PREPARING SCIENCE TEACHERS TO TEACH WITH TECHNOLOGY: EXPLORING A K-16 NETWORKED LEARNING COMMUNITY APPROACH

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ABSTRACT

This exploratory study examines the impact of a professional development program where a K-16 networked learning community approach was implemented to provide training and support for technology integration in science education. The study presents findings from a three-year project with five cohort groups that included 17 student teachers, 17 cooperating teachers, 5 university-level faculty, and 3 student teaching supervisors. Data were collected from pre and post surveys, journal entries, participant observations, and electronic portfolios. Findings indicate that over the course of the program the project participants significantly increased their confidence and competence to integrate technology into the teaching and learning process. Technology-integrated lessons developed by the project participants included the use of a variety of advanced technology tools to facilitate learning in science. Using collaborative partnerships helped many teachers to use technology with their students and increased their motivation and enthusiasm towards technology based training. The study demonstrates that an approach to professional development that encourages networking, mutual learning, and sharing of strategies and resources among science educators is an effective strategy to improve technology integration in science education.

Keywords: Teacher education; Teacher preparation; Professional development; Learning communities; Networked learning communities; Science education; Technology integration

INTRODUCTION

Preservice teachers in science education programs are often required to take an educational technology course taught by an educational technology expert. In such classes, students are supposed to develop a variety of technology-related skills, including the ability to use productivity tools, educational software, and the multitude of resources available online. Students typically are then expected to apply these technology skills to teach content in their subject area. According to Flick & Bell (2000) "this approach is backwards." They argue that teaching a set of technology-related skills and then expecting to find a science content for which these technology skills might be useful limits the use of technology in the science classroom. This is akin to learning about a tool first and then seeking out the educational problem that the tool might help solve rather than letting the curriculum determine what tools should be used (Cooper & Bull, 1997). Flick & Bell suggest that if the goal of using technology in science teaching is to enhance teaching and learning, a different approach is necessary.

Several research initiatives have been exploring how to teach technology within the context of specific content areas. At Curry School at the University of Virginia, for instance, preservice teachers in secondary education take beginning technology courses within their content areas providing students with unique technology experiences related to their own subject area (Thompson, 2006). Research also indicates that focusing on the development of faculty so that they may serve as model users of technology within their content and methods courses is another way to train preservice teachers (CEO Forum on Education and Technology, 2000; Office of Technology Assessment, 1995; Teclehaimanot & Lamb, 2005). Other institutions are exploring field-based models focusing on future teachers' student teaching placements in which field-based mentor-teachers model the integration of technology into educational activities in order to assist preservice teachers with their use of technology during student teaching experiences (Kelley, Wetzel, Padgett, Williams, & Odom, 2004).

A common thread among these initiatives is the intentional effort to teach technology within the context of specific content areas rather than as an isolated topic. The literature suggests that integrating technology in this manner can have a positive impact on preservice teacher attitudes and confidence with regards to technology (Bennett & Scholes, 2001; Pope, Hare, & Howard, 2002) as well as their overall skill level with technology (Albee, 2003; Pope et al., 2002). These outcomes are largely attributed to the fact that preservice teachers are given the opportunity to learn and teach *with* technology rather than just learn *about* it.

In addition to providing teachers with opportunities to learn about technology integration within the context of the different content areas, it is also helpful to give them the chance to collaborate with others as they learn about and experiment with technology tools. Lawless and Pellegrino (2007) recently published a literature review that focused on research dealing with professional development designed to help teachers become proficient in the integration of technology. As part of their review they found several studies that reported on the use of mentors or coaches as a way to help teachers learn more about and practice the effective use of technology in the classroom. These studies revealed that providing teachers with tech savvy mentors and partnering them with teachers who are experienced in the area of technology is an effective way to provide the technical and pedagogical support they need when they attempt to integrate technology (Cole, Simkins, & Penuel, 2002). In addition, using collaborative partnerships helps to allay the fears many teachers have about using technology with their students (Mulqueen, 2001) and can increase the motivation and enthusiasm teachers exhibit towards technology based training (Holbein & Jackson, 1999). This emphasis on collaborative work and mentorship is at the core of the "networked learning community" approach to professional development investigated in this study.

The rationale for learning communities is mostly associated with Wegner's (1998) social theory of learning that calls for communities of practice in which participants mutually engage in the task at hand, focus on joint enterprise, and develop shared ways of working. With respect to teachers, the notion is to provide an ongoing, sustainable vehicle for teacher learning (Parr & Ward, 2006). Parr and Ward describe learning communities as having distinctive features that include shared norms and values, collective learning through collaboration, the application of that learning in a focus on student learning, shared personal practice, and reflective dialogue. Parr and Ward further argue that strong professional learning communities are those focused on "joint work" involving not only acquiring new knowledge but also revisiting the basic assumptions about teaching and learning to improve practice and, as a consequence, student learning.

The increasingly popular online learning environment in which we currently live and work has generated considerable interest in "networked learning communities" where technical infrastructure and networked learning technologies such as the Internet are utilized to support and complement learning communities for the creation and transfer of knowledge within and between individuals and groups as a means for continuous, systematic improvement of practice. As Kerr et al (2003) describe, central to networking is the notion of increasing communication channels that provide opportunity for interaction at different levels. Such communication leads to a range of benefits, such as opportunities for participants to share their knowledge and expertise, opportunities for participants to discuss, plan, reflect on and explore professional issues, increased inspiration, innovation and motivation among participants, increased social contact between individuals from differing backgrounds, empowerment and professional development, a reduction in feelings of isolation (both geographically and emotionally), and increased access to shared resources.

While studies about implementing networked learning community approach to facilitate technology training for teachers exists (see Hartnell-Young, 2006; Lock, 2006; McNeil & Pierson, 2001; Najafi & Clarke, 2008; Parr & Ward, 2006), there is a gap in the research literature examining the impact of these communities among K-16 educators with a specific focus on technology integration in science education. Too little is known about what K-16 educators might gain from a professional development program that calls for their engagement, interaction, and collaboration to use technology effectively in science education classrooms.

In accordance with the existing literature and in response to the growing need for content-area specific technology preparation, the purpose of this study was to investigate the impact of a professional development program where a K-16 networked learning community approach (explained in the following section) was implemented to provide training and support for technology integration in science education. The following research questions were examined in this study:

1. What is the impact of a K-16 networked learning community approach to professional development on technology literacy (knowing *about* technology) and technology integration (teaching *with* technology) among student teachers, cooperating teachers, education and content faculty, and student teaching supervisors in a science education program?
2. What are the patterns in technology integrated projects designed by the project participants that are important to technology integration in science education?
3. What kinds of professional development activities promote and/or influence participating science educators' professional development on technology integration in the classroom?

In the following sections, we first describe the program in which a K-16 networked learning community approach was implemented to provide professional development for technology integration in science education. In this section, we discuss the critical framework that provided the basis for the development of the networked learning community investigated in this study. We then describe the research study that used multiple methods to determine the impact of the professional development model presented. In the subsequent section, we present the study findings accompanied by a discussion of those findings. In the conclusion section, we identify and discuss ways in which the model presented responds effectively to the need for comprehensive technology preparation to improve technology integration in science education.

THE MITTEN PROGRAM AND THE CONCEPTUAL FRAMEWORK

The professional development activities that are presented in this study were part of the Michigan Teachers' Technology Education Network (MITTEN) program, which was a three-year project funded through the Preparing Tomorrow's Teachers to use Technology (PT3) initiative of the United States Department of Education. MITTEN facilitated a networked learning community among K-16 educators, calling for the engagement, interaction, and collaboration of student teachers, cooperating teachers, education and content faculty, and student teaching supervisors. The "center of pedagogy" advocated by Goodlad (1994) provided the conceptual framework for the type of network learning community approach undertaken in this study.

