

INTEGRATING TECHNOLOGY INTO THE MATHEMATICS CLASSROOM: THE ROLE OF TEACHER PREPARATION PROGRAMS

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Today's technology standards (International Society for Technology in Education, 2000) challenge teacher education programs across the nation to address the need to produce computer literate teachers who are confident in their ability to choose and incorporate instructional technology into their classroom teaching. The purpose of this paper is to present a description and analysis of the effects of training sessions on pre-service teachers' ability to evaluate and integrate instructional technology into the mathematics classroom. A group of 70 pre-service teachers participated in training sessions where they evaluated the features of various Pre K-12 mathematics instructional software and websites, and designed technology-based mathematics lessons. The training sessions promoted the pre-service teachers' awareness of, appreciation for, and confidence in their ability to analyze, select, and craft technology-based mathematics lessons.

Today's technology standards (ISTE, 2000) challenge teacher education programs across the nation to address the need to produce computer literate teachers who are confident in their ability to choose and incorporate instructional technology into their classroom teaching. For this reason, it is crucial for teacher educators to share effective ways to prepare pre-service teachers to be able to incorporate technology into their future classrooms. This paper presents a model of how teacher educators can be catalysts in producing teachers who are prepared to integrate technology into the mathematics classroom and suggests directions for future research in this area.

Literature Review

Wenglinsky (1998) used data from the 1996 National Assessment of Educational Progress (NAEP) in Mathematics to study the effects of teachers' use of instructional technology on student achievement in mathematics. Findings revealed that when appropriately used, computers may serve to improve student mathematics achievement as well as enhance the overall learning environment of the school. Teachers who received training in the area of instructional technology were found more likely than those who had not to use computers in effective ways such as in simulations, applications, and math learning games. Wenglinsky (2000) also used the 1996 NAEP

data to show the positive effects of using instructional technology to nurture higher order thinking skills in the mathematics classroom.

Unfortunately, Lederman and Neiss (2000) report that technology courses which are part of teacher preparation programs often emphasize pre-service teachers' learning about technology rather than the integration of technology into classroom teaching. The need for teacher preparation programs to serve as catalysts for the integration of technology into classroom instruction is vital. Abilities, knowledge, and skills in teaching with technology need to be emphasized in the preparation of teachers so that they can make informed decisions about which technology to use for specific teaching purposes.

Linking technology with curriculum has caused significant changes in teaching and learning. Wright (1999) reports higher student achievement, self-concept, attitude, and teacher-student interaction as a result of interactive learning made possible via technology. Kerrigan (2002) has found the benefits of using mathematics software and websites to include promoting students' higher-order thinking skills, developing and maintaining their computational skills, introducing them to collection and analysis of data, facilitating their algebraic and geometric thinking, and showing them the role of mathematics in an interdisciplinary setting. As a result of such research, Neiss (2001) reports the National Council of Teachers of Mathematics pinpoints technology as an essential component of the Pre K-12 mathematics learning environment, influencing the mathematics that is taught as well as enhancing students' learning.

Despite these results and growing access to technology, Kent (2001) reports the U.S. Department

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of Education estimates that only 20% of all public school teachers feel comfortable using technology in the classroom. Of these teachers, 99% have access to computers and the internet somewhere in their schools. However, only 39% reported frequent use of computers or the internet to create instructional materials; 34% used them for record-keeping; and less than 10% used them to access lesson plans, do research, or investigate best practices.

Today's technology standards (ISTE, 2000) challenge teacher education programs across the nation to address the need to produce computer literate teachers who are not just knowledgeable of the internet, word processing programs, spreadsheets, and presentation software, but are also confident in their ability to incorporate instructional software and websites into everyday classroom teaching. Cesarone (2000) reports the National Council for Accreditation of Teacher Education Task Force has recommended more effective uses of technology in teacher education programs, and Halpin (1999) urges teacher educators to determine effective ways to prepare pre-service teachers to integrate technology appropriately into classroom instruction.

Teachers' ability to select appropriate software and websites is an essential component of the ultimate success of effectively integrating instructional technologies into classroom teaching. Ertmer, Addison, Lane, Ross, and Woods (1999) state that "teachers, not technology, hold the key to achieving integrated technology use," while Haughland (2000) states that how computers are used is more important than if computers are used.

The research literature causes one to reflect on the powerful influence that instructional technology might have on teaching and learning if utilized properly. Although research has suggested that the use of technology can improve student achievement and self efficacy, many reports demonstrate that teachers use computers minimally and many are unprepared to integrate technology into their classrooms. One way to prepare teachers to integrate technology into their classrooms is for teacher educators to work with teachers to improve their understanding of, and ability to utilize, technology in meaningful ways in the classroom. This paper describes work done with pre-service teachers that seeks to address precisely how it is that teacher educators can work towards addressing this need.

