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Technology Literacy in the 21st Century: Teacher and Student Outcomes of a Technology Innovation Program Model

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TECHNOLOGY LITERACY IN THE 21ST CENTURY: TEACHER AND STUDENT OUTCOMES OF A TECHNOLOGY INNOVATION PROGRAM MODEL

by

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This dissertation, submitted by Mary Beth Kelley-Lowe in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

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PERMISSION

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Signature MaryBeth Kelley-Lowe

Date November 29, 2004

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ABSTRACT

The study investigated student and teacher outcomes from a Technology Innovation Challenge Grant project, NatureShift *Linking Learning to Life* (NS), to determine if the project influenced teachers' work and student learning. The approaches were twofold: (1) to examine the implementation of higher order thinking and relevant use of technology by students and teachers and (2) to understand a teacher's reactions to and implementation of a teaching model and methodology for Internet delivery and technology use.

A quantitative study examined the student projects and teacher materials created as part of school implementations of the NS model and curriculum. The sources of data were student pre/post test scores of content knowledge and technology use, and student and teacher products resulting from NS implementations. The qualitative study looked at a participant teacher's understanding of NS. The sources of data for this case study were interviews, descriptive field notes from observations, and artifacts including lesson plans and student projects.

All quantitative instruments were subjected to psychometric analysis for content validity and reliability. Pre/posttests were scored and analyzed using the t-test for related samples. Student and teacher products were scored using a five-dimensional rubric.

Outcomes from the quantitative study indicated a positive relationship between student and teacher use of NS and technology literacy. Pre/posttest comparisons of content knowledge and technology application rose significantly after implementation of a model exploration. Student products showed a higher than average implementation of four of the five dimensions, and teacher products showed a higher than average implementation in three of the five dimensions.

From case study coding of observations and interviews of a teacher, the following assertion emerged: Access to educational technology and professional development in technology integration promotes constructivist teaching. Findings from this case study indicate that the teacher utilized a highly constructivist teaching style when technology was employed and a more traditional instructor-directed teaching style when technology was not employed.

Taken together, the quantitative and the qualitative investigations indicate that teacher and student technology literacy were positively influenced when NS was a part of the teaching and learning experience.

CHAPTER I

INTRODUCTION AND BACKGROUND

A time-traveling teacher transported from a classroom in the year 1915 to the 21st century classroom of today would find many familiar elements and enough comfort to teach in most classrooms in America. Palmer Perfect script still runs across the classroom wall, and the globe and pencil sharpener stand at the ready next to the flag, maps, and dictionary. The Industrial Age has given way to the Space Age, the Information Age, and the Age of Technology, but the biggest innovation in many classrooms may be the whiteboard replacing the blackboard and the addition of one or two strange boxes with glowing surfaces standing on tables in the corner.

Today's technology tools are an evident part of daily operations in everything from grocery stores and fast food restaurants to the doctors' offices. Cell phones, ATM machines, palm pilots, digital cameras, video games, DVD movies and music, instant messaging, and the Internet have all assumed increasingly natural roles in everyday worlds of work and play (Thornburg, 2002). As the world shrinks and global communications increase, people carry, wear, and drive devices that communicate via satellite. These technologies are incorporated into the fabric of modern society and have a useful and necessary place in the teaching and learning environment of schools. However, in many school settings at present, they are often underutilized, unavailable, or in the case of email and Internet, sometimes reviled and prohibited (diSessa, 2000).

School is the work world of young people. It serves as a preparation for learning how to live life, not make a living (Postman, 1996). Ideally, education should enable learners to combine culture and vocation successfully and prepare them for the future (Gardner, 1991). Young learners in school today will, after graduation, encounter a very different world than the one they are living in now. Information is doubling every year, while the broad scope and fast pace of communication is shrinking the world and changing life in ways one cannot imagine (Bartels & Hein, 2003).

In a world where there is more to know than can be known by any one individual, learners need to become problem solvers, able to find answers and create personal meaning out of the vast, growing body of available knowledge. As educators respond to technology innovation and cultural changes, they have the opportunity and responsibility to restructure education and blend new technology with 'best practices' and tried and true educational philosophy. John Dewey's (1936, 1963) principles of progressive education, providing students with meaningful experiences that are shared in groups whose members contribute individual expertise and shape personal understanding of events, are supported by the modern tools of technology (Driscoll, 2002; Vannatta & Beyerbach, 2000).

Schools, educators, and classrooms employing 21st century tools, along with ppropriate tasks and processes, must provide young learners with the skills they need ow and in the future. The jobs of tomorrow have not yet been invented, but futurists redict that young people of today will change careers four or five times in their fetimes (Grabe & Grabe, 2001). More than ever, learning will need to be lifelong, as nowledge continues to expand rapidly and new skills will be required for success.

Technology enhances opportunities for students to replace rote recitation of basic facts with authentic learning on a need-to-know basis, by giving students tools to sift through massive amounts of information and generate knowledge of personal significance (Okamato, Cristea & Kayama 2001; Thornburg, 2002).

Acknowledging the need for technological tools as part of educational reform, agencies and new standards were established holding students, preservice teachers, and teachers of teachers accountable for technology literacy (Hird, 2000; Roblyer, 2003). In 1994, the World Wide Web marked its two-year anniversary. Computers' costs and size decreased, as software applications, student usage, and Internet information increased exponentially. This astronomical growth of information and technological function prompted the Department of Education to declare integration of technology into teaching a priority and the focus of the Improving America's Schools Act of Congress (1994)

In the early 1990s computer technology (including the use of the Internet and the World Wide Web, computer software, and digital images) was increasingly recommended as a component of K-16 education while school spending for technology was only $3.3 million per year. The United States Department of Education estimated that a minimum of $11 billion was needed annually over the following 10 years for educational technology (U.S. Department of Education, 1996). In 1994 President Clinton and Director of Education Riley responded to the need for a technology literacy that would ensure America's future in the world economy by establishing the Improving America's Schools Act. Congress passed the Improving America's Schools Act into law making a $2 billion dollar, five year commitment to the Technology for

Education Act of 1994 (Section 2, Title III) establishing the Technology Innovation Challenge Grant (TICG) program (U.S. Department of Education, 1996).

TICG was designed to promote technology literacy in the 21st century by "helping states and local communities to create and implement their own plans for integrating technology into teaching and learning for the purpose of achieving excellence among our students" (Harris, 2002, p. 3). Proposed projects were directed to be demonstrations of innovations that created greater opportunities for students and greater efficiencies in education for teachers and learners. They were to be carefully evaluated and dedicated to development and demonstration of technology integration into teaching and learning. Selection of projects was to be based on designs that served youth and were built on community partnerships that showed commitment of local funds and matching support for projects designed to improve knowledge and learning through technology (Harris, 2002).

Recognizing the changing world and power of new technologies, the first TICG reference for proposals (in 1995) was on educational reform. Teachers were encouraged to become learning coaches who supported and managed diverse learners. The proposal called for sustained professional development to support these new learning technologies, helping to bring them into the curriculum. New technologies would be the tools for teachers and learners to meet 21st century classroom challenges and provide a way for widespread sharing of best ideas with colleagues across the nation.

According to TICG guidelines, each innovative program was required to demonstrate community commitment, innovative integration of technology tools, and attempts to change the way students and teachers used technology tools in everyday life. Each year the call for proposals articulated a slightly different emphasis based on the findings of the previous years. Additional requirements for evaluation and a greater emphasis on sustainability resulted in a diverse range of products and outcomes throughout the duration of the TICG program.

Since the inaugural period 1995-1999, 110 projects have been initiated; of those, over 99 are in various stages of completion, some in year six of seven with approved extensions to complete proposed work. An analysis of the initial 62 projects in 2002 grouped them into the following themes: student learning, professional development, parents and communities, strengthening curriculum, infrastructure, connectivity, leadership and administration, evaluation, sustainability, scaling up, dissemination, and community partnerships (Harris, 2002).

In 1997, the Dakota Science Center and the Grand Forks Public Schools (in partnership with the University of North Dakota and 14 other educational units from around the state of North Dakota) proposed for the third time and were granted $4.5 million dollars for the NatureShift! *Linking Learning to Life* TICG project. Based on best practices from free-choice (informal) and formal teaching and learning, the five year grant set out with an ambitious purpose: to create a Web site and program to promote student -driven/teacher -supported inquiry, conducted in the real world and on the Internet, using relevant technology tools. Student research and activities conducted online, at home, in the classroom and in the community would culminate in individual and group summative projects shared with classmates, families, and published on the Internet.

Formal educational partners, including Grand Forks Public Schools, University of North Dakota, three Tribal Schools, and three public schools provided input on teaching and learning strategies and tested educational products. Informal educational partners including North Dakota Fish and Game, North Dakota State Parks, the State Historical Society of North Dakota, the Sahnish Culture Society, and two libraries provided primary resources, digital images, information, activities, and expertise for the project.

NatureShift (NS) attempted to create a three-dimensional Internet learning porthole designed to enhance critical thinking using expertise from informal and formal educational entities. Postman (1996) emphasized the power of multidimensional learning environments: "Generally, young people have too much curiosity about the world and far too much vitality to be attracted to an idea that reduces them to a single dimension" (p. 30).

Gardner (2001) captured the essence of the philosophy that informs NS when he noted that the capacity to think is very different from knowing lots of information. He stated that intelligent thinking and understanding come about "if one has rounded, three-dimensional familiarity with a subject, so that one can probe in many different ways... and that concept or topic is much more likely to remain with us, embedded in our neural networks, and to be usable in flexible and innovative ways" (p. 1).

In January 200, NS received re-granting funds to launch the NS Ambassador program as part of its dissemination model. More than fifty teachers from across the United States were recruited to be trained and implement the NS program nationwide.

This dissemination marked completion of the final objective of the grant and resulted in a wide array of NS student and teacher projects.

Need for the Study

The 110 TICG projects represent significant effort and dedication of time, money, and talents to integrate technology into K-12 education in new and innovative ways. NS successfully met the seven objectives (Appendix A) set forth for the project. After the Federal Government signaled its satisfaction, the six years of work, evaluations, and government reports were boxed up and shelved in the No Child Left Behind offices, along with the findings from the other completed TICG projects. Appointees of the Bush administration have taken down the TICG Web site, and Clinton's America 2000 initiative has all but disappeared. Meanwhile, most of the TICG projects continue with the same commitment to educational reform that spurred the original initiatives.

NS grew out of the best thinking of informal science educators, university educators, and formal educators who all had a fascination with and commitment to the possibilities of technology integration into learning. The combined expertise of an educational psychologist, middle school technology coordinator, science center director, preservice science educator, and others yielded the initial NS model and an innovative technology integration program that evolved and changed along with the quickly evolving Internet, World Wide Web, and other technology.

NS developers were free to innovate and explore best practice teaching with technology, This large investment of federal money carried with it an obligation toreport on the effectiveness of the $4.5 million dollar NS educational experiment. It was possible to determine ways the project provided a useful response to the 21st century challenge of teaching with technology by investigating the pedagogy behind the NS model and the resulting student and teacher projects. The study may help educators take another look at partnerships between formal and informal education entities and ways that technology can enhance learning and contribute to the technology literacy of teachers and their students.

The commitment of resources and intellectual capital that constituted this project led the researcher to consider several inter-related questions about the NS Project that warranted further research. The size and breadth of the NS innovation required a focused study that investigated the major goals of the program.

Purpose of Study

This study was undertaken: (1) to determine if the pedagogy, Web site, and training of the NS project contributed to teachers' and students' technology literacy and (2) to investigate what happened when a teacher, trained in the pedagogy and Web site, implemented it in a school and classroom. Quantitative research techniques were used to investigate the relationship between teacher and student use of NS and the demonstration of higher order thinking, learning level, relevant use of technology, and understanding of the natural world. Qualitative methods were used to analyze and synthesize a teacher's understanding of the NS program to gain an understanding of the program's influence on the teacher's technology literacy.

NS by its design attempted to elicit inquiry; exploration and learning; higher order thinking; use of technology; and meaningful, authentic research that resulted in student generated projects. This study provides a basis for further discussion and research about how people teach and learn best using the ever changing andevolving technology tools that are available.

Review of the Literature

The review of literature for this study addresses three topic areas related to the role of technology in the classroom, its effect on learning, teachers' attitudes, students' attitudes, and the way these variables influence educational research and practice. In the first section early learning theories are examined as well as the role these theories played in reconceptualizing the stages of cognitive development that inform modern pedagogy. Selected literature explores these theories and educational technology integration research that served as the basis for the NS program.

In the second section current educational trends and the evolution of teaching practices using technology are described. Areas of focus for this literature review include engagement of teachers and learners, demonstration of higher order thinking, learning outcomes, and student and teacher technology use. These topics reflect the main objectives of the NS program and this study.

The beliefs and images of technology held by teachers and learners are explored in section three. Examining research on these beliefs and how they have changed over time serves as a basis for understanding teachers' and learners' perceptions of the NS Web site and program.

Section 1: Learning Theories and Technology Integration

Educators and researchers recognize and draw connections among the early educational learning theories of Dewey, Vigotsky, and Piaget and modern informational and educational technology (diSessa, 2000; Driscoll, 2002; Gardner, 2001; Mioduser, Nachmias, Lahav, & Oren, 2000; Reiser, 2001). A new pedagogy is emerging that includes technology as an essential part of the constructivist method where learners use their instincts to work with materials and experiences that are often specifically selected to support the students' habits, capabilities, and interests (Gardner, 2001; Hird, 2000). Vigotsky (1978) recognized education as a psychological and social process that required educators and researchers to be aware of and responsive to the learners' habits, capacities, and interests. Gardner (1991) describes Piaget's concept of cognitive development and understanding of experiential learning as "qualitative shifts in representation and understanding" (p.28) that were associated with human maturation and understanding of numbers. Gardner (1993) expanded constructivist learning theory by identifying different learning types and multiple learning styles. He recognized the potential of multifaceted technology to accommodate these differences. Vigotsky's (1978) interest in the human ability to create language systems, including numbers and the use of them to solve problems, expanded the understanding of the social nature of learning (Byrnes, 1996). With the exception of verbal language, all symbolic media involve technology of some sort, from written words to digital cameras, designed purposefully to organize, process, and share information (Hird, 2000; Pea, 2000).

Papert (1980) correctly predicted the future potential of computer technology noting that "the computer can concretize (and personalize) the formal," allowing "knowledge that was accessible only through formal processes [to] now be approached concretely" (p. 231). His research on ways the computer medium affects the level of learners' cognition supports Piaget's and Vigosky's understanding of the power of language and numbers. Papert noted that young children who learned simple programming are able to function and reason well beyond their chronological age and developmental level almost to an adult level (Cradler, 2003).