Conceptual Framework: Center of Pedagogy

For Goodlad (1994), the improvement of teacher education requires the collective participation of three principal institutional entities: schools of education, school districts, and colleges of arts and sciences. Although each of these three bodies certainly has critical educational functions that are best pursued in relative isolation, Goodlad emphasized the importance of each as an equal player in a healthy "ecosystem" (p. 9) of teacher preparation and sought to provide a coherent means of providing sustained and meaningful contact among these essential parties in the teacher education enterprise. Thus, the center of pedagogy idea constitutes a means of addressing the shortcomings of the status quo in teacher education, which is normally typified by an "undergraduate curriculum of general and special studies interspersed with essentially required courses in education and student teaching" (p. 10).

As figure 1 illustrates, the MITTEN program's Networked Learning Circle (NLC) mirrors Goodlad's center of pedagogy, calling for the involvement of four groups of participants: (a) student teachers, (b) content-area faculty of the arts and sciences specializing in the student teachers' major field of study, (c) education faculty specializing in educational technology and methods, and (d) experienced practitioners comprised of the student teachers' mentoring teachers and university-based field supervisors. The cooperative activities undertaken among these participants of the MITTEN NLC model enabled the sustained interaction toward the kind of shared meaning that Fullan (2001) identified as vital to educational change and improvement in education.

Content experts: arts and sciences faculty	Student teachers and their technology-enhanced lessons	Methods and educational technology experts: education faculty
	Practitioner experts: school-based master teachers; college based student teaching supervisors	

Figure 1. The "Networked Learning Circle" (NLC): a structure for collaboration on technology integration, adapted from Goodlad (1994).

At the heart of the NLC is the focus on the progress of preservice teachers, a focus that has certain strengths. Foremost among these strengths is the conscious effort to help preservice teachers bridge the gap between the postsecondary and K–12 educational worlds in which they are learning. Most often, having concluded all or nearly all of their coursework, students entering the teaching force are released by their academic instructors into

the hands of their supervising, or host, teachers. A supervising teacher appointed by the student teacher's college or university has an important role in synthesizing the student teacher's teaching experiences with the content and pedagogical knowledge already learned. Yet, like the student teachers themselves, during this clinical experience these supervisors rarely have sustained contact with members of the faculty mainstream. Therefore, the typical student teaching experience has tended to foster—at a most critical juncture in the preservice teacher's preparation—distance between the preservice teachers and their college- and university-based faculty members, rather than promoting important and necessary interaction.

Such patterns of structured separation have been typical of the teacher preparation enterprise in the United States and have had negative consequences of at least two sorts. First, the preservice teacher has been unable to benefit from meaningful continuing contact with content and pedagogical expertise. Second, perhaps even more limiting, the faculty members themselves have been unable, under most prevailing models, to reconnect with the K–12 world in ways that might inform and rejuvenate their own instruction. Smith and Kaltenbaugh (1996) have noted the desirability of establishing the meaningful input of "academicians, master teachers, and master practitioners" to overcome the tendency for each of these vital participants in teacher education to stand as an "autonomous unit" (p. 96). Venues that can foster genuine dialogue between and among preservice teachers and members of these three groups are necessary elements of programs aimed at spurring structural change. The NLC model provides a basis for pursuing this kind of cooperative engagement.

Implementing the NLC Model: The MITTEN Project
The MITTEN project involved the School of Education and the College of Arts and Sciences at a major Midwestern university. A neighboring Community College also participated, as did several local K–12 institutions sponsoring the project's preservice teachers during their clinical appointments. The project's main goal was to prepare future educators with improved knowledge, skills, and confidence regarding the integration of information technology into the teaching and learning process.

In pursuit of this goal, MITTEN offered three different but interrelated professional development activities to project participants: (a) a series of capacity-building activities, (b) a sequence of meetings of the NLCs, and (c) a pair of seminar activities designed for whole-group engagement of all participants. Figure 2 shows the sequence of these events within a single cycle of the project. The meeting of NLCs and the work undertaken within these learning circles were of principal importance to the project, while the additional activities comprised important means of support for those circles.
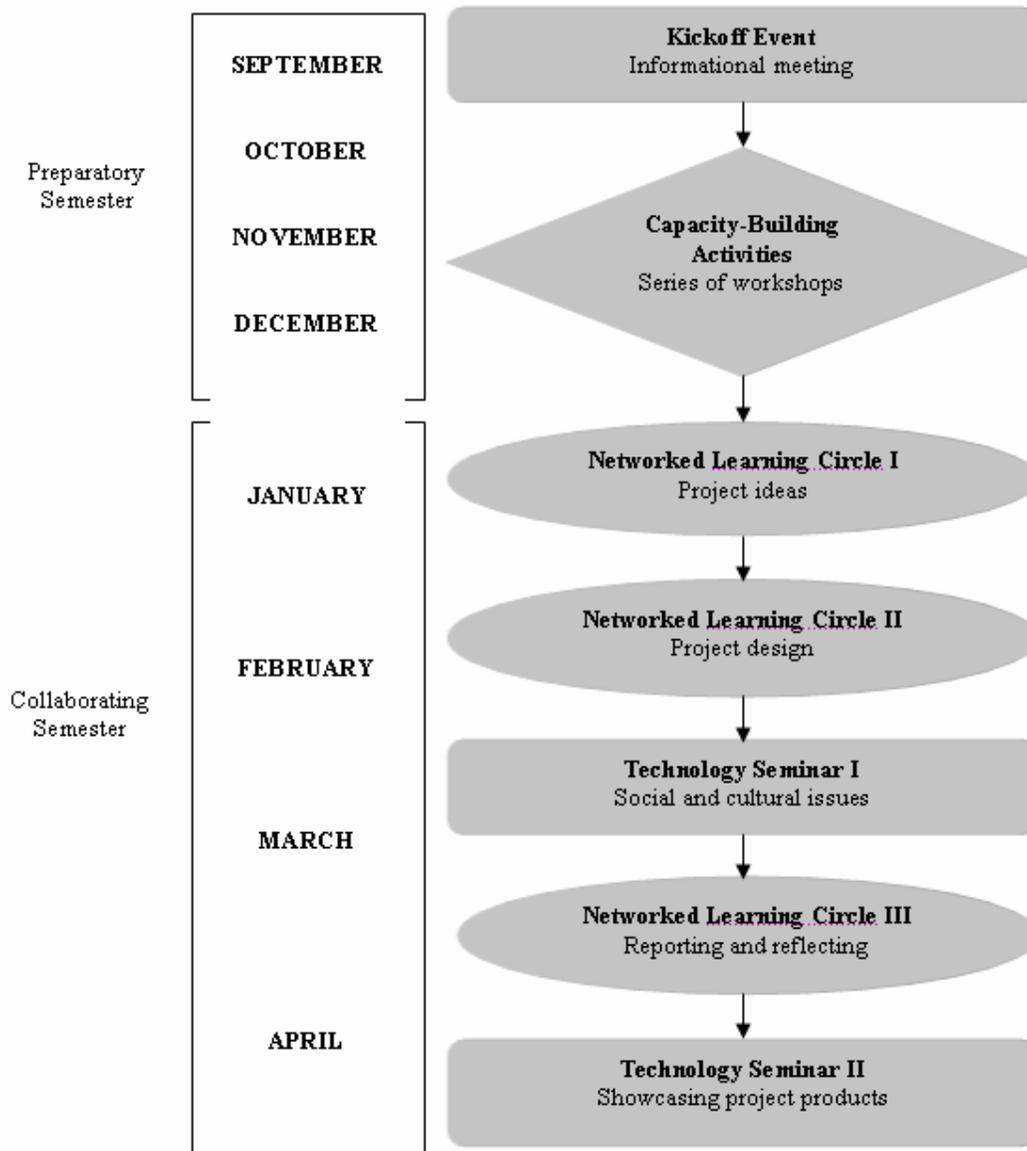
Figure 2. One round of MITTEN events.

