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USING THE TECHNOLOGICAL, PEDAGOGICAL, AND CONTENT KNOWLEDGE FRAMEWORK TO DESIGN ONLINE LEARNING ENVIRONMENTS AND PROFESSIONAL DEVELOPMENT

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ABSTRACT

In this article we sought to understand how social studies teachers' metacognitive awareness of their technological, pedagogical, and content knowledge (TPACK) changed after their participation in a program that consisted of: (a) professional development for the use of an online learning environment; and (b) using an online learning environment in their classrooms. Inservice teachers who went through the TPACK-based program experienced considerable movement within the TPACK diagrammatic knowledge domains and expressed positive and encouraging comments regarding their knowledge domains portrayed within the TPACK framework. Quantitative and qualitative results are shared along with implications of designing professional development, online learning environments using TPACK, and advancing the TPACK framework itself.

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Teacher education has historically focused on content knowledge (Schulman, 1987). It was assumed that by knowing the content area (e.g., science, math, social studies), teachers would be able to successfully teach their students. More recently, however, practitioners and researchers have come to recognize the need for teachers to command varied and different forms of knowledge. Knowing the content, the *what* and the *why*, is not enough for teachers to be able to teach effectively. Teachers must also possess pedagogical knowledge (i.e. know *how* to teach) (Shulman, 1987). In other words, effective teachers utilize both content knowledge and pedagogical knowledge, and understand and appreciate how the two are interrelated (Shulman, 1987).

Considering recent advancements in technology and the fact that 99% of U.S. K–12 schools have had access to the Internet since 2002 (Kleiner & Lewis, 2003), researchers have recently questioned and explored how teachers' technological knowledge fits into effective teaching practices. Technological knowledge by itself is not sufficient in teachers being able to effectively teach using technology. The intersection between technological, pedagogical, and content knowledge guides effective teaching; the art and science of teaching is the negotiation of and synergy between these three forms of knowledge (Koehler & Mishra, 2008; Mishra & Koehler, 2006).

In this article we sought to understand how geography teachers' metacognitive awareness of their technological, pedagogical, and content knowledge (TPCK) changed after they participated in a program that consisted of professional development for the use of an online learning environment grounded in the knowledge domains of technological, pedagogical, and content knowledge.

TPCK/TPACK OVERVIEW

Shulman's (1987) seminal article on the components of teacher knowledge continues to inform and guide preservice and inservice teacher education. Shulman's conceptualization of teacher knowledge was the synergy between *content* and *pedagogical* knowledge, or *pedagogical content knowledge*, which he argued was the heart of teaching (p. 15):

> The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students.

Content or subject matter knowledge is the depth and breadth of knowledge in a specific content area. For example, in geography teachers are experts/extremely knowledgeable in geographic concepts (i.e., location, place, human/environmental interaction)—things that the average person does not know. In

addition, there are many different types of geography, including cultural and physical geography, and each encompasses its own vocabulary and concepts (e.g., topographic maps and geocaching), which geography teachers need to be familiar with. *Pedagogical knowledge* is the knowledge of teaching and learning that spans content areas (i.e., formative assessment, classroom management, and motivation strategies). Teachers make pedagogical decisions about teaching and learning based on their content area. For example, geography teachers consider national geography standards when planning curriculum and instruction.

More recently, other scholars have built on Shulman's conceptualization by including a third component to teacher knowledge—technological knowledge. Mishra and Koehler (2006) recently introduced the union of three different types of knowledge as representative of what teachers need to know, coining the combined framework, "technological pedagogical content knowledge" or "TPCK" (see Figure 1); however, other researchers have previously included and named technological knowledge as a component of teacher knowledge (e.g., Hughes, 2000, 2005; Niess, 2005) while work prior to Mishra and Koehler (2006) also formally introduced the concept of TPCK (e.g., Pierson, 2001).

The TPCK framework strives to "capture some of the essential qualities of knowledge required by teachers for technology integration in their teaching, while addressing the complex, multifaceted and situated nature of teacher knowledge" (Mishra & Koehler, 2006):

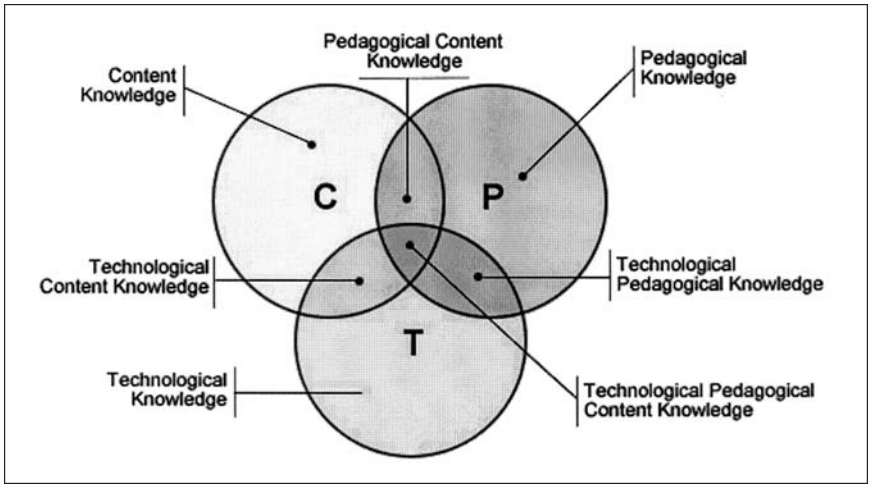


Figure 1. Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006).

> Technological pedagogical content knowledge is an understanding that emerges from an interaction of content, pedagogy, and technology knowledge. Underlying truly meaningful and deeply skilled teaching with technology, TPCK is different from knowledge of all three components individually. . . . TPCK is the basis of effective teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones (Koehler & Mishra, 2008).

Technology integration is a complex and "wicked" problem (Mishra & Koehler, 2006) that the educational technology field has long struggled to understand, define, and explain. The TPCK framework offers us a possible solution.