Computers are human creations that demonstrate the human capacity for inventing whole symbolic systems (Crook, 1994). Through observation and analysis researchers better understand what humans do with the technology tools, and how and why people learn using them (Bull, Bull, Cochran & Bell, 2002). As symbol-creating and symbol-using animals, humans have progressed from the spoken word to the written word and on to numeric language systems and devices (Vigotsky, 1978; Jacob, 1997) that put learners in the position of "constantly interpreting the world rather than responding to it" (Crook, 1994, p. 35).

Dewey, Piaget, Vigotsky, and constructivist theorists that followed played a pivotal role in reconceptualizing the stages of cognitive development that inform modern research and pedagogy (Byrnes, 1996). The interactive qualities of modern technology have taken education beyond the level of information delivery, leading to an acceleration of the cultural process whereby educational technology is becoming a thinking tool (Pea, 2000).

Computer-based presentations that involve some combination of text, pictures, sound, video, and links to the Internet (hypermedia) utilize many elements drawn from current pedagogy and constructivist approaches to learning (Byrnes & Sayre, 2000). There is a commonly held belief that these information technology systems may automatically support and lead to major contributions to the teaching and learning process (Mioduser et al., 2000; Vannatta & Fordham, 2000). It is also thought by some that teaching will continue to improve simply through the adoption of new learning technologies (Archer, 2000; Dede, 2002). Others caution that technology itself will not transform education, but rather how it is used will determine its effectiveness (Baylor & Ritchie, 2002; Davies, 2003).

Researchers and educators have identified several elements characteristic of constructivist learning that are at work in educational technology and hypermedia: 1) hands-on, inquiry-based approaches, 2) use of authentic problems, 3) exploration by collaborative groups, 4) utilization of problem solving strategies, 5) employment of multiple perspectives, 6) generative student projects, and 7) selection and synthesis of large quantities of information (Bush & Sayre, 2000; Dede, 1995; Hird, 2000). An emerging constructivist/technology partnership using hypermedia supports the many facets of contextualized learning, when students have opportunities to connect language to the shared experiences of their life, community, and classroom (Bartels & Hein, 2003).

In this environment, educational technology tools enable learners to develop and utilize multiple intelligences that transform single-dimensional thinking by presenting pictorial, auditory, and textual information from multiple perspectives (Gardner, 1993; Veenema & Gardner, 1996). Educational technology provides the mode, method, and means for teachers and students to take a more naturalistic approach to learning for students with different interests and learning styles (Dede, 2002).

Unlike many other presentation technologies (books, video, television, radio), hypermedia's dynamic structure supports and encourages learners to find, use, and present information in their own way (Dillon & Gabbard, 1998; Driscoll, 2002). The structure mirrors the human brain, ordering large amounts of information with an associative function that requires less internal processing and more readily promotes and supports higher order thinking and constuctivist-based pedagogy (Dede & Palumbo, 1991). As the learners move in multiple directions, they can efficiently capture, organize, and communicate this information and knowledge to others (Dede, 1995; Heller, 1990), making the learning generative and demonstrating critical thinking using higher order thinking skills (Bush & Sayre, 2000).

The parallel structure and function of human metacognition and hypermedia provide a vehicle for learners to incorporate capabilities and apply them to novel situations (Heller, 1990; Dillon & Gabbard, 1998), while the openness of the Internet and other multimedia tools promotes learner disinhibition. Students extend questioning and exploration that "allow the knowledge base to accommodate the learner and not vice versa" (Dede & Palumbo, 1991, p. 17).

The hypermedia-based environment becomes a "lever for learning" and knowledge construction is readily supported when the learners have "the ability to keep many threads alive at once" (Dede, 1995, p. 48). With proper use of educational technology, learners switch from passively receiving to actively assembling what they know to be useful (Grabe & Grabe, 2001).

Technology can be adapted for different learning styles. Teachers can achieve the goals they have set, while the learners choose the methods. Becker's (2000) survey *of teachers' Internet use recognized a relationship between the "constructivist vs.* traditional pedagogy" index scores. The more constructivist the teacher's teaching style the "greater their average use and the more positively they viewed the Internet" (p. 99). A link also existed between use at home and frequency of use in teaching. Becker

(2000) found that 68% of the teachers used the Internet for information-gathering purposes and over half viewed Internet access as essential for their teaching.

However, the sheer quantity of information and multiple connections can lead to information overload (Hargis, 2001). With better presentation and a developed digital literacy students are increasingly better able to navigate where they need to find answers and create meaning using emerging technology tools (Halpin, 1999; Roschelle, Pea, Hoadley, Gordin & Means, 2000). Technology literacy for teachers requires seamless technological integration into the classroom, providing new tools for students to use their own language and experience to express learning peer to peer, student to teacher, and student to expert (Mioduser et al., 2000).

Section 2: Current Educational Trends in Technology Integration

All cognitive theories emphasize a natural progression of thinking from simple to more complex that requires a certain amount of experience, education, and application before learners are capable of functioning at the highest levels (Byrnes, 1996; Bartels & Hein, 2003). Numerous researchers and educators have looked to technology tools for development of these skills, a "catalyst for change in classroom processes because it provides a distinct departure, a change in context that suggests alternative ways of operating" (Sandholtz et al., 2000, p. 268).

Transfer of knowledge and higher order thinking naturally go together but are often lacking in the classroom, where the emphasis is still too often on facts and information delivery (Byrnes, 1996; Driscoll, 2002). Early efforts by Cousins and Ross (1993) demonstrated information technology's positive affect on the use of higher order thinking in areas of organizing, locating, synthesizing, and concluding.

In a later study, Hopson, Simms, and Knezek (2001-2002) used the Ross Test of Higher Cognitive Processes to examine the relationship between higher order thinking and technology use. The treatment group, supported by computer-based classroom teaching stations and technology trained teachers, showed a significantly higher evaluative ability than the control group, but overall there appeared to be a minimal positive effect on student development of higher order thinking skills. The technological environment, teachers' methods of integration, and student technology use are considered influential to demonstration of higher order thinking and technology literacy.

Equipment and Access

Roblyer and Knezak (2003) noted that every technology innovation has ramifications for educational trends, pedagogy, and learning. Their research indicated that the interrelating factors of environment, method, and learner determine the success of learning and must all be considered and studied in future research.

Technical tools from pencils to computers all mediate higher mental functions (Jacob, 1992). Careful consideration and research are required to understand how current educational technology tools and trends are actually affecting teaching and learning. As technology literacy increases, researchers are seeing teachers employing more constructivist practices (Vannatta & Beyerbach, 2000), students engaged in group learning (Lou, Abrami & d'Apollonia, 2001) and increased social communication as part of that learning (Hron & Friedrich, 2003).

When Cohen (2001) compared two high schools to determine the effect of a "technology-rich" constructivist teaching environment on students' learning, she noted that "the use of technology affected all aspects of the teaching and learning style" (p. 356). Although students found the constructivist teaching method confusing at times, they showed a significant positive change in four of six variables: higher motivation, collaboration, responsibility, and satisfaction: however, they had a lower persistence rating.Students in Cohen's (2001) study reported that the assignments and due dates were sometimes stressful, but overall students rated learning in the technology-rich constructivist-based school as more relevant than the traditional students in the objectivist-based school. The study indicated further that students expected technology to be part of their learning in both settings and commented without prompting on its absence in the traditional school.

Poor equipment and lack of equipment are repeatedly cited as the primary reasons for lack of technological implementation and integration by educators at all levels (Hird, 2000, Becker, 2000). In response, schools are buying more equipment and upgrading what they already have (diSessa, 2000; Hird, 2000). Because school districts are "unable to ignore such a deeply permeating innovation" (Pierson, 2001, p. 413), many school districts have purchased equipment with little or no thought to how teachers will be supported in using it, and in fact, the new equipment is not always well utilized.

By 2002, 98% of the schools in the U.S. had at least one computer per classroom, a big jump from four computers for every school in 1995 (Hird, 2000). The disparity between availability and reported low levels of use requires more research on the contributions of technology-based methods to learning in the modern classroom (Roblyer & Knezak, 2003).

Today bandwidth and greater realism are the newest essentials for which society and educators are clamoring (Thornburg, 2003), but access and speed still do not ensure fluency or appropriate implementation. Increasingly, educators and researchers are facing the question of what factors really do contribute to literacy and fluency of technology use. Okamoto, Critea, and Kayama's (2001) examination of learner-oriented, media-oriented learning environments showed their value but pointed to the teacher as the key to successful implementation and achievement of student outcomes.

Technology Literacy and Integration

The National Educational Technology Standards define scientific literacy in terms of technology use. "Effective integration of technology is achieved when students are able to select technology tools to help them obtain information in a timely manner, analyze and synthesize the information and present it professionally" (U.S. Department of Education, 2000, p. 1). Thornburg (2002) advises achieving true fluency by adding "relevant use" of the tools as a criterion for literacy and as a mark that technology is seamlessly entering the schoolroom.

In a K-12 survey, Russell (2003) reported that 93% of the teachers thought that technology standards were important but only 60% felt that technology would have a positive impact on education. According to Poertner et al. (Poertner, Sumner, Tsoisie & Zak, 2002), most teachers search for technology literacy standards that support how they already teach and the lessons they are already using, or they search for lessons to match the standards. Only rarely do teachers actually use standards prescriptively to determine what children are to learn.

In some cases the standards are effectively used to inspire teaching and the creation of innovative teaching using the World Wide Web and other technologies (Roblyer, 2003). The Internet has been branded as a tool for inquiry and constructivist-based teaching and learning (Dede, 2002; Pea, 2000; Rodrigues, 2000). Software and Web design have been transformed over the past decade in response to instructional standards that require collaborative learning and examination of complex and realistic problems from multiple perspectives (Reiser, 2001).

However, when Mioduser and his colleagues (Mioduser et al., 2000) evaluated 500 science Web sites, they found only a small percentage fostered collaborative learning. Most were geared for high school level science information delivery with text as their primary focus. Interestingly, over half were created by museums, colleges, or universities and only 5% of those involved problem solving, indicating "one step ahead for technology, two steps back for pedagogy" (p. 55).

The failure of both formal and informal Web sites to utilize best practice teaching is another demonstration of institutions retaining traditional educational mistakes and building them into the new promising technology along with conservative bias of traditional teaching (Sandholtz et al., 2000). When Rodrigues (2000) studied a collaborative venture between designers and science educators who were intentionally applying constructivist pedagogy, she found that the nature of instructional design was largely incompatible with constructivist learning theory. The active construction of knowledge and the ability for multimedia to facilitate learning were challenging concepts for the designers to grasp. What was intuitive to the user and the designer was often different, as were the many interpretations of the items created.

In a survey of teachers' dispositions and teaching styles, Vannatta and Fordham (2004) found that the teachers who used technology extensively identified themselves as risk takers who understood the constantly changing nature of technology. These teachers reported a willingness to exceed the normal duties of their positions and stated that they were more likely to employ a constructivist teaching and learning style in th r classrooms. However, the majority of teachers remain unwilling to break their established routines and tend to fall back on computers as tools for rote instruction, failing to appreciate the value of technology as a student learning tool (Christensen, 2002). Fewer than half the teachers in the U.S. report using computers for instruction (Becker, 2000). Despite the increasing emphasis on technology infusion, schools continue to neglect technology training for teachers (Dawson & Rakes, 2003).

Zhao and Frank (2003) chose 19 schools that had experienced a recent infusion of technology as part of a school initiative or block grant to study the degree to which teachers and schools were engaged in technology integration. Results showed that 79% of the teachers used computers daily. Of those users 80% used computers for email, and 33% used computers to search the Internet for background information. Only 17% of the teachers used the Internet as a teaching tool and part of student learning.

Pierson (2001) selected exemplary technology-rich elementary classrooms, recommended by technology coordinators, for her study of technology integration. Observed differences in method of technology use and amount of use correlated positively with individual levels of teaching experience, expertise, and the teachers' own personal learning style. The more extensive the teaching experience and the more constructivist the teaching style, the more frequent and relevant the implementation.

Vannatta and Fordham (2004) noted that teachers who used the most technology also tended to teach in a more constructivist style.

According to Reiser's (2001) historical analysis of technology research, the questions being asked have changed with the evolution of technology and its application by users. Studies first focused on technology itself to verify if learning could occur with each new innovation from drill and practice to computer tutorials. Over the past ten years, a change in practice has occurred as schools and colleges replaced the information transfer methods of computer-assisted instruction with hypermedia-assisted instruction (Vannatta & Beyerbach, 2000).

New research and funding opportunities became available following the emergence of the World Wide Web (Harris, 2002). Educators began to perceive it as a tool for learning rather than a tool for teaching. With the evolution of simulations, software, databases, and work tools, research questions focused increasingly on learning with technology and measurement of student outcomes. Distance learning, widespread Internet use, and email have pushed research further towards investigating self-directed, constructivist learning that employs higher order thinking and self-reflective metacognition (Dede, 2002; Reiser, 2001).

Research findings indicate a need for better integration of technology into preservice education. Preparing Teachers for Tomorrow grants focused on the integration of technology training into college teaching for college educators, and preservice teachers are providing strong evidence for the value of technology modeling (Sandholtz et al., 2000; Abbott & Faris, 2000).

Technology Use and Student Outcomes

Research on learner outcomes often compares learning with technology to learning without technology. This either/or comparison has produced conflicting research conclusions, perhaps because it is asking the wrong question. Students can learn with or without technology. What is not known clearly is what aspects of educational technology and pedagogy help students learn (Roblyer & Knezek, 2003).

Thirunarayanan and Perez-Prado (2001 –2002) compared learning outcomes in Web-based and classroom-based learning environments taught by the same instructors using the same assignments. They found only slightly more learning in the Web-based environment.

In a meta-analysis of hypermedia research studies measuring learning outcomes (defined as changes in learner behavior or task performance), Dillon and Gabbard's (1998) study on use of educational technology and learning outcomes indicated that the structural mapping of hypermedia helped novices to acquire an expert's comprehension of a subject. As learner control increased, comprehension increased. However, findings indicated that hypermedia was not an effective learning mode for everyone.

Anecdotal evidence indicates that interactive Web technology supports constructivist learning as students explore paradox, accept challenges, and search for new insights, but more research is needed. Hargis' (2001) study of post secondary science students indicated that learning occurred with both the linear Internet format that delivers information and the more interactive hypertext format, but learners under 20 years of age learned more using the interactive format. The constructivist Internet technology helped younger learners to "participate more easily in education, learn more effectively and enjoy learning more" (p. 480).

Comparing incidental learning and intended learning in a meta-analysis of hypermedia environments, Heller (1990) attempted to define the many issues that educators and designers face in creating hypermedia assisted instruction. With an ability to "keep many threads of inquiry alive at once" (p. 432), hypermedia research offers insight into what and how people learn and the impact this environment has on retention of information, interest in the topic, and motivation to learn (Heller, 1990). Users may be unwilling or unable to discriminate among the many knowledge bits and to benefit from the use of advanced organizers, scaffolding, and icon tools that could potentially help learners identify search objectives and complete projects (Becker, 2000).