Capacity Building Activities. At the post-secondary institution in which this study was conducted, all preservice teachers were required to take an educational technology course prior to their student teaching. To improve the technology readiness of the project's cooperating teachers, field supervisors, and methods and content faculty members and bring their technology skills more in line with those of the participating student teachers, MITTEN offered a set of Capacity Building Activities. The structure of these capacity building activities included workshops, working lunch sessions, and one-to-one mentoring sessions. The general scope of these sessions encompassed three areas of need—telecommunication tools, productivity tools, and educational multimedia— while specific emphasis corresponded to the needs that participant identified on assessment surveys. By improving the technology readiness of the participants and bringing their skills more in line with those of the participating student teachers, the entire cohort was prepared to undertake the work of designing and implementing technology-enhanced instruction, work that occurred during the subsequent collaborating semester.

Networked Learning Circles. The Networked Learning Circle meetings during the collaborating semester involved the most critical set of activities within the program. NLC members met at minimum three times during the course of the term in order to design, revise, and implement technology-enhanced instruction in their classrooms (e.g., course or unit redesign in K-12, syllabi revision at the university level).

As Figure 2 reflects, the first circle meeting (NLC I) provided inspiration and guidelines to encourage technology integration ideas among project participants. Typically, examples of best practices in technology integration were demonstrated. The first NLC meeting readied the participants to consider their instructional practices and how they might be improved through technology integration. Specifically, all participants were asked to survey the learning and technology environments in their classrooms and schools and prepare proposals for learning activities and experiences supported by educational technology.

At the second NLC session, all circle members presented their proposals for technology integration into their professional practice. Student teacher/cooperating teacher pairs presented joint projects for their respective classrooms whereas faculty members and field supervisors focused on their own settings. Consistent with the current Technological Pedagogical Content Knowledge (TPCK, Mishra & Koehler, 2006) discussion in the educational technology community, during and after these presentations, other members of the circles raised questions and made suggestions for the content, technology, and pedagogy of the technology integration projects presented. A range of content, methods, technology, and practitioner experts in the NLCs supported each other with the design of technology-integrated projects. The presentation and discussion activities featured during the NLC II meeting helped circle members for the classroom implementation phase of the cycle.

NLC III generally occurred after the completion of most of the implementation phase and provided time for each participant to report and reflect on successes and challenges encountered during implementation. Because discussion and networking across members of the circle was encouraged, the participants usually learned from the experiences of circle colleagues but also considered how specific uses of technology might be adapted to their own instructional settings and circumstances.

Various assumptions shaped the collaboration within the NLCs. First, all members of the group were primarily present as learners and that each circle included educators at different "levels" but all had a stake in developing their capacity to use instructional technology in meaningful ways. Technology demands openness to learning, even for people close to the realm of technological innovation. A second major assumption embraced by project participants was that co-learning supports the learning of all the members of the NLC (Kariuki, Franklin, & Duran, 2001). The helpful candid observations of other members in each learning circle had the capacity to develop the abilities of each member. Therefore, observing others' progress in using instructional technology was mutually beneficial.

Seminar Activities. The seminar activities served two different but complimentary purposes. First, they built awareness of broader social and cultural issues related to educational technology with attention to topics such as the "digital divide," "assistive technology," and "plagiarism and copyright." For the school-based master teachers in particular, these opportunities augmented their home schools' efforts to contribute to teachers' continuous learning (Darling-Hammond, 1998). A second purpose of the seminar activities was to build and maintain the investment and commitment of those involved by showcasing current products and works in progress, consistent with Fullan's (2001) observation that knowledge exchange is both a motivator and an integral attribute of the competent professional.

In collaborative interaction with members of their respective NLC, each MITTEN participant created a standards based electronic portfolio (Barrett, 2000) that documented their own progress in planning and executing technology-enhanced lessons. Participants used these portfolios to reflect on their growth and learning as well as connect their achievements to the National Technology Standards for Teachers (ISTE, 2000). Each portfolio included five major sections consisting of an introduction, an overview, a narrative of achievements, exhibits, and reflections (see a sample portfolio at http://www.umd.umich.edu/mitten/mnemeth). Production of the e-portfolios containing technology-integrated lessons and learning resources allowed networking among project participants in different cohorts and provided an important venue for the sharing of experiences of project members with broader audiences in the education community.

METHODOLOGY
Research Design
A mixed methods design was used in this study. As Gay, Mills, and Airasian (2006) describe, mixed method research combines both quantitative and qualitative data collection and analysis in a single study. The use of descriptive, comparative, and interpretive components of this study required a combination of quantitative and qualitative research methods in order to appropriately answer the research questions. The first step of the study involved the dissemination of a needs assessment survey and the pretest Technology Survey prior to the beginning of the program. The second step involved an ongoing collection of program participation data and

artifacts from the program activities. The third step involved the administering of the posttest Technology Survey. The final step involved the content analysis of the program participants' e-portfolios.

Participants and Setting
Over a three-year period with five cohort groups (from September 1, 2001 to April 30, 2005), the subjects for this study included 17 student teachers, 17 cooperating teachers, 5 university-level faculty, and 3 student teaching supervisors. In their respective cohorts, each participant was assigned to a networked learning circle, typically consisting of a faculty member in the content area (1), teaching methods (1), and educational technology (1), science education student teachers (4), his or her cooperating teachers (4), and their field supervisor (1). The overarching task of each cohort was to develop and field-test technology-enhanced lessons and projects, leading to course or unit redesign in the K-12 classroom and syllabi revision at the university level.

For each cohort group, the study was announced to student teachers six-months prior to the student teaching semester and volunteers were solicited to participate. Names of the volunteering students were placed in a box and four individual names were randomly drawn to select student teacher participants in each cohort. Student teachers' assigned school districts identified cooperating teacher volunteers to team up with student teachers and participate in the study. Student teacher/cooperating teacher pairs were placed in 14 different schools (5 elementary and 3 high schools) in 10 different school districts. The study was announced to faculty members and student teaching supervisors prior to each academic year and volunteers were asked to participate. Three methods faculty participated in the study, one of them joining the project in two different cohorts. Two content faculty participated in the study, both of them joining in multiple cohorts. Three student teaching supervisors assigned to participating student teachers within their respective cohorts participated in the study, two of them participating in multiple cohorts.

All participants attended capacity building activities, participated in NLC meetings, and engaged in whole group activities such as a kickoff event, a technology seminar focusing on a featured social issue, and a final exhibition showcasing project products. All participants (with three exceptions) performed required activities including implementation of technology-rich lessons, maintaining journals, and developing electronic portfolios. Each participant conducted site assessments using School Technology & Readiness (STaR) Charts (CEO Forum on Education and Technology, 2000) and then developed their projects and lessons considering the technology and resources available to them. There were wide disparities in both equipment and technical support that was available to the project participants in their classrooms and schools. Some "high-tech" level schools had more than two computers (with Internet access) in each classroom, in addition to other computer labs. These schools had the traditional computer labs as well as specialized labs with software and hardware for students to complete complex projects such as digital video editing and production. The schools within the "low-tech" tech group showed lack of technology resources. Classrooms had computers, but were not usually connected to the Internet. Labs and technical support were minimal. The majority of the schools in the project fell in between these two poles at the "mid-tech" level of technology. The schools within this group generally had 1-2 computers with Internet access in each classroom and one computer lab at the elementary schools and 5+ labs at the high schools. Specialized labs and projection capability within the classrooms were limited. Schools in the mid-range had devoted considerable resources to improving their technology resources and training.

Instrumentation
A technology survey designed by the project's external evaluator was used to evaluate the project participants' technology confidence (comfort level) and competence (frequency of use) in two parts (see Appendix A). Part I is comprised of two scales that consist of nine (9) items measuring participants' confidence/competence related to technology literacy (knowing *about* technology). Part II is also comprised of two scales with thirteen (13) items measuring participants' confidence/competence related to integration of technology into teaching and learning (teaching *with* technology). The external evaluator reported successful and satisfactory use of the technology survey for a number of years in different professional development programs confirming its reliability. Additionally, a panel of experts in educational technology reviewed and revised the instrument for content validity.

