PREPARING SECONDARY MATHEMATICS TEACHERS TO TEACH WITH TECHNOLOGY: FINDINGS FROM A NATIONWIDE SURVEY

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The field of mathematics teacher education has been moving collectively towards a common goal of preparing preservice mathematics teachers to teach with technology, which is explicated in the Association of Mathematics Teacher Educators' (2017) Standards for Preparing Teachers of Mathematics*. In this paper we present findings from a national survey of accredited university secondary mathematics teacher education program. The purpose of the study is to describe the current state of the ways in which programs are preparing preservice teachers to teach secondary mathematics with technology.*

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Since the release of the *National Educational Technology Standards for Teachers* (International Society for Technology in Education, 2000), the field of mathematics teacher education has worked to develop common goals about how secondary mathematics teachers should be prepared to teach mathematics with technology. Recently these goals were articulated in the Association of Mathematics Teacher Educators' [AMTE] (2017) *Standards for Preparing Teachers of Mathematics*, which stated that "well-prepared beginning teachers of mathematics are proficient with tools and technology designed to support mathematical reasoning and sense making, both in doing mathematics themselves and in supporting student learning of mathematics" (p. 11). These standards call for prospective secondary mathematics teachers (PSMTs) to be proficient in using digital tools to solve mathematics problems, to "enhance or illuminate mathematical and statistical concepts," to "explore mathematical and statistical ideas and to build conceptual understanding of these," and know when such tools "enhance teaching and learning, recognizing both the insights to be gained and possible limitations of such tools" (p. 12). Although these goals have now been articulated and disseminated, relatively little is known about the ways program faculty have designed courses to meet these goals.

Given the complex nature of teaching with technology, it is evident that teacher preparation programs need to focus on supporting PSMTs' learning to effectively integrate technology in mathematics classrooms. Although standards exist that purport this importance, there are many ways in which teacher education programs might choose to meet this need. In 2003, Kersaint, Horton, Stohl, and Garofalo reported that 21% of mathematics teacher educators in the U.S. who responded to their survey taught a course focused on technology. A few years later, Leatham (2006) reported that 29% of mathematics teacher educators had courses at their U.S.-based institutions that focused specifically on the teaching of mathematics with technology. However, simply identifying whether or not a course focused on teaching mathematics with technology is offered may be misleading. Secondary mathematics education programs might incorporate

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teaching mathematics with technology into methods courses, content courses, or even general educational technology courses (Kersaint et al., 2003; Leatham, 2008). Of course, the scope and nature of such integration could vary drastically across programs.

While the extant literature does have suggestions for the design of courses in which learning to teach with technology is a goal (Lee & Hollebrands, 2008; Leatham, 2008), the research on how that is actually being done is limited and largely out of date. In an aim to provide an update of where we are as a field we conducted a nationwide survey of U.S. secondary mathematics teacher education programs. In this paper we answer the following questions: 1) In what types of courses are PSMTs being prepared to teach mathematics with technology? and 2) What reasons do programs give for why they do not have a course specifically focused on learning to teach mathematics with technology?

Methods

We employed survey methodology (Groves et al., 2009) and mixed methods analysis. The survey was designed to elicit descriptive information (using both closed and open-ended questions) about courses designed specifically to address learning to teach mathematics with technology. For example, after identifying whether or not a mathematics specific technology course (typically referred to as a technology, pedagogy, content [TPC] course) is offered within a program, the remaining questions targeted the structure of the course(s) in which teaching with technology is incorporated, course learning objectives, different types of technology utilized and frequency of use, and types of learning activities included. In this brief report we focus on survey items related to the structure of courses.

We identified all accredited university secondary mathematics teacher preparation programs in the U.S. by visiting the department of public instruction website for all 50 states. Once a list was procured, we visited each university website to verify that the university had an undergraduate secondary mathematics teacher preparation program and, if so, to identify a potential contact person. This search resulted in a list of 956 accredited programs. The survey was sent to all 956 universities along with two reminder emails, if necessary. The response rate was 30%, well above that of previous studies focused on this topic (Kersaint et al., 2003; Leatham, 2006). The sample represents a broad cross-section of universities from 49 of the 50 states.

Descriptive statistics were used to describe the various courses in which programs address preparing PSMTs to teach mathematics with technology and to discern overall patterns and differences between programs with dedicated technology courses and those that do not. In addition, we open coded responses to a question posed to non-TPC programs, "A number of institutions offer a course dedicated to teaching mathematics with technology. What are some of the reasons why you do not offer such a course?" to identify themes related to decisions about not offering a technology-specific course.

