Implementation of Technology in an Elementary Mathematics Lesson: The Experiences of Pre-Service Teachers at One University

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This study examined pre-service teachers' responses to implementing technology into elementary mathematics lessons. Instructional Architect (IA) was the web-base technology used by the pre-service teachers. Four themes emerged from the data: (a) insights into technology, (b) struggles with technology, (c) access to the mathematics and (d) learning communities. Pre-service teachers reported both positive and negative experiences with technology in the classroom. This study provides a better understanding of how pre-service teachers think about using technology in a mathematics lesson which can help to inform teacher education programs on how to support technology integration in elementary mathematics.

The ability to integrate technology in the mathematics classroom is essential for future elementary teachers as they enter the field being required to be able to prepare students for a technologically advanced society. "How teachers learned subject matter is not necessarily the way their student will need to be taught in the 21st century" (Niess, 2005, p. 509). When examining the use of technology in education, the idea of how teachers learn is important for teacher education programs to consider. The National Council of Teachers of Mathematics (NCTM) technology principle states, "Technology is essential in teaching and learning mathematics; it influences mathematics that is taught and enhances students' learning" (NCTM, 2000, p. 24). Teacher education programs need to find ways to provide future educators plenty of opportunities to use and integrate technology in mathematics teaching prior to entrance into the field (American Council of Education, 1999).

Teacher education programs have a duty to prepare future teachers to effectively use technology in mathematics instruction. The NCTM Position Paper on Technology (2003) states, "Mathematics teacher preparation programs must insure all mathematics teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the teaching and learning of mathematics" (p. 2). While NCTM makes recommendations about technology preparation, Smith and Shotsberger's (2001) work revealed that most pre-service teachers do not feel prepared to teach mathematics using technology. Similarly, Carson and Gooden (1999) reported that many pre-service teachers feel that they are not prepared to teach using technology after they graduate. "To counter this reported lack of preparation, teacher educators must study and examine models of effective technology integration in teacher education

programs" (Timmerman 2004, p. 410). Building upon Timmerman's suggestion, this study examined pre-service teachers' responses to the implementation of Instructional Architect (IA), a free online software tool created in the Department of Technology at Utah State University in their field placement during the math methods semester.

Instructional Architect

The main reason for examining the IA was the ease of the technology. Instructional Architect (fig 1.) allows teachers to do several things. First, pre-service teachers can find high-quality resources that are relevant and applicable to their students. Second, pre-service teachers can quickly and easily create web pages that provide instructions for each on-line activity (fig. 2). Basic technology skills such as copy and paste are all a pre-service teacher needs to make an IA project. Next, Utah State houses the web pages for the pre-service teachers; therefore, they don't have to worry about storing the web pages on the classroom computers, and they can access the IA from any computer. Lastly, pre-service teachers have a log-in that is specifically for their students. Once logged-in the students are taken directly to the webpage created by their teacher (fig. 3). There is no need to spend time typing in long and cumbersome website addresses. When a student is on the IA home page for their teacher, all they need to do is read the instructions, click on the links, and work at their own pace.

The Assignment

This assignment was given to pre-service teachers in the math methods course during the 2007-2008 school year. This course is in the second semester of the elementary teacher education program. There are two more semesters of coursework that are needed to complete the teacher certification program at this university. Pre-service teachers were given the assignment to teach a math lesson using the IA. Each student was required to make an IA project for the five mathematics content standards (numbers and operation, geometry, algebra, data analysis/ probability, and measurement) for the grade level for which they were working in their field placement. Students picked one IA project from the five that they created to include in their mathematics lesson. Once students had taught their mathematics lesson with the IA project, they wrote a reflection paper that answered the three following questions: (1) How did you feel about the overall experience of implementing technology into a mathematics lesson? (2) What did you learn as you implemented a math lesson with technology? (3) How can you use technology, such as IA, in your future mathematics teaching?

