Integrating Instructional Technology in Teacher Education: A Case Study of an Elementary Science Methods Course

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Abstract: Prospective teachers and teacher educators both confront practical and philosophical issues in attempting to integrate technology into their practice. This paper reports on a case study of a first-year science teacher educator, a novice with instructional technology, who integrated technology in an elementary science methods course, with the support of a PT3 implementation project, to further her own knowledge and practice while simultaneously helping her students, pre-service teachers, develop their own practice. Qualitative analysis of classroom observations, field notes, student feedback forms, and other documents revealed themes related to technology's role in inquiry, factors affecting the faculty member's development, and pre-service teachers' development of expertise and willingness to use technology themselves. Pre-service teachers' growth and development related to technology integration parallels that of teacher educators.

Introduction

While recent data suggest that computers and the Internet have achieved nearly total penetration in schools today (Market Data Retrieval, 2002), teachers continue to grapple with both practical and philosophical problems posed by the adoption and implementation of technology (Dexter, Anderson, & Becker, 1999). Part of the problem has been a lack of attention to technology integration in teacher preparation; a number of national reports have raised concerns about the lack of focus on technology integration in teacher preparation programs (National Center for Education Statistics, 2000; Panel on Educational Technology, 1997). Shortcomings include limited use of technology in teacher education courses, an emphasis on teaching about technology rather than teaching with technology, and lack of faculty modeling.

Nationally, initiatives such as the U.S. Department of Education's Preparing Tomorrow's Teachers to use Technology (PT3) program are encouraging teacher preparation institutions to develop teacher capacity for using technology (Brush, 2003). At Purdue University, a 2000 PT3 implementation grant, P3T3: Purdue Program for Preparing Tomorrow's Teachers to use Technology, is providing support for faculty development and technology integration in the teacher preparation programs. The overall goals of the P3T3 project are to: (a) prepare pre-service teachers to demonstrate fundamental technology competencies, using technology as a tool for teaching/learning, personal productivity, communication, and reflection on their teaching; and (b) prepare teacher education faculty to teach pre-service teachers in technology-rich environments, modeling approaches that future teachers should use themselves when they teach K-12 students. The project is meeting its goals via several complementary components, including a faculty development and mentoring program designed to assist the faculty in learning new teaching/learning technologies and effectively modeling their use in teacher education courses.

If future teachers are to learn to effectively use technology in K-12 classrooms, they must see it modeled by teacher educators. This, in turn, requires that teacher educators learn to integrate the use of technology in their own practice. Training and support can help teacher education faculty to effectively integrate technology into classes for future teachers (Groves & Zemel, 2000). Purdue's P3T3 project has provided the necessary training and support to teacher education faculty at the university and also fostered the communication and collaboration among teacher educators and educational technologists needed to bring about changes in teacher education. This paper reports on a case study of one science teacher educator who, with the support of the P3T3 project and through collaborations with colleagues, integrated various educational technologies into an elementary science methods course.

Statement of the Problem

The purpose of this study was to examine the attempts of a first year science teacher educator, who entered the process with relatively little experience with instructional technology but received support from the P3T3 project, to integrate various applications of instructional technology into her elementary science methods course. This research addressed the following questions:

- What attempts at technology integration did the science teacher educator make?
- What factors influenced the development and integration of instructional technology in the elementary science methods course?
- In what ways did this integration of instructional technology facilitate pre-service science teachers' learning of science teaching practices and influence their interests in the use of technology?

This paper describes the process through which the science teacher educator developed, implemented, and reflected upon her attempts at influencing pre-service elementary science teachers' engagement, interests, and beliefs about the use of technology in their own learning of science teaching practices. Through this study, we sought to learn more about how teacher educators can successfully integrate instructional technology in their courses in both productive and meaningful ways such that their students, pre-service teachers, gain new knowledge of and interest in integrating educational technology in their own classroom practice.