In the past few years, TPCK has gained momentum and acceptance, and continues to flourish as a theoretical construct that helps researchers, teacher educators, and teachers themselves think about and "do" technology integration in education. In the Winter 2007-2008 issue of the *Journal of Computing in Teacher Education*, an updated version of the TPCK acronym—"TPCK Becomes TPACK!"—is revealed and discussed (Thompson & Mishra, 2007-2008). The argument for this updated acronym is that the insertion of the "A" better represents the interdependence of the three knowledge domains (T, P, C)—so, the framework better explains the "Total PACKage" of teacher knowledge. In line with this new development, we will use the acronym, TPACK, from this point forward in our article.

Acronym-specifics aside, TPACK is a useful theoretical framework that translates well into the worlds of both teachers and educational researchers. In 2005, technology integrationist M. D. Roblyer, noted that the field of educational technology still needed theoretical foundations to support its research. A few years later, the TPACK framework is emerging as one valuable step forward in addressing this theoretical gap (Thompson & Mishra, 2007-2008; Schrum, Thompson, Maddux, Sprague, Bill, & Bell, 2007). Scholars and teacher educators are beginning to discuss and implement the framework in reframing preservice and inservice teacher education programs (Thompson, 2008; http://www.tpck.org/) as well as infusing it in teacher professional development (e.g., Harris, 2008). While most of this bourgeoning TPACK research, especially with regard to content-specific investigations, is currently being presented at research conferences (e.g., Niess, Sadri, & Lee, 2007; Niess, Suharwoto, Lee, & Sadri, 2006), the recent publication of *The Handbook of Technological Pedagogical Content Knowledge for Educators* (AACTE, 2008) focuses exclusively on the TPACK framework. This handbook may provide the catalyst for TPACK

research making its way into peer-reviewed journals (e.g., Doering & Veletsianos, 2007b; Koehler & Mishra, 2005; Koehler, Mishra, & Yahya, 2007, Niess, 2005) and thereby moving the field forward.

Our research seeks to contribute to the literature on how the TPACK framework can be used in inservice or practicing teacher professional development focused on technology integration. Harris (2008) suggests activity types to use during professional development to assist inservice teachers in developing their combined knowledge bases:

> TPCK-related professional development for experienced teachers should promote both autonomous and collaborative instructional decision-making while simultaneously encouraging open-minded consideration of new instructional methods, tools, and resources. Activity types that are keyed directly to required curriculum standards can provide both flexible scaffolding and authenticity of purpose for experienced teachers' TPCK-related learning—a balance of helpful, non-constraining structure/scaffolding for new implementation ideas while acknowledging experienced teachers' agency and expertise in the classroom (p. 267).

While Harris offers insights about how to best build professional development for teachers across content areas, the focus of our research was on a specific professional development opportunity for social studies teachers and how this program impacted their TPACK.

GEOTHENTIC OVERVIEW

GeoThentic

The program on which this study is based is entitled GeoThentic. GeoThentic (Doering, Scharber, Miller, & Veletsianos, 2009) is the next iteration of a multi-scaffolding online learning environment (Doering & Veletsianos, 2007a) for teachers and students with an added professional development workshop that introduces and supports teachers in utilizing GeoThentic within their classrooms. GeoThentic answers Harris' (2008) call for activities for TPACK-related professional development as the program provides flexible and user-controlled scaffolding, authentic experiences and inquiry-based projects, and instructional methods, tools, and resources.

GeoThentic was designed and developed in response to the United States' declining geographic knowledge (Congressional Record References, 2005), the need for effective pedagogy when using geospatial technologies to teach geography (Doering & Veletsianos, 2007a), and that authors of the National Geography Standards have identified geospatial technologies as the only technology that can assist students in meeting all of those standards (Bednarz, 1995; Sui, 1995). Our goal for GeoThentic is to enhance K–12 teacher and student

geographic literacy through an inquiry-based approach to solving authentic geographic problems. Based on the previous work of Doering and Veletsianos (2007a), the project entails the design, development, and delivery of a hybrid course for pre- and in-service K-16 teachers with a desire to learn how to effectively teach geography using a wide-range of geospatial technologies (e.g., Google Earth™) that are available today.

The theoretical foundation for the design of GeoThentic was the development of teachers' technological pedagogical content knowledge within geography, what we described elsewhere as G-TPCK (Doering & Veletsianos, 2007b). Currently, the focus is moving away from *what* teachers should know to effectively integrate technology into their classrooms (Mishra & Koehler, 2006; International Society for Technology in Education, 2008; Zhao, 2003) to studying *how* their knowledge is used within the classroom for the most effective results (Carr, Jonassen, Litzinger, & Marra, 1998; Mishra & Koehler, 2006). Via this program, teachers are developing their technology knowledge—using the geospatial technologies; pedagogical knowledge—investigating optimal pedagogy for geographic problem solving with geospatial technologies; and content knowledge—developing knowledge of the specific content area (geography) needed to effectively teach the problem-solving modules. The seamless integration of the three domains of knowledge is an integral part of GeoThentic.

GeoThentic Modules

GeoThentic ecompasses numerous modules centered on inquiry-based geographic problems. One example of a module within GeoThentic is entitled *Where Should I Build a Hospital?* (Figure 2). In this module, learners analyze socioscientific data to identify the best location to build a new hospital within the San Francisco region. Analyzing data ranging from liquefaction, earthquake frequency, population density, and population income, learners need to identify the best location to build a new hospital, and more importantly, provide a justification for their location based on their analysis. The teacher section of GeoThentic focuses on providing support for teachers to teach the modules. For instance, teachers are introduced to multiple pedagogical strategies of teaching geographic problem-based modules, based on the work of Doering (2004) and the Cognition and Technology Group at Vanderbilt (1990, 1992).

GeoThentic Professional Development

During the formative phases of the development of the GeoThentic learning environment, 20 in-service social studies teachers who were also members of the local geographic alliance were invited to a local university to receive training on integrating GeoThentic into their classrooms and developing their technological pedagogical content knowledge. At the workshop, teachers were introduced to the

Figure 2. San Francisco Hospital module.

concept of TPACK and each domain (technology, content, and pedagogy) was discussed in detail. The specific geographic examples that were provided related to the National Geography Standards and the GeoThentic learning modules. For example, using GeoThentic, teachers developed their technological knowledge as they learned the procedural knowledge of using Google Earth through the use of screen-capture videos; teachers developed their pedagogical knowledge as they used different pedagogical approaches with GeoThentic within their classroom; and teachers developed their content knowledge as up-to-date authentic geographic content was provided for them within GeoThentic. In addition, a professional geographer was present at the workshop to answer any questions related to how a professional geographer would solve a GeoThentic module such as the *San Francisco Hospital* problem described above.