Methods

This qualitative study collected data from two semesters of math methods courses. There were 125 pre-service teachers' reflection papers from the two semesters of courses that were analyzed for common themes. The emerging themes from the data were (a) insights into technology, (b) struggles with technology, (c) access to the mathematics, and (d) learning communities. These four themes describe the pre-service teachers' experiences with implementing technology in a mathematics lesson. Many of the students had similar responses, sentiments, and experiences with this assignment. The analysis of this data provides insight to how this group of pre-service teachers felt about the implementation of technology in mathematics lesson.

Insights into Technology

The first theme that emerged from the pre-service teachers' responses was their insights to working with technology in the classroom. During the university class when the pre-service teachers learned how to create the IA projects, it was evident that all of the pre-service teachers were very familiar with the internet and how

to use it. One pre-service teacher explained, "This assignment made me realize how much the internet can be useful for teachers and students. There are a lot of great resources for teaching math that I didn't realize were out there until I did this project." These feelings about the internet were reported by many students. They were amazed how the internet could be used for teaching. "I found myself, many times, playing the math games on the websites and completely enjoying it. Who would have thought that I would have had so much fun in creating an assignment for class?" stated one pre-service teacher. The realization of how the internet can be a useful tool to pre-service teachers appeared in the data multiple times.

Beyond the internet, pre-service teachers wrote about how technology can be beneficial for mathematics learning. "Technology can be used as a valuable tool in reinforcing math lesson," stated one pre-service teacher. By understanding the amount of resources available for teaching mathematics and that these resources can reinforce classroom mathematics instruction, pre-service teachers are on the road to building pedagogical understanding of mathematics in the elementary classroom.

Struggles with Technology

The second theme that was present in the pre-service teachers' responses was their struggles with technology. Many pre-service teachers reported that they were surprise at the technology available in the schools. The pre-service teachers admitted to having a certain expectation level of technology that would be available for them to use in a mathematics lesson. For some, it was a real shock. "I have learned to not fully rely on technology and always have a backup because things happen with technology in classrooms. This is a hard concept for my generation to understand because we have grown up using computers, playing videogames, and now we can do it all on our cell phones. We have technology everywhere in our lives," stated one pre-service teacher. This explanation is important for those who work in teacher education programs. Many of pre-service teachers have assumptions about technology based on their life experiences.

The assumptions about school technology were supported by another pre-service teacher who stated, "As the students began to get online, I immediately noticed that because so many students were using the internet at the same time, it took a very long time for the pages to load. I didn't realize that the computers at the school were going to be so slow." The struggle with technology was further supported by another pre-service teacher who wrote, "Because of the numerous filters on school computers, many of the links did not work. I did not realize that the school district had so many filters that blocked educational links." The difficulties with school district filters and speed of the internet was reported by many pre-service teachers. The implementation of technology was not as easy as some of the pre-service teachers thought it would be.

While many of the pre-service teachers reported difficulty with the technologies available in the schools and classrooms, there some pre-service teachers that discussed their students' technology skills. "I was surprised that some of the students lack basic technology skills such as using the mouse. I just thought all kids knew how to use a computer. I learned quickly that is not the case" wrote one pre-service teacher. The pre-service teachers' struggles with technology appear to be based on their assumptions about the technology in schools, as well as students' technological ability levels. The pre-service teachers in current education programs have grown up with technology at their finger tips, and this has influenced their perceptions of technology in schools.

Access to the Mathematics

The third theme that emerged from the data was that technology can help provide access to the mathematics that is being taught in the classroom. One pre-service teacher in a first grade reported, "It was nice having both simple and more complex pattern activities because the students could choose to work with whichever one they were more comfortable with. It allowed the lowest and highest students to learn similar things and both are highly motivated." The understanding that technology can be an avenue to provide access to all students in the mathematics classroom helps pre-service teachers to build their mathematics pedagogy.

Other pre-service teachers describe how technology provides access to mathematics in a pedagogical sense. The following description of one pre-service teacher's experience demonstrates her shifting thinking about the use of technology in mathematics instruction.