Individualized instruction was reported to be effective for some learning styles but often placed students in isolation completing projects designed by the teachers (Thirnarayanan & Perez-Prado, 2001-2002). A meta-analysis of 122 studies involving 11,317 students supports the importance of the social interaction while using technology to enhance student outcomes (Lou et al., 2001). In that study small group learning had a significantly more positive effect on achievement and task performance than individualized learning. Hron and Friedrich (2003) linked the increase in learning to social communication and group participation when using Web-based learning.

Section 3: Beliefs and Images of Technology in Teaching

The reciprocal relationship between culture, cognition, and context requires that educators pay close attention "to the meanings that humans create and use to guide their behavior" (Jacob, 1992, p. 295). Educators and researchers may 'decide' how technology and learning will be integrated, but users will ultimately define technology and give it meaning; they will identify its true significance (Sandholtz et al., 2000).

Creswell (1998) notes that it is possible to build meaningful generalizations from detailed understanding of specific contexts. The knowledge that is found in specific cases is "laced with personal bias and values" (p. 19) which must be acknowledged, defined and measured. Extensive research on student and teacher attitudes about technology has been conducted for the last ten years. These attitudes seem to be changing as the technology changes.

Student Attitudes

Children growing up in the midst of the dynamic Internet information technology age are no longer satisfied with passive online presentation of educational material (Hargis, 2003). They expect choice and a chance to find information that they need to move their learning and understanding forward; children's early use, access, and experience with technology is generally positive and currently more pervasive in lower grades (K-8) than in secondary schools (Hird, 2000).

Since use may not indicate educational fluency, researchers continue to call for more studies on diffusion of educational technology and its integration into learning (Roblyer, 2003). In fact, the trend in dedicating money for equipment purchase and neglecting the funding for training and implementation is still an issue nationally (Pierson, 2001).

Young (2000) measured multidimensional changes in the areas of student attitude, confidence, perception of computers, and teacher attitude. She found that despite strides in access, males perceive computers as a male domain. In contrast females do not perceive computers as a male domain but still lag behind in confidence using computers. Another finding of perhaps greater importance concerns the way students orient themselves to computers. Student use at home was equal for both males and females, but females felt unsure of their ability to use computers and did not see a connection between computers and future jobs (Volman & van Eck, 2001).

Technology integration can be a predictor for higher achievement in students who perceive computers as a desirable thing or have friends who use computers and see them as desirable. In some cases "students who viewed computing as socially desirable or image enhancing, or who have friends that were computer users, achieved higher scores on the thinking-skills dimensions" (Cousins & Ross, 1993, p. 112).

In Cohen's (2001) study of learning styles in two schools (a traditional school and a constructivist-based technology-rich school), the enriched learning environment positively affected several aspects of education, as shown by persistence, responsibility, increased satisfaction with learning, and higher test scores. Students enrolled in the Apple Classroom of Tomorrow Program (a pilot project of technology-rich classroom instruction collaboratively designed by the Apple Corporation and classroom teachers) showed 50% less absenteeism than regular classrooms. The biggest in-class changes were observed in how students approached their work. Students demonstrated increased collaboration, inquiry, and problem solving. Prior to entering the program, 50% of the students planned to attend college. This number jumped to 90% after only one year in an Apple Classroom (Sandholtz et al., 2000).

Teacher Attitudes

Personal beliefs underlie all human endeavors. Humans naturally draw on the known and fall back on traditional behaviors in challenging circumstances. Most educators accept the notion that educational technology will help students to learn better (Vannatta & Fordham, 2004), but they "enter the profession with deeply held notions of how to conduct school–they teach as they were taught" (Sandholtz et al., 2000, p. 257) and resist using technology.

Ertmer, Addison, Lane, Ross, and Woods (1999) divided these barriers of technology adoption into first order external barriers (including time, equipment, training) and second order barriers that were more personal (such as traditional views of teaching and learning and fear of losing control of the classroom). While the extrinsic barriers can be overcome with funds and administrative support, the second order barriers are much more difficult to change and remain at the core of every teacher's values and beliefs about teaching and learning.

Teachers are more apt to choose drill and practice because it most closely resembles traditional teaching. Teachers in many studies and at all levels report barriers to implementation that include lack of time, lack of confidence, lack of support, and not knowing how to incorporate the tools and techniques that they have acquired (Becker, 2000; Crook, 1994; Gallini & Barron, 2003).

The way teachers use technology and computers is determined by the teacher's definition and understanding of technology (Pea, 2001). Polar opposites were reported ranging from perceiving it as an inspiration to viewing it as an intrusion; what teachers believe influenced how they viewed and handled barriers to implementation. Vannatta and Fordham (2004) identified three variables that combined to be the best predictors of classroom technology use: 1) openness to change, 2) actual time committed to teaching and 3) self-described teaching style. The higher teachers rated their disposition as risk takers and the more willing that they were to go above and beyond the call of duty, the more they used technology.

Baylor and Ritchie's (2002) quantitative study of 94 classrooms found a connection between factors that facilitate student learning, and teacher skill and morale. In a somewhat circular relationship, teacher technology competency and technology integration were predicted by openness to change. Teacher morale was predicted by commitment to professional development and constructivist use of technology. Technology impact on higher order thinking was also predicted by teacher openness to change and constructivist use of technology.

In their study of the TICG Goals 2000 project, Vannatta and Beyerbach (2000) administered an open-ended survey that revealed that modeling and infusion of technology expanded preservice teachers' understanding of technology use to include a "dynamic constructivist vision of technology and its applications" (p. 144). An increased proficiency and comfort in basic use of technologies accompanied this understanding, but learning skills alone did not transform how teachers used the technology. The researchers determined that, due to pressures of time, the teachers' newly acquired skills still did not readily transfer to classroom application.

Teachers in the Apple Classroom study reported an "approach-avoidance behavior," where changing old habits took time and repeated successes, before teachers permanently changed their way of teaching (Sandholtz et al., 2000, p. 257). In the technology-rich environments teachers rapidly changed attitudes following four stages in their technology literacy development: entering, adoption, adaptation, and appropriation. Appropriation was reached when teaching practices changed as a result of the teacher's success in technology integration and growth in technology literacy.

Most researchers agree that the successful use of computers in the classroom is dependent upon positive teacher attitudes toward computers (Abbot & Farris, 2000; Woodrow, 1991). Positive experiences and an understanding of need can increase teachers' willingness to try new techniques. As computer literacy increased teachers' attitudes toward technology improved (Christensen, 2002).

Fluency and comfort of use improved for teachers and students when the users felt in control of the technology rather being controlled by it. In a study of the effects of a six-stage needs-based technology adoption model, Christiansen (2002) found that considering the needs of the teachers was key to success. Most teachers in his study progressed one stage (in the six stage developmental model) in the first year of the instruction program. Having input into technology choices "had a rapid positive affect on computer anxiety, perceived importance of computers, and computer enjoyment" (p. 411).

Successful experiences with technology led to greater use and better integration of technology, which in turn reinforced changes in teachers' beliefs. When training was perceived as relevant to teachers and helpful in achieving their stated and mandated goals and teachers identified ways that technology helped to meet the needs of their students, then it was employed more readily (Baylor & Ritchie, 2002; Christensen, 2002).

In the push for new technology, administrative purchases and technology innovations are mismatched; purchases are often initiated without the teacher in mind (Pierson, 2001). Teacher training falls behind the priority of equipment acquisition, and desired results are not achieved when teachers perceive technology implementation as an imposition and additional burden (Pea, 2000). Teachers consistently ranked use of technology tools to support their teaching above use of technology as a teaching medium. They reported most frequent use of computers to retrieve, store, and process information, and perceived them as "production tools" rather than "instructional media" (Woodrow, 1991, p. 489). When asked to rate and rank their needs and their students' needs, teachers stated that often computers met neither the needs of the student nor the needs of the teacher (Woodrow, 1992). Including teachers in the design and decision making processes when creating or enhancing technology and innovative computer programs increased the likelihood that the technologies were used (Okamoto et al., 2001).

In school studies (Ertmer, Addison, Lane, Ross, & Woods, 1999; Sandholtz et al., 2000), teachers' employment of computers ranged from using them to supplement existing curriculum to using them to facilitate emerging curricula. Teachers rated highest applications that allowed users to retrieve, process, and present information. Applications in which the computer was used as an instructional or learning tool were given much lower ratings.

The more years of experience teachers had in the classroom, the more comfortable they were using technology. In general younger teachers used computers more and viewed them more favorably than teachers who began their teaching careers before the advent of classroom computer technology. Teachers stated that their first priority for technology use was word processing, and their second priority was as a data and information source or for use in administrative tasks (Christensen, 2002).

Attitudes towards computers and technology may be improved by instructional approaches and meaningful assignments (Abbott & Faris 2000). Relevance is important to adults. Adult learners need a way to apply what they are learning to their life. It is not enough to learn a tool; they must use the tool and apply the tool in real life situations. They need help incorporating the tools into their teaching strategies, lesson plans, and activities. Becker (2000) found that teachers who rated themselves as more constructivist showed a greater overall use of technology and a more positive view of technology. Teachers are more likely to apply technology tools to their teaching than they are to adapt their curriculum to the tools.

Leadership and support from school administrators appears to provide a necessary environment for technology integration to flourish and includes training, access, and support of technology implementation (Woodrow, 1991). Dawson and Rakes (2003) found a positive correlation between the amount of and type of technology training a principal received and the amount of technology integration at the principal's school. With sufficient support and proper training, teachers' anxiety levels dropped and application and integration of technology was more regularly employed. Baylor and Ritchie (2002) found that the degree to which a shared understanding was developed on the role and importance of technology was an important factor in its successful use.

Literature Synthesis

The literature portrays the fast-paced emergence of technology and indications of a rapid adoption by society that is outstripping educational adaptation. Findings indicate that the intuitive beliefs in educational technology in general and hypermedia, in particular, as powerful tools for learning in modern constructivist pedagogy are probably warranted. Learners using hypermedia in constructivist environments have reported greater relevance and satisfaction with learning. There is a demonstrated use of higher order thinking, critical thinking, and meta-cognitive skills in technology-rich classrooms. Teachers' beliefs about and experiences with technology have an effect on their teaching and integration of technology into teaching.

NatureShift

NS was designed and developed to respond to the emerging technologies, modern constructivist pedagogy, and growing demands from government, school boards, educators, and community. NS focused on the interactions between human society, the natural world, and history through a learner-centered, hands-on, Internet-delivered, standards-based, technology innovation project. NS worked in two innovation areas: developing and testing a professional development model, and researching the design and operation of the NS model delivered in an immersive Web site.

The four-part teaching and learning model employed (1) engagement, (2) exploration online (Web adventures), (3) active hands-on exploration in the classroom/community (real world adventures), and 4) the creation of technology products. All four parts of the model were designed to stimulate learners' interest in authentic problems and encourage relevant technology applications in all phases of learning and teaching.

Six modules were proposed initially in four specific content areas: Ranger Rosie–life science, Wounded Hawk–science placed in a cultural context, Robot Lab–physics, Dakota Skies–space studies, Weather Watch–atmospheric studies, and Grand Parents' Attic–history and social studies. In the third year of the project, Memories and Stories replaced Grand Parents' Attic and the Weather Watch module was integrated into Dakota Skies.

Each module had a different NS model exploration as its centerpiece and a virtual guide created to serve as an online learning partner. Modules were similarly designed with online content resources, and links to other Web sites. Icons, sounds, movies, images and hypertext were all designed, written, or selected to reflect and promote engagement and active learning experiences.

Thirteen original NS Partners, representing North Dakota public school districts and statewide service agencies, helped build, test, and implement the Web site and learning model. In the public sector, the State Historical Society of North Dakota, ND Fish and Game, State Parks of ND, Grand Forks and Williston Libraries, Dakota Science Center, Grand Forks Public Schools, and the University of North Dakota contributed expertise, information, images and artifacts that formed the basic content for the modules.

Teachers from three tribal school districts and three public school districts implemented and tested the professional development model and the Web site in their classrooms. These teachers piloted the innovations as they were published and produced new materials and activities that were built into the Web site. All of the partners came together at summer and winter institutes to share projects and findings, learn new technologies, and plan implementations for the coming year. New components of the program were introduced, tested, and refined.

In year five of the project, the NS Ambassador Program was launched. Four week-long institutes were held coast to coast. Sixty-five teachers, representing 35 states, were recruited and introduced to the NS professional development model, teaching and learning model, and Web site. The NS Ambassadors' implementations of NS in their schools across the United States resulted in a wide range of teacher products and student products.

Despite this national outreach, questions still remained about the overall effectiveness and impact technology integration and increased technology literacy had on learning. Barriers of use, cost, difference of teaching style, unwillingness to take on more work or lose control of classrooms still stood in the way of seamless integration.

It seems clear that students' comfort with technology in all its facets is still outstripping adults' comfort. Younger teachers entering the teaching field are products of the technology age, with higher technology literacy they seem open to technology integration. They are willing to learn and to try adding technology to their teaching, especially when it is modeled in their preservice classrooms.

Researchers may be looking at all of the varieties of educational technology but asking the wrong questions about outcomes. It has been known that students can write papers successfully using a pen, a typewriter, or a computer. They may learn the same things from the same assignment using those three modalities. They may pass the English test or the biology pop quizzes with the same score, but the learning experiences are not the same.

The nature of research has changed over the past decade but seems to fall short of investigating what humans are making of the experience of learning using these technologies and how technology use is reflected in the work they do as students or teachers. NS was an innovation designed to incorporate the full gamut of technologies that were available to teachers and learners and provided a response to the understanding that technology integration can change learning.

Research Questions

To better understand how learning and literacy occurs using the NS Web-based innovation, the following research questions were generated for this study:

1) What relationships existed between use of NS and engagement in learning, level of learning, demonstration of higher order thinking, appropriate use of technology, and developing understanding of the natural world, as indicated by evaluation of student and teacher projects?
2) What happened when a teacher attended NS Ambassador professional development training? How did the teacher understand the NS program, Web site, educational model, and technology two years later and how did she integrate them into her teaching?

Delimitation

1. The first part of this study evaluated NS Partner and Ambassador student and teacher projects that were directly submitted as part of the program. At this point it is not possible

to determine what impact and outcome the NS Program has had on other teachers and students, because it is delivered on the Internet to the general public.

2. Pre and post-test data, and post student and teacher evaluations were not available for all of the student and teacher projects that were evaluated.

3. The first part addressed the five learning objectives identified by the external evaluators (Appendix B).

4. The second part included a qualitative interview and observations conducted with one NS Ambassador who used all five modules and used Wounded Hawk extensively.