At the end of the one-day workshop, teachers returned to their classrooms and taught three GeoThentic modules using different pedagogical models. Each module took approximately two 50-minute periods to teach. Our research team collected qualitative and quantitative data before, during, and after the program. For instance, at the end of the program we interviewed all teachers,

surveyed all students, and held nine focus groups with selected students. Even though the data collected inform multiple aspects of GeoThentic, in this article we specifically focus on the concept of the teachers' technological, pedagogical, and content knowledge in the context of GeoThentic and their professional development training.

RESEARCH QUESTIONS

The GeoThentic project focused on enhancing teachers' technological, pedagogical, and content knowledge. As such, we were interested in understanding the impact of the project on teachers' beliefs and perceptions regarding their TPACK. Specifically, this article seeks to shed light on the following questions:

- How do these teachers perceive their TPACK?
- How do these teachers perceive *changes* in their TPACK?
- How were these teachers' technological, pedagogical, and content knowledge influenced by an online learning environment and professional development designed with an *explicit* TPACK focus?

METHOD

Participants

An invitation to participate in this research was sent to a listserv of statewide geography educators who had already expressed interest in participating in the evaluation of technological innovations for teaching geography. Out of the 20 teachers invited, eight teachers from a large Midwestern city and its suburbs chose to participate in this project. Five teachers were female and three were male, with four of them teaching high school and four teaching middle school. All teachers were tenured and had been teaching for more than 10 years, and all but one taught in the public school system. During the study, half of the teachers taught in the metropolitan area and half of them taught in first-ring suburbs. Table 1 lists specific information about each teacher, her/his school, and the classes s/he taught.

Prior to the beginning of this project, we asked these teachers to describe to us what would they like to learn regarding the integration of geospatial technologies in their classroom. Their responses indicated that they were excited about the possibilities that such technologies could afford for their students, ranging from "making lessons engaging and fun" to "implementing the State Geography Standards." In addition, seven teachers indicated that they wanted to enhance their pedagogical repertoire by using geospatial technologies to make their lessons more problem-based, relevant, and authentic.

Table 1. Teacher, School, and Class Demographics

Teacher	Class name	Grades taught	School type	Metro/-Suburb
Teacher A	AP Human Geography Metro Area Geography	9 to 12 (High School)	Public	Metro
Teacher B	Global Studies (Geography)	6 to 8 (Middle School)	Public	Suburb
Teacher C	Human Geography	9 to 12 (High School)	Public	Suburb
Teacher D	World Geography	6 to 8 (Middle School)	Public	Suburb
Teacher E	Human Geography Social Studies	9 to 12 (High School)	Public	Metro
Teacher F	World Geography	6 to 8 (Middle School)	Private	Metro
Teacher G	World Geography World Cultures	6 to 8 (Middle School)	Public	Metro
Teacher H	Geography	9 to 12 (High School)	Public	Suburb

Data Sources

To gain a complete, fully informed, and multidimensional understanding of teachers' perceptions of their technological, pedagogical, and content knowledge, we collected both quantitative and qualitative data. First (and prior to participating in the GeoThentic professional development session), the teachers were asked to evaluate their TPCK using the tool provided in Appendix A. Specifically, the teachers rated their TPC knowledge, provided open-ended responses to explain why they rated themselves in the way they did, positioned themselves on a TPACK diagram regarding their perceptions of their knowledge, and explained why they did so. It is important to bear in mind that this set of data was collected prior to the teachers participating in professional development and prior to them teaching with the GeoThentic. The teachers evaluated their TPCK once again, *after*

they finished teaching with the GeoThentic, *four months after* the professional development training. The data collected at this instance constituted a second data set. At the same time, all teachers were interviewed to discuss the professional development process, the GeoThentic program, and the ratings they gave themselves throughout the study, providing the third data set that informs this study. The interview protocol for the interviews is provided in Appendix B. The interviews lasted approximately 30 minutes each and were semi-structured. To summarize, we collected data from: (a) pre- and post-program Likert scale TPACK ratings; (b) pre- and post-program open-ended responses relating to each type of domain knowledge; (c) pre- and post-program TPACK diagram positioning; and (d) post- program personal interviews.

Data Analysis

This study falls within the broad framework of the interpretive research paradigm. Under this umbrella, our research employed a case study method that can be described as a legitimate and purposeful research method (Yin, 2003). The reasons for choosing this method lie on the fact that we wanted to describe, understand, and explain complex issues that occur in real-life and authentic situations through multiple perspectives (Haas Dyson & Genishi, 2005). Our study can best be described as a case study of teachers who participated in professional development for the use of an online learning environment designed on the basis of the TPACK framework and who subsequently used this environment in their teaching.

To analyze the available data and develop salient categories and patterns, we used the constant comparative method (Glaser & Strauss, 1967). Specifically, using NVIVO, each author analyzed data independently, with each author noting emerging codes, data patterns, and themes that related to answering the research questions. The authors then met six times to discuss, compare, and contrast their individual findings. At each meeting the data were reanalyzed and triangulated across authors and data sources in order to confirm and disconfirm evidence for the patterns working toward reliability and validity. This process continued until consensus was reached between the authors.

RESULTS

The results of our investigation are described using quantitative and qualitative sections. The quantitative section presents aggregate information regarding teachers' perceptions of their TPACK, while the qualitative section delves into a deeper analysis of the meanings behind the quantitative results.

