INFLUENCES ON EARLY-CAREER MATHEMATICS' TEACHERS VISION OF TEACHING WITH TECHNOLOGY: A LONGITUDINAL STUDY

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This paper reports on a longitudinal study of mathematics teachers' development of a vision of teaching with technology where we document professional events and activities that point to continued evolution and devolution of those beliefs. We extend earlier work and ask participants to reflect on the experiences they have had as early career teachers, and how they have influenced their beliefs since graduation. We find that there are significant opportunities for professional learning after graduation, and recommend continued development of graduate-level coursework that is technology-dependent. We also find that the use of Desmos is particularly influential in changing beliefs about the role of technology.

Keywords: Instructional Vision; Technology; Teacher Beliefs; High School Education;

Background

Preservice secondary mathematics teachers (PSMTs) at Miami University take a required mathematics course, where they revisit their own learning of secondary mathematics and investigate concepts by way of problem solving with various technological tools. In previous work, we sought to understand the impact of this course on future teaching practices. We defined *vision of teaching with technology* as an imagined state wherein PSMTs are able to translate their technological beliefs into principles on which they will base future instructional decisions and practice (Cox & Harper, 2016). We found that as a result of participation in this course, PSMTs develop a vision of teaching with technology that is better aligned with that expressed in modern policy documents (e.g., NCTM, 2000, 2014, 2016). We also found that PSMTs draw heavily on their index of personal experiences to illustrate their visions and that descriptions of curricular experiences were central of what PSMTs referred to as "responsible use of technology" (Cox & Harper, 2016).

Drawing on the work of Phillip (2007) and Ertmer (2006), and Pajares (1992), we have delineated technological beliefs as separate from general pedagogical beliefs (Cox & Harper, 2016). We define teachers' technological beliefs as understandings, premises or propositions about the role(s) technology plays in instruction. Thus, when we refer to technological beliefs, we mean those beliefs concerning the role technology plays in mathematics instruction.

We know that inservice teachers seem more likely than PSMTs to perceive the cognitive benefits of technology beyond motivation and fun. Some teachers recognize its power to visualize difficult concepts or meet the needs of diverse learners (e.g., Wachira, Keengwe, & Onchwari, 2008), and inservice teachers seem more likely than PSMTs to believe technology has value beyond a computational device or answer checker (e.g., Wachira & Keengwe, 2011).

Kagan (1992) noted that if a teacher education or professional development program is to be successful at promoting belief change among teachers, "it must require them to make their preexisting personal beliefs explicit; it must challenge the adequacy of those beliefs; and it must give novices extended opportunities to examine, elaborate, and integrate new information into their existing belief systems" (p.77).

After making the PSMTs' preexisting personal beliefs explicit in their vision of teaching with technology, we wanted to examine and document key professional events and activities that point to both continued evolution and devolution of their technology beliefs. This paper reports on a

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longitudinal study of a mathematics teachers' development of a vision of teaching with technology. Since beliefs and practice are dialectic (Thompson, 1992), it is likely that an individual's vision has been impacted by their teaching and other experiences. Moreover, given the importance of indexing personal experiences when articulating a vision, we wanted to document professional events and activities that point to continued evolution and devolution of mathematics teachers' vision of teaching with technology. We sought to answer the research question, what seminal teaching experiences impact an individual's vision of teaching with technology?

Methodology

Participants in this study are recent graduates (2013-2017) of Miami University who have been teaching secondary (6-12) mathematics for at least two years. Supported by our alumni office and social media connections, we identified a pool of 80 possible alumni. Within that pool, 44 had participated in an earlier phase of this research (Cox & Harper, 2016). Those for whom we had collected earlier writing samples documenting their vision of teaching with technology were sent the *Teaching with Technology–Longitudinal* online survey. The Longitudinal survey was sent to 44 individuals, of which 9 responded (response rate of 20.5%). One of the nine responded that they were not currently teaching mathematics. The remainder of the pool (n=36) were sent the *Teaching with Technology* online survey. Of the 36, thirteen responded (response rate of 36%), all of whom reported that they are currently teaching mathematics.

In the first part of both surveys, we invited participants to narrate their experiences with teaching mathematics with technology. Rather than ask for the titles of specific courses that they recently taught, we asked them to imagine a recent course and then identify the mathematics taught within that course by broad discipline. For instance, a participant might report teaching a course that is 75% algebra, 10% statistics, and 15% trigonometry. Then, they are asked to report the types of technology they used. We chose not to list specific brands of technology, and instead asked for the technology genre. For instance, we asked about Dynamic Geometry Software (DGS), rather than specifying GeoGebra or Desmos.

The *Teaching with Technology–Longitudinal* and the *Teaching with Technology* surveys were conducted digitally using Qualtrix software. Both versions of the survey include two lines of inquiry. First, we asked participants to describe their beliefs about the role technology plays in mathematics teaching. Participants in previous phases of research were familiar with this question having answered something similar at the conclusion of a required mathematics technology course in their undergraduate program. In those cases, we phrased the questions on the survey differently. We provided them with their original *vision of teaching with technology* statements written at the conclusion of the mathematics technology course, and invited them to identify passages that still represent their thinking, as well as passages about which they now think differently. Second, we asked participants to identify experiences such as graduate study, professional development, or classroom episodes; as well as the impact (or lack thereof) the experiences have had on their developing vision of teaching with technology.

