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Technology Use of Mathematics Teachers at Urban Schools

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Technology is a fundamental tool for teaching and learning mathematics. It is a key enabler of continuous, lifelong learning, serving as a gateway to directly accessing knowledge and fostering learning. The purpose of this paper is to explore the extent to which teachers use emerging technologies and whether their habits of using technology change after a professional development with a technology focus. Authors of this paper surveyed urban school mathematics teachers about use of software and hardware technology for three major purposes: planning, instruction, and student assessment. The results showed that even though teachers believed the technology was important and helpful in fulfilling teaching responsibilities, their use of these tools were limited but could be increased through professional development.

Overview

Technology has been so intertwined with human life and is now an integral part to it. As a result, it should also become even more eminent and widespread than ever in mathematics classrooms. Emerging technologies in schools have the potential to transform learning and teaching of school mathematics. This change, of course, will have implications for teachers: the expectation is that mathematics teachers' everyday teaching practices should change in a way that integrates technology into mathematics instruction. The purpose of this paper is to explore the extent to which teachers use emerging technologies and to investigate whether their habits of using technology change after a professional development program with a focus on appropriate technology use.

Authors of this paper surveyed teachers to learn about their daily routines in using technology for teaching mathematics. The survey asked about use of software and hardware technology for three major purposes: planning, instruction, and student assessment. Both software (e.g., social networks, mathematics applications, and online collaborative tools) and hardware technology (e.g., document camera, interactive white board, and calculators) are two distinct types of technology the survey addressed in this study. Results showed that mathematics teachers' levels of software or hardware technology use at urban schools were considerably low before a technology-focused professional development program. The program increased the frequency of teachers' technology use in the classrooms months after the program but were still not at an expected level although they reported very positive beliefs about technology. These findings are interesting and have implications for school and district policies and teacher development programs.

Theoretical background

Technology has naturally become a fundamental tool for teaching and learning mathematics (NCTM, 2008). It is a key enabler of continuous and lifelong learning, serving as a gateway to

directly accessing knowledge and fostering learning (U.S. Department of Education, 2010; Domine, 2009). Therefore, with the understanding of how powerful of a tool technology is in enhancing mathematics education, schools and teachers must not only acknowledge the importance of these technologies but they must ensure that **all** students, regardless of their background, academic performance and other demographic and geographic factors, have equitable access to such technologies to move toward justice and beyond in education.

Research shows that teachers and students have narrow knowledge of using appropriate technologies in teaching and learning mathematics (e.g., Niess, 2006). In addition, many teachers have limited access to technology, which makes high levels of mathematics less accessible to students, especially for those who are historically underrepresented (NCTM, 2014). It is obvious that for an effective mathematics teaching and learning, teachers need deep understanding of technology as well as the content and the pedagogy (Niess, 2005). Moreover, "*the single biggest problem facing education today is that our Digital Immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language"* (Prensky, 2013, p.46).

Technology, like any other instructional tool, can be used effectively or poorly in mathematics classrooms. Educational technology on its own is not transformative. Appropriate and effective use of technology is very critical and depends on the teacher (NCTM, 2000). In its recent publication *"Principles to Actions,"* NCTM (2014) clearly states that both software and hardware technological tools are essential components of a high-quality mathematics instruction in which students can *"learn and make sense of mathematics, reason mathematically, and communicate their mathematical thinking"* (p.4).

The integration of the development of technology with that of knowledge of content, teaching, and learning is therefore critical. NCTM (2008) suggests that teacher education and professional development programs must continually revamp teachers' knowledge of emerging technologies and its applications in classrooms. This paper thus addresses a critical issue in mathematics education by focusing on mathematics teachers' appropriate use of technology.

Study design

The goal of this paper is to explore mathematics teachers' habits of using technology at a local level and to see if a technology-enriched professional development would make a difference in their practice in terms of technology use in mathematics instruction. The three primary research questions that guided this study are:

- To what extent do teachers use emerging technologies in mathematics instruction?
- For what purposes do teachers mostly use technologies for mathematics instruction?
- To what extent does the frequency of their technology-use change after a three-week technology-enriched professional development?

Mathematics teachers representing several urban school districts in the southwestern U.S. participated in a three-week content-based, technology-rich professional development during one of two summers: 2012 and 2013. There were four classes in the summer programs: elementary class (grades K-3 teachers), intermediate class (grades 4-6 teachers), middle school class (grades 7-8 teachers), and high school class (grades 9-12 teachers). The overarching goal of the professional development was to improve teachers' pedagogical content knowledge in mathematics. One of the program objectives was to improve teachers' methodology in the appropriate use of technology. Teachers took a pre-survey before the program and a delayed post-survey approximately 8 months afterwards leaving enough time to put what they have

learned into practice. The surveys served three purposes: (a) first, to learn about teachers' daily technology use for teaching mathematics at their schools, (b) then, to learn for mainly what purpose they use them, and (c) lastly, to see if they changed their practice after a technology-rich professional development.

Data include responses from 140 K-12 mathematics teachers over two years. Teachers were 44% African American, 6% Asian, 24% Hispanic, and 26% White. They were 23% male and 77% female.

The surveys included 15 items that asked teachers to indicate the extent to which they had used particular technologies for three different purposes: planning, instruction, and student assessment. There were five items for use of software and ten items for hardware towards each purpose. The items were on a 4-point Likert scale (0-never, 1-sometimes, 2-often, and 3-almost always). Lastly, there were three items asking teachers how useful they thought technology was in fulfilling their teaching responsibilities for three purposes (4-point Likert scale: 0-not at all, 3-very much). Cohen's weighted Kappa was calculated for both pre- and post-surveys to ensure the reliability of items.