Study Context

The faculty development component of the P3T3 project provided professional development activities and support structures to help teacher education faculty learn to utilize educational technology in their own practice. These included a two-day "start-up" workshop, technology skills development workshops, information sessions, financial incentives, and a year-long support/mentoring program for participating faculty members. During the fall of 2002, the P3T3 project launched a new mini-grant initiative to encourage faculty members to propose and implement new technology integration initiatives.

The science teacher educator who was the subject of this study, a new faculty member at the university, participated in one of the final start-up workshops offered by the project, in the summer of 2002. Subsequently, she took part in both skills development workshops and Techie Talk sessions, and she took advantage of the drop-in help sessions provided by the project staff. In addition, she submitted a proposal for a small P3T3 faculty mini-grant in the fall of 2002. After reviewing the syllabus for her elementary science methods course, she determined that applications for instructional technology were not only missing but clearly warranted. She devised an action plan that would emphasize the significant role instructional technology plays in fostering scientific inquiry, critical thinking, and problem-based learning. Her plan included developing and implementing units that incorporated the use of Excel, PowerPoint, digital cameras, and lab probes. For example, one class activity required students to use digital cameras to chronicle their use of productive questioning while engaging in an inquiry-based lesson on batteries, bulbs, and electricity. For a final product, student teams gave PowerPoint presentations that profiled their digital photos and written explanations of their scientific inquiries.

The data presented in this study reflect the results of the science teacher educator's technology integration attempts made during the spring 2003. Currently, the science teacher educator continues to modify and implement technology integration activities while collecting additional formative and summative feedback from her students.

Data Collection and Analysis

Data were collected in the form of feedback forms, classroom observations, field notes, journaling, and document review (e.g., student work and instructor's lesson plans). A feedback form, constructed by the science teacher educator, was designed to gather feedback from students about their engagement with each IT application. The feedback form measured the following: *clarity* of instruction, *difficulty* with the application, *interest* in the application, and *practicality* of the application. In addition, the feedback form included several open-ended questions that encouraged students to share their ideas and concerns about the application and to propose ways they envisioned using the application in their own practice. Field notes were recorded based on the instructor's own classroom observations of students' engagement with each IT application. Additional documents, such as completed classroom assignments, rubrics, and the instructor's lesson plans, were collected and reviewed. Lastly, the science teacher educator maintained a daily journal that chronicled her attempts at developing and implementing each IT application.

Data analysis involved continual interpretation of each source of data with particular attention to the ways the instructor and her students were making meaning of each instructional technology application throughout the course of the study. Data were analyzed using grounded theory (Strauss & Corbin, 1990). The first step entailed open coding of the data (Miles & Huberman, 1994) including the students' feedback forms, student work, and the instructor's journal entries. During this phase, attention was given to identifying indicators of concepts and categories that fit the data. Categories and concepts that appeared repeatedly led to the construction of themes based on the instructor's attempts at implementing instructional technology. The viability of the construction of themes was then tested via triangulation with other relevant data sets (e.g., field notes from classroom observations and other supporting documents) (Miles & Huberman, 1994).

Findings

The findings of this study document the integration of instructional technology in one science teacher educator's methods course. This study provides a broad view of the factors that supported this activity, including the support of the P3T3 project. In addition, this study paints a picture of what technology integration looked like when incorporated as a teaching tool in a science methods classroom. In this study, the following themes emerged which can be used to inform the design of teacher preparation programs and the work of the science teacher educators within them.

Inquiry Through Technology Use. The science methods course that was the subject of this study includes an in-depth examination of several key themes related to science teaching, learning, and assessment at the elementary school level. This includes class assignments that explore the use of process skills, productive questioning, fair test investigations, and assessment design. Underpinning each of these assignments is the primary goal for our students to learn more about how to engage children in scientific inquiry. Supplementing these class assignments are field-based experiences where students incorporate elements of inquiry by conducting interviews with children and teaching two independent lessons using productive questions and the learning cycle, respectively.