Quantitative Findings

The quantitative results (see Table 2) indicate a general tendency of TPACK to shift across time. Approximately 59% of teacher ratings were different between

Table 2. Teachers' Perceptions of Their TPACK on a 5-Level Likert Scale

		Teacher A	Teacher B	Teacher C	Teacher D	Teacher E	Teacher F	Teacher G	Teacher H
Pre	Technology	3	4	3	4	2	3	3	3
	Pedagogy	5	4	4	3.5	4	4	2	5
	Content	5	3.5	3	4	4	4	4	3
Post	Technology	4	4.5	3	4	4	5	4	3
	Pedagogy	5	4.5	3	4	5	3	2	2.5
	Content	5	4	3	4	4	5	4	4
Pre/Post	Technology	1	0.5	0	0	2	2	1	0
Change	Pedagogy	0	0.5	–1	0.5	1	–1	0	–2.5
	Content	0	0.5	0	0	0	1	0	1

the pre- and the post-survey, indicating that teachers' perception of their knowledge domains changed over the duration of the GeoThentic program. Additionally, it appears that teachers perceived a largely positive change in their technological, pedagogical, and content knowledge after engaging with the GeoThentic program as indicated by the fact that out of the 14 ratings that did change between the pre- and the post-survey, 11 were positive while just 3 were negative.

In addition: (a) the most positive change occurred in the technology knowledge category with five out of eight teachers indicating that their technology knowledge increased; (b) the technology and content knowledge components exhibited only positive changes; and (c) five out of eight teachers indicated that their knowledge increased in at least one of the three knowledge components. The pedagogy knowledge component exhibited mixed results: three teachers perceived an increase in their pedagogy knowledge; three perceived a decrease in their pedagogy knowledge; and two felt that their pedagogy knowledge remained unchanged.

Finally, the tendency of TPACK to change over time—in other words, the idea that teachers perceive their TPACK as being a dynamic and malleable phenomenon—is illustrated in Appendix C. These figures plot the teachers TPACK positioning before and after their participation in the GeoThentic program. Each teacher is marked as an individual arrow. Their initial position is marked as a circle and their ending position is marked as the tip of the arrow.

Qualitative Findings

Based on the teacher interviews, the professional development opportunity of the GeoThentic program had a highly positive impact on the teachers' knowledge development and confidence in teaching geography with technology. The teachers immediately gravitated to discussing their experiences by reflecting on each knowledge domain (technology, pedagogy, and content). In addition, our conversations with the teachers revealed themes of empowerment through the development of the knowledge domains, confidence through "on-demand" support of the knowledge domains, and the "dynamic" qualities of TPACK. These are discussed in turn.

Technology Knowledge

The most positive change occurred within this knowledge domain. Teachers' open-ended responses and interviews revealed that content and lesson-specific technology knowledge was viewed as an "incredible opportunity" to realize the potential of technology within the classroom. All teachers responded they knew about Google Earth™ (GE), but had no idea how it could be used to get students to "do geography." Three of the teachers noted that when they had "played" with GE

in the past, they simply let their students "fly around" and they had no idea how to actually use the tool to analyze data. Jim[1] said,

> It was incredible to learn about the data layers and how to use them. The ability to turn layers of data on and off to let students do their analysis was what has transformed my thinking with this technology. It seems like this is where we have wanted to get our students to, but didn't know how to do it. Now I do.

Julie commented,

> I thought I knew Google Earth, but when I went through the training and the modules, I realized how little I knew and how I could really use the technology. This moved me and others in the program away from thinking about technology as a linear process, but that it can be used effectively when learning content.

Jordan noted,

> I used Google [Earth] for finding locations as I didn't know how to use the layers and the embedded features. The technology assistance was wonderful—both within the workshop and after we returned to our classroom within the GeoThentic environment. There is something in the air here and I think you are on to something!

Pedagogical Knowledge

Of great interest is that in the pedagogy domain, three teachers indicated an increase and three teachers indicated a decrease in their pedagogical knowledge. Based on the teachers' responses and interviews, teachers noted that the rating process enabled them to reflect on their teaching practices. The act of self-assessment allowed teachers to evaluate their existing pedagogical methods and practices. Because the training and their engagement with GeoThentic exposed teachers to additional pedagogical methods, some teachers viewed this as an enhancement of their knowledge (positive difference between pre- and post-project ratings) and some saw this as an indication that their knowledge of pedagogy was not as much as they had reported in the pre-survey (negative difference between pre- and post-project ratings). Betsy shared,

> I thought I knew how to use GIS technologies like Google Earth—was I wrong! I had no idea we could do so much and when I thought I knew how to teach with it, I definitely didn't. This was a great change.

Christy said,

> This is always what has been missing when learning technology. We would learn how to use the technology, but had no idea how to teach with it.

[1] All names used are pseudonyms.

Marvin noted,

> I have been teaching for over ten years and have always thought I knew technology really well. From Hyperstudio to now Flash, I know it. What I have always had a difficult time with is understanding how to teach with the technology. Having different teaching ideas in the GeoThentic program was great. I tried all three of the approaches and although I think one worked better, it got me to think about what I was doing.

Content Knowledge

There were only positive changes within this knowledge domain. All teachers showed and stated that their geography knowledge increased. Using GeoThentic, they stated that they were "teaching geography," rather than teaching students how to use a technology and the focus could be on what geographers actually do. David said,

> This is where I saw the positive change for me. I truly believe I wasn't doing geography before this but that I was having students complete worksheets. The environment and professional development helped me think about teaching with a geography lens.

Sally said,

> As they say within the social studies, we are a jack-of-all-trades and master-of-none. It is foolish to develop any type of professional development or program and not have a strong content portion. I wonder how many of us in the professional development actually had a geography course when we were students? Probably only a few of us and that's why I love this approach.

Empowerment through Knowledge Domains

All of the participants stated that they felt more confident when using the GeoThentic program because all three knowledge domains had been addressed in detail and there was "easy access" to the knowledge domains when they left the workshop. All of the teachers felt that the TPACK approach to professional development and learning environment design was "vital" as it "empowered" them and didn't make them feel dependent on someone else, thus increasing confidence. Christy shared,

> I loved this experience because it gave me what I needed to be successful and also increased my awareness of what I knew and what I thought I knew! I constantly wonder why we haven't taken this approach before? Is it that it just takes too much time or maybe we have just not thought this way before?

Jack commented,

> Well, I guess we finally have a way to talk about what we need to know and we have some guidelines to develop our lessons in the future. This is great that

> we have all the areas of knowledge we need to be successful. I didn't know my content and teaching methods very well in the past, but I feel good about what I know now.