The researchers developed and used a guideline for journal entries underlining the purpose of the journals and its framework to help participants in writing their respective "evaluative journal" entries. The researchers also developed and used an electronic portfolio guideline describing the purpose of the electronic portfolio and its framework to help participants to present their achievement in teaching with technology in a meaningful way. Copies of the journal and e-portfolio guidelines are available by contacting the lead author.

Data Collection
Various forms of data were collected related to each of the research questions. A combination of quantitative and qualitative methodologies were employed, including (a) quantitative data collected from the pre- and post Technology Survey, and (b) qualitative data collected from the needs assessment survey, participants' journal entries, participant observations in NLC meetings, and technology projects and summery reflections within the electronic portfolios.

Data Analysis
The research questions drove the data analysis. The data were acquired through the technology survey administered twice in a pre-test/post-test design. Five-point Likert scales were used to measure participants' confidence (1 = very anxious or even afraid of to 5 = eager) and competence (1 = never to 5 = daily) in both technology literacy and integration of technology into teaching and learning. As described by Hinkle, Wiersma, & Jurs (1994), a paired-samples *t* test was conducted to compare means for the same variable measured at two time points (e.g., pre-test and post-test) on the same set of subjects. To treat the missing data, the researchers excluded cases analysis by analysis and used all cases that had valid data for two variables in a pair in the test for that pair.

Qualitative data analysis of the needs assessment survey, journal entries, and reflections articulated in electronic portfolios were conducted on a continuous basis throughout the program. The leading researcher organized and sorted data as they were collected and followed three repeating steps (reading/memoing, describing, and classifying) in analyzing qualitative data (see Gay, Mills, Airasian, 2006) for the retrieval of information and understanding of the data. A peer debriefing process among the researchers was used to check emerging themes and conclusions generated during the analysis.

Two researchers of this study are educational technology faculty and have extensive expertise in technology integration in the classroom. They conducted a content analysis of the e-portfolios developed by the project participants to identify the patterns in technology integrated projects. The Exhibits section of each e-portfolio included copies of units of instruction, lesson plans, examples of student work, and other instructional materials. Analysis of each lesson included within the individual e-portfolios consisted of reviewing the technology used and determining both the role of the teacher and students in the use of that particular technology.

There were a total of 38 e-portfolios created by the project participants. Each student teacher was paired with a cooperating teacher to develop and implement a set of technology enhanced lesson plans. Therefore, for every cooperating teachers' portfolio that was analyzed there was a corresponding student teacher portfolio that included an identical set of lesson plans. These portfolio "pairs" were viewed together as one since they featured the same lessons. This resulted in the analysis of 17 paired portfolios, 14 of which were at the elementary level and 3 at the high school level. None of the project participants were teaching at the middle school level. Two content faculty, one methods faculty, and one student teaching supervisor who worked independently, created the remaining 4 portfolios. One student teaching supervisor submitted an incomplete e-portfolio and it was not analyzed. There were two methods faculty and one field supervisor who did not complete e-portfolios.

The number of data sources and the frequency of the data collection effort helped to create a fuller understanding of the impact of the MITTEN experience.

Limitations
The present study has some limitations that need to be taken into account when considering the study and its contributions. A total of 42 participants in the study is characteristic of what might be considered a pilot in preparation for a more extended study. The study participants were volunteers based on their interest in using technology in science teaching and may not be representative of science educators in general. The quantitative survey data was collapsed across project participants and had too few in each subgroup to be analyzed by subgroups (e.g., science student teachers vs. faculty).

FINDINGS
Confidence and Competence in Technology Use
The technology survey examined the project participants' technology confidence (comfort level) and competence (frequency of use). The paired-samples *t*-test results indicated that over the course of the program the project participants significantly improved their confidence and competence in technology literacy as well as the integration of information technology into the teaching and learning of science.

Technology Literacy (knowing about technology). As shown in Table 1, the paired-samples *t*-test results for Part 1 (Technology Literacy) on the survey indicated a significant increase (at the .05 level) in scores from pre-test to post-test for each item tested on the survey with only two exceptions.

Table 1: *Paired-Samples T-Test Results: Part 1-Technology Literacy*

Survey Question	Degree of Freedom (df)	Comfort *t* test (2 tailed >.05sig.)	Frequency of Use *t* test (2 tailed >.05 sig.)
1.	29	-1.720 (.096)	-1.682 (.103)
2.	29	-2.105 (.044)	-.817 (.420)
3.	29	-2.041 (.050)	-2.112 (.043)
4.	29	-3.832 (.001)	-3.010 (.005)
5.	29	-3.072 (.005)	-2.454 (.020)
6.	29	-5.000 (.000)	-2.850 (.008)
7.	29	-4.650 (.000)	-3.159 (.004)
8.	29	-4.279 (.000)	-3.465 (.002)
9.	29	-3.393 (.002)	-3.071 (.020)

The results of the *t*-test for Part 1 indicate that throughout their participation in the MITTEN program the project participants made significant increases in their use of computers for common purposes of connectivity such as sending and receiving e-mail with attachments, using Internet search engines, and retrieving, saving, and using electronic information. Similar increases were made for creating multimedia presentations, using advanced computer functions such as using chat rooms, QuickTime movies, and video input, manipulation, and output. Participants increased their use of graphics application to create professional looking documents, newsletters, and publications. They also made significant changes in the frequency with which they created and modified personal or professional web pages and employed technology in assessment such as using electronic portfolios or grade books. Study participants significantly improved their understanding about some social and ethical issues related to technology use in the classroom such as data privacy, equitable access, free speech, copyright, and school technology policies.

There was no significant change in participants' comfort in using the computer for the "ordinary" purposes: word processing; opening, modifying, printing documents; record keeping, or to use computers and appropriate software to use or create databases and spreadsheets.
Scores for these questions did not increase significantly over the course of the program where a negative value for *t* for each of these cases indicated that the mean post-test score was larger than the mean pre-test score. These results weren't surprising as participants already performed these types of tasks on a regular basis and were, therefore, quite familiar and comfortable with them.

Integration of Technology into Teaching and Learning (teaching with technology). As shown in Table 2, the paired-samples *t*-test results for Part 2 (Integration of Technology into Teaching and Learning) on the survey indicated a significant increase (at the .05 level) in scores from pre-test to post-test for each item tested on the survey with no exception.

Table 2: *Paired-Samples T-Test Results: Part 2-Integration of Technology into Teaching and Learning*

Survey Question	Degree of Freedom (df)	Comfort *t* test (2 tailed >.05 sig.)	Frequency of Use *t* test (2 tailed >.05 sig.)
1.	29	-3.071 (.005)	-3.353 (.002)
2.	29	-5.524 (.000)	-4.948 (.000)
3.	29	-3.315 (.002)	-4.416 (.000)
4.	29	-3.427 (.002)	-4.777 (.000)
5.	29	-4.883 (.000)	-5.067 (.000)
6.	29	-4.650 (.000)	-5.110 (.000)
7.	29	-4.349 (.000)	-6.430 (.000)
8.	28	-4.559 (.000)	-4.887 (.004)
9.	28	-2.736 (.011)	-4.623 (.000)
10.	27	-2.274 (.031)	-3.349 (.002)

11.	28	-4.589 (.000)	-5.087 (.000)
12.	29	-5.137 (.000)	-7.738 (.000)
13.	29	-4.878 (.00)	-3.832 (.001)

The results of the *t*-test for Part 2 indicates that throughout their participation in the MITTEN program the project participants made significant improvements in helping students to operate a variety of hardware tools such as computers, LCD projectors and scanners, and to use video hardware and software in engaging and constructive ways. Similarly, they made significant increases in the amount of time spent helping students use sophisticated and content specific applications as well as developing student abilities to learn applications outside of formal training. Participants significantly improved their ability to help students become proficient in using search tools and evaluating and using results of Web searches as well as developing their skills and helping students develop skills in creating multimedia presentations and products that support engaged learning. They also made significant improvements in helping students become skilled at developing technology-enriched learning activities that are authentic, multidisciplinary, and connected to district, state, and national standards; helping students to utilize technology-enriched instructional strategies in which learning is highly interactive and responsive to student needs; and helping students use technology to support authentic, performance-based, ongoing assessment including portfolios. Study participants significantly improved their ability to help students understand how to create a classroom environment in which technology is a shared responsibility between teachers and students, and where its use is transparent and in need of limited teacher direction. There was also a significant increase in the use of interactive electronic tutorials to teach specific lessons or material to specific students or groups of students. Further, participants made significant gains in understanding and using technology to enhance teaching and research and to maximize student learning as well as mentoring their colleagues in using technology to improve the teaching and learning process.

