Changing Technological Pedagogical Content Knowledge (TPACK) through Course Experiences

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Abstract: Teachers' understanding of Technological Pedagogical Content Knowledge is critical in accomplishing successful technology integration in teaching. This study investigated how in-service teachers' beliefs about teaching and technology changed as a result of a set of educational technology summer courses, conducted both face-to-face and online. A single-group pretest-posttest design was used to examine how in-service teachers' understanding of the relationships between technology, content, and pedagogy changed over the semester. Twenty-three graduate students completed both the pre-test survey and post-test survey on teachers' knowledge of teaching and technology. The results of dependent *t*-tests on each of the twelve sub-scales suggested that students gained deeper and more complex understanding of technological pedagogical content knowledge.

Purpose

Technology integration is a complex and ill-structured problem which requires deep understanding of complicated interactions of multiple factors (Koehler, Mishra, & Yahya, 2007). In order to help teachers integrate innovative technology into their subject areas instruction and learning, we need to better understand the underlying factors that can foster technology integration. Technological Pedagogical Content Knowledge (TPACK) is a framework for understanding the specialized, multi-faceted forms of knowledge required by teachers to integrate technology in their teaching. (Koehler & Mishra, 2008; Mishra & Koehler, 2006).

The purpose of this study was to understand if in-service teachers' understanding of TPACK could be changed as a result of an intense educational technology course sequence designed to create an experience that would expose teachers to ideas and skills from educational technology in the context of theories of learning and development from educational psychology.

Teachers' knowledge, which takes a variety of content and forms, may influence their classroom practices. A number of studies have reported consistencies between teachers' knowledge and beliefs about teaching and learning and their instructional practices in the classroom (Calderhead, 1996). Research also suggests that teachers' knowledge plays an important role in determining their actions in the classroom (Hughes, 2005). Therefore, it is necessary to better understand the changing process of teachers' knowledge (Fives & Buehl, 2008).

Based on prior research on TPACK (Koehler & Mishra, 2005), we expected that students should show gains in the sub-scales of TK, TCK, TPK, and TPACK at the end of the course. Since developing content knowledge or pedagogy knowledge was not the primary goal of this course, we did not make specific hypotheses about the changes in the sub-scales of CK, PK, and PCK. We were also interested in the magnitude of changes in each sub-scale.

Theoretical Framework

Recently, considerable interest has surfaced in using TPACK (Koehler & Mishra, 2008; Mishra & Koehler, 2006) as a framework for the teacher knowledge required for effective technology integration. The TPACK framework connects technology to curriculum content and specific pedagogical approaches and describes how teachers' understandings of these three knowledge bases can interact with one another to produce effective

discipline-based teaching with educational technologies. In this framework (see Figure 1), there are three interdependent components of teachers' knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK).