On-Demand Support through a TPACK-based Online Learning Environment

Six of the teachers mentioned that in the past they would leave workshops and have no idea how they would actually use what they learned within their classroom. The GeoThentic workshop provided a new perspective for them. Julie said,

> The best thing is that I didn't leave the workshop wondering if I could do it myself. I knew I could use the online environment whenever I needed help. It was very refreshing.

Matt commented,

> Well, it seems I never have enough time to learn everything I need to successfully teach every aspect of the social studies. The online environment focused on [technological pedagogical content knowledge] is exactly what was needed.

Dynamic TPACK

Throughout the interviews the teachers reflected significantly on their TPACK. They discussed in detail how they believe the workshop influenced their TPACK movement to the center of the TPACK diagram. Yet, three of the teachers discussed at length the TPACK figure and how it is missing the context of the classroom. The teachers described that, reflecting on their assessments of themselves within the TPACK figure, the figure should be questioned. If each circle, which is now the same size across knowledge domains, represents equal knowledge, context has a great significant influence on perceptions of the three knowledge domains. Depending on factors such as grade level, technology access, student population, etc., the TPACK figure should *also* be able to dynamically represent the knowledge one *uses* in addition to the knowledge one *has*. Jim commented,

> I have taught middle and high school social studies. I would argue that my pedagogical and technological circle is much larger in the middle school classroom and my content circle is much larger in the high school classroom. Everything in education is variable and we can't forget that.

SUMMARY

Teachers participating in the GeoThentic program reflected actively on their technological, pedagogical, and content knowledge. Our work with them and our

investigation of their practices and their way of thinking about their knowledge domains allowed and enabled us to revisit the way we view the TPACK framework—a point to which we turn next.

IMPLICATIONS

There are several implications of our research on practicing teachers' metacognitive awareness of their technological, pedagogical, and content knowledge. We discuss these in turn, relating our findings to recommendations for practice and future research.

Professional Development Provides Opportunity for Teachers' TPACK Development

Professional development often relates to advancing one knowledge domain. The TPACK framework, however, pushes trainers and researchers to rethink the knowledge that teachers should have. It may be beneficial to rethink professional development in light of the findings of this study. Rather than viewing professional development as a way to allow teachers to expand on a specific knowledge base, perhaps we should view professional development programs as an opportunity to bring the areas of technology, pedagogy, and content knowledge together, as one knowledge base. Rather than separating knowledge related to three areas, it may be more valuable to transform professional development programs into modern interventions aimed at enhancing the intersection of knowledge domains that guide effective teaching.

Viewing TPACK as a separate knowledge domain was inherent to our workshop described above. However, a critique of our manuscript, and perhaps of our research in general, could be that too much focus was placed on the individual knowledge bases (T, P, and C) rather than the knowledge that results from the union of these three knowledge bases. We urge others to consider the idea that shifts in individual knowledge bases also suggest gains in TPACK. If teachers lack technology knowledge, how can they approach teaching and learning through a frame of TPACK? A focus on lacking knowledge bases is key before teachers can think of TPACK as a new knowledge base.

TPACK Metacognition Moves Practice Forward

In our research, the TPACK framework proved to be a metacognitive tool that teachers used to enhance geospatial technology integration into their classrooms by helping them visualize how their technology knowledge and skills work in tandem with their other knowledge domains about teaching and learning. The process of thinking about TPACK explicitly, by charting it on a visual representation, encouraged teachers to be metacognitve about their teacher knowledge strengths and areas of growth. Roblyer and Doering (2009) incorporate the

TPACK framework into the Technology Integration Planning (TIP) model, which benefits teachers by giving them a general approach to address challenges involved in integrating technology into teaching. There are six phases to the model that outline a set of planning and implementation steps that help ensure technology use will be meaningful, efficient, and successful. Roblyer and Doering (2009) note that experienced technology-using teachers tend to do these steps intuitively; however, for new teachers or those just beginning to integrate technology, the TIP model provides a helpful guide on procedures and issues to address. In both the TIP model and in the research presented in the article, teachers were asked to identify *where* they believe they see themselves within the TPACK framework. Pope and Golub (2000) emphasize that preservice teachers need "to be critical consumers of technology, to be thoughtful users who question, reflect, and refract on the best times and ways to integrate technology." In order to be "critical consumers," all teachers need to be explicitly aware of their current knowledge bases in the areas of TK, TCK, TPK, and TPACK (Hughes & Scharber, 2008). This metacognitive awareness of TPACK enables teachers to set learning goals for themselves and, in turn, make thoughtful decisions for technology integration.

Online Learning Environments for Teacher Development and the Theoretical Construct of TPACK

The majority of teachers within this study referenced the on-demand TPACK support the GeoThentic provided when they left the professional development workshop. As noted in the professional development literature (Fullan & Stiegelbauer, 1991), "one-shot" professional development does not work. Teachers need to be supported when they return to their classrooms. When this support can be grounded in TPACK, teachers' confidence of actually using what was taught in the professional development may increase. Thus, as instructional designers, grounding the development of online learning environments and the professional development in TPACK, we may be moving in the direction of a sound combination for longitudinal success.

Advancing TPACK: A Dynamic Concept Informed by Context and Knowledge Use

The TPACK framework is a static framework that focuses on the domains of knowledge that teachers possess. Albeit useful and applicable to teacher education, we discovered that this framework has three limitations. First, when a teacher is in the classroom, actively working to engage students and draw them into a lesson, the knowledge that s/he *possesses* is less important than the knowledge s/he *uses*. The knowledge that a teacher uses is obviously *derived* from the knowledge that s/he possesses, but knowledge possession and knowledge use may not

necessarily correlate. Imagine, for example, a special education teacher being given a second grade classroom to teach. Even though the teacher may have a breadth of knowledge on pedagogies used within special education, a number of those teaching strategies may not be applicable to the mainstream classroom. What difference does it make, then, that the teacher possesses pedagogical knowledge regarding special education if s/he makes minimal use of that knowledge?

