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Algebra Remediation in Indiana: Questions Raised from a Survey

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Over the past two decades, national educational organizations (e.g., National Council of Teachers of Mathematics [NCTM], 2000; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO], 2010) have emphasized the importance of Pre-K-12 students' algebraic understanding and described ways in which students should engage in the learning of algebra. NCTM has advocated a broad vision of algebra such that Pre-K-12 students "understand patterns, relations, and functions; represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; and, analyze change in various contexts" (NCTM, 2000, p. 37). Several Standards for Mathematical Practice in the *Common Core State Standards for Mathematics* (*CCSSM*) (NGA & CCSSO, 2010) support this expanded vision of algebra: reason abstractly and quantitatively, model with mathematics, look for and make use of structure, and look for and express regularity in repeated reasoning. However, this vision of algebra starkly contrasts the traditional practices in many high school algebra classrooms that primarily focus on symbolic manipulation and mastery of skills, include problems that are often de-contextualized, abstract, and devoid of meaning, and teach students to follow rules instead of thinking algebraically. Our vision for high school algebra aligns with the spirit of the recommendations from NCTM and within the *CCSSM*, and it supports the idea that mathematics courses should provide meaningful experiences for students to develop algebraic reasoning, conceptual understanding, and procedural fluency.

Pre-K-12 students' experiences in mathematics dictate, to a large extent, their potential for success in both post-secondary educational opportunities and technical careers. Adelman (1999) found that mathematics, more than any other subject, most strongly influenced whether or not students completed a Bachelor's degree. High school algebra courses, in particular, serve as a gateway to advanced mathematics that will require students to reason quantitatively. In fact, because of algebra's impact on students' future learning and employment opportunities, Robert Moses, founder of the *Algebra Project*, declared access to algebra as a civil right (e.g., Moses & Cobb, 2001; Moses, Kamii, Swap, & Howard, 1989). However, students who have failed algebra often have negative views of mathematics and usually avoid taking higher-level mathematics.

Research investigating students' access to algebra has reported algebra course-taking patterns, including an increase in both the number of students taking Algebra I in eighth grade and the frequency of failure in Algebra I courses (e.g., Finkelstein, Fong, Tiffany-Morales, Shields, & Huang, 2012; Loveless, 2008; Stein, Kaufman, Sherman, & Hillen, 2011). In a study of course-taking patterns of 24,000 middle and high school students in 24 districts in California, Finkelstein et al. (2012) found that 34% of these students repeated Algebra I, which was more than double the percentage of students repeating any other course. In addition, very few students who repeated Algebra I—and received instruction similar to that of before—demonstrated proficiency the second time taking the course: 21% of students first taking Algebra I in eighth grade were proficient and only 9% first taking the course in high school were proficient as course repeaters.

Because of these dire potential consequences for students who fail algebra and because of the lack of extant literature related to algebra remediation, we investigated the current state of algebra remediation in Indiana. By "algebra remediation" we mean any experiences offered to students during or after their initial exposure to Algebra I content that intend to enhance what students know or can do with respect to algebra. We sought to collect information regarding programs currently in place for algebra remediation, including the programs' selection process, operation, and level of satisfaction. We present these results in three parts and then synthesize their implications for Indiana educators and learners: (1) general information about schools, (2) information about algebra offerings, and (3) information about algebra remediation.

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About the Journal

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General School Information

We distributed an online survey to Indiana high school principals through the "IDOE—Indiana Mathematics" community in Learning Connection (https://learningconnection.doe.in.gov). We asked principals to forward the survey to the person who could best answer questions about algebra remediation efforts in their school. Because respondents could choose whether or not to answer each question, the number of responses ranged from 2 to 35 per question, and we denote the number of respondents for particular questions with an *n*. Of the 35 respondents who answered at least one survey question, 83% were principals or assistant principals while 17% were mathematics department chairs, mathematics curriculum coordinators, mathematics coaches, or mathematics teachers. A majority of the respondents who took the survey (67%, *n*=24) described their school as rural, and the second largest number of respondents described their school as suburban (25%, *n*=9). Sixty-six percent (*n*=23) of all schools followed a semester schedule; 40% of the schools reportedly used a block schedule for the school day compared to the 37% using a traditional schedule (e.g., eight 50-minute periods each day). Table 1 summarizes additional demographic information collected from the respondents.