Patterns of Technology Use in Science Classrooms

Electronic portfolios of project participants contained technology-integrated projects at the K-12 and university level. Content analysis of electronic portfolios provided data useful for understanding the project participants' patterns of technology use in their classrooms.

Projects created by the preservice/inservice teacher pairs included the use of a variety of advanced technology tools while facilitating the learning in science. Some examples at the early elementary level (1st and 2nd grades) included using digital pictures and presentation tools such as KidPix to learn about animals and using a Multimedia Encyclopedia, Kidspiration, and educational software such as Dinosaurs: An Interactive Journey into the World of Dinosaurs to learn about comparing and contrasting animals. Examples from multi-age classrooms (2nd and 3rd, and 3rd, 4th, & 5th grades) involved using graphic organizers and research on the Internet to learn about sound and light and using Microsoft Excel and PowerPoint, Kidspiration, and electronic learning logs to learn about animals and habitats.

Upper elementary level (4th-5th grades) examples included using Kidspiration, Microsoft Excel and Power Point, iPhoto, and iMovie to learn about the relationship of living things; using similar productivity tools including the Internet to learn about simple machines; and using Internet search engines, directories, and databases, and HyperStudio to understand behavioral and structural attributes of animals as well as learn about their habitats.

None of the project participants were teaching at the middle school level. Some of the examples at the high school level included using eChem, MDL Chime Web plugin, PowerPoint, and ChemFinder to learn about molecular biology. Other examples included using a variety of Web sites that provided audio and visual representations to develop science projects in the area of integrated natural science on maps and earth physical science maps, plate tectonics, earth crust deformation, earthquakes, and volcanoes.

Projects created by university faculty also presented multiple forms of technology use. One content faculty incorporated technology into her teaching using electronic reserves to improve student preparation for her class. She also used weekly electronic "warm-up" question pages, a Flexcam, video monitor and digital projector, and developed a database that stored exam questions in an easily retrievable format. Another content faculty used the VideoCam microscope projector, incorporated a new program called CyberEd that was installed on her computer in a lecture room, and used digital cameras and Photoshop in her Zoology class. One methods faculty created a course management site where he could hold discussions, share files and links, and facilitate the submission of assignments. He also used different simulation programs to help students examine and construct an understanding of issues related to weather. One faculty who supervised student teachers' field experiences showed increased use of technology in their daily practice such as using emails, sending and receiving email attachments, using online discussion boards, and developing and sharing electronic versions of lesson plans.

There was a clear distinction in the plans for technology integration between the university faculty and the K-12 student/cooperating teachers. As Figure 3 illustrates, the university faculty were focused on using technology for organization, information dissemination, and to enhance the delivery of content. Faculty use of technology was more focused on how the instructor would use different tools in their instruction and to communicate with students. Providing access to resources such as websites, downloadable files and videos of model teaching were higher priorities than providing the students the opportunity to create artifacts using a broad range of technologies.

Student teacher/cooperating teacher pairs placed more emphasis on having their students conduct research, create artifacts, and present information. All but one of the portfolios analyzed in this area included students conducting research or finding information online and then sharing that information by typing a report, creating an electronic presentation or making some other type of technology-based artifact. As Figure 4 illustrates, Microsoft Office products were quite popular with PowerPoint being used most frequently followed closely by Word and Excel. Many of the lessons also included students using Kidspiration to create concept maps and other graphic organizers to represent their knowledge.
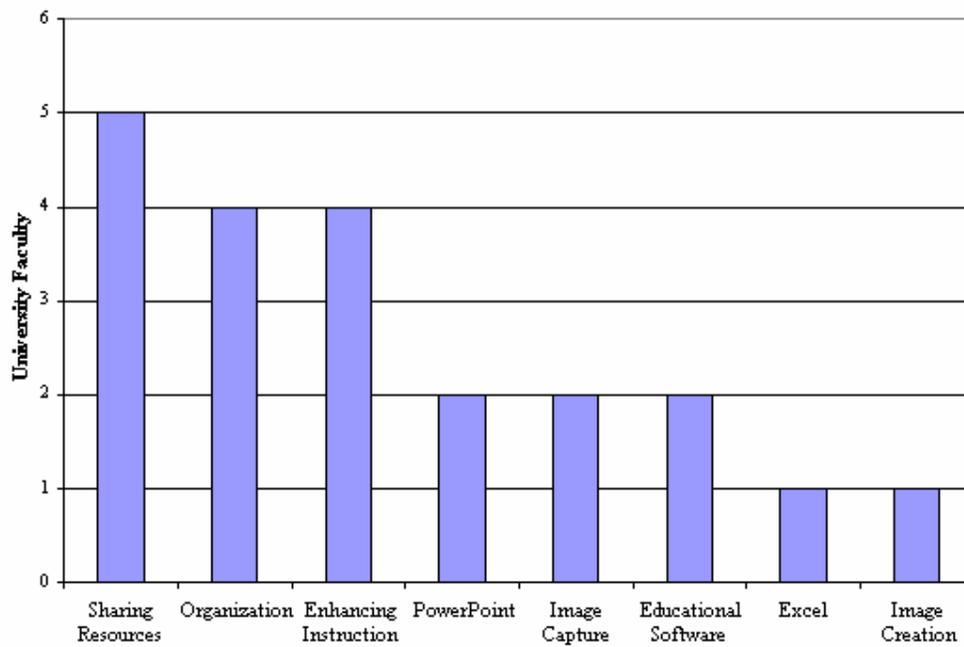

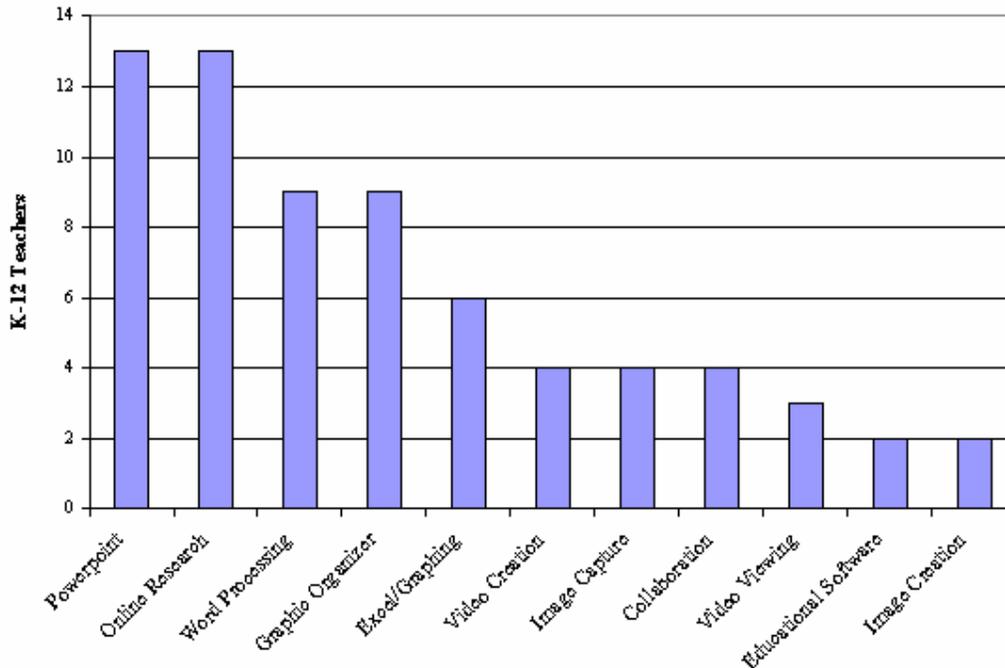**Figure 3:** Technology Use by University Faculty.