A group of 70 pre-service teachers participated in training sessions in which they evaluated the features of various PreK-12 mathematics instructional software

and websites and designed technology-based mathematics lessons tailored to the content they anticipated teaching. The training sessions were integrated into a required course of the teacher education program that focused on technology in the school, community, and workplace. The pre-service teachers were undergraduate students in their second year of study and were registered in one of four course sections taught by the same professor.

The sessions attempted to broaden pre-service teachers' knowledge about, and strengthen their ability to select, software and websites for specific uses in the mathematics classroom. Through active participation in collaborative activities involving the development of technology-based lessons, the training sessions also sought to improve the pre-service teachers' confidence levels as practitioners of technology-based instruction. Descriptions of the training sessions as well as the pre-service teachers' reactions to them are shared to broaden the knowledge base and serve as a step towards specifically guiding the ways teacher educators prepare their pre-service and in-service teachers for today's technology-based mathematics classrooms.

Initial Assessment

An initial assessment was conducted to guide the design of the training sessions. The pre-service teachers completed a questionnaire about their previous experience with instructional technology and their self-confidence in reviewing and integrating software and websites into the teaching of mathematics. They were asked to supply the specific software titles and websites they had previously used at school, home, and/or work, along with an explanation of how and for what purposes the software and websites were used. Interviews with all of the pre-service teachers were also conducted. These interviews allowed participants to speak candidly about their written responses and allowed the interviewer to form a deeper understanding of the pre-service teachers' comments.

The initial assessment indicated that 91% of the pre-service teachers had used Word Perfect or Word for typing research papers, 43% had designed presentations with PowerPoint, 33% had created spreadsheets with Excel, and 96% of the pre-service teachers had used the internet mainly for the purpose of e-mail. The assessment also showed only 30% of the pre-service teachers had used software for instructional purposes. Of this 30%, 9% used it at home for standardized test preparation. 4% of the pre-service

teachers had used reading and math readiness software with children, ages 4-6, in an after-school program. 17% of the pre-service teachers used software when they were students in school, but only 3% had used it regularly in either science or math classes. The remaining ten reported sporadic use of software that did not relate to classroom topics.

All of the pre-service teachers felt insecure about their ability to review mathematics software and websites. Their comments revealed they “would not know where to begin” if asked to select instructional technology or to design a technology-based lesson for the mathematics classroom. A common misperception was software and websites used in classrooms contained only games that students could play once content was mastered.

Training Sessions

The pre-service teachers participated in training sessions (see Table 1) involving the review and

integration of software and websites into the teaching of mathematics. The training sessions allowed the instructor to prepare the pre-service teachers to enter their future mathematics classrooms not only knowledgeable about the capabilities of instructional technology, but also experienced enough to confidently review and appropriately integrate their selected software and websites into classroom teaching. The training sessions required the pre-service teachers to collaborate and actively engage in using the skills they were learning. The rationale for such a feature stemmed from human development theorist Lev Vygotsky who emphasized “the importance of social relations in all forms of complex mental activity” (p.10), and other constructivist advocates who stress that teachers can most effectively acquire new knowledge through collaboration with other teachers and teacher educators (Prawat, 1993).

Table 1

Training Sessions

Training Session Type	Description	Length
Introductory Sessions	Provided pre-service teachers with demonstrations of instructional technology leading to discussions concerning its use in the mathematics classroom and development of a set of evaluation criteria.	Three 1-hour sessions
Guided Evaluation Sessions	Provided pre-service teachers with the opportunity to evaluate instructional technology and acquire insights from one another by sharing findings and opinions.	Three 1-hour sessions
Paired-Learning Sessions	Provided pre-service teachers with the opportunity to collaborate and actively participate in the instructional technology evaluation process.	Three 1-hour sessions
Lesson Planning Sessions	Provided pre-service teachers with the opportunity to use newly acquired skills to appropriately select and integrate technology into classroom mathematics lessons.	Two 1-hour sessions

Introductory Sessions

The training sessions began with three 1-hour whole group instructional class periods that involved the professor demonstrating a piece of mathematics software and a mathematics website for the elementary (Pre-K-5), middle (6-8), and secondary (9-12) school levels. The professor guided discussion and posed questions so that the pre-service teachers could share their thoughts about the characteristics of the instructional technology, determine the purpose

(conceptual development, skill building, promotion of mathematical reasoning/higher order thinking skills) of the software and websites, establish the type of instruction possible (individual, paired, small group, large group, whole group), and assess the benefits of using the software and websites as opposed to other teaching tools. This exchange of ideas provided the framework from which evaluation criteria were developed (see Table 2).