Assumptions

For the purpose of this research the following assumptions were used:

1. The NS four-part model built into the Web site www.naturshift.org provided the basis for all five learner-directed modules. It was assumed that all five modules were designed to deliver direct experience with the model for teachers and learners.

2. The original 14 NS partner sites were involved with the project from first inception to the sixth year dissemination. Representatives selected to participate in professional development and program development seminars held in the winter and summer throughout the five years were chosen by their institutions. Although new representatives were added and some dropped out, all of the training was assumed equal for all partner sites.

3. The NS Ambassador Program, initiated in January of 2001, targeted teachers from 35 different states who were selected because of their interest in and demonstration of technology implementation. Superintendents nominated teachers or they volunteered after seeing the Web site or hearing a presentation. It was assumed that all of the

teachers who participated in the NS Ambassador program were equally prepared to implement the model through the NS Ambassador training program held in North Dakota and on both coasts.

Summary

This chapter presented an overview of current learning theory literature and current research on constructivist teaching and learning, critical and higher order thinking, effective use of technology, engagement of teachers and students when using technology, and their attitudes toward technology. The cognitive learning theories selected are part of modern pedagogy and served as a basis for the creation of NS.

Current research indicated a positive relationship between constructivist learning environments and learning using educational technology. Teachers demonstrated a shift toward more constructivist epistemology when they taught using technology. A limited review of research on teachers' and learners' use of computers, hypermedia, Internet, World Wide Web, and its effect on learning outcomes and demonstration of higher order thinking indicated an increase in learner satisfaction, and an increase in employment of higher order thinking, but only moderate increases in learning. An overview of the common beliefs and attitudes held by teachers and their students toward use of educational technology indicated that attitudes have become more positive as technology has evolved and become ubiquitous. Younger teachers were more willing to use technology in their teaching. Overall technology literacy increased when teachers integrated technology in ways that were meaningful to them.

The NS program was designed to address issues of constructivist teaching and technology integration reviewed in the literature and served as the focal point for this research study. Following is a chapter on the methods and procedures used to address the research questions. In Chapter III a quantitative study is presented. In Chapter IV a qualitative study is presented. Both chapters were written as stand alone chapters and, therefore, both have short literature reviews and methodology sections for the respective studies. A concluding chapter that serves as an overall synthesis of the dissertation follows.

CHAPTER II

BACKGROUND AND METHODOLOGY

This study grew out of a six-year interest and involvement with NS. NS is a tangible expression and outgrowth of the mission and philosophy of the Dakota Science Center, which is characterized by a commitment to equity, empowerment, and hands-on learning of science and technology. The Center began in 1992 as an after-school program led by a concerned parent seeking quality science and technology experiences for her daughter and friends. With support of informal and formal educators, the program developed into a regional hands-on science and technology center focused on learner-directed exploration. Seizing the TICG funding opportunity, the Dakota Science Center proposed a white paper to the Grand Forks Public Schools in 1994 that was the basis for NS.

I was fortunate to be a part of much of the planning and implementation of NS, from early discussions and meetings with some of the partners, to hiring of staff following the grant award in 1997. As an original member of the NS development team for the Wounded Hawk module, I remained part of NS throughout its 6-year history of innovation and implementation.

Evaluation of NS was conducted routinely by external evaluators over the six-year history of the grant. During the development of the education model, Web site, and professional development program in years 1 through 4, evaluation centered primarily on the administration of the project and efforts by developers and administrators to meet the seven objectives as stated in the grant (see Appendix A). Years 5 and 6 focused on dissemination and evaluation of outcomes from student projects and teacher products.

As the project neared completion, the external evaluation team for the grant wished to assess the impact of NS on student learning as well as the impact of NS on educators' work in their classrooms as demonstrated in their NS implementation. To accomplish this, external evaluators developed a five-part plan to provide impact and outcome assessment of the results of NS implementation on teachers and students.

For the present study, quantitative and qualitative methods were used to reexamine the evaluators' findings, revalidate the outcomes, and gain a better understanding of the project. The first part of this chapter describes the quantitative procedures used to reevaluate the student and teacher projects and student pre/post tests. The second part of this chapter describes the qualitative procedures used for the study and analysis of a participating teacher's perceptions of NS. The UND Institutional Review Board approved procedures used in this study for dealing with human subjects in September of 2003.

Quantitative Procedures and Methodology

A secondary quantitative analysis of NS outcomes was conducted, using results measured by student projects, teacher projects, and pre/post-tests of student content knowledge. Both teacher projects and student projects were scored using rubrics. The rubric instrument was also applied to the pre/post think-write questions to assess learning level, interaction with the natural world, engagement, and demonstration of higher order thinking using the same criteria as for student and teacher projects. Data from these instruments were used to describe the measurable impact and outcome results of the NS implementation on the ambassador/teachers and students.

Instruments

External evaluators developed the instruments used in this study as part of a five-part evaluation plan for the NS project. The instruments included a pre/post cognitive evaluation instrument (Appendix C) and rubrics for assessing teacher and student projects (Appendix D).

The pre/post evaluation instrument template consisted of five multiple-choice content questions, five multiple-choice technology questions, and two think-write questions. Teachers determined and inserted content and the technology items into the instrument that were specific to their NS implementation.

The ten multiple-choice questions each offered four choices: a correct answer, a close distracter, and two other distracters. The think-write questions were designed to assess students' use of the higher-order thinking skills of identification, comparing and contrasting in their writing before and after a NS classroom implementation. One question asked for content recall, while the second required higher-order thinking through synthesis and application of content.

A five-dimension rubric with five ratings (0–4) measured the extent of student and teacher projects' achievement in the following areas: Engagement in learning, Interactions in the Natural World, Level of Learning, Higher Order Thinking Skills, and Use of Technology. The five-level rating scale provided a semantic match between the qualitative description for each scale and the numeric value.

The rubric was based on five dimensions drawn from NS project goals. The five dimensions of achievement were as follows:

- Engagement in Interaction- The amount of engagement in exploration and learning required to produce the individual project.
- Interactions among the natural world, human society and history- illustrated by projects that connect to community, especially cultural or gender sensitive issues
- Level of Learning –indicated by the level of content or activities involved compared to grade level
- Demonstration of Higher-Order Thinking – level of thinking skills required or demonstrated including comprehension, application, analysis, synthesis problem solving and decision making
- Technology Use – the number of technology tools used or required to develop an individual project.

The highest rating of 4 indicated extensive engagement, extensive illustration of interaction with the natural world, above grade-level learning, extensive demonstration of higher-order thinking and use of four or more technologies. In contrast, the lowest rating level of zero indicated negligible engagement, negligible interaction with the natural world, below grade level learning, negligible demonstration of higher-order thinking, and no use of technology. Ratings of 1, 2, and 3 indicated progressively greater accomplishments: A rating of 1 indicated a slight demonstration of the five dimensions and one implementation of technology. Ratings of 2 in any category indicated average, expected performance for the grade level and two relevant uses of technology. Ratings of 3 indicated performance above grade level, though less than the achievements of level 4.

Reliability and Validity

The content of the pre/post tests was considered reliable, because teachers selected the content items and all pre/post tests followed the same format. These pre/post documents were analyzed for internal consistency reliability by using a traditional reliability measure of coefficient alpha. Cronbach's coefficient alpha reveals the proportion of total variance that is due to actual variation across the members of a given population. Alpha values of .800 or higher are acceptable. The results are reported in Table 1. Findings from this analysis indicate that the project-generated tests were very reliable and could be used to assess the pretest and posttest differences for all the NS pretest-posttest data.

In order to assess the consistency of rubric scoring, the rubric instruments were subjected to a rater-reliability analysis of five scales that included content validity and reliability judged for internal consistency. The investigator established inter-rater reliability with the two expert evaluators by having 19 teacher products rated independently by the researcher and comparing the results to the independent evaluations of the two external evaluators. The inter-rater reliability for each of the five dimensions and for the total score is reported in Table 2. Overall reliability for the five dimensions of .957 indicated that the researcher was assessing products reliably as compared to the evaluators and that her ratings could be used to evaluate student and teacher products.

Table 1. Results of Reliability Analyses for Eight Classroom Tests.

	Pretest/posttest Reliabilities (N = 356)		
Grade Level	Number of Students	Number of Items	Reliability
Grades 3-5	68	10	.863
Grade 4 Pam	43	10	.827
Grade 5	52	10	.831
Grade 6-7	18	10	.846
Grade 4-5	66	10	.820
Grade 6	30	10	.861
Grade 6-7	40	10	.815
Grade 4	47	10	.820

Sampling

The sample for this study included all the student and teacher products submitted to the NS project by Ambassadors before the conclusion of the program. NS Ambassadors were recommended and nominated at the state level. Sixty-four Ambassadors from 35 states were chosen to participate in the program based on their comfort with technology and commitment to technology integration. The majority of participants were classroom teachers or technology coordinators in elementary and middle schools.

As part of the national Ambassador initiative, participants agreed to attend a five-day training, become familiar with the NS model and Web site, and plan and execute an implementation for their classroom. Four regional Ambassador trainings were held from January 2002-July 2002 in Grand Forks, ND, New York City, Seattle, WA, and Bismarck, ND.

Ambassadors were trained in the content, model, and five exploration modules of NS. At the conclusion of the training, teachers presented the implementation plan for their classroom, school, or district that they had formulated. This implementation was to include using the Web site and model with students, having students create summative projects, and administering pre/post tests of content and technology knowledge. From this effort, NS Ambassadors submitted 48 teacher products, 41 student products, and 178 pre/post tests. All were evaluated for this study.

Table 2. Inter-Rater Reliability of the Investigator and Evaluators' Rubrics for the Five Dimensions and Total Scores.

	Inter-Rater Reliabilities N = 19	
Dimension	Number of Products	Reliability
Engagement in Exploration	19	.948
Illustration of Interactions	19	.906
Level of Learning	19	.848
Higher Order Thinking	19	.899
Use of Technology	19	.912

Data Analyses

SPSS software was used for all data analyses. Pre and posttest scores of content knowledge and technology use for 178 students were analyzed. A paired samples t-test provided pretest and posttest comparisons of total scores for each grade. Sub-scores measuring acquired knowledge and a measurement of technology use were generated. The pretest and posttest measurements were expressed as means and standard deviations. NS outcomes based on the pretest-posttest data are reported in Chapter III

Forty-one student products from seven classrooms were evaluated using the rubric. These products were rated on the five dimensions using a five-point scale ranging from 0-4. Ratings of 0 and 1 indicated no or minimal implementation, while a rating of 2 indicated an expected level of implementation suited to grade level. Ratings of 3 and 4 indicated student implementation above expected grade level. Total scores for each group were computed to obtain frequency, percentage, mean, and standard deviation in the five dimensions. Evaluation results based on the rubric data are provided in Chapter III.

Forty-eight teacher products were evaluated using the rubric. The products were rated individually on the five dimensions using the five-point rating scale of 0-4. Ratings of 0-1 indicated that the teacher product showed no, or little, implementation in the five dimensions and used only one type of technology in their implementation. Scores of 2 indicated expected implementation for that grade level, and scores of 3-4 indicated a high degree of implementation in the five dimensions that was above expected level for the grade. Findings from the teacher rubric data are provided in Chapter III.

information that relates to the research question (Tashakkori & Teddlie, 1998). Research tends to follow an open-ended line of questioning using interview data, observation data, document data, and audiovisual data (Creswell, 1998). A variety of research paradigms are employed including ethnographies, grounded theory, case studies, phenomenological research, and narrative research. These are all categorized as qualitative research (Creswell, 2003; Yin, 1984).

Stake (1995) describes a case study as "an event, an activity, a process, or one or more individuals . . . bounded by time and activity where researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (p. 1). The NS implementation was based on modern pedagogy and the complex interaction of educational and cognitive theories that center on constructivism.

As a unique innovation with stated goals and objectives that evolved over a five-year period, NS lent itself to the case-study paradigm. The project received input from designers, content experts, educators, and students. NS continued to change in response to emerging technology and the input from users and evaluators. It had a beginning and an end, thereby providing the obvious, common sense boundaries considered essential for a case study (Creswell, 2003).

In case studies the researcher sets the conditions and standards for the case. Multiple data sources including interviews, artifacts, journals, audiovisual, and observations may be used to provide a detailed description of the case, issues and themes (Stake, 1995; Creswell, 2001). Yin (1984) includes participant observation as a sixth source of data. Rather than being a passive observer, the researcher may have an active role in aspects of the case. This active role can include "serving as a staff member in an organizational setting, or being a decision maker in the setting" (p. 86). In light of my closeness to the project, this interpretation of the participant observer helped me to feel confident in pursuing the qualitative line of analysis.

According to Stake (1995) contemporary qualitative researchers take on the role of interpreter and "nourish the belief that knowledge is constructed rather than discovered" (p. 99). Because my theoretical perspective and philosophical stance is constructivist, I chose the case study paradigm for this study in order interpret the structural elements, educational model, technological attributes, and teacher understanding of NS. The aim was to uncover the significant factors that were characteristic of NS and the Wounded Hawk module in particular.

Application of Method

All NS Ambassadors were considered equally proficient in their teaching ability and use of the many technologies and strategies recommended by the program. Therefore, teacher selection criteria were based on teacher availability and the Ambassador's use of Wounded Hawk as one of her/his NS implementation projects.

Once IRB approval was obtained, a teacher was contacted from Southwestern Elementary School who had participated in the first Ambassador training held at the Dakota Science Center in January of 2002. She had submitted lesson plans and conducted an implementation of the Wounded Hawk module the following year. In addition, she was knowledgeable about NS, having conducted NS trainings and having arranged adoption of the program at her school. She was the former school technology coordinator, and due to budget cuts had switched that year to a 2nd grade classroom teaching assignment.

Site visits were arranged through a series of phone calls and emails. Two interviews and a day of classroom observation were scheduled for the end of January 2004. The teacher and I had a preliminary meeting the day before her class to go over the research procedures and sign the letter of agreement (Appendix E). At that time, we set up a schedule for interviews and observations and toured her classroom and the school.

Interviews were to be conducted before and after classroom observations. The first interview focused on the teacher's background, teaching experience, teaching philosophy, and plans for the classroom observation day. The second interview focused on technology integration in order to find out how the teacher understood the Ambassador program, NS, and all its facets.

Data Gathering

A letter of consent (Appendix E) was signed before the fist interview was conducted. The teacher informant was assured anonymity. Pseudonyms for both teacher and school were used throughout the study. It was explained that the subject could withdraw from the study at any time. Because the school had adopted NS as a school program, they waived the need for a school or district permission form.

A set of questions, and 12 qualitative response cards (Appendix F) served data collected through the interview portion of the study. The interviews were recorded using an audio recorder and later transcribed and coded for categories of response.