Figure 4: Technology Use by K-12 Teachers.

Appendix 2 includes the listing of the technology-integrated projects developed by the various participants. Projects are listed by grade level including information about the curriculum/unit, content, technology used, and corresponding URLs.

Factors that Promote and/or Influence Teaching with Technology
Analysis of the journal entries, participant observations in NLC discussions, and summary reflections in electronic portfolios provided data useful for understanding some of the factors that promoted and/or influenced participating science educators' technology integration in the classroom. The qualitative analysis generated three broad themes impacting participants' technology initiatives; (a) motivation and determination, (b) sharing resources, information, and ideas, (c) time, preparation, and technical support.

Motivation and Determination. For most participants, the MITTEN program was a "valuable" professional development experience in many ways. They felt excited about and "determined" to find more ways of utilizing technology in the classroom even with limited resources, and "motivated" to implement technology in the curriculum. One student teacher reflected on her experience:

> I would not change a single minute of my experience with this project…Because of this experience, I am determined to find more ways to utilize a single computer in the classroom…Throughout this project I have learned a great deal about how to use technology in the classroom. I think my greatest achievements however have been learning how to make things happen with what is available and finding additional (free) resources.

One cooperating teacher expressed her feelings in a similar way:

> My participation in the MITTEN program has been a most rewarding experience for me, my MITTEN student teacher and my students! I feel so empowered and confident about my technology skills! After 14 years of teaching, I feel as if my batteries have been recharged again, with many fresh and exciting ideas to use with my students! I am more motivated than ever to implement technology into my curriculum. It has been one of the most rewarding experiences of my life! I'm so proud of the work that we created in this project.

Similar to student teachers and cooperating teachers, one faculty member wrote the following passage on the reflection page of her e-portfolio expressing her feelings for her MITTEN experience:

Prior to my involvement with MTTTEN, I was aware of most of the technology in this portfolio, but I was not completely comfortable with incorporating it into my teaching…Overall, my MITTEN experience made me aware of how effective technology can be in teaching classes. It provided me with the impetus to try things that I had been reluctant to try before.

A student teaching supervisor shared a similar reflection:

Through my own increase in professional information power, I can facilitate greater use of the Internet among my students. I surely enjoy taking a "technological odyssey" in my search for instructional strategies for the new millennium.

The reflections provided above clearly indicate that most participants appreciated the professional development opportunities that the MITTEN program provided for them. It appears that the MITTEN program positively impacted participants' motivation and determination to use technology in the classroom.

Sharing Resources, Information, and Ideas. Participants enjoyed meeting with other teaching professionals and valued the networking among K-16 educators that the MITTEN program facilitated. The following passage from a cooperating teacher illustrated the feelings of many others:

I realized once again how important it is for people to cooperate and share resources, information, and ideas…I have also learned the value of networking with others for support and information. The sum of people involved with this project, including the university professors and lab staff, are responsible for the success of each individual.

Another cooperating teacher expressed similar experiences and feelings working with her student teacher:

The MITTEN project brought a new aspect to the collaboration between student teacher and cooperating teacher. It allowed for a learning environment between both of us. I was able to assist Megan [student teacher] with curriculum and management in the classroom, and she was able to assist me with utilizing technology in the classroom…This experience has motivated me to continue implementing technology into the curriculum…I will definitely utilize technology to enhance my lessons in the future.

One student teacher echoed the feelings of the cooperating teachers above:

Entering the classroom in January, I was feeling a little bit nervous about how exactly I was going to incorporate technology into my unit. I was aware of many types of technology that were available, but I was not sure how to utilize them in the classroom. After talking with my [cooperating] teacher, we found that between the two of us we had many good ideas to work into our unit.

A faculty member expressed her feelings of appreciation towards the MITTEN project since it introduced her to a group of people with whom she can "discuss the uses of technology in teaching." A student teaching supervisor described his feelings in a similar way articulating on the NLC meetings where he especially found it helpful when [they] "could find and share new ideas that were simple enough to apply to [his] projects." He said on his e-portfolio reflection page that "sharing [ideas] with other supervisors …provided [him] many opportunities to develop [his] own projects."

As the passages above suggest, most participants appreciated the collaboration and the teamwork that the NLC model provided. The regular communication and collaboration among project participants helped foster a productive "learning community."

Time, Preparation, and Technical Support. Participants expressed need for extra time, preparation, and technical support for enhancing lessons with technology. The following passages from a student teacher and a cooperating teacher illustrate the feelings of many others:

I learned that enhancing lessons with technology takes time and preparation. It was worth the effort because the students were highly motivated and really enjoyed learning.

> A lack of technical support and limited resources has made it difficult to integrate more technology into my classroom of fifth graders…Dealing with computer and software glitches while supervising students can be overwhelming for even an experienced teacher. Lack of preparation time was also a huge concern, although our experimentation was eased by having both of us [student teacher and cooperating teacher] available in the classroom.

The reflections provided above indicate that most participants at the K-12 level believed that being prepared and organized was critical for educators and maybe even more important when using technology.

Even though the technical support was readily available at the university level, the time factor seemed even more critical for most faculty members. Project leadership observed increased confidence and competence in technology skills of those faculty members who volunteered to participated in multiple cohorts. Considerable time and professional development seems needed to help these faculty members to move beyond their traditional practice. Two methods faculty who participated in the MITTEN project and were involved in most project activities including helping student teacher/cooperating teacher pairs in their technology initiatives, were not able to develop their *own* technology projects nor were they able to complete their e-portfolios due to various time constraints they expressed in informal communications. This was also the case for a student teaching supervisor. At times, project leadership observed that it was a challenge to help some faculty give up the teacher role and become a learner.

DISCUSSION

The new understanding gained from our research highlights some of the benefits and limitations of the network learning community approach among K-16 science educators in order to learn about and integrate technology into the teaching and learning process.

The first objective of this study was to investigate the impact of the K-16 networked learning community approach to professional development on technology literacy (knowing *about* technology) and technology integration (teaching *with* technology) of student teachers, cooperating teachers, education and content faculty, and student teaching supervisors in a science education program. The paired-samples *t*-test results suggest that over the course of the MITTEN program the project participants significantly improved their confidence (comfort level) and competence (frequency of use) in technology literacy as well as integrating technology into the curriculum. Project participants made significant improvements in using computers for connectivity, graphics applications, multimedia presentations, creating and modifying a personal or professional web pages and electronic portfolios. They also significantly improved their understanding about social and ethical issues related to technology use in the classroom such as equitable access, copyright and plagiarism, and school technology policies. More impotently, project participants made significant improvements in helping students use a variety of technology tools with content specific applications as well as becoming skilled at developing technology-enriched learning activities that are authentic, multidisciplinary, and connected to district, state, and national standards.

