Jl. of Technology and Teacher Education (2013) **21**(3), 337-353

Integration of Technology in Elementary Pre-Service Teacher Education: An Examination of Mathematics Methods Courses

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Instructors (N = 204) of elementary mathematics methods courses completed a survey assessing the extent to which they stay informed about research related to effective uses of educational technology and the kinds and numbers of educational technologies they include in their courses. Findings indicate that, while they view educational technology research as important to their field, mathematics methods instructors are neither accessing such research nor using technology in their courses to any great degree. Additionally, instructor accessing of educational technology research, including practitioner-focused articles, was a significant predictor of their technology use. This paper describes these findings and suggests implications for the fields of educational technology and mathematics education and for teacher education programs.

INTRODUCTION

Technology is becoming an ever-increasing presence in elementary mathematics classrooms, with K-12 school districts dramatically increasing their expenditures on technology over the past two decades (Peslak, 2005). This trend will likely continue due to the importance researchers and educational organizations place on technology for students' acquisition of mathematical ideas, critical thinking skills, and ability to collaborate and com-

Thus, evidence suggests that instructors of mathematics methods courses should play an important role in training pre-service teachers how to effectively integrate technology in their future mathematics instruction. There is little information, however, about whether instructors of methods courses are inclined and prepared to integrate educational technology into their courses. Further, little research exists about the kinds of technology currently utilized in methods courses and the purpose for which they are included.

Study Goals

The present study had two main goals. The first goal was to gather more information about the extent to which instructors of mathematics methods courses use technology in their courses. Previous studies that have examined the integration of technology in methods courses have done so through case study of one or two courses (e.g., Blankson, Keengwe, & Kyei-Blankson, 2010; Li, 2005). The case study approach, while valuable for exploring in depth the ways in which technology is integrated, does not provide information related to the general integration of technology across teacher education programs. The current study complements these case studies by providing a broader description of the use of technology in mathematics methods courses. This study surveyed over 200 instructors of mathematics methods courses from a range of geographic regions and kinds of institutions (e.g., private vs. public). Instructors reported not only the types of technology they used in their mathematics methods courses but also their purposes for using them.

The second goal was to examine instructors' perceptions of educational technology research and the extent to which they access that research. This aspect of the study provides some information about the value that teacher educators, outside of the field of educational technology, place on staying current with advances in the field. It also provides information about the extent to which mathematics education faculty stay informed about research related to effective uses of educational technology, which is important if they are to be expected to integrate it into their courses.

The third goal was to examine the factors that might influence the extent to which mathematics methods instructors integrate technology in their courses. More specifically, the study tested the extent to which instructors' integration of technology was influenced by four factors: their academic position, an educational technology course requirement in their teacher education program, their perceived importance of educational technology re-

search, and the extent to which they access educational technology research. The first hypothesis was that newer/younger professors might have more experience using technology, and, thus, might be more likely to incorporate technology into their teaching. The second hypothesis was that the requirement of an educational technology course would lead to less integration of technology in methods courses; whereas, the lack of a stand-alone course might incline an instructor toward incorporating technology to a greater extent. The final hypothesis was that instructors who believe educational technology research is important and who seek out such research, might be more inclined to use technology in their methods courses. A better understanding of the factors that influence the integration of technology in teacher preparation courses is important for determining ways to increase technology use in these courses.

METHOD

Participants

Participants were instructors of elementary mathematics methods courses at higher-education institutions, all of which were affiliated with the American Association of Colleges of Teacher Education. To identify potential participants, the researchers visited department websites, sending email requests to department chairs as needed. This process generated a list of 699 instructors. All of these potential participants received an initial email request to complete a national survey about practices in mathematics methods courses and up to four reminder requests. The final response rate was 29.6%, within the norm for participation rates on large-scale survey studies.