Keeping the working hypothesis in mind, I began observing, taking notes, and recording my questions throughout the day, paying particular attention to teacher/student conversations and the phrasing of instruction around the use and integration of technology. The room layout, placement of technology, and location of other teaching materials, as well as room decorations, were all noted in order to understand the classroom climate. Notes were kept throughout the daylong classroom observation. Based on classroom observations, a few clarifying questions were added to the second interview.

The second interview began with general clarifying questions about the day of teaching. Discussion moved to open-ended questions about NS and the Wounded Hawk module in particular. Interview questions and prompt cards (Appendix F) were used to elicit the teacher's thoughts about NS, the teaching and learning model, and technology in general. The twelve open-ended, unrelated words (happy, worried, technology, exploration) stimulated free association responses to words associated with NS.

Data was also gathered from a technology class. The teacher videotaped a representative example of the weekly 4th grade technology lessons she regularly taught each of the five 2nd grade classes in the technology room. She chose the lesson and set up the video taping to capture the full view of the room and student/teacher dialogue. The technology session was viewed and notes were taken as if it were a classroom observation. Later actual dialogue was transcribed and added into the observation. All data from the technology class notes and specific dialogue from the videotape were transcribed and coded as part of the total observation.

Understanding the Data

Open coding began with the research question for the study: What were the components of NS design, educational model, and delivery that were intended to promote technology literacy? How did a NS Ambassador/Partner understand the NS program, Web site, and educational model and technology? Coding started with the terms that represented the NS goals (engagement, learning, higher-order thinking, interactions, technology integration). The number of codes soon expanded to include technology products, teacher focus, student focus, learning, teaching, and routine among others.

At the end of the open coding process of the three datasets over 50 codes had been used. The three datasets were combined into one set of field notes and recoded. When more than one code applied to a phrase the phrase was separated to support the additional codes. In some cases codes were combined or abandoned in favor of an overarching term that better suited the meaning of the phrase. This resulted in 20 distinct codes that were applied to a clean transcript.

The researcher generated a count of code frequency using the Microsoft word search feature. It was possible to consistently select key phrases that represented the 20 codes. Connections between the codes resulted in two codes becoming categories for the other 18 codes and associated phrases.

When the categories were placed on a wall with associated phrases placed below them, themes emerged under each of the two categories. The interrelationship between the themes demonstrated the lessons learned from NS as a case study. These themes provided the basis for one assertion, and four sub-assertions that emerged through the process of the case study. The assertion as well as the codes, categories, and themes that supported it are described in Chapter IV along with questions for future consideration.

Summary of Quantitative and Qualitative Methods

The quantitative study attempted to determine if the use of NS had a relationship to student engagement, level of learning, demonstration of higher-order thinking, appropriate use of technology, and developing understanding of the natural world. Data from 187 student pre/posttest scores, 41 student product rubric scores, and 48 teacher product rubric scores were statistically analyzed and reported in Chapter III.

The qualitative study used the case study method to determine how a teacher understood the components of NS program, Web site design, educational model, and delivery that were intended to promote technology literacy. The case study obtained data from interviews, classroom observation, and artifacts, including the Web site and journal. These data were analyzed and reported in Chapter IV.

Both chapters were written in a journal format that included an introduction, background literature, a description of methodology, presentation of data, interpretation of data and a conclusion. For this reason some information from this chapter is repeated in Chapter III and Chapter IV.

CHAPTER III

STUDENT AND TEACHER OUTCOMES FROM A TECHNOLOGY INNOVATION PROJECT

Introduction

Since the early 1990s, the fast paced and constant evolution of technology has kept educators and researchers in a perpetual state of flux, responding and adapting classroom practice and research questions to the emerging innovations. The World Wide Web and hypermedia have been intuitively recognized and embraced as the new essential tools for the classroom (Dede, 2002; diSessa, 2000; Driscoll, 2002; Mioduser, Nachmias, Lahav & Oren, 2000). The acceptance of technology as the essential tool for 21^{st} century knowledge processing and learning has spurred major investments in and initiatives for developing and implementing educational technology (Hargis, 2001; Sandhotz, Ringstaff & Dwyer, 2000; Vannatta & Beyerbach, 2000).

One such effort to address the growing demand and perceived need for technology literacy in K-12 education was led by the Department of Education. In 1994 the integration of technology into teaching was declared a national priority. That year the United States Congress passed the Improving America's Schools Act. Part A of that document, known as the Technology for Education Act of 1994, created the Technology Innovation Grant Program (TICG).

This two billion-dollar, five-year commitment represented the largest single amount ever designated for an educational technology initiative (U.S. Department of Education, 1996). It also offered open-ended opportunities for educators to innovate with the new technology tools and best education practices. Richard Riley, Secretary of Education under the Clinton administration, described the goal of the program as "helping states and local communities to create and implement their own plans for integrating technology into teaching and learning for the purpose of achieving excellence among our students" (Harris, 2002, p. 3).

This period of innovation coincided with a time when researchers were having difficulty precisely identifying the outcomes produced by educational technology integration (Baylor & Ritchie, 2002; Roblyer & Knezek, 2003). A growing body of recent research indicated that integration of technology influences how teachers teach and students experience and express learning (Okamato, Cristea & Kayama, 2001; Salovaara & Jarvela, 2003). A new research agenda was called for to examine teacher and student outcomes resulting from the recent trends and initiatives (Pea, 2000; Roblyer & Knezek, 2003; Waxman, Connell, & Gray, 2002).

Awarded in 1997, the NatureShift *Linking Learning to Life* (NS) grant was one of 110 U. S. Department of Education TICG matching grants. This five-year initiative began with the goal of creating an educational technology product that would increase and enhance student and teacher engagement in learning, demonstration of higher order thinking, level of learning, relevant use of technology, and connection to the natural world. The major objectives (Appendix A) were to be achieved through the creation of a Web site and educational technology program to promote student driven/teacher supported inquiry, conducted in the real world and on the Internet, using relevant technology tools.

This study examined the relationship between the use of NS and the level of student learning, engagement, demonstration of higher order thinking, appropriate use of technology, and increased understanding of the natural world. In order to measure student and teacher outcomes the researcher analyzed student products, teacher products, and pretest/posttest scores that were generated from NS implementations in schools across the country. An overview of current educational research in the areas of engagement, learning, higher order thinking, and technology use provided a starting place for this study.

Literature

Computer technology has been found to be a powerful cognitive tool (Dede, 2002; Jacob, 1992); however, it is known that learning occurs with or without computers (Hargis, 2002). Although the majority of studies indicated only modest increases in student content acquisition through the integration of technology (Dillon & Gabbard, 1998;Waxman et al., 2002), students reported greater engagement and motivation when technology was employed as part of the learning process (Cohen, 2001). Students expressed the expectation that technology should be a part of their classroom, and they reported higher confidence and demonstrated more initiative and effort, while learning in technologically rich environments (Cohen, 2001).

Research indicated that learning changes in a variety of ways when technology is integrated into the classroom (Thirunarayanan & Perez-Prado, 2001-2002; Cohen, 2001). Deeper-level cognitive strategies, student inquiry, and collaboration were observed more frequently when technology was integrated into the learning process (Mioduser, Nachmias, Lahav & Oren, 2000). Complex scientific concepts were more readily understood when technology was used to introduce the learning tasks, structure the problem solving, revise the information, and create products that represented the understanding students had gained (Salovaara & Jarvela, 2003).

A meta-analysis of recent research on the effects of teaching and learning with technology on students' cognitive, affective, and behavioral learning outcomes showed a "modest, positive effect of teaching and learning with technology on student outcomes" (Waxman et al., 2003, p. 12). A change in students' learning style was observed that promoted collaboration. When compared to traditional information delivery classrooms, students in technology-rich environments employed higher order thinking skills more frequently during the learning process (Hopson, Simms & Knezek, 2001-2002).

When technology was used to facilitate students' analysis, synthesis, and application of learning, students had the ability to choose how, when, and where they would participate in the learning (Harris, 2001; Lajoie, 2000). Pea (2000) noted that the application of technology was especially effective when students were finding solutions to real world problems and expressing understanding of the natural world through technology projects.

Personal involvement of both the teacher and the pupil is essential for meaningful learning and implementation of higher order thinking (Byrnes, 1996). How students are taught, how the learning is structured, and teacher attitudes all have an influence on learning (Christensen, 2002). The teacher, serving as the example of an engaged learner, demonstrates the processes by which learning occurs. Students respond and follow the teacher's model.

Three predictors that were found to increase student content acquisition and use of higher order thinking were the "teacher's strength of leadership, teacher openness to change, and the constructivist use of technology" (Baylor & Ritchie, 2002, p. 395). In another study, a negative predictor for learning and demonstration of higher order thinking was the percentage of time students used technology while working alone (Lou & Abrami, 2001). The more students worked alone, the less effective the experience.

Hopson, Simms, and Knezek (2001-2001) noted that the elementary school students in technology-enriched classrooms with access to computers and trained teachers demonstrated better use of higher order thinking skills. Ross, Hogaboam-Gray, and Hannay (2001) confirmed that teachers' expectations and beliefs influence students' confidence and ability to accomplish personal goals that required computers. Teacher computer efficacy was directly related to student achievement using technology. When students switched to classrooms with higher teacher computer efficacy, student achievement and positive attitudes toward technology increased.

As indicated by these and other studies, however, the greatest observed classroom change was in the pedagogic style of the teachers, which became increasingly learner-centered. This change was facilitated by cooperative groups of students who were "focused on application rather than acquisition of knowledge" (Hopson et al., 2000-2001, p.116). When support and training using hypermedia was high, student and teacher use shifted from knowledge acquisition and drill and practice to synthesis and application of content (Baylor & Ritchie, 2002).

Despite the increasing availability of technology, teachers reported two barriers to integrating technology in their teaching: 1) lack of technology skills, and 2) limited understanding of how to integrate the technology effectively (Ertmer, Addison, Lane, Ross & Woods, 1999). Schools in a hurry to acquire technology neglected training in technology integration (diSessa, 2000). Support for professional development, technology training, and administrative buy-in for technology implementation at the school and district level were major factors in teacher implementation of technology (Dawson & Rakes, 2003).

Vannatta and Beyerbach (2000) found that the best predictor of technology integration was "instructional proficiency" (p.135). When the best practices of technology integration were modeled in workshops and teachers developed technology-rich applications for their own classrooms, technology literacy increased. This "instructional literacy" was demonstrated as teachers completed assignments and created products using the technology that they were being encouraged to employ with their students.

The NS project understood the important role of the Ambassador teachers in achieving the goals of the project. Teacher training included basic technology training, opportunities for teachers to become proficient in the emerging technologies, and a chance to provide input on how those technologies could be used in their classrooms. Ambassador teachers were encouraged to custom fit their curriculum and classroom to NS with an emphasis on learning, student engagement, learning, demonstration of higher order thinking, appropriate use of technology, and a connection to the natural world.

Research Questions

In order to investigate NS and understand if a relationship existed between use of NS and enhanced student and teacher outcomes, the basic research hypothesis for the study was: What was the positive relationship between the use of NS and student and teacher outcomes? Analysis of student pretest and posttest differences and evaluation of student and teacher products resulting from NS implementations determined outcomes for this study.

Based on the three assessment instruments used for this study the hypothesis was tested with three research questions: What was the relationship between use of the NS model and mean differences in students' test scores for content knowledge and technology application? Did student products using NS program receive above average ratings in any of the five dimensions? Did teacher products using the NS model receive above average ratings for any of the five dimensions?

Method

The researcher conducted a secondary quantitative analysis of student and teacher products and student pre/post-tests of student content knowledge submitted as part of the national NS Ambassador initiative conducted in 2002. The teachers for this study were elementary and middle school educators and technology coordinators who had been recommended and nominated at the state level. Sixty-four Ambassadors from 36 states were chosen to participate in the program based on their commitment to technology integration and comfort with educational technology.

Ambassadors participated in a five-day workshop on the NS model, the NS web site, and the NS exploration modules. The workshops were held in four locations: New

York City, NY; Seattle, WA; Bismarck, ND, and Grand Forks, ND. At each of the workshops teachers learned about NS, practiced the education model, explored each of the five modules, and designed a NS implementation for their school or district. Ambassadors agreed to create a teacher product representing their implementation and to submit the resulting student products and pre/posttests at the conclusion of their implementation. These test scores and product ratings provided the data for this study.

Sample

NS Ambassadors submitted 48 teacher products, 41 student products, 178 pre/post tests, and 76 think/write responses to the Dakota Science Center from May to December 2002 as part of their NS Ambassador Implementation. All available items that were submitted were evaluated for this study.

The 41 student projects from six classrooms all used PowerPoint software. The student products were copied onto CD-ROM disks by the NS ambassador/teachers. Student pre/posttests were submitted as hard copy. These tests were handwritten by the students and numbered for student anonymity. The 48 teacher products were created in Microsoft Word software and delivered on CD-ROM. All teacher products followed the same NS Exploration template format that was provided and used at the four national trainings.

Instruments

External evaluators developed the three instruments used in this study as part of a five-part evaluation plan for the NS project. The instruments used were a pre/post evaluation instrument (Appendix C) and rubrics for teacher and student projects (Appendix D).

Five multiple-choice content questions, five multiple-choice technology application questions, and two think/write questions were used to construct the pre/post evaluation instrument template (Appendix C). The multiple-choice questions offered four options: a correct answer, a close distracter, and two less probable distracters.

The two think/write questions were based on content that was to be covered in the NS implementation. Questions were designed to assess the students' understanding of NS content and the students' ability to use higher order thinking to apply the content to real world situations. The first question measured student recall of content, and the second question was designed to elicit synthesis and application of that information in a real world situation.

A five-dimension rubric with five ratings measured the extent of student and teacher projects' achievement in the following areas: Engagement, Interactions in the Natural World, Level of Learning, Higher Order Thinking, and Use of Technology. The five-level rating scale provided a semantic match between the qualitative description for each scale and the numeric value. The rubric was based on five dimensions drawn from NS project goals. The five dimensions of achievement were as follows:

- Engagement in Interaction- The amount of engagement in exploration and learning required to produce the individual project.
- Interactions among the natural world, human society and history- illustrated by projects that connect to community, especially cultural or gender sensitive issues.
- Level of Learning –indicated by the level of content or activities involved in comparison those expected of the grade level.

- Demonstration of Higher-Order Thinking – level of thinking skills required or demonstrated, including comprehension, application, analysis, synthesis problem solving and decision making
- Technology Use – as measured by the number of technology tools used or required to develop an individual project.

The highest rating of 4 indicated extensive engagement, extensive illustration of interaction with the natural world, above grade-level learning, extensive demonstration of higher-order thinking and use of four or more technologies. In contrast, the lowest rating level of zero indicated negligible engagement, negligible interaction with the natural world, below grade level learning, negligible demonstration of higher-order thinking, and no use of technology. Ratings of 1, 2, and 3 indicated progressively greater accomplishments: A rating of 1 indicated a slight demonstration of the five dimensions and one implementation of technology. Ratings of 2 in any category indicated average, expected performance for the grade level and two relevant uses of technology. Ratings of 3 indicated performance above grade level, though less than the achievements of level 4, which included four relevant technology applications.