Table 1
Demographic School Information

Percent of Non-White Students in School (*n*=35)		
Percent of Non-White Students	Responses	Percent of Schools
1% - 25%	31	89%
26%-50%	3	9%
51%-75%	0	0%
76%-100%	1	3%
Percent of Students Receiving Free or Reduced Lunch (FRL) (*n*=35)		
Percent Receiving FRL	Responses	Percent of Schools
1% - 25%	4	11%
26%-50%	27	77%
51%-75%	3	9%
76%-100%	1	3%
Percent of English Language Learners (ELLs) (*n*=35)		
Percent of ELLs	Responses	Percent of Schools
1% - 25%	31	89%
26%-50%	1	3%
51%-75%	0	0%
76%-100%	3	9%

Overall, the responses were fairly representative of Indiana public schools in general (see http://compass.doe.in.gov/dashboard/enrollment.aspx?-type=state for the 2012-13 school year for corresponding information). The majority of respondents (89%, *n*=31) had a low percentage of non-white students in their school. This sample is similar to Indiana public schools as a whole, as approximately 72% of students enrolled in 2012-13 were white. Seventy-seven percent of respondents (*n*=27) had 26-50% of their students receiving free or reduced lunch; again, this is comparable to the overall statistics in Indiana, as approximately 49% of students enrolled in Indiana in 2012-13 received free or reduced lunch. Finally, 89% (*n*=31) of respondents had 1-25% of English Language Learners in their schools; 5% of students enrolled in Indiana public schools in 2012-13 were English Language Learners.

Algebra Information

Nearly three-quarters of respondents (72%, *n*=23) reported that their Algebra I classes had 21-30 students; fewer respondents (22%, *n*=7) said they have 11-20 students in Algebra I classes; and, even fewer had 31-40 students (6%, *n*=2). The majority of respondents (87%, *n*=26) reported that their students learn Algebra I content in a course titled "Algebra I." The remaining respondents (13%, *n*=4) indicated that both "Algebra I" and "Integrated Math I" courses offered Algebra I content. The most common curriculum resource used in Algebra I was a textbook (46%, *n*=12); these textbooks included *Prentice Hall Algebra I*, *Holt McDougal Algebra I*, *McGraw Hill Algebra I*, and *McDougal Littell Algebra*. None of the NSF-funded, NCTM *Standards*-based curricula, such as *Interactive Mathematics Program* (*IMP*), *Core-Plus Mathematics Program* (*CPMP*), and *College Preparatory Mathematics* (*CPM*) were reportedly used in the responding schools' Algebra I courses. The second most common curricular resource used for teaching and learning Algebra I was software technology (42%, *n*=10), including the use of ALEKS (*n*=4), Acuity (*n*=2), MathXL (*n*=1), the TI-83 graphing calculator (*n*=1), and unnamed software (*n*=2). This result suggests that technology has become an integral part of Algebra I classes in many of the respondents' high schools. The remaining respondents (12%, *n*=3) indicated that their schools use school- or district-created assessments as curricular resources in Algebra I.

The vast majority of respondents (*n*=34) indicated that at least half of their high school students passed the Algebra I End-of-Course Assessment (ECA) in 2012. Of these 34 responses, 68% (*n*=23) reported ECA pass rates between 76 and 100 percent whereas 29% of respondents (*n*=10) reported pass rates between 51 and 75 percent in 2012. Even though such data only represents a small number of schools, the results align with Indiana's overall statistics. In fact, 94% (*n*=280) of Indiana school corporations (*n*=297) had at least half of their students pass the 2012 ECA. Indiana's 2012 ECA pass rate ranged from 27% to 98% across schools (Indiana Department of Education, 2012).

Questions about Algebra Remediation

The survey polled how algebra remediation was structured in respondents' schools, and Table 2 summarizes the responses. The most popular algebra remediation structure reported was additional or extended algebra periods offered or required for struggling students (81%, *n*=25), and remediation either before or after school or in the summer was also relatively common (58%, *n*=18). The majority (54%, *n*=17) of "other" structures reported involved additional time spent learning algebra during the school day by way of an "instructional resource" period or "success" period. In all cases, mathematics teachers supervised algebra remediation, and 40% (*n*=12) of respondents also reported supervision by special education teachers.