The final sample of respondents included elementary mathematics methods course instructors (N = 207) from 195 different higher-education institutions within the continental United States. The participants held a range of positions, but the majority were tenure-track professors: Full Professors (17.9%), Associate Professors (29.5%), Assistant Professors (38.4%), and Other (e.g., adjunct) (14.2%). The majority of participants (79%) reported that the teacher education program with which they were affiliated required students to complete a stand-alone educational technology course.

municate (ISTE, 2007; NCTM, 2000), as well as the inclusion of "skillful technology use" at every grade level as a standard of mathematical practice in the Common Core Mathematics Standards (CCSSI, 2011). Research suggests, however, that the value of classroom technology for mathematics learning depends, in large part, on teachers' ability to use it effectively (Driscoll, 2002; Zbiek & Hollebrands, 2008).

Thus, in order for districts' investment in technology to positively affect student mathematics learning, teachers must learn how to support students' mathematical understanding via technology, beginning at the pre-service teacher level (Kay, 2006). Unfortunately, there is little empirical data about the extent to which technology is currently integrated into pre-service teacher education across a range of programs. This data can inform changes in teacher education programs as well as help district administrators predict professional development needs related to technology. Thus, this study used a large-scale survey to gather information about the extent to which mathematics teacher educators integrate technology into their courses.

Educational Technology and Mathematics Learning

Policy makers and researchers view educational technology—including hardware (e.g., Smartboards, document cameras, digital recorders, desktop and laptop computers, handheld computing devices, calculators, probeware) and software (e.g., Word, Excel, Tinkerplots, Geometer's Sketchpad), web-browsers, media programs, and applets (e.g., NLVM or Illuminations)— as an essential aspect of 21st century mathematics teaching and learning (Aziz, 2010; CCSSI, 2011; NCTM, 2000). They believe that integrating this technology into classroom instruction is important for helping students develop and practice digital age skills that are now necessary for economic and personal success (Partnership for 21st Century Skills, 2011).

Indeed, research has found that the integration of technology in elementary mathematics instruction has various positive effects. Technology increases student engagement and positive orientations toward subject matter (e.g., Khairiree & Kurusatian, 2009; Smith, Higgins, Wall, & Miller, 2005). Children who interact with computers during instruction remain engaged with tasks for longer periods of time and demonstrate higher levels of performance on a range of mathematical concepts than children whose instruction does not include computer-based activities (Yelland, 2005). Technology also supports better understanding of content and more fluent problem solving (NCTM, 2000; Zbiek, Heid, Blume, & Dick, 2007). For example,

statistics lessons that integrate Tinkerplots generate greater gains in students' understanding of data presentation and analyses than statistics lessons that use more traditional formats (Khairiree & Kurusatian, 2009). Similarly, Lazakidou and Retalis (2010) conducted a case study of 24 students and documented large gains in students' ability to problem solve independently and collaboratively while participating in a computer-based program. Thus, research supports the view that technology is an important tool for mathematics learning and instruction.

Teachers' Preparation for Using Educational Technology

However, the effect of educational technology on student learning depends on teachers' ability to integrate it effectively (Driscoll, 2002; Cuban, 2001). Teachers who lack specific technology knowledge and skills tend to integrate technology less in their instruction, even when the resources are available (Hew & Brush, 2007). In addition, teachers' attitudes and beliefs about technology (Ertmer, & Ottenbreit-Leftwich, 2010), their knowledge about how to enhance instruction using technology (Ertmer, & Ottenbreit-Leftwich, 2010; Hughes, 2005), and their knowledge about how to support and manage students' use of technology (Yelland, 2005) seem to affect the quality of technology integration. Because a teacher's ability to integrate technology is so influential upon her students' ability to learn from technology-based instruction (Angrist & Lavy, 2002), greater integration of technology in pre-service teacher training is likely to yield positive outcomes on student learning.

The most effective way to prepare pre-service teachers to use technology in their classrooms may be to include technology in domain-specific courses (AACTE, 2008; Niess, 2005). Studies note little correlation between pre-service teachers completion of a stand-alone technology course and their knowledge of how to integrate technology in instruction (Bell, Maeng, & Binns, 2013; Hare, Howard, & Pope 2002). Further, studies suggest that pre-service teachers are more likely to take-on and effectively implement new approaches when the approaches are taught and practiced in the context of their content area and pedagogy (Ball & Cohen, 1999; Darling-Hammond, Wei, & Orphanos, 2009). These findings indicate that presenting educational technology in mathematics methods courses, which emphasize practical pedagogical approaches for teaching mathematics, may be the most effective means of building technological pedagogical content knowledge (Mishra & Kohler, 2006), so that novice teachers are able to teach with technology effectually.

