

# **Developing Teachers' Technological, Pedagogical, and Content Knowledge in Mathematics**

## **Abstract**

Technological pedagogical and content knowledge (TPACK) has been adopted as a framework to help describe the various components of knowledge that are associated with teachers' effective integration of technology. This study describes the influence of an inservice professional development program on teachers' TPACK related to their mathematics teaching. Two participants were interviewed and observed teaching mathematics on days they reported using technology in their teaching. Inductive qualitative analysis was conducted to identify themes for each teacher, and across teachers. In both cases the professional development increased participants' technological knowledge (TK) and their use of technology in their classroom. However, participants' used technology in ways that focused on basic knowledge and did not facilitate higher-order thinking skills.

## **Background Information**

### **TPACK: Overview and Implications**

Neiss (2005) argued that in order for teachers to effectively use technology in their teaching, they must develop a pedagogical content knowledge (PCK) related to technology, in essence technological pedagogical content knowledge. Mishra and Koehler (2006) conceptualized the framework as a three-circle Venn Diagram citing that technology, pedagogy and content each have their separate areas, but also interact with one another in pairs, and also in the center area which represents the intersection of knowledge of technology, pedagogy and content. Effective professional development programs supporting technology integration must address knowledge related to technology, pedagogy and content and each of the intersections.

### **Research Study**

The study aims to examine teachers' development of TPACK while participating in a professional development program related to technology integration. The study was designed to address two research questions:

- 1) What influence do mathematics teachers report about the influence of professional development on their TPACK related to their mathematics teaching?
- 2) In what ways do teachers enact TPACK in their mathematics teaching?

### **Context of Professional Development**

The professional development included 30 hours of workshops over 5 days. The activities addressed technologies and pedagogies associated with technology-rich instruction. The first three days introduced teachers to specific technologies, such as podcasting, digital storytelling, interactive whiteboards, educational games and Web 2.0 tools. During the last two days, teachers were able to receive individual or small group assistance using any of the technologies they wanted to learn more about. On the last day teachers spent six hours collaboratively planning technology-rich lessons and units with their colleagues.

The professional development project provided teachers with their own laptop, a projector and an interactive whiteboard for their classroom. Also, each school received money to purchase other software and technologies to meet the specific needs of their teachers. Both Sarah and Ellen's schools purchased video cameras, document cameras and interactive assessment tool to use in their classroom.

Participants took part in a week-long professional development project designed to support the integration of technology across content areas. Ellen, an eighth grade mathematics teacher, attended 30 hours of workshops. Susan, a fifth grade teacher, attended 30 hour of workshops for lead teachers, and then facilitated workshops for colleagues during three weeks of the summer workshops. As part of the professional development each teacher received a laptop computer, an LCD projector and an interactive whiteboard in their classroom.

### **Participants**

Two participants took part in this study; Sarah, a fifth grade teacher, and Ellen, an eighth grade teacher. Both teachers participated in at least 30 hours of a summer professional development program designed to support their use of technologies in their teaching. These participants were purposefully selected because they self-reported consistent technology use in their math classes. A case study design was used to examine each teacher individually. In this instance, each individual teacher represents a case.

Sarah has taught for six years. She taught fourth grade for four years before moving to fifth grade. Sarah teaches all subjects, but in the past two years taught only mathematics and science. Sarah was part of the technology

leadership team. She attended a week of workshops at the beginning of the summer and then supported teachers during the four weeks of workshops by facilitating sessions. Prior to the study, Sarah had been using an interactive whiteboard in her classroom on a daily basis for two years. She reported that the whiteboard supported her presentation of information and was not very interactive, in terms of student use. Ellen has taught for six years. She has taught eighth grade math her entire career. This year she is teaching only Algebra I to eighth grade students and freshmen at the local high school. Ellen participated in 30 hours of workshops over five days during the summer. Prior to the study had been using the graphing calculator frequently with her students. She reported that calculator use was largely modeling and guided with students only working independently after she had given ample guidance and step-by-step instructions.

### **Data Sources**

Both participants participated in an interview that lasted approximately 20 minutes and were observed twice while teaching mathematics. These data sources were selected in order to address the research questions.

**Interview.** The interview occurred within the first month of the school year for both participants. The protocol was semi-structured and focused on participants' report on their previous uses of technology, what they learned during the professional development and how they planned to apply their new knowledge into their classrooms. Both participants were asked the same general questions. Follow-up questions were posed based on the teachers' responses. Both interviews lasted approximately 20 minutes in length.

**Observations of mathematics teaching.** Each participant was observed twice during the first two months of the study. The classroom observations were announced and occurred on days that participants reported that they were integrating technology into their teaching. The purpose of the observations was to collect data when participants felt they were doing their "best" work at teaching mathematics with technology. Observations for each participant occurred within the same week in order to get a thorough picture of technology use, as opposed to establishing growth over time.

During the observations, the first author served as an onlooker and took field notes with a focus on three aspects of the lesson: tasks that the teacher posed, teachers' use of the technology and students' use of the technology. The first author also had a copy of the ISTE Classroom Observation Tool (<http://icot.craftyspace.com/>) with him. The instrument was completed immediately after the lesson was completed.

### **Data Analysis**

Data analysis was conducted using an interpretivist lens. Interpretivism (Bogden & Biklen, 1992) assumes that individuals form their own understanding of contexts and events based on the experiences that they participate in. To this end, data from the interviews were used to address participants' perception of what they learned during professional development, what they needed to better teach mathematics with technology, and their interpretation of how well they were using technology. Data from the observations served as objective evidence of participants' use of technology during their teaching.

The first author coded the interview data by interview question (Bogden & Biklen, 1992). For example, for the first interview question about how teachers used technology last year, a response such as "for note taking and to model problem solving strategies" would have a primary code of technology use last year, but also be coded as modeling and problem solving as secondary codes. Codes were organized and grouped by interview question first for each participant. Then they were organized across research questions in order to find commonly occurring codes that each participant had mentioned repeatedly. After the interview data was organized, themes were generated. The data was then rechecked to verify all of the themes.

To address the second research question, the field notes and data from the Classroom Observation Tool from the classroom observations were coded using the Lens of Enacted Practices. The Lens of Enacted Practices is derived from research studies that have analyzed teachers' instructional practices based on the level of implementation (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Hufferd-Ackles, Fuson, & Sherin, 2004; Schifter & Fosnot, 1993; Thompson, 2005). The lens is a refined version of an instrument used in previous research (Author 1, 2006). The lens provides a quantitative framework about teachers' instructional practices that can be elaborated on with the qualitative data from the field notes.

### **Findings**

Findings have been condensed to fit the page limits of this proposal. Through the first round of data analysis the following themes have emerged:

Findings	Components of TPACK
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Both participants are using new technologies in their classroom and their mathematics instruction	Technological Pedagogical Knowledge (TPK), TPACK
Both participants use technology to facilitate presentation of information and class discussions.	TPK, TPACK
Both participants do not	
Sarah has embraced a more learner-centered classroom while Ellen maintains a more didactic classroom environment in mathematics	PCK, TPACK
Students are engaged during the mathematics lessons when technology is used	TPACK
Students are working on low-level mathematical tasks	PCK

#### Discussion

In the final paper, the findings will be elaborated on, in addition to implications concerning developing teachers' TPACK through professional development experiences.

#### Works Cited

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