Table 2

How is algebra remediation structured in your school? (Choose all that apply.)

Response	Number of Responses (*n*=31)	Percent
Additional algebra periods	22	71%
Before/after school	11	35%
Summer school	7	23%
Extended algebra periods	3	10%
Other	17	54%

The majority of respondents (60%, *n*=18) reported that materials used in algebra remediation were "both purchased and developed" while 13% (*n*=4) reported only "purchased" materials, and 27% (*n*=8) reported only "developed" materials. Schools reportedly used four textbooks for algebra remediation (i.e., *Holt 1*, *CTB/McGraw-Hill*, *Glencoe*, and *Scholastic Workbook*) and nine different software programs with the most popular being ALEKS (38%, *n*=9) and Acuity (17%, *n*=4). In all cases, mathematics and special education teachers were credited with the development of non-purchased materials. All respondents (*n*=29) reported that teachers were involved in the selection of the algebra remediation program, model, and materials; slightly more than half indicated that school administrators were also involved in the selection process.

When asked how schools reached their decisions to use particular types of algebra remediation, the most commonly stated influences were: information gained from other schools (28%, *n*=5); input from mathematics teachers (22%, *n*=4); and content needed for success on the ECA (17%, n=3). Data results (31%, *n*=5) and research findings about best practices (31%, *n*=5) were reported as the most common rationales for the selection. Table 3 summarizes the survey results related to how schools determined which students needed and received algebra remediation. The vast majority of schools used ECA performance to determine whether or not a student needed or was required to participate in algebra remediation. Half of the schools surveyed also used students' course grades to inform their decisions.

Table 3

How do you determine which students need or receive algebra remediation? (Choose all that apply.)

Responses	Number of Responses (*n*=30)	Percent
ECA performance	28	93%
Course grade	15	50%
Placement test score	7	23%
Other	8	7%

The survey also included an open-ended question about the effectiveness of schools' algebra remediation and asked for evidence of their reported claims. Four themes emerged from the responses: (a) eight respondents (30%) reported an increase in test scores as evidence of the effectiveness of their remediation efforts; (b) five respondents (19%) stated that they could not report on the effectiveness of the remediation as it was too early to tell; (c) four respondents (15%) reported an increase in the scores of "re-testers;" and, (d) four respondents (15%) reported positive results from the addition of classes. Reports of measures for evaluating effectiveness included ECA scores (41%, *n*=19), success and improvements of "re-testers" (17%, *n*=8), teacher and student feedback (13%, *n*=6), and course grades and test scores (11%, *n*=5).

Of the 30 survey respondents, only 8 (27%) reported that they were considering alternative programs for algebra remediation. The reasons stated for this consideration included: "Many of our re-testers did not pass in 2012;" "Not satisfied with the current system of moving to Geometry after failing the ECA;" and, "Constantly reviewing and restructuring the curriculum to meet the needs of individual students." When asked if there was anything else respondents wanted to report about their algebra remediation, several (*n*=8) offered additional comments:

- "Our success is part teacher/instruction; part class-size; part 'educating' students for buy-in to the program."
- "It works well because of the teachers!"
- "Our remediation program was voluntary six years ago. Our school has embedded the remediation into the schedule to increase the opportunities for re-teaching and remediation."
- "The plan we had in the past was working very well for us. We are struggling to find a new solution and plan given the new course restrictions from the state and staffing on trimesters."