Thus, evidence suggests that instructors of mathematics methods courses should play an important role in training pre-service teachers how to effectively integrate technology in their future mathematics instruction. There is little information, however, about whether instructors of methods courses are inclined and prepared to integrate educational technology into their courses. Further, little research exists about the kinds of technology currently utilized in methods courses and the purpose for which they are included.

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The third goal was to examine the factors that might influence the extent to which mathematics methods instructors integrate technology in their courses. More specifically, the study tested the extent to which instructors' integration of technology was influenced by four factors: their academic position, an educational technology course requirement in their teacher education program, their perceived importance of educational technology re-

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Survey Development and Content

Data were collected using an online survey that took approximately 25 minutes to complete. The research team constructed the survey through an iterative, collaborative process in accord with survey design best practices (Fowler, 1993). In addition to the team's revisions to the multiple drafts of the survey, it underwent both substantive and methodological reviews by two mathematics education professors with quantitative methodology expertise. The final survey reflected all changes (e.g., provision of examples, or the addition of pertinent questions) suggested by these external reviewers.

The survey collected a range of information about the elementary mathematics methods course, including: instructors' perceptions of the importance of educational technology research, the extent to which instructors access that research, and their integration of technology into their methods courses. On all items, participants were asked to respond keeping in mind the most recent mathematics methods course taught and in regards to "research with implications for elementary mathematics education."

The particular items used to assess instructors' perceptions of the importance of educational technology research and the extent to which instructors access that research can be found in Table 2. Participating instructors rated their agreement with the statements (e.g., "Educational technology research addresses topics, issues and problems that are important to elementary mathematics education.") using a 5-point agreement scale from *strongly disagree* to *strongly agree*. Reliabilities for similar items were high, with Cronbach's alphas (α) ranging from .82-.91.

These instructors also indicated whether or not they incorporated particular technologies in their course and whether they did so to enhance their own instruction and/or to instruct pre-service teachers about how to use it for classroom instruction. For this item, instructors could also select "other" and list additional technologies. The particular technologies included in the survey appear in Table 1.

RESULTS

This section presents the results related to each of the three research goals, in turn. First, findings related to three aspects of instructors' integration of educational technology into their mathematics methods courses are presented: (1) the kinds of technologies integrated; (2) the number of different technologies integrated; and (3) the purpose for technology integration

(to enhance their own teaching or to instruct pre-service teachers how to use it in classroom instruction). Then, instructors' perceptions of the importance of educational technology research and the extent to which instructors access that research are presented. Last, analyses examining which factors potentially influence whether instructors integrate technology in their courses and the number of different technologies they integrate are presented.

Integration of Educational Technology in Mathematics Methods Courses

Kinds of technology integrated. Overall, a large majority of the instructors (89%) in our sample reported using at least one of the technologies included in the present survey in their most recent elementary mathematics course. Strikingly, however, of the 9 kinds of technologies included, only one, calculators, was integrated by more than half (62%) of the instructors (see second column of Table 1). The percentage of instructors who integrated the other technologies ranged from 6% to 58%, with probeware being integrated by the fewest instructors and interactive whiteboards by the second greatest number of instructors. This pattern of responses suggests that there is a good deal of variability in the kinds of educational technologies integrated into mathematics methods courses.

Number of technologies of integrated. Next, the researchers examined the number of technologies that individual instructors reported integrating into their mathematics methods courses. On average, instructors reported integrating 2.93 (SD = 1.94) different technologies into their elementary mathematics course. To further examine the range of different technologies being integrated, the researchers recalculated the number of different technologies used by individual instructors, not including the three technologies integrated by the greatest percentage of instructors (calculators, interactive whiteboards, and applets). Without these technologies included, the mean number of different technologies integrated in elementary mathematics methods courses decreased to 1.20 (SD = 1.32), suggesting that most instructors integrate only one additional technology in addition to calculators, interactive whiteboards, and applets.