> The math instruction in my third grade class is very traditional and they "don't get to use technology as they learn." As she was teaching her math lesson using technology, she noticed that the students were engaged, discussing mathematics, and able to discuss the following day what they had learning during her lesson. "I was very surprised by the students' recall of my lesson. When I asked them what was different, one boy replied, "the computer helped me to understand what you were saying." I now understand how technology can be an instructional strategy.

Other pre-service teachers had similar experiences and shifts in their thinking about the use of technology in math lesson. Another pre-service teacher stated, "Not only did using IA bring a change of attitude in the kids; it brought a change of attitude towards my methods of teaching mathematics." Beginning to think about technology in terms of pedagogy is important for pre-service teachers as they face teaching in an ever changing technological society.

Under this umbrella of providing access to mathematics for students, some of the pre-service teachers discussed technology as a manipulative. "I have always thought manipulatives were most important in math, and now I have learned and experienced a new way of using manipulatives. Virtual manipulatives allow the students to broaden their thinking by using a concrete concept of learning. While I was observing the students, I noticed many of them making real life connections and relating back to prior knowledge. This shows me manipulatives like IA web pages and other virtual manipulatives, really work." This is an interesting, yet important way of viewing technology in mathematics instruction.

Learning Communities

The development of learning communities related to the implementation of technology was the final theme that came from the pre-service teacher data. In many of the classrooms students are expected to discuss their mathematical thinking. One pre-service teacher describes the learning environment in her second grade classroom.

> After students record the answer to their work problem in their math journals, they meet on the rug to discuss their answers and how they solved the problem. I like this because it allows other students to see different ways of solving a math problem. With IA activity, students not only shared what they learned with each other, but they did it without being guided to do so.

This pre-service teacher was not alone in her reporting of students engaging in on-task discussions about mathematics. Another pre-service teacher observed that when the students worked on the IA projects, "they talked with the

person next to them and had good conversations pertaining to the material that they were learning." Getting children to discuss their mathematical thinking is not an easy task. The use of technology is another method for engaging in learning. "As students were working on the IA project they were able to interact with each other and with myself, and I felt like they were really learning" reported a pre-service teacher who was in a fourth grade classroom. Developing a mathematical learning community can be a very daunting task, especially for novice teachers. It seems that for some of the pre-service teachers that the implementation of technology into a mathematics lesson was an impetus for mathematical discussions.

Discussion

The implementation of technology into a mathematics lesson can be an intimidating task for many teachers. The pre-service teachers in this study had a wide variety of experiences with this assignment. The key themes the pre-service teachers discussed in their reflections were insights into technology, struggles with technology, access to mathematics, and learning communities. These themes have important implications for teacher education programs. The pre-service teachers insights into technology were really "ah-ha" moments for these future educators. Timmerman states, "prospective teachers need course experiences that incorporate educational technology for classroom teaching in meaningful ways" (2004, p. 410). For the pre-service teachers in this study found the implementing of the IA projects was meaningful in both positive and negative ways. Since these pre-service teachers were early in their teacher education program, it is promising that they have these realizations about technology and what is available to them as educators.

One of the most important finding in this study was the pre-service teachers' struggles with technology in the classroom. Research tells that pre-service teachers don't feel prepared to use technology in their mathematics teaching (Carlson & Gooden, 1999; Smith & Shotsberger, 2000). These pre-service teachers reported having assumptions about the technology in classrooms. They expected a fast, high-quality technology and were surprised when the technology in their field placement was not what they expected. So the question arises: Do pre-service teachers feel unprepared because of the assumptions they have about the availability of technology in schools or do pre-service teachers feel unprepared to teach mathematics using technology because of the comfort level with technology? The responses from the pre-service teachers in this study suggest that research needs to investigate further about the assumptions pre-service teachers have about technology and how these assumptions impact the implementation of technology in the classroom.