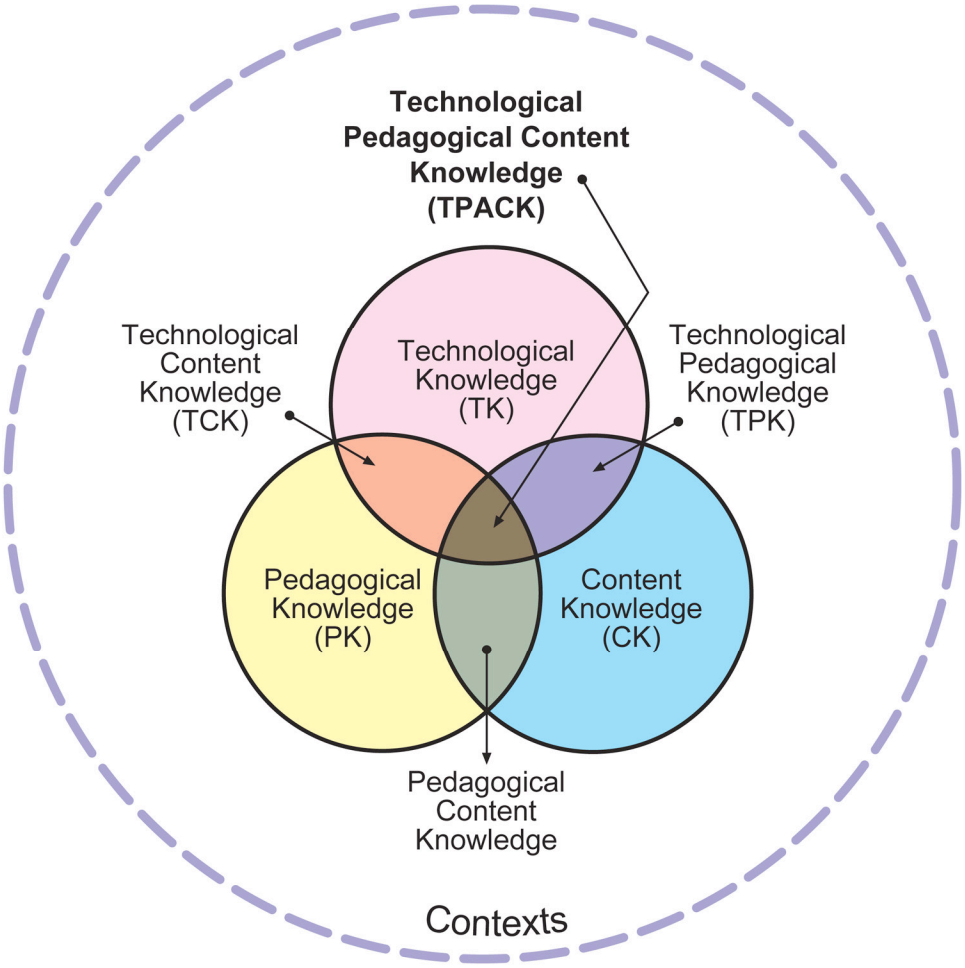

Figure 1: The Components of Technological Pedagogical Content Knowledge

Content Knowledge (CK) refers to the knowledge about the subject matter that is to be learned or taught. Mathematics, literacy, science, and social science were of particular interests in our study. Pedagogical Knowledge (PK) refers to the knowledge about the processes and practices or methods of teaching. It includes knowledge about classroom management skills, teaching strategies, evaluation techniques, and the nature of target audience. Technology Knowledge (TK) refers to the knowledge about both the standard technologies and more advanced technologies. It enables teachers to understand information technology, apply it properly, identify useful technologies, and continually adapt to changes in technology (Mishra & Koehler, 2006; Koehler & Mishra, 2008).

Equally important within this framework are the interactions among these bodies of knowledge represented as Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). In the following sections we will explore each of these components, with particular emphasis upon the intersections among the three primary components (Koehler & Mishra, 2005).

Pedagogical Content Knowledge (PCK) derives from Shulman's idea of knowledge of pedagogy that is applicable to the teaching of specific content (Shulman, 1986). PCK is the knowledge about what teaching approaches fit the content and how elements of the content can be arranged for better teaching. The model of PCK emphasizes the importance of teachers' knowing about the learning of their students and the learning environment (Cochran, DeRuiter, & King, 1993; Fives & Buehl, 2008). Technological Content Knowledge (TCK) refers to the

knowledge about the manner in which technology and content influence and constrain one another. The use of different technologies can impact students' learning differently. Technological Pedagogical Knowledge (TPK) refers to the knowledge about how teaching and learning change when particular technologies are used. Teachers need to be equipped with knowledge about various technologies and be able to use them as pedagogical strategies in their classrooms. Finally, **Technological Pedagogical Content Knowledge** (TPACK) refers to the knowledge that emerges from an understanding of an interaction of content, pedagogy, and technology knowledge. Quality teaching requires developing a nuanced understanding of the complex interplays between three key sources of knowledge: technology, pedagogy, and content and how they play out in specific contexts (Mishra & Koehler, 2006; Koehler & Mishra, 2008).

Although this framework has helped researchers and practitioners to reason about the relationships between content, pedagogy, and technology, researchers have noted the need to develop: reliable measures for each of the components of TPACK framework, agreement about what approaches do (or do not) change teacher' knowledge, and a sensitivity to the contexts in which these approaches work (or do not work).

Koehler and Mishra (2005) investigated the changes in students' perception about Technological Pedagogical Content Knowledge using a short survey measure. Our study was in the same vein as the previous study in the sense that we shared similar research questions (e.g., changes in beliefs), research methods (e.g., pre and post-test comparison), and the TPACK theoretical framework. That said, this study extended the work in Koehler and Mishra (2005) which was focused on a specific course, by using a robust survey tool which measured teachers' TPACK across multiple contexts.

Method

Design

An one-group pretest-posttest design (Campbell & Stanley, 1963) was used to examine how teachers understood the relationships between technology, content, and pedagogy. It was hypothesized that students would report more integrative understanding of technology and its relationship to teaching and content.