Table 1

Percentage of instructors who reported integrating various educational technologies in their mathematics methods course

Educational Technology	Integrate for any purpose	Purpose for integration	
		To enhance instructor's own teaching	To instruct pre-service teachers how to use them for future mathematics instruction
Calculators	62%	21%	64%
Interactive Whiteboards	58%	45%	50%
Applets	44%	28%	41%
Online Discussion Tools	40%	31%	25%
Software (e.g., The Geometer's Sketchpad, RM Math)	35%	19%	30%
Website Creation Tools	27%	17%	23%
Blogs	14%	10%	8%
Podcasts	9%	7%	4%
Probeware	6%	3%	6%

Purpose for technology integration. The extent to which pre-service teachers were explicitly being trained to use various educational technologies for mathematics instruction was of particular interest. Thus, instructors' purpose for integrating the various technologies in their course—either for enhancing their own teaching or to instruct pre-service teachers how to use it in classroom instruction—was examined (see Table 1). A related samples McNemar Change Test indicated that a greater percentage of instructors reported integrating technology into their courses for the purpose of instructing pre-service teachers how to use them: 69% of instructors reported integrating at least one technology to enhance their own teaching, while 81% reported doing so to instruct the pre-service teachers how to use them, $\chi^2(1, N = 204) = 10.11, p < .001$. More specifically, a significantly greater number of instructors reported integrating calculators, $\chi^2(1, N = 204) = 75.87, p < .001$, software, $\chi^2(1, N = 204) = 9.19, p < .001$,and applets, $\chi^2(1, N = 204) = 13.80, p < .001$, for the purpose of instructing pre-service teachers how to use them; whereas, the other technologies seemed to be integrated about equally for both purposes.

Instructors' Perceptions of Educational Technology Research

First the extent to which the present sample of instructors of elementary mathematics methods courses perceive educational technology research to be important and the extent to which they access that research was examined. For the relevant items, both the percentage of respondents falling into each agreement level as well as the mean response across all participants for each item are reported.

Perceived importance. As shown in Table 2, instructors indicated their agreement with two items related to their perceptions of the importance of educational technology research. On both items, more than half of the instructors either "agreed" or "strongly agreed" with the importance of educational technology research to mathematics education: 66% for the item stating that educational technology research findings are applicable to mathematics education and 53% for the item stating that educational technology research addresses topics, issues and problems that are important to elementary mathematics education. The mean ratings on these questions across all participants were slightly above 4.00, indicating that, on average, instructors agreed that educational technology research was applicable and important to mathematics education.

Accessing. Also shown in Table 2, instructors indicated their agreement with three items related to the extent to which they access research from the field of educational technology: keep abreast of empirical research; read empirical articles; and read practitioner-friendly articles summarizing research from the field of educational technology. Across the three items, the percentage of instructors who "agreed" or "strongly agreed" ranged from 40% to 51%. A greater percentage of instructors "agreed" or "strongly agreed" that they read practitioner-friendly articles (51%) than empirical articles (40%). The mean ratings on these questions across all participants were slightly above 3.00, indicating that on average instructors were neutral ("neither agree or disagree") about whether they accessed research from the field of educational technology. Importantly, there was excellent reliability among these three questions ($\alpha = .904$), which suggests that professors who access one resource were more likely to access others.

Relation between perceived importance and accessing. The pattern of results suggested that although instructors generally perceive educational technology research to be important to mathematics education, they generally do not access that research. To test whether perceived importance and accessing were related, a correlation analysis using instructors' mean response across the two items measuring perceived importance and instructors' mean

response across the three items measuring accessing was conducted. The results found no relation between instructors' perception of the importance of educational technology research and the extent to which they access that research, $r = -.03$, $p = .69$.