As a math educator, it was very interesting how many of the pre-service teachers viewed technology as a one way to provide access to mathematics learning. The understanding that technology can be a vehicle for gaining entry into mathematical learning is important because pre-service teachers are developing their mathematics pedagogy. "An effective way to prepare pre-service teachers to use technology in mathematics is to prepare them to utilize technology for student use as a tool" (Kurz, Middleton, Yanik, 2003, p.313). The implementation of IA in a mathematics lesson provides the type of learning experience described by Kurz et al. Building on the idea that technology is another strategy to help students have access to mathematical concepts; the pre-service teachers gained a broader understanding of instructional strategies that are available in the mathematics classroom.

The development of mathematics learning communities using technology as a catalyst for discussion was a surprise in the data. Using Pirie and Schwarzenberger's definition of discourse, "purposeful talk on a mathematics subject in which there

are genuine contributions and interactions" (1988, p. 460) some of the pre-service teachers in this study had firsthand experience of mathematical discourse come to life in their lessons. The integration of technology into a mathematics lesson allowed for some of the pre-service teachers to see how discourse can happen in the math classroom.

While this assignment is only the beginning of the pre-service teachers' understanding of the implications of technology use in the mathematics classroom, overall it was a learning experience, either positive or negative, for all of the pre-service teachers. "Computers are essential tools for teaching, learning, and doing mathematics" (NCTM, 2000, p.24). Teacher education programs need to examine methods that allow for elementary pre-service teachers to gain the knowledge necessary for implementing technology into the mathematics classroom. The Instructional Architect assignment examined one method of technology integration in mathematics, although future research needs to be done to examine more methods of technology integration. This is just the beginning for teacher education programs to understand what is necessary to provide future teachers with the skills for strong technology implementation in the elementary mathematics classroom.

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Author's Note

Dr. Julie Herron, assistant professor, teaches elementary math methods at the University of Alabama. Her research interests include the use of technology in math methods courses and early childhood mathematics.

Figures

Figure 1. Instructional Architect Homepage.