Procedure

A pre-test survey, which measured students' initial understanding about the relationships between technology, content, and pedagogy was administered online during the first week of a target course. An identical online survey was given out to the students during the final week of the course.

Participants

The survey was administered to students in a summer program specifically dealing with technology integration in teaching. Twenty-three students enrolled in an hybrid set of educational technology master's level courses, completed the pre-test survey and 17 students completed the post-test survey. The majority of students were females (91%). These participants were mostly in-service teachers with several years of teaching experiences.

These three courses were covered as an integrated seminar over a period of six weeks — two weeks face-to-face and four weeks online. For the first two weeks students met on campus every day from 9:00 AM to 4:00 PM. The following four weeks were conducted online, with the students working on projects and assignments. Participants worked on a range of assignments that required them to learn and use technology in multiple pedagogical contexts. These assignments included developing digital video to explore student understanding of particular topics, writing a technology based grant proposal for transformative learning, developing a wiki on key topics in educational technology, and exploring web 2.0 technologies and designing a personal web portfolio.

Measures

A Survey of Teachers' Knowledge of Teaching and Technology (Schmidt *et al*., 2009) was used in this study. The survey contained 5 demographic questions and 54 self-report items that measured students' beliefs about teaching and technology. The self-report items used a five point Likert scale to rate the extent to which participants

agreed or disagreed with statements about their beliefs on the relationships between technology and teaching. Some of the items had to be revised and rewritten since the original survey was specifically developed for the K-6 pre-service teachers. The survey contained twelve sub-scales because the CK, PK, and TPK scales consisted of multiple sub factors. Each sub-scale included questions that were content specific (e.g., I can teach lessons that appropriately combine science, technologies and teaching approaches) and/or content general (e.g., I can choose technologies that enhance the content for a lesson). The completed survey is presented in the Appendix.

Data Analysis

Dependent (matched-pair means) *t*-tests were used to analyze the pre and post test differences for each of the twelve sub-scales. For the pre and post test differences in each sub-scale, *t*-statistics, *p*-values and Cohen's *d* measures were reported.

Results

Prior to the dependent *t*-tests we checked the reliability for each sub-scale using the pre-test data. Cronbach's alpha coefficients for each sub-scale ranged from .40 to .98.

Sub-Scale		Pre-Test: Mean (SD.)	Post-Test: Mean (SD.)	Matched-Pair *t* (*df* = 16)	*p*-Value	Cohen's *d*
TK	(7 items)	.71 (.12)	.80 (.08)	3.73	.002**	.85
CK	Social Studies (3 items)	.68 (.19)	.78 (.15)	1.73	.100	.31
	Math (3 items)	.75 (.18)	.81 (.15)	2.09	.053	.36
	Science (3 items)	.73 (.16)	.78 (.15)	1.56	.137	.33
	Literacy (3 items)	.73 (.15)	.81 (.09)	2.49	.024*	.63
PK	(7 items)	.81 (.09)	.84 (.08)	1.32	.206	.31
PCK	Pedagogy Change (4 items)	.77 (.19)	.43 (.19)	4.42	<.001***	1.18
	Pedagogy Selection (4 items)	.69 (.12)	.74 (.12)	1.83	.086	.47
TCK	(4 items)	.66 (.13)	.74 (.12)	2.16	.046*	.63
TPK	Technology Impact (4 items)	.78 (.09)	.84 (.10)	2.16	.046*	.66
	Technology Use (4 items)	.78 (.11)	.83 (.08)	1.88	.079	.53
TPACK	(8 items)	.72 (.12)	.80 (.08)	2.98	.009**	.81

*:$p<.05$; **$p<.01$; ***$p<.001$

Table 1: Summary Statistics for the Survey of Teachers' Beliefs in Technology and Teaching

The results of paired *t*-tests suggested that students' knowledge about technology improved as a result of the course while their knowledge about content and pedagogy did not improve in general. These results also showed that students' understanding of the relationships between technology and content (TCK), the relationship between technology and pedagogy (TPK), and the relationship between technology, pedagogy and content (TPACK), all improved over time. Surprisingly, students' knowledge about the interaction between pedagogy and content (PCK) changed too.