Students used technology in the course in a variety of ways (see Table 1). Common productivity software such as Excel and PowerPoint were integrated into the units as well as hardware including digital cameras and probeware, electronic sensors (e.g., temperature probes, heart rate monitors) interfaced to a computer. Each application also supported one or more process skills of science as outlined by the National Science Education Standards (NRC, 1996).

Unit of study	Assignment	IT application	Product
Introduction to process skills	Determine the distribution of colored M&M's	Excel PowerPoint	PowerPoint presentation
Engaging in scientific inquiry	Design and conduct an investigation that determines the effect of SUV's on traffic	Excel Digital cameras PowerPoint	PowerPoint presentation
Learning to use laboratory probes	Examining the temperature of our hands (Extremity Remedy)	Lab probes	Mini-report with data table
Exploring children's science learning through productive questioning and journaling	Record responses to productive questions while engaging in an inquiry-based activity	Digital cameras PowerPoint	PowerPoint presentation with digital photos
Planning and conducting scientific investigations through performance-based assessment	Determine the effect of temperature on making ice cream	Lab probes Excel	Written report
Designing a fair test investigation	Design and conduct a fair test investigation using lab probes (e.g. Cold Pack Lab)	Lab probes	Written report

Table 1: Overview of course IT applications

In Table 2, we outline one example of each student team's performance with one particular class assignment that not only emphasized the use of inquiry but also the role of technology in communicating their learning of scientific inquiry (See Table 2). In particular, the use of technology enabled students to: (a) design and conduct a scientific investigation; (b) employ simple equipment and tools to gather data and extend the senses; (c) use appropriate tools and techniques to gather, analyze, and interpret data; and (d) use technology (and mathematics) to improve investigations and communication of their investigations.

Inquiry skill (NRC, 1996)	**Student Teams**				
	1	**2**	**3**	**4**	**5**
Ask a question about objects, organisms, and events in the environment	X	X	X	X	X
Identify questions that can be answered through scientific investigations	X	X	X	X	X
Plan and conduct a simple investigation	X	X	X	X	X
Design and conduct a scientific investigation	X	X	X	X	X
Employ simple equipment and tools to gather data and extend the senses	X	X	X	X	X
Use appropriate tools and techniques to gather, analyze, and interpret data	X	X	X	X	X
Use technology (and math) to improve investigations and communications	X	X	X	X	X
Use data to construct a reasonable explanation	X			X	X
Communicate investigations	X	X	X	X	X
Communicate explanations	X			X	X
Think critically and logically to make the relationships between evidence and explanations	X				
Recognize and analyze alternative explanations and predictions	X				

Table 2: Inquiry skills demonstrated by individual student teams on the Digital Journaling class assignment.

Statement	**Process skills (M&M's)**	**Scientific inquiry (SUV)**	**Extremity Remedy**	**Digital journaling**	**Scientific investigations (Ice cream)**	**Fair test investigations (Cold Pack)**
How *interesting* did you find today's use of IT?	3.51	4.25	3.89	4.25	4.50	3.40
Rate the *clarity* in my instruction with giving directions on using the technology	4.00	4.00	4.12	4.50	3.95	3.73
How *useful* was today's lesson in using IT?	4.00	4.00	4.00	4.00	3.73	3.60
Rate the level of *difficulty* with today's application of IT	1.51	1.25	1.50	2.25	2.00	1.93
How likely do you envision yourself integrating this application in your own classroom teaching?	4.52	4.50	4.00	4.00	3.50	3.73

Table 3: Average frequency (on a Likert scale of 1 to 5) of students' responses to statements from feedback forms for each instructional technology application (N = 14)

The Role of Instructional Technology in the Elementary Science Classroom. Through ongoing formative assessment, the students reported improved skill development and interest in incorporating instructional technology approaches within their own prospective practice. Students reported "learning new ways of introducing concepts such as, endothermic and exothermic, using temperature lab probes", "using digital cameras as way of journaling children's science learning," and "instructing children how to design fair test investigations using lab probes" (Reflective statements, Spring 2003). These findings suggest that students learned more than just science content but also how to promote scientific inquiry and self-reflection.