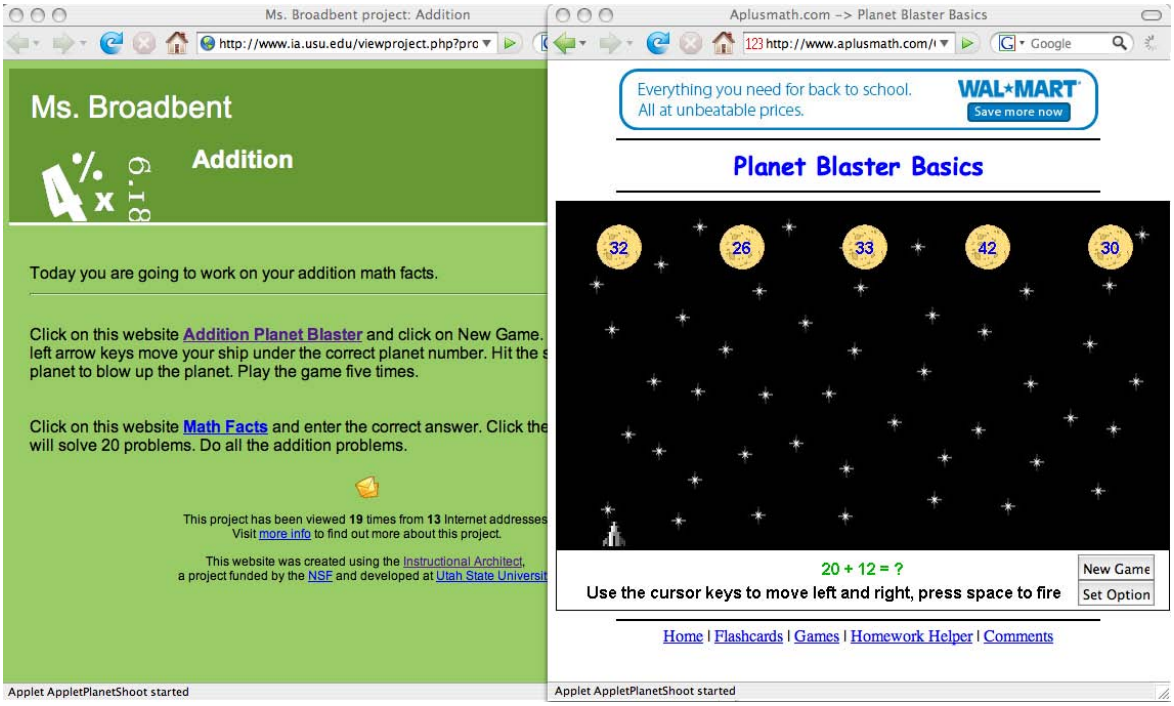

Figure 2. IA project for second grade addition practice.

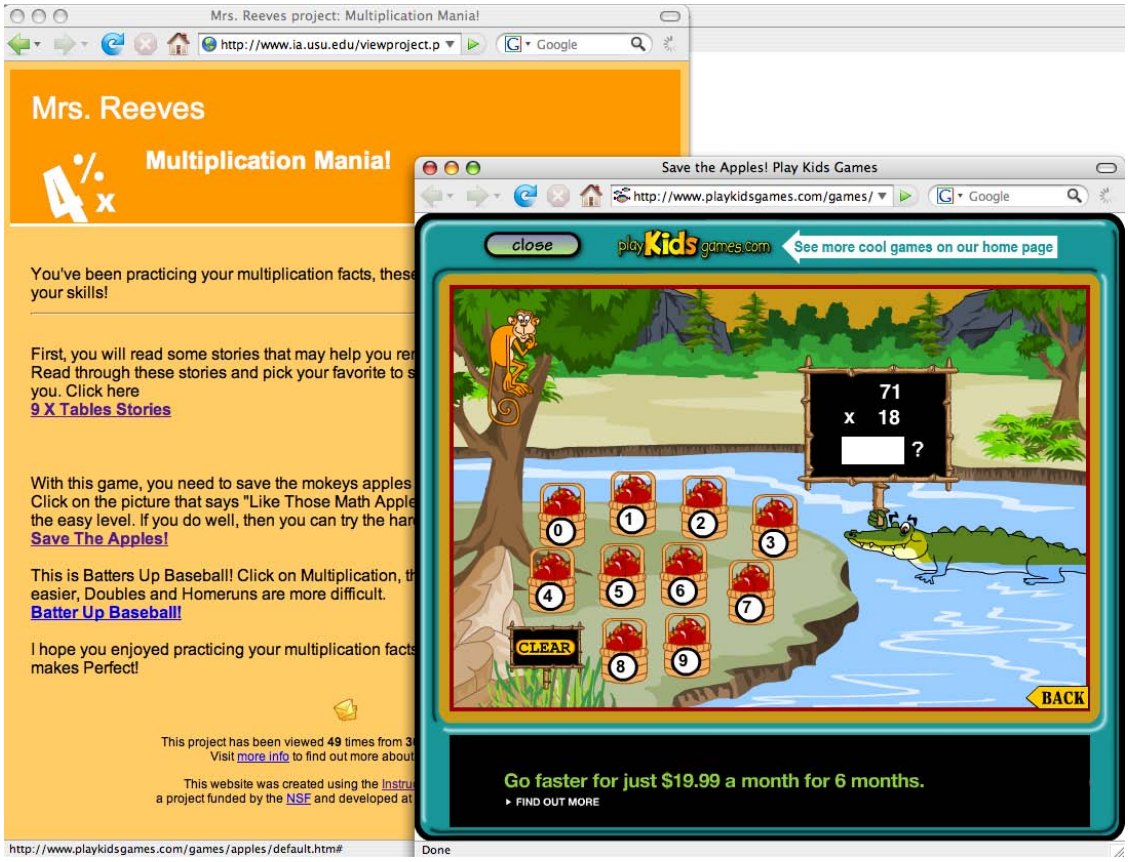

Figure 3. IA page for fourth grade multiplication game