Second, the knowledge that a teacher *uses* is heavily contextual. It depends on varied factors including the specific classroom culture, student characteristics, school and district policy, and numerous other factors that can neither be predicted nor accounted for a priori. Simply put, uses of a teachers' knowledge depend on the context of a specific situation—be it a specific classroom or a specific lesson. For instance, a science teacher may not be able to use her content knowledge when faced with a gifted child who knows more about the lesson than she does. The complexities of the classroom arising due to context should be explicitly recognized in the framework. Importantly, good teaching goes beyond notions of knowledge and effectiveness—teaching should also be socially appropriate and empowering to the students (Doering & Veletsianos, 2008).

Third, teachers do not use all three of the knowledge domains equally. Depending on the context of a situation and the various levels of knowledge a teacher has, certain domains of knowledge may be used more than others. For example, a teacher may rely heavily on his/her technology knowledge to deliver a lesson. We call this a technology-dominated knowledge base. Likewise, teachers can possess a pedagogy-dominated knowledge base or a content-dominated knowledge base.

In summary, to advance the TPACK framework researchers need to think of it as a dynamic concept. Specifically, context influences both teacher knowledge and practice. In turn, teacher knowledge influences practice, and practice influences which types of knowledge are used more in the classroom. Overall, the TPACK framework should be seen as an evolving and multi-faceted entity rather than a static representation of teachers' knowledge as depicted by current TPACK diagrams.

One way to represent these issues into a transformed TPACK framework is shown below. Figure 3 indicates that knowledge use can be represented by differing size circles (the diagrams indicate a teacher who encompasses a content-dominated knowledge base), while context can be viewed as a variable that engulfs the whole figure as it influences the way teachers' knowledge is *applied* and *used* in the classroom.

TPACK Makes Sense and is User-Friendly

Finally, TPACK seems to resonate and "make sense" to teachers, and therefore has promise in shaping the future of technology integration, both in research and practice. TPACK is not one of those "ivory tower" theories that academics dream

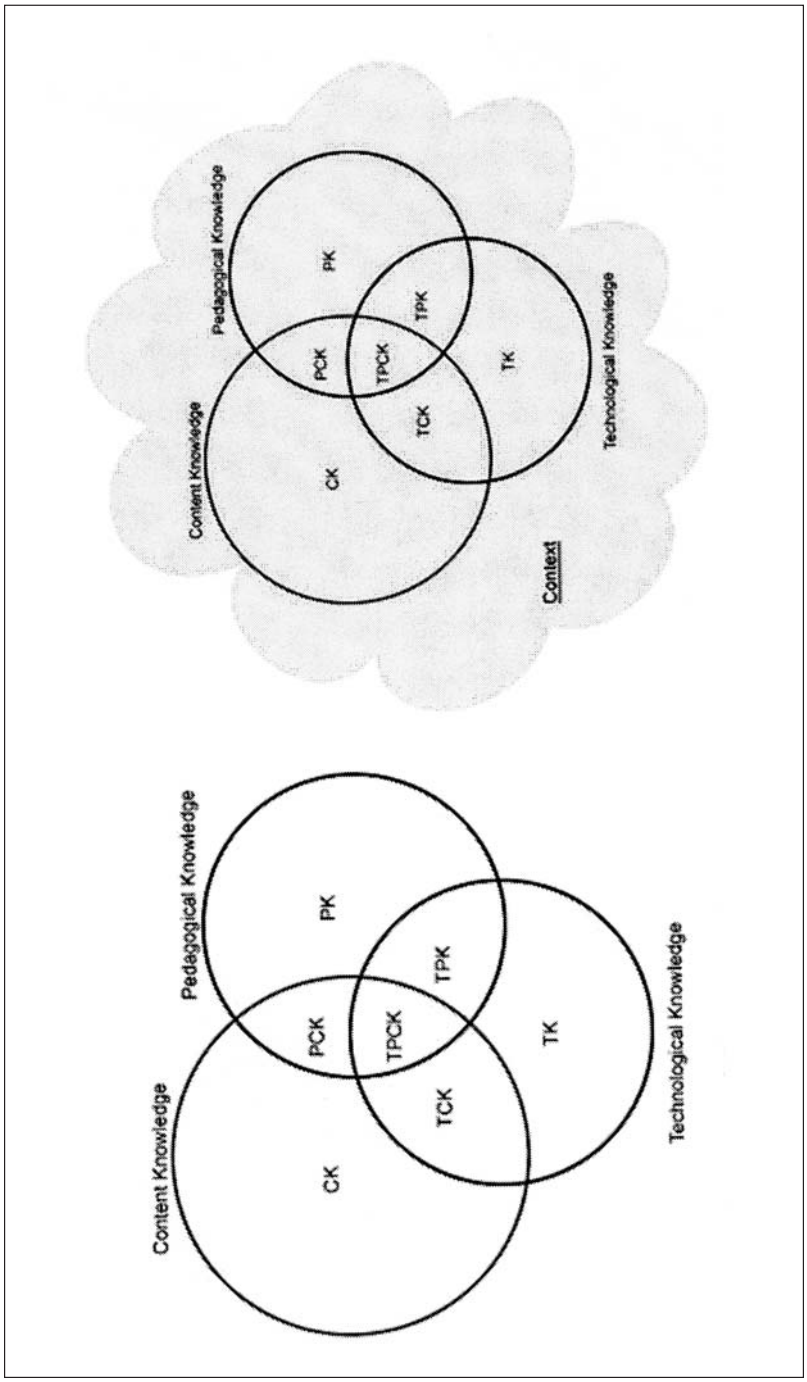


Figure 3. An updated view of TPACK.

up and then try to implement or prove in K–12 settings. As we can see with the teachers involved in this research, TPACK is user-friendly. The three domains of teacher knowledge are easily recognizable and familiar to both teachers and researchers, and incorporating them into professional development is not a difficult task. Furthermore, teachers found the TPACK framework both helpful and motivating.

However, questions remain about how to best implement a TPACK framework in a professional development setting, how to measure TPACK growth, and the impact of teachers' TPACK on student learning. More specifically, technology has been referred to as the "sleeping giant" in the field of social studies education (Martorella, 1997) and, to date, the "sleeping" potential of technology has not been realized (Bolick, Berson, Coutts, & Heinecke, 2003) with little research on technology within social studies teacher education being conducted. For instance, geospatial technologies, including Google Earth™, are technologies that have not reached their potential within the social studies. Many factors have contributed to this lack of integration ranging from the lack of pedagogical models to the lack of appropriate research designs and methodologies (Baker & Bednarz, 2003). TPACK offers the fields of geographic and social education, as well as the larger field of educational technology, a research framework for guiding teachers' knowledge assessment and development as well as actual technology integration in their classrooms. Extending and enhancing the TPACK framework, both in terms of the findings of this study and the work of colleagues, may be a way to finally realize the potential of technology in the real-world classroom.