The rubric was modified for evaluation of the think/write responses on the pre/posttest. Two dimensions (engagement and technology use) were removed from the rubric because they did not apply to the content of the questions.

Reliability

The pre/posttest instruments were considered content valid because teachers had developed and selected the content items concurrently with the design of their classroom implementation. All pre/post tests followed the same format and template

The eight educator-generated pre/post instruments were analyzed for internal consistency reliability using Cronbach's coefficient alpha. Reliabilities for all instruments were above the .800 level, ranging from .815 to .863 coefficient alpha. This indicated that the project-generated tests were reliable and could be used to assess the pretest and posttest differences across the grade levels.

In order to assess the consistency of rubric scoring, the rubric instruments were subjected to a reliability analysis of five scales that included content validity and reliability judged for internal consistency. The investigator established inter-rater reliability with the two expert evaluators. Nineteen teacher products were rated independently by the researcher on the 0-4 scale and compared to the independent evaluations of the two external evaluators. Overall reliability for the five dimensions of .957 coefficient alpha indicated that the researcher was assessing products reliably as compared to the evaluators and that her ratings could be used to evaluate student and teacher products across the NS implementation.

Data Collection

NS Ambassador/teachers completed and submitted their classroom implementations to the Dakota Science Center over a six- month period from March 2003 to July 2003. Submissions included 41 digital copies of student products, 48 digital copies of teacher products, and 178 hard copy pre/posttests. The researcher gathered and recopied these items for offsite analysis.

The pre/post tests were scored and entered into spreadsheets. Student products were previewed, then rated by grade level, and entered into a spreadsheet by class. Teacher products were previewed and evaluated using the five dimensional teacher rubric. Teacher scores in the five dimensions were entered into a spreadsheet for analysis as one group.

The rubric instrument was modified and used to analyze student responses to the teacher-generated think/write questions. The modified rubric included three of the five dimensions: level of learning, higher order thinking, and interactions with the natural world. Answers were reviewed to determine overall level of knowledge and understanding for the group of responses. Responses from each test were given one rating for each of three dimensions using the 0 – 4 scale. These scores were entered into a spreadsheet for analysis by class using SPSS software.

Results

All data from the teacher-generated pretest and posttests, student products, and teacher products were analyzed using SPSS software. The measurable impact and outcome results of the NS implementation on the ambassador/teachers and students for each of the analyses are described in the sections that follow.

Student Pretest and Posttest Comparisons

The teacher-generated tests were used to compare students' performance before and after the NS classroom explorations and implementations. The tests had two components. The first component measured knowledge about the exploration. The second component measured knowledge about technology usage and application.

Data from 356 tests were analyzed using a paired samples correlation t-test. Scores were broken down as a measurement of Acquired Knowledge, Technology Application, and Total Score. Measurements were expressed as means and standard deviations for 24 comparisons in eight classrooms. The pretest and posttest comparisons examined knowledge acquired, computer usage, and total score. The results are reported in Table 3.

Pre/post comparisons of acquired knowledge went up significantly in seven of the eight class groups following a NS exploration. The student scores for content knowledge increased by one point on average after the NS implementation. Pre/post comparisons of technology application also increased significantly after the NS implementation, increasing by two points on average.

Seven of the eight classes had a significant increase in total score at the .05 level, indicating that content knowledge and relevant technology use went up after a NS implementation. One class showed no significant difference between scores before NS implementation and after NS implementation.

Student Product Evaluation Results

Total scores for student ratings were computed to get percentages for the five dimensions at three general levels of achievement. Student products that scored 0 or 1 were considered below expectations. Products scored with a 2 were considered average for the grade level and placed at the expected level. Any product with a rating of 3 or 4 demonstrated a level of implementation that was above average and above expected grade level. Evaluation results, based on the rubric data expressed as percentages of student products that demonstrated the five dimensions at three general levels of expectation are found in Table 4.

Table 3. Results of the Pretest and Posttest Comparisons for Content Knowledge, Technology Usage and Total Scores for Five Educators' Implementations (N = 356).

Measurement of Knowledge Acquired

	Pretest		Posttest			
Grade	Mean	SD	Mean	SD	t-value	p
3-5	2.00	1.41	4.43	.60	9.86	.001
4	2.48	1.25	3.84	.90	3.70	.001
5	1.48	.96	2.52	1.20	3.10	.003
6-7	1.78	1.30	4.00	1.00	4.06	.001
4-5	3.16	1.04	4.43	.78	5.66	<.001
6	3.00	1.22	4.94	.24	6.40	<.001
6-7	3.70	.98	4.00	1.21	.86	ns*
4	4.00	.88	4.65	.65	2.87	.006

Measurement of Technology Application

	Pretest		Posttest			
Grade	Mean	SD	Mean	SD	t-value	p
3-5	2.80	1.90	4.66	.55	6.50	<.001
4	2.71	1.12	4.21	.85	4.83	<.001
5	1.60	1.29	3.26	1.20	4.81	<.001
6-7	1.89	1.45	3.33	1.32	2.21	.045
4-5	3.61	.92	4.91	.28	7.96	<.001
6	3.08	1.26	4.94	.24	6.01	<.001
6-7	3.80	.62	3.80	.77	.00	ns*
4	3.08	.88	4.78	.42	9.27	<.001

Measurement of Total Score

	Pretest		Posttest			
Grade	Mean	SD	Mean	SD	t-value	p
3-5	4.80	3.05	9.09	.81	9.29	<.001
4	5.29	2.14	8.05	1.43	4.83	<.001
5	3.08	2.00	5.78	2.34	4.45	<.001

Table 3 cont.

	Measurement of Total Score					
	Pretest		Posttest			
Grade	Mean	SD	Mean	SD	t-value	p
6-7	3.67	2.00	7.33	2.06	3.83	.001
4-5	6.77	1.43	9.34	.84	9.02	<.001
6	6.08	1.98	9.88	.49	7.68	<.001
6-7	7.50	1.15	7.80	1.85	.54	ns*
4	7.08	1.28	9.43	.94	7.18	<.001

Table 4. Percentage of Student Products at Three General Levels of Expectation Across Five Dimensions (N = 41).

	Level of Attainment in Each Dimension of the Rubric		
Dimension	Below	Expected	Above Expected
Engagement in Exploration	6.3	12.5	81.3
Illustration of Interaction	33.3	37.5	29.2
Level of Learning	4.2	6.3	89.5
Higher Order Thinking Skills	4.2	35.4	60.4
Use of Technology	8.3	22.9	68.7
Total Score	11.3	22.9	65.8

Over half of all students' projects (62%) were rated above the expected level for their grade on four of the five dimensions. Students demonstrated an above average or above expected rating in: use of technology, level of learning, engagement in the exploration and use of higher order thinking, but failed to demonstrate an above average understanding of interactions with the natural world.

Of particular interest was the high level of learning and engagement demonstrated in the products. Both dimensions in student projects were rated more than 80% "Above Expectations". In addition, 69% of the products used 3 or 4 technologies, more than were often required by the teacher lesson plans.

Interactions Among the Natural World was the only dimension that showed an average or below average implementation. Over 70% of the student products demonstrated a below average or average implementation. These students' projects failed to connect to the community or include cultural or gender sensitive issues.

Teacher Product Evaluation Results

Forty-eight teacher products or lesson plans were evaluated using the rubric. The products were rated individually on the five dimensions, using the five-point rating scale of 0-4. Teacher –generated lesson plans that were rated 0-1 were considered below expected grade level. The products failed to implement technology or only used the computer. The products showed a limited amount of engagement needed for students to complete the activities and little or no demonstration of higher order thinking, integration into the natural world, or the learning level was considered below the expected grade level.

Scores of 2 indicated expected implementation for that grade level in all dimensions and the use of computer and one other technology in the lesson. Projects rated with a 3-4 demonstrated an above average demonstration of engagement, higher order thinking, level of learning, a clear connection to the natural world, and use of 3 or more technologies. Results from this analysis are provided in Table 5.

Table 5. Percentage of Teacher Products at Three General Levels of Expectation Across Five Dimensions (N = 48).

	Level of Attainment in Each Dimension of the Rubric		
Dimension	Below	Expected	Above
Engagement in Exploration	4.9	22.0	73.2
Illustration of Interaction	36.6	24.4	39.1
Level of Learning	0.0	7.3	92.7
Higher Order Thinking Skills	9.8	22.0	68.3
Use of Technology	41.5	22.0	36.6
Total Score	18.6	19.5	61.9

Total scores were computed for educator lessons to get percentages of products at three general levels of achievement: below expectations, at expectations, and above expectations. Teacher-generated lessons were rated above average or expected level in three of the five dimensions: engagement, level of learning and demonstration of higher order thinking skills. The level of learning for the teacher products was particularly high with over 90% rated above expected level for the grade level. More than half the teachers (68%) included higher order thinking in their products above the expected level for their grade.

Technology use and interactions with the natural world were not rated above average for the majority of products. Only about 30% of the teacher products included three of four technologies as part of the lesson and demonstrated an interaction with the natural world. Overall, 61.9% of the teacher lessons reached the "Above Expectations" level in all five dimensions, although of technology use and illustration of interactions were average or below average.

Think/Write - Pre/Posttest Results

The rubric used to evaluate student and teacher products was modified and applied to the think and write pre/post tests. Using the criteria of the rubric, data were scored 0-4 in three dimensions, and analyzed using a paired samples t-test. Results are found in Table 6.

The level of learning, demonstration of higher order thinking, and interaction with the natural world did increase beyond.001for all three dimensions. The pretest and posttest scores for think and write responses showed an increase in level of learning, higher order thinking, and interaction with the natural world after students had participated in a NS project.

Discussion

This study investigated the student and teacher products from classroom implementations designed to promote engagement in exploration of science and social studies topics. NS Ambassador teachers and learners were asked to use technology in relevant ways that supported hands-on learning explorations of relevant topics. The investigations were to be conducted in the context of the learners' natural world, community, and society. The intent was that these interactions would raise the level of learning and promote the use of higher order thinking skills.

Table 6. Results of the Pretest and Posttest Comparisons for Acquired Level of Learning, Higher Order Thinking and Interaction for Think/Write Responses (N = 70).

	Pretest		Posttest			
	Mean	SD	Mean	SD	t-value	p
Level of Learning	1.68	1.02	2.57	1.03	7.20	<.00
Higher Order Thinking	1.40	.93	2.18	.93	7.06	<.00
Interaction with Nature	1.44	1.06	2.17	1.06	5.73	<.00

Students

Initially, the grant set out with a goal to "do no harm." NS was not designed to increase content knowledge, but rather promote higher order thinking, learner engagement, and interaction with the natural world. However, seven of the eight classrooms had a statistically significant gain in content knowledge following the implementation of NS. The mean scores for content knowledge rose about one point on average (Table 3) indicating that content knowledge did increase after using the NS implementation. Based on these findings, student learning increased following NS implementations as demonstrated by the statistically significant pretest and posttest differences.

NS implementations had a greater effect on students' understanding of technology application than it did their knowledge acquisition. The mean score for technology application rose almost two points (Table 3). This was not totally unexpected, because the primary goal of NS was to increase technology literacy and higher order thinking. Technology integration was a "required" part of the Ambassador implementation. Relevant technology was consistently emphasized and taught at the Ambassador training sessions, highlighted in the planning documents, and evident on the Web site. Therefore, the change in student technology application scores might have resulted from the Ambassador teachers increased "instructional proficiency," a known predictor of increased technology integration (Vannatta & Beyerbach, 2000, p.135).

What was more revealing about NS outcomes in this study were the student products. More that 88% of the student projects were rated at or above expected level on all dimensions. More than 66% of the student products showed at or above level of Engagement in the Exploration, and almost 90% showed an above-expected level of learning. These findings pointed to a high level of student initiative and involvement that has been researched and measured in other technologically rich learning environments (Cohen, 2001; Mioduser et al., 2000).

Engagement was the central theme of the NS Web site and was articulated specifically at Ambassador training sessions and was a part of the planning templates. Research indicates that students find learning with technology engaging in its own right. Perhaps when technology is purposefully built into all aspects of the lesson, it enhances the experience for the learners.

After NS implementations, 68.7% of the students used three or more technologies in a relevant manner in their products and 22.9 % used two. This level of relevant technology use indicated an increase in technology literacy that has been sought by technology initiatives nationwide (Harris, 2001; U.S Department of Education, 2000). These results supported the changes seen in student pretest/posttest scores for technology application and represented a significant positive outcome for this study.

Over 95% of the students demonstrated higher order thinking skills that were at or above the expected level for their grade. The high percentage of students who demonstrated higher order thinking using NS corroborated earlier research on increased higher order thinking in technology rich environments (Hopson, et al., 2001-2002). As a major goal of the project this level of achievement indicated a very significant and positive outcome of NS.

Only 29.2% of the student products demonstrated an Illustration of the Interactions in the Natural World. The greater percentage (33.3%) was below expected grade level. Clearly this dimension was not evident to the learners and may not have been understood by the teachers. This dimension was similarly low in teacher lesson plans, indicating they did not understand it either and may not have included it effectively in the lessons. There seems to be a direct connection between the teachers' understanding and what students had implemented.

Students showed a modest change in Level of Learning, Higher Order Thinking and Interaction with Nature in their think/write responses. These think/write responses did uphold the ratings that were seen in the student products and indicated an almost equal increase in the three dimensions considered.

These outcomes, taken together, indicated a positive relationship between use of NS and over half of the student outcomes being above expected levels in four dimensions: engagement, level of learning, technology use, and higher order thinking but not in dimensions of illustrations of interaction. Interestingly, students did talk about connections to the natural world in their think/write responses that were not evident in their products.

Teachers

Teachers who used NS showed ratings above expected levels in three dimensions of engagement, level of learning, and higher order thinking but not in dimensions of illustrations of interaction and technology use. NS Ambassadors' prior experience with technology and quality of their teaching may have contributed greatly to the outcomes of this study. Their commitment of time to participate in the Ambassador training, plan and conduct and implementation, combined with their known commitment to technology evidenced by their interest in the program, are all predictors for the increases that were observed in this study. Results also indicate that teacher lesson plans were rated higher than expected in three areas of Engagement in Exploration, Level of Learning, and Demonstration of Higher Order Thinking Skills. More than 73% of the products demonstrated an above average amount of engagement in exploration of learning than would be seen and expected in most teacher products at similar grade levels.

As mentioned, more that 60% of the teacher lessons illustrated an average or below average understanding and implementation of Interactions in the Natural World. More than 63% of the lesson plans had an average or below average requirement for technology application. Requirements for use of two technologies was included in 22% of the lesson plans and only 18.6% called for one technology application. Perhaps teachers used more technology than they articulated in their products, because student use and application of technology was rated much higher than that of the teachers.