Participant growth in technology knowledge and skills was also evidenced by the vast array of technology-enhanced lesson and unit plans contained within the electronic portfolios. Projects created by the preservice/inservice teacher pairs included the use of advanced technology tools while facilitating the learning of science in different grade levels. For their "exemplary" technology projects, four participating student teachers received statewide recognition from the Consortium of Outstanding Achievement in Teaching with Technology (COATT, http://www.coatt.org). One student teacher/cooperating teacher team published their project titled "Seeing the Unseen: Molecular Visualization in Biology" in the Learning and Leading with Technology journal (see vol. 32 no. 4, p. 24-29). Some faculty members made changes in their courses and syllabi that reflected a greater use of technology to teach and communicate with their university students. Faculty who oversaw the student teachers' field experiences employed the use of telecommunication tools in their daily practice.

The authors' second objective was to investigate the patterns in technology integrated projects designed by the project participants that are important to technology integration in science education. Content analysis of the e-portfolio assessments suggested a clear distinction in the plans for technology integration between the university instructors and the K-12 teachers. The university instructors focused on using technology to improve their instruction and communicate with students. This emphasis might be partly explained by the fact that the university instructors were working with adult learners as opposed to K-12 students and they likely had higher expectations for their students to take responsibility for their own learning. Therefore, providing access to resources such as websites, downloadable files and videos of model teaching were higher priorities than providing the students the opportunity to create artifacts using a broad range of technologies.

The K-12 teachers placed more emphasis on having their students conduct research, create artifacts and present information. Most of the technology-integrated lesson plans at the K-12 level included students conducting research or finding information online and then sharing that information by typing a report, creating an electronic presentation or making some other type of technology-based artifact. Productivity tools were also quite popular among the K-12 teachers with PowerPoint, Word, and Excel being used most frequently. Many of the lessons also included students using graphic organizers such as Kidspiration to create concept maps to represent their knowledge. The authors would like to point out that students could have created each of these artifacts (concept maps, class presentations, research reports, graphs) without the use of the corresponding technology. However, using Word to type a report, for instance, or Kidspiration to create a concept map allowed them, potentially, to be more productive and work more efficiently and these are the most common benefits that teachers strive for when working at what Sandholtz, Ringstaff, & Dwyer (1997) call the "adaptation stage" of technology integration. At this stage, the emphasis is placed on students using technology to produce things more efficiently. As described by Dias (1999), during the adaptation stage there is more frequent integration of new technologies into the classroom. One interesting finding of Dias that relates directly to the MITTEN project is that teachers operating at the adaptation stage benefit from a system of support that may include peer observation and team teaching, flexible scheduling for the planned activities, and introduction to, and discussions of, alternative pedagogies. This is precisely the kind of support system created by the Network Learning Circles.

The third objective of this study was to investigate what kinds of professional development activities promote and/or influence participating science educators' professional development on technology integration in the classroom. The findings suggest that most participants appreciated the collaboration and the teamwork that the MITTEN NLC model put in place. By participating in collaborative professional development activities, student teachers and practicing teachers were able to work with university level content experts while getting valuable field experiences in authentic classroom settings where they could try their hand at teaching with technology. The findings highlight the fact that providing teachers with opportunities to learn about technology integration within the context of their teaching environment and allowing them to collaborate with others as they learn about, and experiment with, new technology tools is an effective way to provide the technical and pedagogical support they need when they attempt to integrate technology. Consistent with the findings of this study, the emphasis on collaborative work within an authentic setting for teacher professional development is well documented in the literature (see Cole, Simkins, & Penuel, 2002; Holbein & Jackson, 1999; Lawless & Pellegrino, 2007; Mulqueen, 2001). It appears that using collaborative partnerships helps many teachers to use technology with their students and increase their motivation and enthusiasm towards technology based training. Providing teachers time and technical support are also critical factors within this structure in order to utilize technology for instructional purposes.

The collaborative activities undertaken among the participants of the MITTEN program presented mixed results for the university faculty when it comes to their professional development in technology use. An assumption shaped the collaboration within the network learning circles with an expectation that all members of the group are learners regardless of their "levels" and all have a stake in developing their capacity to use instructional technology in the classroom. The findings imply that for some faculty this assumption has been proven in this study. Some faculty; however, need considerable time and professional development to move beyond their traditional practice.

CONCLUSION
Most higher education institutions require an educational technology course as a core component of their teacher preparation programs (Leh, 1998). Such courses play a critical role in introducing preservice teachers to fundamental technology concepts and skills (Kim and Peterson, 1992; Lambert, Gong, & Cuper, 2008). However, a stand-alone technology course is not considered a sufficient way to prepare new teachers to use technology effectively in their future practice (Hunt, 1994; Flink & Bell, 2000). One way to help preservice teachers learn how to teach with technology is to provide them with models of teachers using technology effectively in various learning environments (Ross & Wissman, 2001). These models could be in the form of university faculty who use technology in the instruction of their methods or content area courses (Hughes, 2003) or provided as the result of field experiences that take place in technology rich K-12 classrooms (Marshall, 1993). Combined with these notions, the Network Learning Community approach implemented in the MITTEN program encourages networking, mutual learning, and sharing of strategies and resources among K-16 educators and provides an effective strategy to improve technology integration in the classroom. Establishing and fostering a genuine dialogue between and among preservice teachers, inservice teachers, and education faculty provides a basis for cooperative engagement and addresses the need for comprehensive technology preparation in order to improve technology integration in the classroom.

Student teachers particularly gain from NLC engagement, interaction, and collaboration as they experience the applications of technology tools in a real classroom setting. Collaborative partnership with their mentoring teachers along with the content and pedagogical support they have from their university faculty increases their motivation and enthusiasm when they attempt to integrate technology in the curriculum.

Although many practicing classroom teachers believe computers are valuable sources of information for students and integral to functioning in society (Wepner & Tao, 2002), they also often lack knowledge (Karchmer, 2002) and time for planning to use the computer for instructional purposes (Novak & Knowles, 1991). The existing research suggests that effective inservice teacher professional development should place teachers within environments that are learner-centered (Bransford, Brown, & Cocking, 2000), take place within a relevant contextual setting (Loucks-Horsley & Matsumoto, 1999), focus on content knowledge, general pedagogical knowledge, and pedagogical content knowledge (Shulman, 1987), align with teacher practice (Garet, et al., (2001), last over a sustained period (Supovitz & Turner, 2000), and include activities teachers participate in, rather than get lectured about (Garet et al., 2001). Aligned with this notion, the NLC model provides the encouragement and support practicing teachers need to become comfortable with using different technologies for specific instructional purposes. The NLC model also facilitates the development of a collaborative relationship between the student teacher and cooperating teacher in which each fulfills the role of mentor for the other depending on the skills to be acquired and the abilities of the participants.

There are various questions to consider in regards to the development of technology use among faculty through the NLC structure. Faculty welcome opportunities for sharing their knowledge and expertise with preservice and inservice teachers concerning their technology-integrated projects but indicate mixed progress on their own development in using instructional technology in the classroom. Some faculty members find the NLC structure mutually beneficial and assume the learner role in addition to their expert role. Some need considerable time and professional development to move beyond their traditional practice. For some other faculty it is a challenge to give up the expert role and become a learner. Further studies should include a sampling from a much broader faculty audience in order to more adequately study the impact of the NLC model on faculty members' professional development in technology use.

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APENDIX 1
Technology Survey
NAME:…………………………………………….   **Date**:…………………………………….

I. Technology Literacy

Each question requires two answers. First, indicate how you *feel* about the technology competency in question. To what degree is this competency within your "comfort zone"? Please use the following scale of 1-5:

        1 = very anxious or even afraid of
        2 = reluctant
        3 = ambivalent
        4 = comfortable
        5 = eager

Secondly, indicate the *frequency* or degree to which you employ or use or do this competency or tool or task. Please use the following scale of 1-5:

        1 = never
        2 = seldom or monthly
        3 = occasionally or weekly
        4 = often
        5 = daily

1. Use computer for the "ordinary" purposes: word processing; opening, modifying, printing documents; record keeping.
        How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
        With what *frequency* do you do this, or employ this competency (1-5)? ____

2. Use computer and appropriate software to use or create databases and spreadsheets.
        How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
        With what *frequency* do you do this, or employ this competency (1-5)? ____

3. Use computer for the most "common" purposes of connectivity: sending and receiving e-mail including attachments; using URL's and search engines on the Internet; retrieving, saving and using electronic information.
        How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
        With what *frequency* do you do this, or employ this competency (1-5)? ____

4. Create multimedia presentations including sound, graphics, or animations in an application such as Appleworks, HyperStudio, PowerPoint, KidPix, Avid Cinema.