Discussion

Despite the admittedly limited results of this survey, which were due to lower response rates and a smaller sample size of participants than anticipated (including only one urban school), nearly all respondents reported that they offer their algebra content in an Algebra I course (i.e., few offer integrated courses) and use fairly traditional algebra textbooks. The lack of use of textbooks that align with NCTM's broad vision for high school algebra calls into question whether NCTM's vision is promoted and enacted in these classrooms. Sixty-eight percent of respondents reported ECA pass rates of at least 75%. Algebra remediation was most typically offered as extra course periods during the school day, and this remediation was always supervised by mathematics teachers and sometimes also by special education teachers. Schools often used textbooks and software technology during remediation, and these resources were, in all cases, teacher-selected. Administrators were also often involved in selecting these resources and programs. The primary driver for both the selection of the remediation programs and the measure of their efficacy was ECA scores. Because the aforementioned survey results regarding algebra remediation represent only 35 high schools in Indiana, it is not possible to draw generalizable conclusions. However, the survey provides some information about the state of algebra remediation in these schools and certainly begs further data collection and research due to the importance of algebra in terms of Indiana students' mathematical learning and potential for

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succeeding in higher-level mathematics courses, post-secondary education, and careers that require mathematical literacy or expertise.

In addition, many questions arise from these survey results and more general concerns about algebra learning. One such question is whether or not enough "proactive" strategies are in place along with the "reactive" algebra remediation efforts described here. What would such proactive strategies look like? Are schools utilizing extant research related to early algebra learning (e.g., Cai & Knuth, 2011; Kaput, Carraher, & Blanton, 2008; van den Heuvel-Panhuisen, Kolovou, & Robitzsch, 2013) to prepare K-8 students for future algebra experiences? Another question resulting from this survey is related to the ways in which algebra and algebra remediation are taught in Indiana schools. Given the types of textbooks used in the responding schools and the procedural focus of many of the remediation programs (e.g., ALEKS, Acuity), it seems that remediation often repeats "more of the same" instead of making efforts to develop algebraic habits of mind (e.g., Driscoll, 1999), engage students in reasoning and sense making related to algebra (e.g., NCTM, 2009), or provide opportunities for students to participate in algebraic modeling related to real-world problems (e.g., Lesh & Zawojewski, 2007). According to Finkelstein et al. (2012), it is unlikely that students will succeed in Algebra I the second time around if they are taught using similar pedagogical strategies. Finally, given that the ECA is a high-stakes assessment in which much is invested to help our students succeed, we need to ask ourselves questions about our philosophical stance on learning algebra. What do we want our students to know and be able to do when they leave our algebra classrooms—and why? We hope this study and its results serve as a starting point for these conversations and for collaborative efforts to provide opportunities for high school students to meaningfully engage in algebra.

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Technology Use of Novice Teachers in Mathematics Classrooms

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As pre-service teachers (PSTs) transition from collegiate coursework to their student teaching assignment to their first year of teaching, dreams of making a difference in young students' lives become a reality. This transition period, however, can be overwhelming as teachers attempt to build productive relationships with their students. Finding solutions to ease this transition would not only improve the quality of life for new teachers, but also improve the quality of instruction for their students. One tool that can support this transition is the effective use of technology during lessons. Technology is changing every profession by improving work conditions and production. In education, technology has the potential to change low-level cognitive demand tasks to high-level tasks if student reasoning is emphasized (Smith & Stein, 1998). Technology has the capacity to allow students to take on roles in the classroom that were once exclusively the domain of the teachers (Zbiek & Hollebrands, 2008); it has also altered the conceptual landscape of modeling (Kaput, 1998). The question, however, is not whether technology is important within the classroom but rather how technology can support teachers in delivering highly-effective classroom instruction.

Pertinent Literature

Numerous research studies have explored how teachers have incorporated technology in the classroom in recent years. Lee (2005) claimed it is hard for prospective teachers to monitor students' problem solving skills while using technological tools. Because prospective teachers are new to theories regarding students' understandings and are just beginning to understand how to behave as teachers, they struggle to coordinate the two efficiently.

Technology use has been researched in methods courses as well. Meagher, Özgün-Koca, and Edwards (2011) developed a mathematics methods course with an emphasis on technology that required PSTs to utilize technology in middle and high school field experiences. Their research concluded that even though methods courses prepared PSTs for technology use during their teaching, PSTs still needed practice using technology in order to be convinced that they could implement it effectively during instruction. The direction of recent research has focused on teachers' Technological Pedagogical Content Knowledge, or TPACK (Koehler & Mishra, 2009). The research community has documented that teachers need more than just content knowledge to effectively engage in the work of a professional educator. TPACK research aims to understand the interplay among knowledge of technology, knowledge of pedagogy, and knowledge of content. Wang and colleagues (2013) suggested that methods courses have the potential to play a critical role in PSTs' development of TPACK. Therefore, teacher preparation programs need to consider the impact their courses can have on the development of all three types of knowledge and on the intersections of these types of knowledge.