The authors investigated the change in teachers' practices for using technology in their daily activities related to teaching mathematics. Aggregating teachers' frequency score in use of technology produced a total score for teachers' technology use. For each of 15 items, teachers received 1 point for responding "never", 2 points for "sometimes", 3 points for "often", and 4 points for "almost always". Adding it up for each of three purposes of use produces the total maximum score of 180 (15 x 4 x 3). The authors then analyzed the gain in teachers' use of technology scores from before to after program through ANOVA (paired-samples *t*-test). The authors also computed the effect size (Cohen's d) to understand how noteworthy the gains were. Additionally, changes in the frequency of teacher's use of particular technology were also analyzed on an item-by-item basis using Wilcoxon nonparametric signed-rank test.

Findings

The survey items were highly reliable: Cohen's Kappa values were 0.918 for pre-survey and 0.933 for the post-survey. Results showed that teachers used emerging technologies not frequently prior to summer program. On average, when each survey item was evaluated individually, teachers reported low frequencies in using these particular technologies (e.g., math apps, document camera) for the majority of items: 23 of the items got ratings less than 2 (sometimes); 18 items got ratings between 2 (sometimes) and 3 (often); and only 4 items got ratings of 3 (often) or more. These figures got better months after the professional development: 16 ratings less than 2 (sometimes); 22 ratings between 2 (sometimes) and 3 (often); 7 ratings of 3 (often) or more.

Teachers reported that they used technological tools more towards planning and instructional purposes than student assessment. On average, they use emerging technology more frequently than 2 (sometimes), less frequently than 3 (often) for the first two purposes whereas they use technology less than 2 (sometimes) for student assessment.

Table 1. Paired-samples *t*-test results for total scores in frequency of technology use

					Paired Differences								
								95% C.I.					
Survey	Mean	N	S.D.	S.E.	Mean (gain)	S.D.	S.E.	Lower	Upper	t	df	Sig.	Effect size
Pre	1.06	140	0.41	0.05	0.18	0.38	0.04	0.09	0.27	5.57	139	0.00	0.47
Post	1.24	140	0.46	0.05									

Table 2. Significant gains (Wilcoxon signed-rank test) for specific technologies by three teaching-related purposes

Technology	**Purpose**
Software	
Online Learning Management Systems (e.g., Blackboard)	Planning*** Instructional*** Assessment***
Math Apps	-
Websites	-
PowerPoint (Teacher use)	-
PowerPoint (Student use)	-
Hardware	
Interactive Whiteboard (to project materials)	-
Interactive Whiteboard (for interactive activities)	-
Document Camera	Planning* Assessment**
Computer (to view materials)	Assessment*
Computer (for interactive activities)	-
Tablet Computer	Planning*** Instructional** Assessment*
Calculators	-
Student Response System	Planning* Assessment*
Digital Camera/ Video Recorder	-
GPS	-
Usefulness of Technology Overall	-

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Comparison of total scores revealed that there was a significant increase in teachers' use of technological tools months after the professional development (Table 1). Large effect size

confirms the strength of this increase. However, when looked at the particular technological tools, although teachers increased their frequency of use for every individual technological tool, significant increases occurred only for some of the technological tools for specific purposes (i.e., not for all purposes – see Table 2). It is interesting to note that the tablet computer and document camera, which had been heavily used during the professional development, were two types of tools in which teachers showed the most significant increase in using. Lastly, teachers believe that the technological tools are very beneficial for the three purposes for teaching-related activities (Table 3). No significant changes occurred in teachers' beliefs from pre- to post-survey (their belief ratings were already quite high at the beginning.)

Table 3. Descriptive statistics for teachers' beliefs about usefulness of technology for three teaching-related purposes*

	Pre-Survey			Post-Survey		
Purpose	Mean	S.D.	S.E.	Mean	S.D.	S.E.
Planning	2.63	.822	.093	3.63	.440	.050
Instructional	2.59	.648	.073	3.68	.342	.039
Assessment	2.17	.987	.112	3.15	.252	.029

* No significant changes occurred in teachers' beliefs.

Conclusions

These results show that even though teachers believe the technology is important and helpful in fulfilling teaching responsibilities, their use of these tools are limited. Although they significantly increased their technology use in mathematics classrooms after a technology-integrated professional development, the end-point in the frequency of technology use was not considerably high. This might be because of timing constraints (having not enough time to integrate technology into lessons [Bauer & Kenton, 2005] under testing-pressure.) Certain characteristics of classrooms and schools, such as equipment, technical assistance, and leadership, may act as barriers to technology use (Smerdon et al., 2000).

This is an alarming sign because teachers need to be equipped with skills to use new technologies appropriately for the good of our students (NCTM, 2014; President's Committee of Advisors on Science and Technology, 1997). Although this study shows not very good news in terms of teachers' use of technology, the promising sign is that providing teachers with appropriate professional support might help overcome teachers' limited use of technology.

Significance

This study is significant and has serious implications because it shows that teachers at urban schools do not use technology at higher levels. The substantial investment in hardware, software, and infrastructure schools and districts put into place will be a waste of time, efforts, and resources if K-12 teachers are not provided with the appropriate preparation and support that they need to effectively integrate emerging technologies into their teaching.

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