Results

We hypothesized that there could be many potential influences on teachers' vision for teaching with technology once they left their teacher preparation program. We chose to focus our questions on three: graduate education, professional development workshops and colleagues. Due to space restrictions, we will expand on only one of these, professional development. Then, we will take a longitudinal look at how these teachers' beliefs have evolved.

Professional Development

Of the 21 participants, fifteen did not report having participated in any professional development (PD) workshops related to the teaching of 6-12 mathematics with technology. Here, we focus on the six who did. Of those six, five were specific about the focus of the PD. Four of the six experienced math-specific professional development. This took two forms. Some of the math-specific technology PD described took the form of individual or department-based PD focused exclusively on Desmos. Other teachers experienced PD at state conferences where they attended sessions about incorporating technology into their classroom planning and teaching. One commented about the benefit of conference-based PD, "I was able to gain insight about other teachers' experiences with new technology and collaborate with other math teachers to learn more about the availability and access of technology for students in other districts."

In addition to math-specific PD, two teachers received other technology-focused PD, but reported that it was oriented toward classroom management or non-mathematical applications such as Kahoot, Google Classroom, or other apps.

Additionally, we asked participants to tell us whether this activity influenced their vision of teaching with technology, or impact how they incorporated technology into their teaching. All felt that they had felt influenced, however the way that they described the influence was different for those experiencing math-specific and non-math-specific professional development. For those who reported non-math specific PD, the influences they expressed were more oriented toward pedagogical shifts in assessment, differentiation, and project-based learning. Those who experienced math-specific PD reported that they now incorporated specific technologies into lesson planning and teaching. These teachers were better at generating content using GeoGebra and Desmos, and felt more confident about how to incorporate it more regularly in their teaching. In all cases, the influences were most often described as improved technical knowledge and in no cases did the descriptions indicate a change in TPCK (Mishra & Koehler, 2006).

A Longitudinal Look

We now narrow our view to just those eight participants who were a part of our earlier study, where they wrote statements about their vision of teaching with technology. For these eight participants, we have additional data wherein they respond to these statements from their current perspective. We chose to categorize these responses as either *renunciations* or *amplifications* of their earlier beliefs. We asked participants to identify up to six passages in their original sample and describe why they either continued or stopped believing something specific and related to teaching mathematics with technology. Not all participants chose to either renounce or amplify a passage, and some teachers chose more than one passage to address.

Renunciation. Three participants identified portions of their previous writing that they wanted to renounce. All three participants no longer believed that students would use technology as a distractor or to "goof off" during class, and came to see it as more valuable than before. "As a teacher I have found that sometimes this free exploration with technology allows for students to make deep connections and allows for them to think freely and oftentimes more critically." One participant went further and renounced their earlier beliefs about technology as indiscriminately good. They wanted to make a more clear distinction between those technologies that simply make teaching easier and those that impact mathematical learning.

Amplification. There were seven times that participants identified portions of their previous writing to amplify. From these passages, we find that early career experiences serve to amplify the need to incorporate digital technologies into education in general. Participants still believe that the educational needs of students change over time and reflects the increased presence of digital technologies in the workforce. As one participant noted, "this passage resonates with me, because I

know that I am in a profession where I will have to be continually changing the way I teach. ...our job is to prepare them, and technology allows us teachers to give our students more appropriate learning experiences.

There were two participants who chose to amplify statements that were more specific to mathematics instruction. The first of these focused on the potential of technology to go beyond the application of learned procedure and address the fundamental "why" behind the algorithms. The other participant amplified the role of technology in helping students be more reflective learners of algebra when they use technology to get quick and early feedback.

Discussion

Looking across the three spheres of influence: Additional Coursework, Professional Development and Colleagues, it is clear to us that early career teachers continue to have opportunities to learn about technology for teaching. With more than half pursuing graduate degrees, it would be a good idea to continue to develop graduate-level content courses that incorporate technology for teaching mathematics. Similarly, it is clear that mathematics-specific professional development can influence teachers to utilize new technologies in lesson planning and instruction. Developing stand-alone experiences that can be enacted during department meetings or building-wide PD time might be another way to influence teacher beliefs about the role of technology in mathematics instruction.

Based on specific responses, we recommend incorporating Desmos into professional experiences for early-career teachers. Whether in graduate classes, PD, or in conversations with colleagues, participants are talking about and learning about Desmos. Needing to learn about a technology that students will be using on standardized assessments seemed to be a strong motivator for individual learning, but also district-wide professional development planning. Further, when Desmos is used in graduate-level mathematics curriculum, teachers find that exposure useful and influential.

Conclusion

Our original findings indicated that our mathematics problem solving with technology course had a short-term impact on preservice teacher beliefs about teaching mathematics with technology. This study documents not only the longevity of that belief change, but also the identification of significant experiences in the lives of new teachers that either act to amplify or disrupt those changes over time. This study also positions new teachers as *people from whom we can learn*. We feel that studies that position mathematics teachers as knowledgeable professionals are especially needed at a time where teachers are often deprofessionalized and undervalued.

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