Additional data from students' formative feedback forms indicated increased interest in and ability to use technology (See Table 3). Students indicated relatively high interest in and usefulness for the majority of applications. Additionally, students reported relative high interest in integrating more than half of the instructional technology applications within their own practice.

Discussion

The study provides one example of what the integration of instructional technology into an elementary pre-service science education course might look like. From these results we can conclude that instructional technology has the potential to play a significant role as a teaching tool that enables pre-service science teachers to design, plan, and conduct scientific investigations. In addition, it provides a framework necessary for prospective science teachers to begin thinking about the actions they can take in response to the growing need for preparing young children to be both scientifically and technologically literate. Several factors contributed to the success of this science teacher educator's work. These factors primarily reside in one of two realms: *external* and *internal motivation*. For the purposes of this study, we define external motivation as those factors that served as a driving force outside of the teacher's own practice. Internal motivation refers to factors that derived from within the teacher's own practice and the ways she thinks about her own practice including her beliefs and values for science teaching and learning.

External Motivation. Three main factors influenced the science teacher educator's technology use in her own teaching practice: 1) administrative support (including funding); 2) equipment access; and 3) faculty professional development and informal technical assistance. The P3T3 mini-grant not only provided the instructor with the financial support to purchase new equipment, including temperature probes, cardio sensors, and new desktop computers, it also allowed the instructor the flexibility and creativity to generate innovative ways to engage students in inquiry using technology. In addition, access to additional equipment housed within the department made the development and implementation of technology in the course both feasible and manageable. This access included computer labs for larger classes, the ability to set up lab stations in more than one classroom, and the ability to assign equipment to individual students as well as several student teams. Accompanying this support was the assistance of both faculty and graduate students in educational technology who were affiliated with the P3T3 project. The science teacher educator and her students were able to consult with faculty and graduate students about the software applications and tools implemented in the course. The support and access provided by the P3T3 project were able to overcome what Ertmer (1999) described as first-order barriers to technology integration.

Internal Motivation. Unique to this study is the science teacher educator's own beliefs, interest, and commitment to improving not only her own teaching but improving her students' understanding of teaching. After careful review of the existing teacher preparation program and respective course syllabus, it was clear to her that the program lacked instructional technology applications, other than the use of PowerPoint and the Internet in several course assignments. Her own personal interest to learn more about instructional technology and its applications proved to be integral part of her success at incorporating them into her own practice. She wanted to go beyond technology as an "add on" (Niess, 2001), "communication medium" (Weinburg, Smith, & Smith, 1997), and "resource" (Davis & Falba, 2002) for her students and desired to infuse it in her own course and practice such that it would play a significant role in helping children engage in inquiry (Lederman & Niess, 2000), develop higher order thinking skills, and enhance their ways of learning science and learning how to teach science (Davis & Falba, 2002). The willingness of the science teacher educator to reflect on and change her own practice to integrate instructional technology overcame second-order barriers (Ertmer, 1999), those beliefs and attitudes that are often hamper technology integration efforts even when access to technology is not an issue.

Significance of this Work to Educational Technology and Teacher Education

What we have learned is that for teacher educators and pre-service elementary teachers to make instructional technology an integral part of their practice, they must develop an awareness and understanding of its applications. As Bai and Lehman (2003) have noted, if faculty development for technology integration focuses on content, takes into consideration the individual faculty member's needs, and provides individualized support, the result can be changes in perception that lead to changes in practice. With sustained administrative and technical support, teacher educators, such as the science teacher educator in this study, can develop the supportive environment necessary to test out their ideas, generate action plans, and reflect on their results. The development of this expertise is fostered by a collaborative environment in which teacher educators and educational technology specialists construct collective knowledge about their practice. Pre-service teachers' development of skills in using technology and their coming to understand its importance in the service of content instruction in the classroom parallels this process. Simply put, as pre-service teachers make decisions about their own teaching, experience it, and reflect upon it in the context of their preparation program, they are better able to construct educational understandings that are similar to those espoused by the teacher educators.

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