familiar with these pedagogies within their own learning experiences. Many have learned via projects and have learned via the Jigsaw strategy in some of their higher education courses. The pre-service teachers leveraged tools that supported the cooperative learning component of Jigsaw such as web-based acquisition tools, such as Snipd (http://www.snipd.com/) for researching information in expert groups and slide presentation software for illustrating what students learned in their home groups. The element of authenticity emphasized in PjBL designs likely prompted the pre-service teachers to choose presentation type technologies such as Prezi for their students to present their real-world projects to "authentic audiences."

Technology integration scores tended to be higher in lesson plans created for teaching models with which the participants were most familiar such as Direct Instruction, Jigsaw, and PjBL. Technology integration scores were lower in those lesson plans created for teaching models with which they had little experience, such as Concept Attainment and Inquiry-Based Learning. The "outlier" was the Inductive Model that had high scores, which were likely due more to the pre-service teachers' experience and familiarity with concept mapping tools than their familiarity with the pedagogy.

IMPLICATIONS

In summary, the pre-service teachers' self-reported perceptions were that their technology integration competencies were high. Their end-of-semester presentations reflected three distinct views of technology's role in learning. Their views of technology integration included trendy, pragmatic, and pedagogical. The appropriateness of their choice of technology tools for integration in their technology-enhanced lesson to illustrate various pedagogies was mixed. Higher TPK scores were apparent in the lesson plans associated with models of teaching with which they had the most familiarity as learners themselves. The appropriateness of their choice of tool appeared to be related to the quality of their conceptual understanding of the pedagogy.

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

Clearly TPK is a complex construct. Its nuances are difficult to measure and challenging to teach. Moreover, TPK is a new construct for many pre-service teachers and many teacher educators who have had limited or no experience in using technology as tools to support instruction. As illuminated by this study, pre-service teachers are at various positions that range along a continuum from viewing technology in overly simplistic ways to viewing technology in more sophisticated ways that connect the technology with the pedagogy. Effective technology integration in teaching and learning requires teachers to be able to think about technology as a tool that can authentically support instruction when the appropriate pedagogical approaches are considered. This is indeed a challenging undertaking but one that can be facilitated and managed through very deliberate and concentrated efforts, such as providing multiple opportunities for practicing the pedagogical reasoning required in designing technology-enhanced instruction for student learning.

Theoretical Implications: The Complexities of TPK as Evolving Pedagogical Reasoning

TPK is more than a simple addition problem, i.e., "technology + pedagogy." It is an interwoven construct that embodies pedagogical expertise that is continuously evolving and changing as new experiences are had by teachers (Mishra & Koehler, 2006; Pierson, 2001). This pedagogical reasoning is impacted by ability to make connections between past learning experiences, current learning experiences, and anticipated future practice. Furthermore, the development of TPK requires teachers to be able to:

- consider the content that needs to be transformed into a representation that their students can comprehend (Shulman, 1986);
- choose an appropriate instructional strategy or method that best fits the content to be learned (Dell'Olio & Donk, 2007);
- analyze the cognitive processes in which their students must engage to deeply learn the content (Bower, Hedberg, & Kuswara, 2010); and
- identify and model the use of effective technological tools that may serve as "cognitive partners" for their learners and themselves (Angeli & Valanides, 2009).

Practical Implications for Teacher Education: Intentional Development of TPK

TPK is a complex interplay of learning theory, pedagogy, and technology tools to support instruction. Hofer and Grandgenett (2012) clarify this by stating the following: "TPK, in essence, is the knowledge that helps teachers to maximize a particular technology affordances to support a pedagogical strategy or model" (p. 85). Proper development of TPK in pre-service teachers requires immersion in rich pedagogical and technological learning environments where effective pedagogy and technology are modeled. Teacher education courses and programs need to be structured in ways that transparently and explicitly address pedagogical reasoning.

Limitations

This study had several limitations. The small sample size of the participants decreases the generalizability of the findings. The data from the self-reported surveys relies on the participants' ability to provide accurate information (Sue & Ritter, 2007). Analyzing multiple forms of data and employing three individual experts to analyze and interpret the data mitigated potential researcher bias.

Conclusion

Future research is recommended into deliberate and intensive development of TPK in teacher education. Such development work should not be the responsibility of a few teacher educators; instead, it must be modeled and taught through a) the use of multiple pedagogies that best fit the content to be learned and b) supported with technological tools that enhance student learning. This process can be facilitated through strategically designed teacher education courses to move pre-service teachers along a continuum of integrating technology with pedagogy. Pursuing this goal in a straightforward and transparent manner will ensure that pre-service teachers become adept in choosing appropriate technology to fit the pedagogy and content. Studies such as this one are in line with Shulman's (1987) call to action by exploring the various contexts of teaching and teacher education where far too often "its complexities [are] ignored" (p. 6). A longitudinal study following these pre-service teachers as they perform in their student teaching and future teaching employment would demonstrate how TPK progresses over time with practice.