LIMITATIONS AND CONCLUSIONS

While this research has yielded valuable insights for the expansion and improvement of the TPACK framework, it is imperative to note that our investigation should be questioned for limitations. For instance, this research relies on self-reported data regarding teachers' perception of their TPACK knowledge domains. Even though such data is valuable in drawing inferences about individuals' perceptions, it is also important to measure changes in TPACK. Future research could build on this limitation, quantitatively evaluating changes in teacher knowledge or expertise. In addition, it is possible that the results presented herein could be due to teachers' understandings of the TPC terms changing over time and being a result of the training intervention.

Finally, while we present an updated view of TPACK, further support is needed to justify a change of the established framework. For this reason, we urge others to critically question both this article and the established TPACK framework in an attempt to further improve our understanding of factors influencing the ways technology is integrated in the classroom.

APPENDIX A
Pre- and Post-program TPACK Reflections

Please assess your current knowledge domains by choosing the number that best represents where you believe you would align yourself.

1. What is your technology knowledge in the classroom?
   1 = Novice and 5 = Expert

   1 2 3 4 5

   Why do you rate yourself where you do?

2. What is your content area knowledge in the classroom?
   1 = Novice and 5 = Expert

   1 2 3 4 5

   Why do you rate yourself where you do?

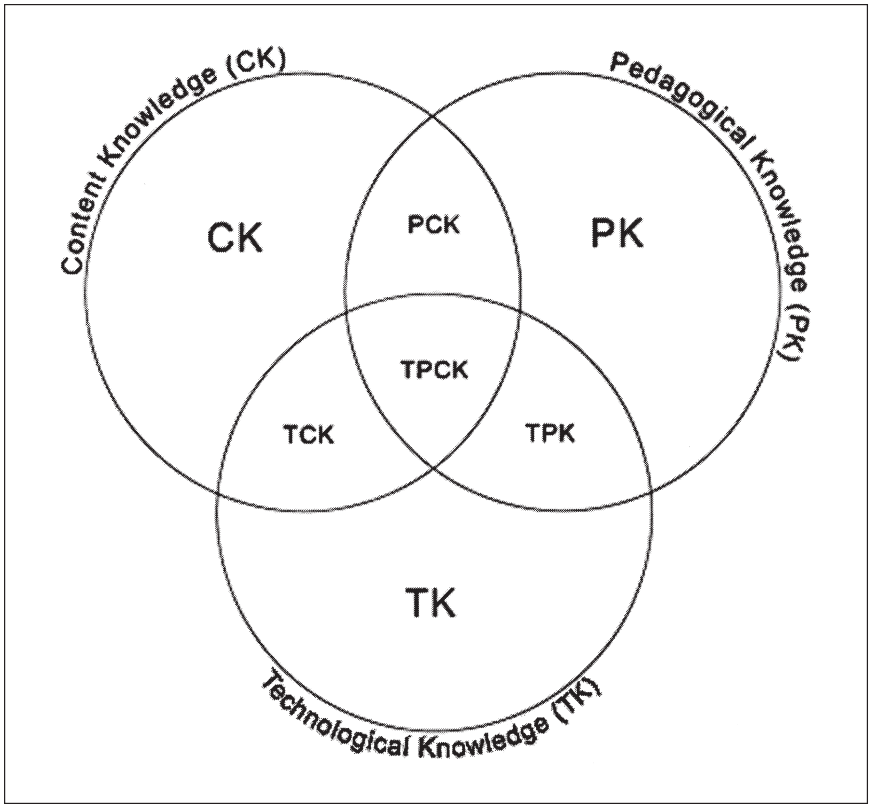
3. What is your pedagogical knowledge in the classroom?
   1 = Novice and 5 = Expert

   1 2 3 4 5

   Why do you rate yourself where you do?

APPENDIX A (Cont'd.)

Below is a graphic representing technological pedagogical content knowledge (TPCK). Using a star symbol, please note where you believe you would currently align yourself.



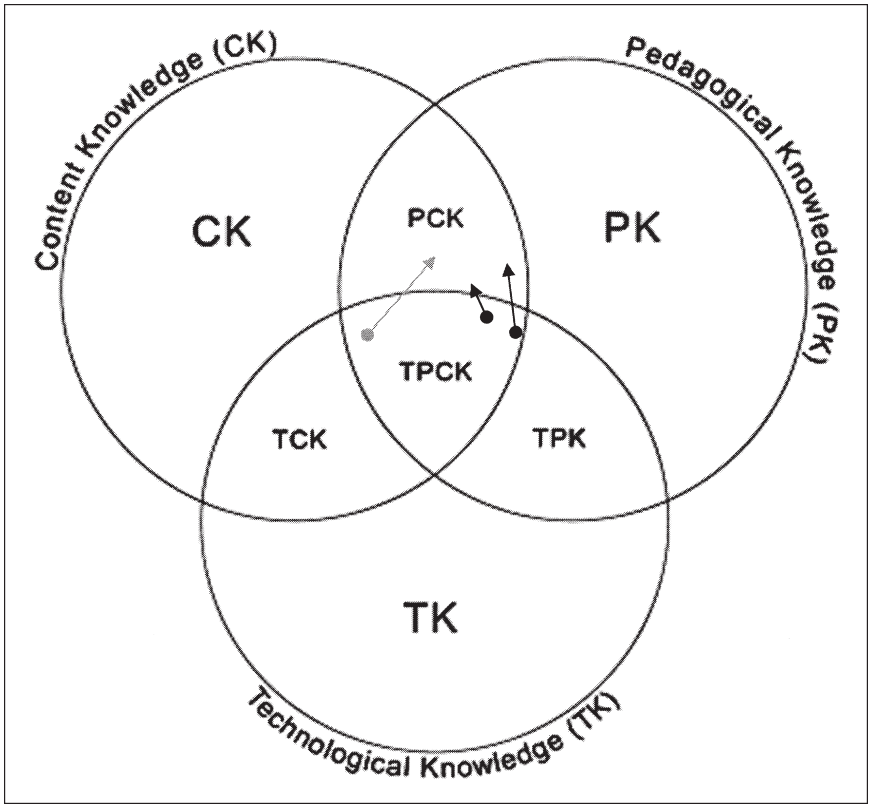
Why did you place yourself in the location you did?