Findings and Discussion

Of the 290 programs that responded, 71 (25%) reported that they offer a designated TPC course (referred to as TPC programs going forward), 214 (74%) indicated they do not have a designated course, but instead integrate technology across other courses (referred to as non-TPC programs going forward), and two (<1%) reported that technology preparation is not included in their program. It is encouraging that, with the exception of these two programs, the remaining programs (n=288) represented in this study provide a number of opportunities for PSMTs to

learn about teaching and learning mathematics with technology. The 25% of programs that currently offer a TPC course is practically the same proportion from a decade ago (29% according to Leatham, 2006). In the remainder of this brief report we focus on the types of courses in which goals related to preparing PSMTs to teaching mathematics with technology are intentionally integrated when a TPC course is not offered and the reasons programs give for why they do not offer a TPC course.

Types of Courses in Which Teaching Mathematics with Technology is Integrated

Of the 214 non-TPC programs, 158 (74%) reported the titles of courses in which they integrate technology. Of those 158 programs, 64 (41% noted they integrate technology in one course, 44 (29%) across two courses, and 50 (32%) across three or more courses. Typically, the courses identified were mathematics methods courses (143 of the 302 courses reported, 47%). However, 83 (53%) were mathematics or statistics content courses, 51 (33%) were general education methods courses, and seven (4%) were field experience courses (e.g., student teaching). For the 41% of programs that indicated they integrate technology in only one course, that one course is typically a mathematics education methods course (70%), with the second most common course type being a general education course (19%). Looking across the number of courses in which technology is integrated, 21 programs (13%) indicated technology was integrated into only mathematics and statistics content courses and 15 programs (10%) indicated technology was integrated into only general education courses.

It is notable that 23% of the non-TPC programs are not integrating technology into a mathematics education course. Given the complexity of integrating technology into mathematics pedagogy, this separation from mathematics specific methods is concerning. In addition, 29% of programs are integrating technology in only a single mathematics methods course. While integrating in a mathematics specific methods course does suggest attention to pedagogical considerations, integration into a single course suggests minimal time is being allocated to this very complex practice in these programs.

Reasons for Intentionally Integrated Courses Instead of TPC Courses

Programs that indicated they did not offer a TPC course (n=214) were asked why they did not offer one; 136 (63%) of these programs provided an explanation as to why. The most common reasons for choosing to integrate across courses rather than offering a TPC course were program limitations such as credit limits (35%) and program size (24%). In addition, it is notable that 4% indicated there was no faculty expertise to design or teach a TPC course. One respondent wrote “We currently do not have instructor expertise to design coursework around teaching math with technology.” Thus, it appears that many non-TPC programs do not offer TPC courses because of programmatic constraints rather than purposeful choice.

Table 1: Reasons for Intentionally Integrated Courses Instead of TPC Courses

Reason	Percentage
Program credit limits don’t allow adding another course	35
Low program enrollment	24
Sufficient Attention in other courses	21
Believe integrating across is more impactful	9
Lack of faculty expertise	4
Not required by state/accreditation agencies	4
Faculty does not believe in using technology	2
No faculty consensus on need of such course	2

Although one in five (21%) of the non-TPC programs suggested that program decisions about integrating teaching with technology across methods courses was intentional due to sufficient attention in other courses, their responses make one wonder about the validity of those statements. For example, one respondent explained, "There is the sense that something like technology is best integrated across other courses (I tend to agree with that to some extent), though I cannot say we do a very good job of it." Another wrote, "Because we incorporate technology across required mathematics courses." In contrast, some respondents (9%) noted that their intentional integration was done because they believed integration was more impactful than offering a TPC course. For example, one respondent wrote, "To have a course dedicated to technology alone flies in the face of expecting students to use technology at any time in any course in which the technology is deemed appropriate." The most concerning responses were those that indicated intentional integration was chosen because the faculty does not believe in using technology. This belief was expressed by 4% of the respondents through statements like "I do not believe technology is a vehicle for discovering mathematical principles" and "Because it is not an effective way to teach math."

Conclusion

Although every program is working within their local constraints to make decisions about how to best address the goals set out by AMTE with respect to preparing PSMTs to teach mathematics with technology, some of the reasons provided for not including a TPC course give rise to issues that should be important to the field. For example, 8% of responding programs indicated they do not have faculty expertise to develop such a course. If we consider that the sample represented in the study likely favors the use of technology in mathematics education, it is highly possible that there are many more programs for which there is not adequate faculty expertise related to learning and teaching mathematics with technology. There are some projects currently underway (e.g., Enhancing Statistics Teacher Education with E-Modules [ESTEEM], Preparing to Teach Mathematics with Technology – Examining Student Practices [PTMT-ESP]) aimed to address faculty expertise with respect to preparing PSMTs to teach with technology, finding ways to ensure these faculty are aware of existing projects and their materials should be a priority.

Preparing PSMTs to teach mathematics with technology remains an area of emphasis in our national standards (AMTE, 2017; NCTM, 2012) and an area where, across our programs, we have yet to converge on a common understanding of the most effective ways to meet our goals. We hope that this paper provides fodder for conversation as we collectively work to prepare all teachers to productively incorporate technology in the teaching of mathematics.

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