REFERENCES

Almekhlafi, A. G., & Almeqdadi, F. A. (2010). Teachers' perceptions of technology integration in the United Arab Emirates School classrooms. *Educational Technology & Society, 13*(1), 165-175.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*, 154-168.

Bogdan, R. C., & Biklen, S. K. (2003). *Qualitative research for education: An introduction to theories and methods* (4th ed.). New York: Pearson Education.

Bower, M., Hedberg, J., & Kuswara, A. (2010). A framework for Web 2.0 learning design. *Educational Media International, 47*(3), 177-198.

Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education & Development Using Information & Communication Technology, 8*(1), 136-155.

Brupbacher, L., & Wilson, D. (2009). Developing TPCK (Technological Pedagogical Content Knowledge) in teacher preparation programs. In I. Gibson et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2009* (pp. 4020-4024). Chesapeake, VA: AACE. Retrieved from http://www.editlib.org/p/31287

Cavin, R. (2008). Developing technological pedagogical content knowledge in preservice teachers through microteaching lesson study. In K. McFerrin et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2008* (pp. 5214–5220). Chesapeake, VA: AACE. Retrieved from http://editlib.org/p/28106

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2010). Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society, 13*(4), 63-73.

Dell'Olio, J. M., & Donk, T. (2007). *Models of teaching: Connecting student learning with standards.* Thousand Oaks, CA: Sage Publications.

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education*. New York: McGraw-Hill.

Funkhouser, B. J., & Mouza, C. (2013). Drawing on technology: An investigation of preservice teacher beliefs in the context of an introductory educational technology course. *Computers & Education, 6*(2), 271-285.

Glaser, B. G. (2001). *The grounded theory perspective: Conceptualization contrasted with description.* Mill Valley, CA: Sociology Press.

Harris, J., Grandgenett, N., & Hofer, M. (2010). Testing a TPACK-based technology integration assessment rubric. In D. Gibson & B. Dodge (Eds.), *Research highlights in technology and teacher education* (pp. 323-331). Chesapeake, VA: Society for Information Technology and Teacher Education. Retrieved from http://www.editlib.org/p/33978

Hofer, M. & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of preservice teachers in a secondary M.A.Ed. program. *Journal of Research on Technology in Education, 45*(1), 83-106.

Jaipal, K., & Figg, C. (2010). Unpacking the "total package": Emergent TPACK characteristics from a study of preservice teachers teaching with technology. *Journal of Technology and Teacher Education, 18*(3), 415-441. Chesapeake, VA: SITE.

Jamieson-Proctor, R., Finger, G., & Albion, P. (2010). Auditing the TK and TPACK confidence of preservice teachers: Are they ready for the profession? *Australian Educational Computing*, *25*(1), 8-17.

Jang, S., & Chen, K. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers. *Journal of Science Education & Technology, 19*(6), 553-564.

Kereluik, K., Mishra, P., Fahnoe, C., & Terry, L. (2013). What knowledge is of most worth: Teacher knowledge for 21st century learning. *Journal of Digital Learning in Teacher Education*, *29*(4), 127-140.

Koehler, M. J. & Mishra, P. (2005). Teachers learning technology by design. *Journal of Computing in Teacher Education, 21*(3), 94-102.

Lei, J. (2009). Digital natives as preservice teachers: What technology preparation is needed? *Journal of Computing in Teacher Education, 25*(3), 87–97.

Merriam, S. B. (1998). *Qualitative research and case study applications in education: Revised and expanded from case study research in education.* San Francisco, CA: Jossey-Bass.

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

Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education*, *33*(4), 413-430.

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage Publications.

International Journal of E-Learning & Distance Education
La Revue internationale de l'apprentissage en ligne et de l'enseignement à distance

Volume 29(2) 2014

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-22.

Sue, V. M., & Ritter, L. A. (2007). *Conducting online surveys*. Thousand Oaks, CA: Sage Publications.

Taba, H. (1962). *Curriculum development: Theory and practice*. New York: Harcourt Brace & World.

Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education*, *59*, 134–144.

Authors

Kathryn S. Lee is an Associate Professor in Curriculum and Instruction at Texas State University, and a teacher educator in the secondary education graduate program. Her focus is promoting teachers' development of technological pedagogical content knowledge in the design of authentic and engaging learning experiences for their students. E-mail: kl10@txstate.edu.

Shaunna Smith is an Assistant Professor of Educational Technology in Curriculum and Instruction at Texas State University. Her research focuses on technology integration strategies within K-12 and post-secondary learning environments, and, as a former art teacher, she is also interested in how hands-on use of design-based technologies impacts multidisciplinary learning. E-mail: sfs36@txstate.edu.

Beth Bos is an Associate Professor at Texas State University in the Department of Curriculum and Instruction. She teaches math education and secondary education courses. Dr. Bos manages a Master Mathematics Teacher EC-4 certification program. The use of technology in teaching mathematics is her established area of expertise. E-mail: bb33@txstate.edu.

CNIE RCIÉ