Table 2

Instructors' self-reported agreement with the importance of educational technology research and their own accessing of educational technology research

Survey Constructs and Items	Percentage of Instructors Falling Within Each Rating Category					Mean Rating (*SD*)
	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	
Importance						
Educational technology findings are applicable to mathematics education	0.6%	3%	31%	50%	16%	4.15 (.99)
Educational technology research address topics, issues, and problems that are important in elementary mathematics education	0.6%	3%	43%	40%	13%	4.04 (1.07)
Accessing						
I keep abreast of empirical research from the field of Educational Technology	10%	21%	23%	35%	11%	3.20 (1.19)
I read empirical articles to access research from the field of Educational Technology	10%	24%	25%	30%	10%	3.06 (1.17)
I read practitioner friendly articles to access summaries of research from the field of Educational Technology	9%	18%	23%	33%	18%	3.34 (1.21)

Influences on Education Technology Integration in Mathematics Methods Courses

Four factors that might potentially be related to instructors' integration of technology into their elementary mathematics courses were tested: academic position, an educational technology course requirement in their teacher education program, perceived importance of educational technology research, and the extent to which they access educational technology research. The correlations between these factors and our continuous measures of integration—the number of different educational technologies integrated by instructors for any purpose, for the purpose of enhancing their own teaching, and for the purpose of instructing pre-service teachers how to use it in classroom instruction were calculated.

Only instructors' accessing of educational technology research was found to be related to the measures of technology integration: accessing and number of different technologies used for any purpose was $r = .51$ ($p < .01$), accessing and number of different technologies used to enhance instructor's own teaching was $r = .38$ ($p < .01$), and accessing and number of different technologies used to instruct pre-service teachers how to use them was $r = .46$ ($p < .01$). Thus, of the factors examined in the present study, only accessing emerged as a potential predictor of instructors' integration of technology into mathematics methods courses.

As illustrated in Table 3, accessing significantly predicted each of the three measures of technology integration. It accounted for 26% of the variance in the number of different technologies instructors used for any purpose, 21% of the variance in the number they used to enhance their own teaching, and 14% of the variance in the number of they used to instruct pre-service teachers how to use them in future mathematics instruction.

Table 3

Instructors' accessing of educational technology research as a predictor of number of different technologies integrated in mathematics methods course

Dependent measure	*B*	*SE B*	β	R^2
Any purpose	1.29	.17	.51	26%
To enhance own teaching	.51	.11	.38	14%
To instruct pre-service teachers how to use in future mathematics instruction	.62	.10	.46	21%
Note: All R^2's and *B*'s are significant at the $p < .01$ level				

Given that accessing was found to be such a strong predictor of the number of different technologies used, logistic regressions were conducted to test if it also predicted whether instructors integrated *any* technology in their mathematics methods course. Two separate logistic regressions were conducted, using accessing as a predictor of two dichotomous measures of integration: use of at least one technology to enhance instructors' own teaching and use of at least one technology to instruct pre-service teachers how to use educational technology in future mathematics instruction. At least one technology for any purpose was not included as a dependent variable because this measure was close to ceiling; 89% of instructors reported using at least one technology for any purpose.

As illustrated in Table 4, accessing was found to be a significant predictor of both the integration of a technology for enhancing instructors' own teaching and for instructing pre-service teachers how to use it. For each one point increase on the accessing measure, the odds that instructors integrated a technology into their mathematics methods course to enhance their teaching increased from one to 1.42 and that they integrated a technology to instruct pre-service teachers how to use it increased from one to 2.07. Thus, the data indicated that accessing educational technology research seems to influence whether instructors integrate technology in their courses at all as well as the number of different technologies they integrate.