Heid and Blume's research on technology in classrooms concluded, "Technology does not act alone in producing an effect on teaching and learning. Such effects are the result of a range of configurations of technologies, teachers and learners, curriculum, mathematical activity, mathematical thinking, and other aspects of teaching-learning settings" (2008, p. 429). Among these aspects that affect students' success at any grade level, we believe teachers play a vital role. As Wilson stated, "It is teachers who will make the difference between success and failure, and it is teacher education that must serve as a major conduit that connects teachers with new technologies, research, curricula, and policies" (2008, p. 415). Therefore, we decided to investigate the relationship between student teachers (STs) and technology using Dick and Hollebrands' classification of technology use in mathematics education.

Two Main Technological Classifications

Dick and Hollebrands (2011) classified two different types of technology in mathematics education: conveyance technologies and mathematical action technologies. Conveyance technologies are used to transmit information without mathematical interaction while mathematical action technologies enable users to perform mathematical actions such as calculations, graphing, and explorations. Both types of technology are important to achieving target learning goals. Conveyance technologies include many tools such as *PowerPoint* while mathematical action technologies include software programs such as *GeoGebra* or *TinkerPlots* that require users to dynamically interact with mathematical material. Whether a specific technology might be used more often as a conveyance technology or a mathematical action technology does not imply it should be placed into either particular category. Rather, *how* it is used during a specific classroom activity determines its classification.

Research Questions

Understanding how student teachers incorporate technology in the classroom may provide insight into how to improve the field of teacher education. Training PSTs to incorporate both conveyance and mathematical action technology is a particularly important aspect of teacher preparation that has the potential to improve the mathematical instruction of their future students. Therefore, we developed the following research questions focused on understanding the relationship between elementary education STs and technology:

- What types of technology do student teachers utilize during mathematics lessons?
- How do student teachers utilize technology during mathematics lessons? Do they use technology in a conveyance manner or mathematical action manner?

Methodology

Kay's (2006) review of literature regarding mathematical technology research provided evidence that teachers' use of technology has been studied in a variety of qualitative and quantitative ways. For this research study, we used an exploratory approach that relied on observation data gathered in a previous project. Upon analyzing this data, we found empirical evidence surrounding elementary education STs' use of technology in mathematics instruction.

Data Sources

The Iterative Model Building (IMB) project was funded by a grant from the National Science Foundation that focused on revising elementary teachers' pre-service field experiences. The IMB project used an experimental approach, investigating the effectiveness of a pre-service field-based course in which student thinking was foregrounded in both small group interviews and whole-class teaching. During the second phase of the IMB project, two researchers observed 79 STs implementing mathematics lessons. The STs were observed teaching mathematics two times during their student teaching experiences, thus providing 158 lessons of data. Of these 158 lessons, 146 lesson observation protocols were completed that included many different questions and scales to assist with analysis of each lesson. The observers rated each protocol on a scale from 1 to 5; two statements on the lesson protocol were:

- I.A.5 The design of the lesson incorporated appropriate tools such as technology, manipulatives, and measurement tools.
- I.A.6 Presents concepts using a variety of representations such as models, pictures, tables, and graphs.

Ratings on these two items provided a starting point to understanding trends in elementary STs' relationships with technology. Additionally, the researchers analyzed each observer's lesson observation protocol summary for information on use of specific technologies. This data source allowed the researchers to gather specifics on whether ratings on items I.A.5 and I.A.6 were linked to technology (e.g., a computer) or manipulatives (e.g., unifix cubes). Pertinent information was recorded about each ST.

Another source of data was the set of observers' field notes describing different aspects of each lesson. The researchers analyzed field notes from both observers in order to not only confirm types of technology mentioned on lesson observation protocols but to also understand how those types of technology were being used by STs – as either conveyance technology or mathematical action technology. For example, if STs used interactive whiteboards merely as a projector of material, it would be classified as a conveyance technology. Field notes often provided important details describing how STs used technology. Together, protocol items and field notes provided the foundation for understanding STs' use of technology in the classroom.