APPENDIX B
Semi-structured Interview Protocol

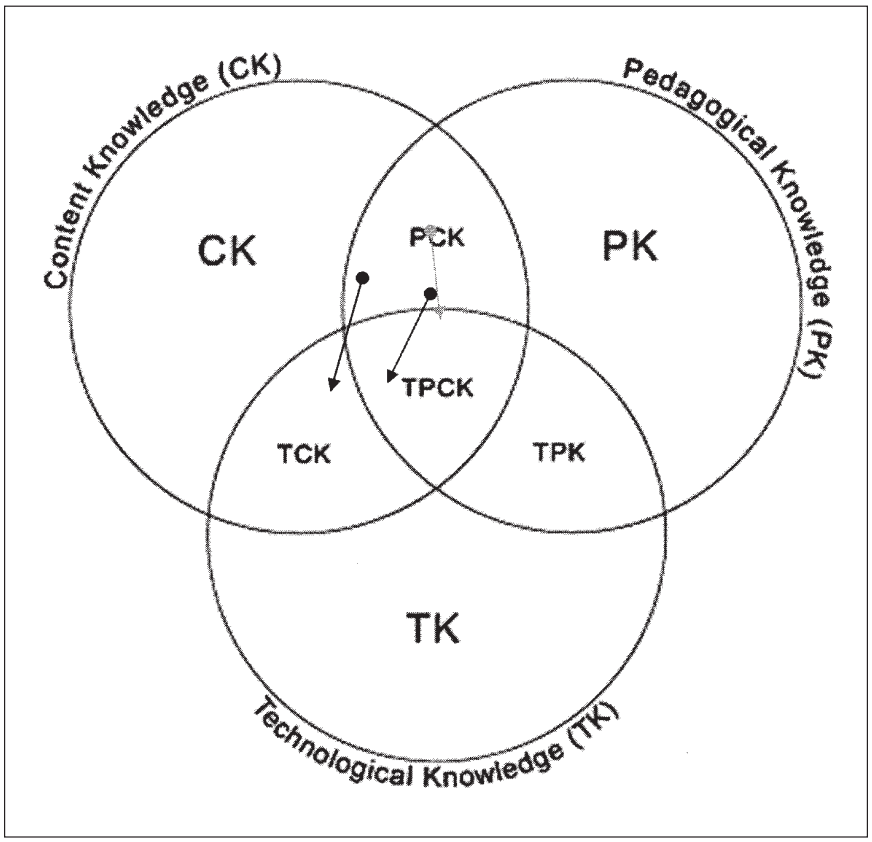
1. What did you think of the lessons?
2. What did you like about the lessons?
3. What did you dislike about the lessons?
4. What pedagogy did you believe was most successful? Why?

5. What pedagogy do you believe was least successful? Why?
6. Based on observing your students complete the lessons, what do you believe your students liked about the lessons?
7. Based on observing your students complete the lessons, what do you believe your students disliked about the lessons?
8. How feasible do you think it would be to use such a program in your classroom?
9. Do you have any ideas for improvement? What issues should we consider the next time around?

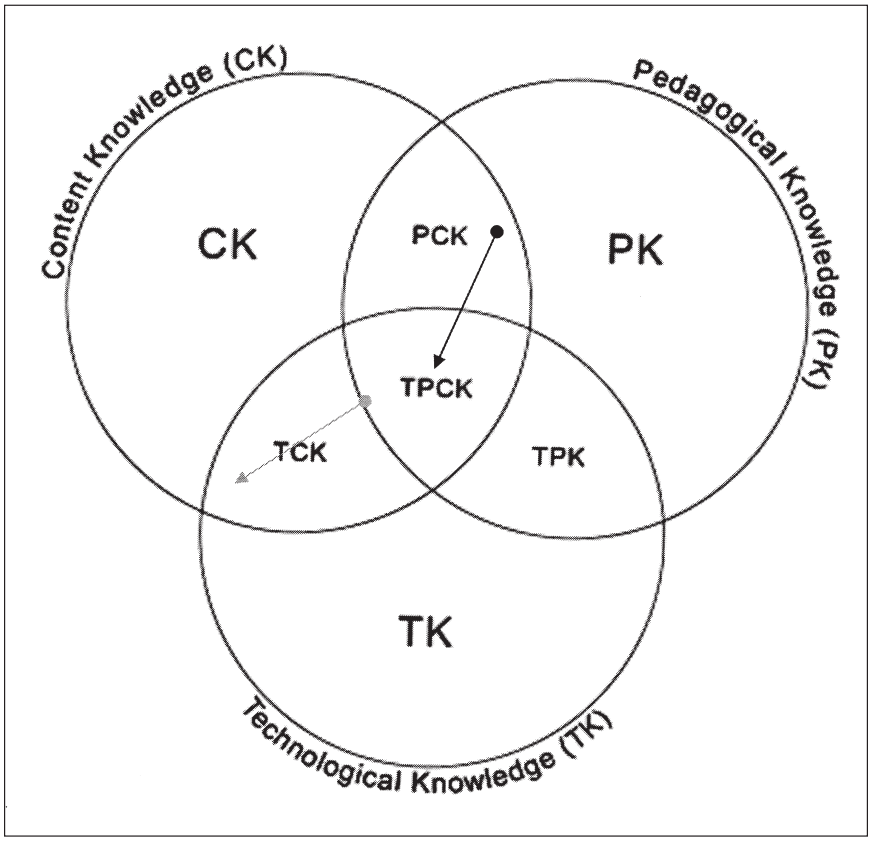
APPENDIX C
Teachers' TPACK Movement
Technological Pedagogical Content Knowledge (TPCK)



APPENDIX C (Cont'd.)



APPENDIX C (Cont'd.)



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