How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

5. Use more "advanced" computer functions such as chatrooms; QuickTime movies; video input, manipulation and output; large-group presentations connecting computer and projection devices.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

6. Use graphics to create professional-looking documents, newsletters, publications; these might include such programs as PrintShop or Corel Draw, clip art from disks or the Internet, or the use of a scanner or digital camera.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

7. Create and modify a personal or professional web page.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

8. Employ technology in assessment (e.g. electronic portfolios or gradebooks)
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

9. I am aware of controversial aspects of technology use including data privacy, equitable access, free speech issues; understand ethical use issues and know the differences among freeware, shareware and commercial software; understand university or school district's policies related to these issues.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

II.   Integration of Technology into Teaching and Learning

1. Help students to operate a variety of hardware tools (e.g., computers, LCD projector, scanner).
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

2. Help students use video hardware and software in engaging and constructive ways rather than for passive viewing.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

3. Help students use sophisticated and content specific applications as well as develop their abilities to learn applications outside of formal training.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

4. Help students become proficient in using search tools and evaluating and using results of searches.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

5. Develop and help students develop skills in creating multimedia presentations and products that support engaged learning.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

6. Help students become skilled at developing technology-enriched learning activities that are authentic, multidisciplinary, and connected to district, state, and national standards.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

7. Help students to utilize technology-enriched instructional strategies in which learning is highly interactive and responsive to student needs.

How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

8. Help students use technology to support authentic, performance-based, ongoing assessment including portfolios.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

9. Help students understand how to create a classroom environment in which technology is a shared responsibility between teachers and students, and where its use is transparent and in need of limited teacher direction.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

10. Use tailored (to the individual or to small groups) editable learning modules (interactive electronic tutorials to teach specific lessons or material to specific students or groups of students).
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

11. Generally understand and use technology to enhance teaching and research.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

12. Generally understand and use technology to maximize student learning.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

13. Mentor professional colleagues in using technology to improve teaching and learning.
How do you *feel,* to what degree is this competency in your comfort zone (1-5)? ____
With what *frequency* do you do this, or employ this competency (1-5)? ____

APPENDIX 2
Technology-Integrated Projects in Science Classrooms

Grade Level	Curriculum/ Unit	Content	Technology Used	URL
1st Grade	Incorporated Science	Animals with jointed legs	Digital pictures, Kid Pix, Way Cool Creepy Crawlers video, thinkquest.org, Math Keys software, Kidspiration software	http://www.umd.umich.edu/ mitten/emuylaert
2nd Grade	Scientific Exploration	Teaching science process skills: observation, classification, communication --compare and contrast animals by creating a binary classification system	VCR, camcorder, digital camera, Kidspiration, KidPix, Dinosaurs: An Interactive Journey into the World of Dinosaurs software, Dinosaurs!: The Multimedia Encyclopedia, Microsoft Word and the Internet.	http://www.umd.umich.edu/ mitten/ssobocinski
Multi-Age (2nd-3rd)	Science	Sound & Light	Graphic organizers, reading and writing, research on the Internet, and variety of software	http://www.umd.umich.edu/ mitten/lvanhauter
Multi-Age Classroom	Life Science	Animals and Habitats	Microsoft Excel and PowerPoint,	http://www.umd.umich.edu/ mitten/handerson

(3rd,4th,5th)			Kidspiration, e-learning log,	
4th Grade	Electrical Energy	Static electricity, Building a Circuit, magnetic poles, magnetic fields, batteries	Digital video and still cameras, scanners, Kidspiration, Appleworks and PowerPoint, WebQuest	http://www.umd.umich.edu/ mitten/jherm
4th Grade	The Relationship of Living Things	Food chains; the idea of adaptation and camouflage	Kidspiration, Microsoft Excel and Power Point, Mac iPhoto, and iMovie.	http://www.umd.umich.edu/ mitten/hpeterson
4th grade	Science	Electrical energy and the properties of Magnetism	Kidspiration, Word, PowerPoint, LCD Projector, Digital Camera Digital Video Software, Scanner Digital Video Camera, Internet	http://www.umd.umich.edu/ mitten/mnemeth
4th & 5th Grades	Weather	Four seasons	Digital camera, digital video camera, MS Word, Kidspiration, LCD projector, Internet, PowerPoint	http://www.umd.umich.edu/ mitten/jabuzahria
4th & 5th Grade	Simple Machines	Simple machines	PowerPoint, Internet, Excel, MS Word, iMovie	http://www.umd.umich.edu/ mitten/aevans
5th Grade	Earth science	Why Do We Have Seasons- misconceptions students have about the seasons?	Software: Science Court-Seasons, WWW	http://www.umd.umich.edu/ mitten/soswald
5th Grade	Forces At Work	Understanding of the terms velocity, average speed, constant speed, acceleration,	Kid Pix, student-graphing program, MS Word, Inspiration	http://www.umd.umich.edu/ mitten/kltarpley
5th Grade	Human Circulatory System	Circulatory system, components of blood, the human heart and how it works, journey of a red blood cell in the human body	Video equipment, Digital cameras, Internet, Microsoft Word, PowerPoint, Excel, Calculators Stop watches Altiris Vision	http://www.umd.umich.edu/ mitten/jguibord
5th grade	Science	Rainforest	WWW, Kidspiration, Power Point	http://www.umd.umich.edu/ mitten/cavis
Elementary Learning program for gifted & talented students	Life Sciences	Behavioral, structural attributes of animals and their habitat	Internet using Search Engines, Directories, and Subscription Databases; digital camera; MS Word; Hyper Studio	http://www.umd.umich.edu/ mitten/czink/czink_index.htm
9th grade	Science Foundations	Human Impact	Internet, Inspiration Microsoft Word, PowerPoint, Publisher Blackboard.com	http://www.umd.umich.edu/ mitten/rwilliams
9th and11th	Physical	Earth Physical	MS Word, Excel,	http://www.umd.umich.edu/

Grades	Science and Integrated Natural Science	Science Maps, Plate Tectonics, Earth Crust Deformation, Earthquakes, and Volcanoes	PowerPoint, Internet, digital camera, video camera, scanning device, Web sites with a variety of audio and visual	mitten/rbrockhaus/indexrb.html
9-12th grade	General Biology	Molecule visualization	Software: eChem, MDL Chime Web plugin, PowerPoint, chemfinder.com	http://www.umd.umich.edu/mitten/jfinnan
University Level	BIOL 130 and NSCI 233	Introduction to Organismal & Environmental Biology; Learning By Inquiry: Life Science	Electronic Reserves (ERes), Online "warm-up" questions, Flexcam, video monitor and digital projector, Digital camera, Test bank database	http://www.umd.umich.edu/mitten/jnesmith
University Level	General Biology and Zoology	Structures of living organisms, Anatomy and Physiology, respiratory system	Excel, FrontPage, Photoshop, Digital Camera VideoCam, CyberEd CD Set	http://www.umd.umich.edu/mitten/cbida
University Level	Science Methods	Course Website Gradebook, Online discussion board, simulations and data collection	Coursetools (a course management site) with discussion board option, Filemaker Pro, riversci.com	http://www.umd.umich.edu/mitten/cburke
University Level	Supervising Student Teaching	Recommended websites, presentations, Online Calendar, Lesson plan templates	FrontPage, PowerPoint, MS Word	http://www.umd.umich.edu/mitten/bkolnowski