Table 2

Evaluation Criteria adapted from Roblyer, 2003

1.	Connection to mathematics standards.
2.	Appropriate approach to mathematics topics with respect to grade, ability, and reading level(s).
3.	Worthwhile mathematical tasks.
4.	Presence of conceptual development, skill building, and problem solving/higher order thinking skills.
5.	Use of practical applications and interdisciplinary connections.

Guided Evaluation Sessions

During the next three 1-hour training sessions, the pre-service teachers used the evaluation criteria to review a piece of mathematics software and a mathematics website for each of the grade levels: elementary, middle, and secondary. As the students and professor together assessed the instructional technology, each of the evaluation criteria was addressed. The similarities and differences among the software and websites were addressed as well as the specific use of each software and website in the classroom. The predominate strengths were noted and used to determine those programs and websites best suited for specific classroom settings and objectives such as whole group instruction, small group instruction, conceptual learning, skill building, problem solving, practical applications, and interdisciplinary connections. For example, the pre-service teachers distinguished how the mathematics software and websites that contained manipulatives, visual displays, and multiple representations would be appropriate for conceptual development, while those that engaged the students in real-life situations such as owning a business and designing architectural blueprints were best suited for problem solving and practical applications.

The pre-service teachers also considered the interactive features by which students were given feedback about their responses and were guided to explore multiple methods of solution. They looked for assessment and record-keeping aspects of the software and websites that would aid in the evaluation of students' conceptual understanding, computational skill, and problem solving ability. The pre-service teachers also noted instructional technology that promoted writing in the mathematics learning process. Throughout the discussions, one of the pre-service teachers volunteered to record and report the sessions to the whole group. These notes were used to provide a

summary of the discussions and as a way to promote reflection on the pre-service teachers' findings.

Paired- Learning Sessions

For the next three 1-hour training sessions, the pre-service teachers were paired and asked to review an additional 6 items of instructional technology that included a piece of software and a website for each of the elementary, middle, and secondary levels. They were instructed to use the previously developed evaluation criteria to guide their reviews. Throughout this assignment, the students were asked to note their level of engagement and their degree of comfort with the evaluation process. Conferences between each of the pairs and the professor were held to discuss the instructional purpose and appropriateness of the software and websites they were evaluating.

When all pairs completed their evaluations, the professor had them discuss their findings and recommendations with the entire group. The pre-service teachers justified their conclusions by demonstrating specific features of the software and websites to their classmates. Feedback from the entire group was elicited after each of the evaluations, giving everyone the opportunity to share ideas.

Lesson Planning Sessions

The same student pairs were given the task of designing a technology-based mathematics lesson plan for an assigned topic and grade level. During a 1-hour training session, the professor assigned the topics and grade levels and explained the requirements of the task. These requirements included the typical structure used for planning a lesson (aim, behavioral objective, motivation, materials, procedure, summary, evaluation, follow-up) used in all of the education courses of the pre-service teachers' education program. They were to select and integrate either a piece of software or a website as their main technological teaching tool. The lesson plan follow-up was to involve a piece of instructional technology that was not used in the main portion of the lesson but would extend the lesson's objectives. For example, if a team developed a lesson about multiplying fractions for grade four using a piece of software, their follow-up could use a website featuring multiplication of fractions for grade four. The professor shared a checklist (see Table 3) with the pre-service teachers to guide the development of their technology-based lesson plans.

Table 3

Checklist for Development of Technology-Based Lessons adapted from Roblyer, 2003

1	Should activities be individual, paired, small group, large group, whole class, or a combination of these?
2	What instructional activities need to come before the introduction of the technology resource?
3	What instructional activities need to follow the introduction of the technology resource?
4	How will you assess students' learning progress and products?
5	Should the lesson take place in a lab or will classroom computers be adequate?
6	Will you need projection devices or large screen monitors?

During another one-hour training session, the pre-service teachers shared what they envisioned as the characteristics of a technology-based lesson. A set of lesson plan criteria (see Table 4) emerged from this dialogue and provided a framework to assess the quality of the lessons. Students received guidance and feedback throughout the remainder of the semester from both the professor and fellow classmates on lesson plans designed to incorporate instructional technology.

Table 4

Lesson Plan Criteria developed by Roblyer, 2003

1	The technology activity is a seamless part of the lesson.
2	The students are focusing on learning with the technology, not on the technology itself.
3	Lesson objectives could not be accomplished or accomplished as well if the technology weren't there.
4	The contributions of the instructional technology are evident.
5	All students are engaged with the technology and benefiting from it.

Presentations

Each pair of pre-service teachers presented their lesson plans using PowerPoint and engaged the class in using their selected piece of software and website. The pre-service teachers who were not presenting the lesson used the lesson plan criteria developed in class

to help them take notes and critique the lessons. The presenters elicited feedback from the class and responded to their classmates' comments, questions, and suggestions. Whole group discussions followed each presentation and provided a forum for the exchange of ideas and constructive criticism.