Results

The collected data showed that 42 of 79 participating elementary STs (53%) used technology during their mathematics instruction. Of the 146 lessons rated on lesson observation protocols, 68 lessons (47%) used some sort of technology (not just a manipulative or additional tool). The types of technology used in these lessons were interactive whiteboards, visual presenters, the Internet, videos, tablets, and electronic flash card devices.

Interactive Whiteboards

Eighteen STs used interactive whiteboards (usually Smart boards) in 27 lessons. Observation protocols reported that 12 STs used interactive whiteboards as a blackboard to write down information such as the date, some mathematical vocabulary, and solutions to questions. They also used interactive whiteboards to show a video during instruction and also as a formative assessment tool to work through daily math problems or quiz solutions.

Visual Presenters

Visual presenters were the most widely-used type of technology in classrooms; observation protocols showed that 26 STs used visual presenters during 37 lessons. STs used visual presenters to display material through a document camera, overhead projector, or a stagnant computer display. Visual presenters were used to project a worksheet or "Daily Math Review" on a projection screen, and to display manipulatives such as money or rulers as aides to help solve problems. Elementary students also volunteered to physically work on questions using the visual projector in front of the class. STs used them also as a lecture aide to write problems on transparencies and work through problems in front of classes. For example, one ST used a visual presenter to show a round-clock on transparency and explain how to calculate time. Computers with a projector were used as a visual presenter to display a worksheet from the digital resources of textbook publishers. Visual presenters were also used as a formative assessment tool by displaying student work on the board and asking students to explain their work to the class.

The Internet

We found that STs would have to use another technology, such as a desktop computer or iPad, to view Internet resources. However, the Internet played a different technological role in lessons because of the versatility of online resources. Student teachers used the Internet to provide students with opportunities to play online math games and also as a lesson workstation. They used online quizzes as a formative assessment tool. Elementary students also used online textbook resources to check answers to questions.

Videos

Our results revealed that 13 STs used videos during their instruction. Some videos supplemented instruction by showing examples of different kinds of geometric shapes or showing multiplication problem procedures. The use of videos often utilized interactive whiteboards or desktop computers, but the moving delivery of images distinguished videos as a separate group of technology.

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Tablets

Tablets were combined with iPads and electronic flashcard devices as individualized technology. Only three STs used tablets in three lessons possibly because school corporations are only beginning to access tablet technology and promote student tablet use in the classroom. Tablets allow students to each carry their own piece of technology, providing an easier avenue for schools to execute one-to-one initiatives where every student has one laptop or tablet (Dunleavy et al., 2007). An instance of tablet use involved elementary students practicing addition and subtraction on electronic flashcards in a procedural manner. Another observation protocol indicated that elementary students used tablets as calculators.

We focused on the five types of technology explained above to analyze the manner in which STs used technology during lessons. The table below lists the total number of STs and lessons for each category.

Table 1

Summary of types of technology used by STs.

	Interactive White-boards	Visual Presenters	Internet	Videos	Tablets
Number of Student Teachers (n=79)	18	26	5	13	3
Number of Lessons (n=148)	27	37	9	16	3

From the above table, one might notice that the numbers for the types of technology do not precisely add up to the totals given at the beginning of this section. Totals vary because some STs who used technology in their lessons may have used more than one type of technology. For example, one ST used a Smart board, video, and computer during the same lesson for different purposes.

The table shows that 18 STs used interactive whiteboards in a total of 27 lessons. According to observers' notes, only two STs actually used interactive whiteboards *interactively* with their students in two lessons. In one of these lessons, a ST asked students to paint numbers on the screen based on information given about them being even or odd. When we looked at field notes and observation protocols again along with lesson plans, the data suggested that this lesson was an active way of using an interactive whiteboard to help students learn about even and odd numbers. The table also shows that 26 STs used visual presenters in 37 of the lessons. According to field notes, only in ten lessons did STs use visual projectors interactively by writing on the device or highlighting some part of information being shown to the class. This suggests that STs used visual presenters mainly as a conveyance technology.