Table 4

Instructors' accessing of educational technology research as a predictor of integration of a technology

Dependent measure	*B*	*SE B*	Wald	*df*	Significance	Odds Ratio
To enhance own teaching	.35	.16	4.58	1	.03	1.42
To instruct pre-service teachers how to use in future mathematics instruction	.73	.23	10.49	1	.001	2.07

DISCUSSION

Current integration of technology in methods courses

Previous findings suggest that the value of educational technology to student learning depends, in part, on teachers' preparation for using it meaningfully in the classroom. Yet, the current results provide evidence that pre-service teachers do not receive sufficient training on how to integrate technology into their teaching. Technology is not utilized in a large portion of elementary mathematics methods courses, despite evidence that preparing pre-service teachers to use technology in the context of methods courses may be most effective. While instructors reported using a variety of types of technology, none of these were integrated consistently across instructors and programs. The only technologies used by more than half of the instructors were calculators and Interactive White Boards. Thus, the present results indicate that the lack of technology in methods courses is pervasive across different kinds of programs and across regions, and not just emblematic of the individual courses that have been included in case-studies.

One potentially positive finding is that instructors do seem to have the intent of preparing pre-service teachers to teach with technology when they do integrate it into their courses. A greater percentage of instructors reported integrating technology into their courses for the purpose of instructing pre-service teachers how to use them, than for the purpose of enhancing their own teaching. Given this finding, it seems worthwhile for future studies to explore more deeply *how* instructors integrate technology for this purpose (e.g., Do instructors model how to use the technology by having students engage with the technology? Or do instructors demonstrate or identify activities for which the technology can be used?), and effects that various approaches may have on pre-service teachers ability to use technology in their future instruction.

How can the integration of technology in methods courses be increased?

Importantly, while this study provides support for the view that technology is not sufficiently integrated into teacher education programs, it also provides insight into how to address the problem. Among the factors examined in this study, the extent to which instructors access educational technology research, including practitioner-friendly research, emerged as the only significant predictor for whether they integrated technology into their cours-

es. Instructor accessing of educational technology research also predicts the number of different kinds of technology they include in their elementary mathematics methods courses. Academic position, whether the teacher education program in which instructors worked had an educational technology course requirement, and instructors' perceptions of the importance of educational technology research were all unrelated to the extent to which instructors integrated technology in their courses. While other factors not examined in the present study, such as lack of access to technology, may be also related to instructors' integration of technology into their courses, the present results point to instructors' accessing of educational technology research as a potential mechanism for increasing technology integration.

Unfortunately, the results indicate that the majority of mathematics teacher educators do not seek out and access educational technology research. Only about half of the elementary methods instructors who participated in the current survey reported reading practitioner-friendly articles related to educational technology, and even fewer reported reading research articles on the topic. This lack of accessing does not seem to be due to instructors' apathy toward technology or the sense that educational technology research does not have implications for mathematics education. On average, instructors indicated that they believed educational technology research was applicable and important to mathematics education. Yet, there was no relation between instructors' perception of the importance of educational technology research and the extent to which they access that research.

What are other potential reasons that mathematics methods instructors do not access educational technology research? One reason may be a lack of time available for reading research. If this is the case, then educational technology researchers might consider increased use of media other than journal articles (e.g., research briefs, online videos of conference presentations) to disseminate their findings to domain experts. A second reason may be instructor expectations for being able to comprehend the research. If this is the case, then teacher educators may benefit from receiving short trainings related to technology to increase their general knowledge of the field and its terminology. There are likely other explanations, each with unique implications. Thus, examining which factors influence teacher educators' accessing of educational research, along with other ways to potentially increase technology integration in mathematics methods courses, seems to be an empirical question that is worth investigating.

CONCLUSION

Districts are making large financial investments in technology because it is a component of the Common Core Mathematics Standards and viewed as a critical learning tool. Thus, pre-service teachers should be prepared to use technology to teach mathematics well. Although pre-service teachers see technology as ubiquitous in their everyday lives, they need instruction on how to teach effectively with technology (Russell, et al., 2003). Unfortunately, this study provides evidence that this may not be occurring consistently across teacher education programs. The problem may be partially addressed, however, by increasing the extent to which mathematics teacher educators access relevant educational technology research.

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The authors would like to acknowledge Todd Reeves, Katherine Ariemma Marin, and Colleen Ganley for their contributions to the research and to Tim Fukawa-Connelly and Jeremy Zelkowski for their critical feedback on the paper itself.