The level of learning was above average for over 90% of the teacher products These lesson plans required and articulated the implementation of higher order thinking skills at or above expected level in more that 91% of the products. These results indicated that teachers were implementing indicate that two important goals of the NS program were being influenced by use of the model, Web site, and modules.

Summary

Findings from this study indicated positive student and teacher outcomes when the NS innovation was employed. These outcomes supported achievement in four of the five primary educational goals of NS program. The evaluation of student and teacher products indicated that the NS education model promoted technology literacy.

When NS was employed, there was a statistically significant increase in students' acquisition of content knowledge. The students demonstrated a higher level of technology understanding in their pre/posttest and in technology application in the creation of their summative products. The majority of student products also demonstrated an above average employment of higher order thinking skills, learning level, and learner engagement. The majority of students implemented an average or below average understanding of interactions with society and the natural world.

Outcomes from the teacher-generated lesson plans indicated that these teachers created lessons that demonstrated above average engagement, above average demonstration of higher order thinking, and above average level of learning. The teachers' products demonstrated average or below grade level implementation of technology and a lack of connection to the natural world and society. The teachers' failure to fully communicate these two dimensions in the teacher-generated lessons could explain why students failed to demonstrate these concepts in their products. However the students integrated technology in their projects beyond the level suggested in the teaching lesson plans.

Overall, the data supported NS having had a positive effect on student and teacher outcomes. There is a positive correlation between technology use and constructivist teaching style (Vannatta & Fordham, 2004). By participating in the Ambassador program, teachers showed a commitment to teaching and a willingness to learn new teaching strategies. Their participation demonstrated a willingness to take on new tasks that required work above and beyond normal working hours. They agreed to integrate technology into their teaching and learning process and followed the more constructivist-teaching model presented in the NS program, indicating a willingness to change often associated with teachers who are technology users (Christensen, 2002).

It would be helpful to know what these teachers had to say about their experiences with NS and the lasting effects (if any) of this program on their technology literacy and teaching style. Chapter IV attempts to address some of these questions through a qualitative study of a teacher's understanding and implementation of this technology innovation.

CHAPTER IV

A TEACHER'S UNDERSTANDING OF TECHNOLOGY INNOVATION

Introduction

Technology has propelled many educators rapidly down the road of innovations in an attempt to understand and integrate the evolving technology tools of society into the teaching and learning of the classroom. In 1997, the Dakota Science Center, in partnership with the Grand Forks Public Schools and 14 other educational partners from around the state of North Dakota proposed for the third time and was granted $4.5 million dollars from the U.S Department of Education for the NatureShift! *Linking Learning to Life* (NS) project.

NS was one of 110 Technology Innovation projects that taken together represented the single most costly educational initiative for technology ever funded by the U.S Department of Education (Harris, 2002). Based on best practices from free-choice (informal) and formal teaching and learning, the five-year NS grant set out with an ambitious purpose to change the nature of learning and teaching through application of innovative technologies. The program promoted student-centered, hands-on, teacher - supported learning with emphasis on relationships between the natural world and human society and history. Partners created a Web site filled with authentic resources, a four-part teaching and learning model, online Web creation software, and a professional development program that promoted student and teacher technology literacy. The technology literacy was to be demonstrated by student and teacher products submitted to the project.

In January 2001 NS received re-granting funds, as part of its dissemination model, to launch a corps of Ambassadors to serve as mentors and colleagues promoting and implementing the program. The majority of the dissemination occurred in the last year of the project (2002 – 2003). Classroom teachers and technology coordinators were nominated at the state level based on their commitment to implementation of technology in the classroom. These educators were recruited to attend a five-day professional development session and then conduct an NS implementation in their classroom and/or school.

From January to March 2002, 65 teachers were selected to attend five-day Ambassador training sessions held in Grand Forks, North Dakota; New York City; Seattle, Washington; or Bismarck, North Dakota. As part of the training teachers agreed to conduct a NS implementation in their classroom or school using one of the five modules and submit student technology products and their lesson plans for the implementation.

NS Ambassador dissemination marked completion of the final objective of the grant and resulted in a wide array of NS student and teacher projects. Understanding what happened when a teacher attended a NS Ambassador professional development training and how the teacher understood the NS program, Web site, and educational model two years later warranted examination. In order to develop an understanding of the NS innovation this study attempted to capture in the form of a case study valuable information about a teacher's understanding of technology and its implementation.

Literature

Stake (1995) describes a case study as "an event, an activity, a process, of one or more individuals …bounded by time and activity where researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (p. 1). Postman (1996) described the innate human capacity and tendency to analyze and make sense of our surroundings, and to "make meaning through the creation of narratives that give point to our labors, exalt our history, elucidate the present and give direction to our future" (p. 7). Human narratives take on a myriad of forms and can be used to assess the understanding that participants have of an event or product.

The Internet supports a process approach to learning by providing the necessary elements for higher level thinking tasks (Hartley & Bendixen, 2001). Computer-based presentations that involve some combination of text, pictures, sound, video, and links to the Internet (hypermedia) utilize many elements drawn from current pedagogy and constructivist approaches to learning (Byrnes & Sayre, 2000). Hypermedia provides multi-directional links to connect information logically, creating learning webs that enable users to create new learning environments (Hopson, Knezak & Simms, 2001-2002) and "move from information representation to knowledge representation" (Dede & Palumbo, 1991, p.17). The shift from "possessing knowledge to processing knowledge" indicates a cultural shift towards technology literacy (Hargis, 2001, p. 42).

Dillon and Gabbard's (1996) search for research on learning outcomes using hypermedia indicated that Technology helps novices acquire an expert's representation of a subject. When the technology provided learner control, comprehension increased but this did not occur for all users. It seemed clear that new technologies did not invent the uses, but that the users and creators did (Dede, 2001).

Mioduser, Nachimus, Lahav and Oren's (2000) study of over 500 Web-based science learning environments revealed that the majority of sites targeted high school level students with a focus on information retrieval found in over half the sites (53%). Programs generally used standardized tests for evaluation of learning, and very few (5%) included problem solving, decision making, or collaborative work. Only 28% of the sites included inquiry-based activities of any kind. Interestingly, museums and academic institutions created the few Web sites that fostered collaborative learning or inquiry.

It is evident that hypermedia and computer technology have not changed the classrooms of the nation to a large extent when compared to change in other areas of society (diSessa, 2000), but changes in the field of education are on the rise. Users' attitudes, skills, and technology literacy are tied to the social context in which they are working. Woodrow (1992) recognized the connection of technology literacy to teaching and suggested "it is socially and educationally important to research circumstances under which teachers feel comfortable" (p. 202). As technology has become more pervasive in the workplace, the home and the recreation of American society student and teacher expectations of use and familiarity with technology have increased (Hird, 2000).

Beyond simple knowledge processing and information delivery, Web-based learning has fostered social communication and participation of learners in more ways than conventional learning (Hron & Friedrich, 2003). Implementation of contextualized learning that focused on student technology projects required learners to pull information from teachers and experts rather than having teachers push the information (Thornburg, 2002). The Web-based learning environments supported student manipulation of information, communication peer to peer, and connection to online experts (Mioduser et al., 2000). Hypermedia added the ability for students to choose when, where, and how they would participate in the learning. The "user control" brought together a vast wealth of previously unavailable learning resources (Hargis, 2001). Not only could students learn in technologically-rich environments, literature indicated that teaching and learning changed in ways that supported higher order thinking, critical thinking, engagement, and self regulation. The biggest change was in the classroom teaching style, which became much more constructivist.

Teacher attitudes, what teachers think of technology and how teachers understand it, determine how they use it in their own lives and in the classroom (Abbot & Farris, 2000; Pea, 2001). Effective modeling of technology use in preservice and professional development situations can have a huge impact on how teachers implement it in their teaching, how their students use it in their learning. Ultimately, the teachers' attitude about technology has an effect on their students' attitude (Vannatta & Fordham, 2004). Openness to change and dedication to teaching are predictors for technology integration (Baylor & Ritchie, 2002). When a teacher's technological efficacy increases, there is an increase in the students' technological efficacy (Ross, Hogaboam-Gray & Hannay, 2001).

This intimate connection between teacher and learner, as well as the correlation between teacher attitude and teacher efficacy warranted a close examination of a teacher's understanding of technology as part of the NS program.

NatureShift- The Case

NS fulfilled the criteria for a case study with "boundaries and working parts" and a mission that helped in understanding the uniqueness and complexity of the project (Stake, 2001, p. 17). Based on modern pedagogy and the complex interaction of educational and cognitive theories that centered on constructivist pedagogy, NS had a beginning and end, centered on seven goal statements (Appendix A) and a project mission as follows:

> NatureShift Linking Learning to Life is a student-centered, Internet-delivered standards-aware and curricula-based project focused on the interactions between the natural world and human society and history. At the heart of NatureShift is a teaching and learning model that empowers and engages participants in the act of lifelong learning. The NatureShift Model will inform new regionally focused, Internet-supplemented curricula that can be embraced across the nation.

By design, NS attempted to create a three-dimensional Internet learning porthole by selecting hyperlinks, engaging questions, media, images, and information to enhance critical thinking. Postman (1996) emphasizes the power of multidimensional learning environments, "Generally, young people have too much curiosity about the world and far too much vitality to be attracted to an idea that reduces them to a single dimension" (p. 30). The working parts of this project included the NS Web site, NS teaching and learning model, NS exploration modules, and NS professional development which emphasized learner-centered, teacher-supported explorations that occurred in the learners' classroom, school, and/or community. A brief explanation of the NS working parts follows, and a visit to the Web site, www.natureshift.org is recommended to better understand this program and its products.

Teaching and Learning Model

The NS Exploration Model supported student inquiry, exploration, hands-on investigation, and project-based learning that was learner-driven and teacher-supported. Designed around the four-part teaching and learning model (depicted in Figure 1) of engagement, Internet research, hands-on activities, and technology projects published on the Internet, the model was flexible and could flow in multiple directions depending upon the needs of the learner. The Web site was designed to support student-centered, constructivist learning, making it possible for students in the same classroom to take different paths while exploring the same questions.

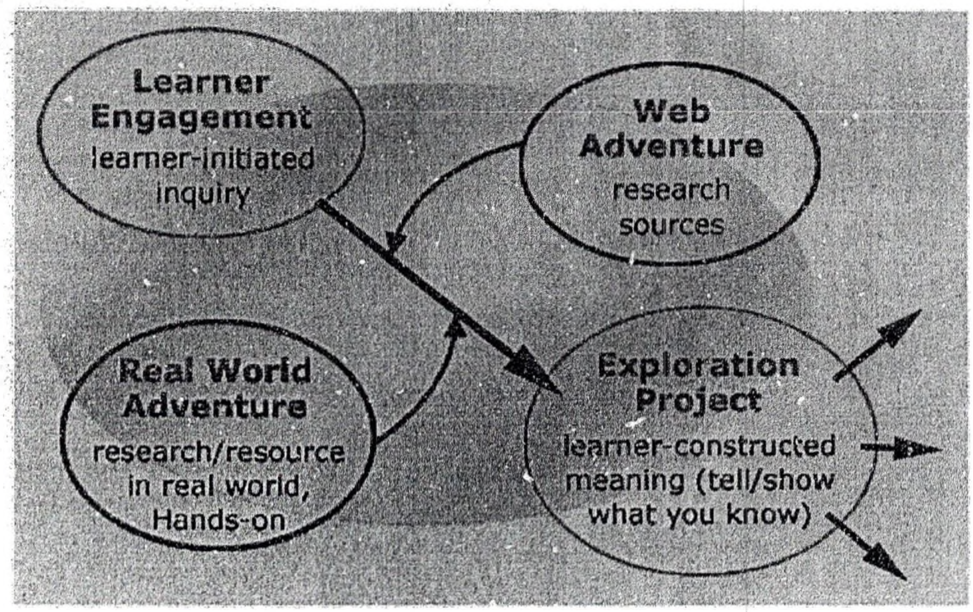

Figure 1. The NatureShift Exploration Model

Web Site

Learner Engagement was achieved through rich graphics, sounds, digital images, movies, and java software programming. Engagement was used to present authentic problems and encourage users to research these problems online and in their communities. This approach supported a terminal project goal of promoting learners' critical thinking and use of higher order thinking skills

Investigation and inquiry were conducted on the Internet as users explored Web Adventures in virtual worlds using relevant technology tools and a series of online hyperlinks. Hyperlinks within the Web site included online tutorials, knowledge sets and knowledge checks, activities to try on the Internet, and a vast set of resources and Web links specific to the questions posed in the NS explorations. Connecting to other Internet sites supported engagement and allowed students to conduct their research in their own way, at their own pace, based on their learning needs. This approach to student-directed exploration addressed one of the terminal goals: raising the level of learning.

In addition to student research, investigations, and activities online, the NS Web site encouraged Real World Adventures that included hands-on experiments, scientific inquiry, and data gathering to be conducted in the classroom, at home, outdoors, and in the community. Here students were able to apply new knowledge to local events, environmental phenomena, and community issues. This directly addressed another of the terminal project goal: connecting student learning to the natural world, human society, and history.

Real World Adventures using problem solving, hands-on inquiry, and investigation culminated in individual and group summative Exploration Projects to be shared with classmates, families, and ultimately published on the Internet. Students were encouraged and instructed to use a variety of technologies throughout the exploration process. Tutorials and vast collections of authentic digital resources, primary sources, primary and secondary source documents, images and movies were available for use making portfolios and student projects.

A free, online Web creation software tool (iMatrix) intended for student collection, organization, and evaluation of information was available to assist with the creation of the Exploration Projects that were showcased on the Web site. The creation and sharing of summative projects that used technology addressed a fourth terminal goal: demonstration of technology literacy through the selection and use of relevant technologies to share understanding.

The four model components used in combination were intended to support all five terminal NS goals. Effective demonstration of the goals in student and teacher products was considered a measure of technology literacy for student and teacher users.

Modules

The NS model was to be employed as users explored five interactive learning modules that provided opportunities to investigate: 1) history and social studies, 2) life science, 3) astronomy and space studies, 4) physics, and 5) science in a cultural context. Engagement was at the heart of each module leading students to ask questions and use technology applications for the creation of projects that presented the understanding and learning from their collected data and experiences. Each module challenged learners to take on the role of scientist, historian, or explorer, as they researched questions online, conducted hands-on experiments, and found answers to the questions posed in the module. Then the students researched similar questions found in their own communities, schools, and families.