In cases where STs used the Internet, videos, or tablets, details given in observation protocols or field notes were not enough to determine if the technology was used as mathematical action technology. For example, one lesson had STs asking students questions, trying to enhance instruction with a video. Although this video discussion involved more interaction than just showing a video, the interaction was not directly between students and technology.

Conclusions

Our data provided enough evidence to answer our two initial research questions. The first research question asked, "What were the different types of technology used by STs?" Five types of technology emerged from our research: interactive whiteboards, visual presenters, the Internet, videos, and tablets. The variety of technology types suggests that teachers are exposed to a variety of resources depending on their schools; therefore, training PSTs for a variety of technologies should be considered during PST coursework. With 53% of STs using some type of technology during lessons, university educators should consider increasing technologically- driven assignments in classes that expose PSTs to a wide range of technological resources.

In answering our second research question concerning whether more conveyance or mathematical action types of technologies were used in the classroom, our data suggests that STs used technology almost exclusively in a conveyance manner during mathematics lessons. We have considered that lesson observation protocols did not specifically ask observers to analyze how STs used technology during lessons. However, after a thorough analysis of observation protocols, field notes, and interview transcripts, we found no instances of mathematical action technology use. This lack of mathematical action technology in STs' lessons is particularly concerning due to the capabilities technology has for students to learn mathematical ideas in a dynamic manner.

When reviewing these results, however, we must consider that many different factors impact technology use in the classroom (Heid & Blume, 2008). The availability of different kinds of technologies may be limited in some of these particular STs' classrooms. If STs did not have access to technological resources, criticism directed towards their lack of technological use is not only overly critical but unfair. Our data sources did not provide information regarding whether STs chose *not* to use readily available technology; so, researching STs' motivation for using technology was not possible. However, the lack of mathematical action technology use does provide evidence that there exists a gap in providing our students with mathematically dynamic experiences.

Suggestions

Understanding the deficiency in STs' technological use is only important if our actions change in the future. We have compiled a handful of suggestions for mathematics educators to consider implementing in order to improve STs' technology use. Although these suggestions may not be innovative, they bear repeating as change often takes long periods of time.

1. Mathematics teacher educators should consider introducing conveyance and mathematical action technology types into classroom discussions and also highlight the power of each technology. The NCTM standards state that "technology should not be used as a replacement for basic understandings and intuitions" (2000, p. 25). Therefore, teacher education programs should ensure that PSTs understand how technology should be used to provide advanced perspectives to students' understandings and to create innovative opportunities for both the learning and teaching of mathematics. As Lei (2009) suggested, exposing PSTs to a rich variety of technologies can help them see its role in teaching and learning. This exposure can guide PSTs as they begin implementing technology into their classroom instruction (Lee, 2005).

2. Teacher education programs need to prepare PSTs to use technology for more than individual needs (Lei, 2009) and prepare them with skills to overcome the complexities of using technology in a constructive way (Wilson, 2008). Teacher educators should consider building technological awareness assignments into the design of education degree programs, particularly during mathematics education coursework. Assignments where PSTs use technology in a mathematically active manner can make a significant difference in teacher preparation.

3. K-12 practicing teachers should consider mentoring STs to utilize technology in the classroom and build lessons that require the integration of technology. Meagher and colleagues (2011) found that PSTs whose practicing classroom teachers used technology and who were exposed to technologically-rich environments during field experiences were more inclined towards using technology in their instruction.

4. Complementary to suggestion three, field experiences should inquire about available classroom technology and attempt to place PSTs in environments that have access to both technology and practicing teachers who are already or willing to use technology. Although teachers do not always have access to dynamic technologies, advocating for schools to purchase and utilize technology to improve instruction can impact STs' long-term technology use. PSTs who have minimal or no access to technology in their field experiences often have a negative approach to using technology while teaching and learning mathematics (Meagher et al., 2011).

There are many different reasons contributing to STs' limited use of technology during mathematics lessons. Despite these reasons, technology has been shown to provide valuable mathematical insights for students when implemented as mathematical action technology. Perhaps Zbiek and Hollebrands said it best when describing the importance of incorporating technology in the classroom: "If we give teachers mathematical technology as nets, but provide no personal learning experiences and no support, we should not be surprised when they prefer to continue to catch their mathematical and pedagogical fish by hand" (2008, p. 338).

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