Each of the pre-service teachers critiqued their own lesson in written form as a way to reflect on their lessons as well as their classmates' comments and suggestions. Within these written reflections, the pre-service teachers discussed the strengths and weaknesses of their lessons along with ways to improve them. These self-assessments were a culminating element of the training sessions that portrayed the pre-service teachers not only as active participants in the evaluation process, but also as reflective practitioners of technology-based mathematics instruction.

Reactions

Upon completion of the training sessions, the pre-service teachers were given a second questionnaire. They were asked to reflect on their experiences reviewing and integrating mathematics instructional technology, their understanding of the uses of technology in the mathematics classroom, and their comfort level teaching mathematics using technology. The pre-service teachers were specifically asked to comment on the positive and negative aspects of the training sessions, the most beneficial uses of mathematics instructional software and websites, their self-confidence in evaluating and integrating instructional technology into mathematics lessons, and their attitudes towards themselves as mathematics educators using technology-based instruction. Interviews were again conducted with all of the participants so that they could speak candidly about their written responses. Patterns in responses revealed the pre-service teachers' positive evaluation of the training sessions, increased awareness of the power of instructional technology, and heightened levels of confidence in their ability to use technology-based mathematics instruction.

The questionnaires revealed that 94% of the pre-service teachers viewed the training sessions as a completely positive experience. Of those responding that the training sessions were not completely positive, the only negative aspect reported involved technical difficulties that infrequently occurred when a program wouldn't run or a website wouldn't respond. Responses showed that the pre-service teachers valued using a set of evaluation criteria when reviewing

software and websites, they enjoyed working with a partner as well as sharing their work with others in the class, and they indicated that the “support system” present within the design of the training sessions guided their inquiries and gave them opportunities to brainstorm with others to refine their ideas.

Eighty-six percent of the pre-service teachers indicated that they viewed software and websites as “great tools” that can promote best practices and provide content information and motivational activities. Their comments included: “Instructional technology can enhance the mathematics learning environment by providing visual demonstrations, interdisciplinary connections, and practical applications,” “Teachers don’t have to hunt for information about math topics,” “Software and websites can readily give teachers the information they need to understand the topics they teach,” and “Instructional technology helps the teacher bring mathematics to life with real-world connections.”

Fifty-seven percent of the pre-service teachers responded that they were more aware of the tremendous potential technology had for helping students to conceptualize and apply mathematics. A common response was “Instructional technology allows teachers to plan and implement mathematics lessons with ease and efficiency that would otherwise take them months to prepare and facilitate.” They marveled at the capability of software and websites to model concepts using multiple representations, integrate writing into the mathematics classroom using electronic journals, and link mathematical concepts such as ratio and proportion and geometric relationships to architectural blueprints and artistic designs. They also looked forward to involving their future students in using instructional technology to run a mock business while learning about practical applications of mathematics.

Eighty-three percent of the pre-service teachers commented that they were more confident in the process of evaluating software and websites. Their responses indicated greater self-confidence in appropriately selecting and integrating instructional technology. Their responses included: “We didn’t just accept the first thing we saw,” “We selected tools that were relevant, motivational, and would really benefit kids,” and “We were able to focus on the software and website features and see both the pros and the cons of their use in the classroom.” The pre-service teachers commented that the development of technology-based lessons was an experience that “put theory into practice.” Integrating technology into their own lessons

seemed to “open a door to a different world of teaching and learning” for them. Their comments included statements such as: “It was helpful to have us present our lessons and critique each other as well as ourselves,” “We seemed to learn from each other rather than from what we were just assigned,” and “Actually incorporating a piece of software and a website into my own lesson gave me the opportunity to implement what I learned to do.”

Conclusions and Recommendations

Research reveals positive effects on teaching and learning when technology is used to its fullest potential. It is therefore important that teacher education programs determine effective ways to prepare teachers to integrate technology into their classrooms. The study described in this paper investigated the effects of engaging pre-service teachers in training sessions designed to prepare them to integrate technology into mathematics instruction. Findings revealed that the training sessions promoted the pre-service teachers’ awareness of, appreciation for, and confidence in their ability to analyze, select, and craft technology-based mathematics lessons. This study serves as a stepping-stone for future research. Longitudinal investigations involving comparisons of confidence levels and lesson quality among classroom teachers who participate in the instructional training described in this paper with those who don’t would further define the effects of the training. Incorporating and studying the effects of the training sessions in professional development programs and graduate courses would also provide deeper insight into its influence on in-service teachers as well as pre-service teachers.

Training teachers to integrate technology coupled with continued investigation into its effects on teaching and learning serve to empower technology-based learning environments. This study’s model proved to be successful and can be used by teacher educators in technology courses as well as mathematics methods courses. The research efforts presented in this paper exemplify how higher education can serve as a catalyst towards effective use of instructional technology.

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