Given that the course was an educational technology course with an emphasis on practical applications of technology, this finding was encouraging. Not only did understanding of technology change as hoped, but teachers enrolled in the course gained a deeper understanding of how technology related to other aspects of teaching (mainly, content and pedagogy). Moreover, except for PCK, there was no change on those topics that the course did not address.

Implications

Although our findings relied on data yielded from a self-report survey, several important implications for both research and practice were found. First, we employed quantitative research methods to examine the changes in students' understanding about teaching and technology. While several qualitative studies have been conducted to explore students' understanding of complex interaction between technology and teaching, few studies have used validated quantitative measures (Koehler & Mishra, 2005). For further research triangulated methods (e.g., classroom observation, interview) should be employed to examine the changes in in-service teachers' instructional practices. Second, this study showed that questionnaires could serve as an assessment tool to reliably assess components of the TPACK framework within the context of teacher preparation courses. Third, from a practical standpoint, the findings from our study could provide valuable insight into the development of students' TPACK.

We realize the limitation of using the survey method in exploring the relation between the changes in teachers' knowledge and the improvement in their teacher practices. It is our belief, however, that the changes in teachers' knowledge can lead to the changes in their classroom practices and that these changes can be reliably measured by the TPACK survey. This study demonstrates that it is possible to design suitable course experiences to address, and develop, students understanding of the knowledge components suggested by the TPACK framework. Instructors of educational technology courses can, and should, create innovative courses that can offer authentic opportunities for integrating technology in real teaching.

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Appendix A

A Survey of Teachers' Knowledge of Teaching and Technology

TK (Technology Knowledge)
I know about a lot of different technologies.
I have the technical skills I need to use technology.
I keep up with important new technologies.
I know how to solve my own technical problems.
I can learn technology easily.
I frequently play around the technology.
I have had sufficient opportunities to work with different technologies.

CK (Content Knowledge)
I can use a mathematical way of thinking.
I can use a literary way of thinking.
I can use a scientific way of thinking.
I can use a historical way of thinking.
I have various ways and strategies of developing my understanding of mathematics.
I have various ways and strategies of developing my understanding of literacy.
I have various ways and strategies of developing my understanding of science.
I have various ways and strategies of developing my understanding of social studies.
I have sufficient knowledge about mathematics.
I have sufficient knowledge about literacy.
I have sufficient knowledge about science.
I have sufficient knowledge about social studies.
I know about various examples of how mathematics applies in the real world.
I know about various examples of how literacy applies in the real world.
I know about various examples of how science applies in the real world.
I know about various examples of how social studies applies in the real world.

PK (Pedagogical Knowledge)
I can use a wide range of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.).
I can adopt my teaching style to different learners.
I know how to assess student performance in a classroom.
I am familiar with common student understandings and misconceptions.
I can assess student learning in multiple ways.
I can adopt my teaching based-upon what students currently understand or do not understand.
I know how to organize and maintain classroom management.

PCK (Pedagogical Content Knowledge)
I know that different mathematical concepts do not require different teaching approaches.
I know that different literacy concepts do not require different teaching approaches.
I know that different science concepts do not require different teaching approaches.
I know that different social studies concepts do not require different teaching approaches.
I know how to select effective teaching approaches to guide student thinking and learning in mathematics.
I know how to select effective teaching approaches to guide student thinking and learning in literacy.
I know how to select effective teaching approaches to guide student thinking and learning in science.
I know how to select effective teaching approaches to guide student thinking and learning in social studies.

TCK (Technological Content Knowledge)
I know about technologies that I can use for understanding and doing mathematics.
I know about technologies that I can use for understanding and doing literacy.
I know about technologies that I can use for understanding and doing science.
I know about technologies that I can use for understanding and doing social studies.

TPK (Technological Pedagogical Knowledge)
I have the technical skills I need to use technology appropriately in teaching.
I can adapt the use of the technologies that I am learning about to different teaching activities.
I am thinking critically about how to use technology in my classroom.
I have the classroom management skills I need to use technology appropriately in teaching.
My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
I can choose technologies that enhance the teaching approaches for a lesson.
I can choose technologies that enhance students' learning for a lesson.

TPACK (Technology Pedagogy and Content Knowledge)
I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.
I can teach lessons that appropriately combine literacy, technologies and teaching approaches.
I can teach lessons that appropriately combine science, technologies and teaching approaches.
I can teach lessons that appropriately combine social studies, technologies and teaching approaches.
I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.
I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.
I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.
I can choose technologies that enhance the content for a lesson.