Guides, specific to each of the five modules, encouraged the users to experience a NS Exploration in one of the five distinct subject areas by posing questions, offering ideas for investigation online, and directing the students to conduct research in their own communities. In the Ranger Rosie Exploration module (Natural-Life Sciences) the guide Rosie encourages learners to explore three ecosystems online and help her solve three eco-mysteries in the virtual North Dakota prairie, forest and wetland. After proving students have mastered the basic skills of scientific investigation they are encouraged to find, solve, and write up eco-mysteries found in the ecosystems where they live.

The Moon guide welcomes users to Dakota Skies (Astronomy, Space Science) and challenges them to learn the language of the planets and the solar system. Students use these skills of language and observation as they explain where they live using astronomy and their own night sky.

Physics is highlighted in the Robot Lab module (Physics, Engineering, Robotics). The Robot guide leads students through the eight laboratories featuring basic principles of physics. Robot suggests simple hands-on activities that showcase energy, electricity, magnetism, gravity and five other physics basics. Students are then ready to follow the survival diary found by a female biologist who is conducting research on a Pacific Island. Students recreate the experiments and adapt them to challenges they face in their environment.

The Clock guides emerging historians through the Memories and Stories Exploration (History and Social Studies). Students learn the art of being an historian and explore the history of North Dakota as they learn skills of movie making, interviewing, and interpreting primary and secondary sources. Users take this knowledge home by finding the oldest things in their homes and communities and by sharing the knowledge with others online and in the classroom.

As an educational developer for NS, I was responsible for the research, creation, and development of the fifth module, Wounded Hawk. The ideas for this module, as well as the information, images, drawings and content, were contributed and/or approved by a teacher from White Shield Elementary School, the Sahnish Culture Society, and the Sahnish (Arikara) tribal Elders living on Fort Berthold Reservation.

The Wounded Hawk module presents natural science and history in a cultural perspective as it considers the past, present, and future. Hawk challenges people with the question "Can you survive here?" The Survival Challenge takes the visitors back in time with help from Sahnish Elders to fall of 1804 on the banks of the Missouri River. Visitors discover the natural resources and technological skills that were used by Sahnish Indians living in the villages there.

Designed and laid out similarly to the other four modules, Wounded Hawk places science in a cultural perspective while it engages students in planning personal survival strategies for living on the banks of the Missouri River in the 1800s Sahnish Village and in the modern world. Activities and content in physical science, life science, regional ecology, geology, and Native American technology prepare learners to look at similar concepts and issues in their own communities.

As part of the exploration, students create an online parfleche or pouch to store digital images, ideas, and products using the NS iMatrix software. This pouch serves as an online portfolio where learners collect, manage, analyze, apply, and share what they have learned.

In the final stage of the learning model, the summative project asks students to select and research an environmental, historical, or societal issue that faces their community and reflect on how this issue has changed from the past to the present. Taking it a step further, they are asked to consider this issue as it may present itself in the future. Students use a guided set of activities to take their thinking from analysis to synthesis culminating in a shield project where they share their learning of the past, present, and future, then present their wish for the world. These shield projects are to be shared in their classrooms, online, and in their communities.

Research Questions

To better understand the impact of the NS initiative and the Wounded Hawk module, in particular, a set of research questions emerged for this study. What happened when a teacher attended a NS Ambassador professional development training? How did the teacher understand the NS program, Web site, educational model, and technology two years later and how did she integrate them into her teaching?

I was interested in what happened when a technology coordinator (who had a demonstrated commitment, interest, and skill teaching with technology) attended a NS Ambassador training. I wanted to speak with and observe someone who had experienced NS professional development, conducted a NS in-service in their school, and specifically implemented the Wounded Hawk Exploration in their classroom.

I felt that learning how a teacher understood the NS program, Web site, and educational model could provide insight into the effect that this program had on teacher technology literacy. I wondered what elements of the NS experience would remain two years after the NS Ambassador training and wanted to see how the teacher implemented technology with her students.

Method

The pace of the NS project implementation had left little time for reflection during development and dissemination. Looking at NS as a case study provided an opportunity to examine what had been created. The artifacts, interviews, and observations of this case study revealed a teacher-participant's understanding of the NS project in particular and technology in general. Taken together, the working parts of NS, artifacts, observations, and interviews provided an understanding of this initiative and potential for future applications of technology. In order to gain an understanding of the program's influence on a teacher's technology literacy, qualitative methods were used to analyze and synthesize the Ambassador teacher's understanding of the NS program, Wounded Hawk module, and teaching with technology. The data and information for this study came from the NS Web site, lesson plans created by the Ambassador teacher, interviews, and classroom observations. Each of these information sources provided data for the case study. The Wounded Hawk Module, as described above, was the subject for a more detailed analysis of the teacher's understanding of a NS Exemplary Exploration designed to elicit higher order thinking and appropriate use of technology.

The Ambassador Teacher

Anne was the NS Ambassador selected for this study. A 20-year veteran teacher committed to and experienced with educational technology, she was nominated by the her Department of Education state office to participate in the NS Ambassador program based on her commitment to technology integration.

Anne had an established track record integrating emerging technology into teaching and learning. A Web search of her name revealed that she had her own technology help Web site, had been involved in many technology initiatives, and in addition published and led workshops on classroom technology integration around the nation.

At the time of the NS Ambassador training, Anne was the Technology Coordinator for Southwestern Elementary School and was serving as the district coordinator for another TICG program. Anne demonstrated her willingness to learn more about technology when she agreed to travel 1000 miles (on short notice) to attend the Ambassador Training session held in Grand Forks, North Dakota in January, 2002.

There she and 24 other teachers, technology coordinators, and administrators explored the NS Web site, studied its teaching and learning model, the five modules, and then planned dissemination for their schools and classrooms. At the workshop Anne chose the Wounded Hawk module and one other for her NS implementation. During the training, she planned a unit for her school and outlined a plan for disseminating the NS program to her district.

Upon returning home, she successfully conducted a Wounded Hawk Exploration with the second grade students at her school. She also offered an in-service training session on NS for her school, and arranged for a NS workshop for her district as part of the Project Venture teacher in-service.

A recognized supporter of educational technology, Anne began using technology as part of her teaching in 1994. When asked about her interest in technology, she described her personally driven quest for more and more technology for her classroom. "I don't even remember exactly how I stumbled into it, but I could suddenly see all kinds of possibilities for it and how it could impact education and help education and help kids and support kids."

Moving from classroom teacher to Technology Coordinator brought Anne in touch with the emerging equipment and the latest technology integration initiatives. In 1998, she was selected to be a mentor teacher for another TICG program. This program focused on mentoring and technology training of classroom teachers to support technology integration.

State budget cuts of 2003 placed her back into a classroom as a second grade teacher. Anne continued to pursue, promote, and integrate technology into the curriculum for the entire second grade. Recognized within the school as the technology expert, she was able to redesign education delivery for the entire second grade. In response to the cuts, she piloted a second grade team teaching approach with the four other second grade teachers. Each teacher taught the last hour of the day in their area of expertise as classes rotated from science to art, social studies, technology, and language arts over the week. Anne taught the technology integration component for all five classrooms.

She was committed to technology in all of its forms as a valuable tool that enabled more learning to happen. She repeatedly described technology as, "fun, it's a tool, it's an aid, it's a support piece, it's an enrichment piece. I mean it's . . . it is all of those things." Anne linked technology with her teaching style. She described her teaching philosophy as student-centered and ever changing and evolving, "all children have talent, all students have gifts, and all students can learn. But it is up to the teacher to find out what those gifts are and to help the child recognize them in themselves and help them grow to their fullest potential."

Anne spoke openly about her teaching philosophy and experience. She shared her feelings about the future of educational technology as well as her recollections of the NS Ambassador training and her current understanding of the NS program. Anne's comments and responses to questions during interviews and her dialogue with students in the classroom provided the data for this study.

Data Collection

The situated nature of learning, tying learning to the context in which it occurred, required looking at the people of the classroom (teacher and learners) acting together (Taylor, 2000). Attention was paid to the means of mediation that evolved in the classroom between the teacher and the students. The interactions created and delivered within the socio-cultural context of the second grade classroom in the school provided insight into this teacher's instructional language and use of technology. These observations in combination with responses to questions about NS were transcribed, coded, and analyzed for this research.

Interviews and observations occurred over a two-day period. The interviews were taped using a cassette recorder and directly transcribed into a Word document along with the observations from the daylong class. Videotape of Anne teaching in the technology room was viewed and transcribed for use in this study. The lesson plan and NS implementation plan from the Ambassador Training were also analyzed.

The Setting

Observations of the Anne and her class were on the Wednesday before "100 day," the hundredth day of school. The hexagonal classroom had five six-sided tables set up for the 5 family groups. Cubbies formed a freestanding wall where books and coats were stored. An in-basket and bins for lunchboxes lined the wall opposite. A reading nook with kidney shaped table, bookshelves, and six chairs filled the far corner. On the opposite side, eight iMac computers sat back to back on two tables with a TV monitor mounted in the corner above. A teaching counter at the front of the room had water, sink, and other supplies behind it. A teacher's desk was placed to the right but did not look like it was used for seatwork. Whiteboards lined three walls with a few posters decorating the room and the ubiquitous Palmer script poster running along the top of one wall.

Students entered quietly, single file, led by the line leader and the teacher. Getting down to the business of school, students placed backpacks in their cubbies, ordered lunch or put their lunch in a bin and got to work getting out their planners, checking the agenda on the board. Class jobs of calendar keeper, messenger, line leader, line monitor, lunch box carrier, board manager, library manager, floor manager, and two chat and chew (two students who sit and have lunch with the teacher) were listed on the wall. Students talked quietly sharing their "100 Things" that they brought in with others in their family table. Others were already busy working and looking over their homework from the day before and beginning their daily brain wake-up.

On the whiteboard a spiral of words flowed one into the other Wet Wednesday > lunch > grow > mad minute > welcome > morning procedures > brain wake-up > guest > reading groups > recess > music > PE > capacity > lunch > morning procedures. The calendar person set up the calendar for the day, the board person cleaned off yesterday's messages, and the agenda on the wall read:

Quietly come in and put your things away
Look at your papers and put in your backpack
Put your homework in the tray
Put your lunch card in the box
Greet our guest
Start your brain wake up
Study your spelling words
Read a poem
Have a great day

I was introduced as a guest to Anne's second grade class. This was a short week, since Monday had been a school holiday. Anne's class spent the entire day in the classroom except for lunch, recess, gym, and music. The usual last hour rotation to language arts, math, social studies, science and technology was cancelled since it was a four-day school week. I followed the students throughout the day and attended the second grade teachers team planning session where the five teachers coordinated themes, spelling words, integrated activities, lessons, and discussed technology applications for the coming week.

The setting for the technology class was a traditional technology room layout. Eight tables were set up with a row down the center, four tables to the right and four tables to the left. Each table sat four students and held four iMac computers each with a headphone set. A teaching computer, operated by an aide sitting at the front of the room, was projected on a large screen at the front left of the room. A large poster 4'x 10' recreating a keyboard covered the front whiteboard.

Anne rotated around the room, instructing and assisting the students during the technology class. Students used a red plastic cup to signal the teacher for help, to signal when they had achieved a task, and to indicate when their screen looked like the teachers.

Role of the Researcher

I met Anne when she attended the Ambassador Training session in Grand Forks. She had rotated with the other 25 participants through all five of the NS modules and chose Wounded Hawk to focus on for an implementation at her school. One year later I was invited by the director of Project Venture to lead a NS workshop in Anne's school district. Anne assisted in leading some of the NS activities as part of the NS workshop at her district. Earlier in the year, she had conducted a NS in-service at Southwestern Elementary for all the teachers. The school had adopted NS as one of their programs and Anne was the contact for teacher support.

When I asked Anne to participate in this study, I knew I would have to be very careful to avoid bias. It was necessary for Anne to feel that she could speak openly and truthfully concerning her thoughts and feelings about NS. I did not want her to worry that she might hurt my feelings, or hesitate to say anything that was not positive.

The regular formalities of a qualitative study were followed. IRB permission was obtained for this study. A letter of agreement was drafted (Appendix E) and signed by Anne prior to the interview. I explained that she was free to withdraw from the study at any time without penalty. I encouraged her to speak freely and answer with words that truly described her recollections, thoughts, and feelings. Because this was a research study, I needed her to speak up and say what she really thought, not what she thought I might like to hear. I also needed her to be more objective about her NS comments, specifically those related to the module I had created, Wounded Hawk.

Coding

After all of the interviews and observations had been transcribed, open coding began. The 90-page transcription began with the first interview, followed by the observations of the teaching day and technology class, and the text of second interview. I repeatedly read the transcripts until I was familiar with the flow of the words and the phrases.

As I reread the interviews and the notes from the classroom observations, the sentences were broken into phrases. Initial codes, relating to the NS goals of engagement, learning, technology integration, interactions with the natural world, and higher order thinking, were applied to the phrases where they fit.

Keeping the research question for the case study in mind I wondered how an experienced educator who had a demonstrated commitment to technology understood the NS program two years after the initial training and what she had to say about technology in general. When code words or questions came to mind, I jotted these in the margins as the text began to break up into smaller phrases. New codes were added freely as needed to identify the nuances of the field notes and interviewer comments. Some phrases had several codes or a code might appear in the center and the phrase would be divided.

As the large set of 80 codes were laid down, they overlapped, doubled up, and appeared as groups. Each code was tallied using a Microsoft word search., Overarching codes were chosen that best captured the meaning of field notes or comments that had multiple codes. After careful reflective re-reading, the entire clean transcript was recoded with 20 codes. When one of the 20 codes would not fit, it was necessary to look back at the prior coding to see what had been selected before. This process continued until it became almost automatic, and it was time to look for the categories of codes.

Select phrases that corresponded to each code were placed beneath them. The codes and field notes associated with the codes were arranged and grouped on a large table. As the codes were moved around the table they became divided into two general groups. Two codes, "Teacher-directed" and "Constructivist", became the two categories for the other 18 codes. Codes and phrases in the Teacher-Directed category were associated with artifacts related to drill and practice, reprimands, and routine classroom management. The codes and field notes in the Constructivist category were associated with examples of active teaching and technology integration.

Several themes emerged as the field notes and observer comments associated with the codes were reexamined. Taken together, the themes and field notes associated with them supported the assertion for this case and four sub-assertions. These codes, categories, themes, and assertions comprise the results of this qualitative study and can be viewed in Figure 2.

Findings

This study attempted to determine what happened as a result of the NS program, provide an understanding of the NS initiative, and consider potential application of the model. The purpose of this study was to investigate how an experienced technology coordinator/teacher understood the NS program and technology two years after the professional development, and how the teacher understood and used technology in her teaching. From the data two themes e emerged through observations of and conversations with the NS Ambassador Teacher.

CODES

Praise	Reprimand
Instruction/Teaching	Management
Learning	Routine
Teacher Question	Student Question
Beliefs	Interactions
Engagement	NatureShift
HOT	Internet/WWW
Motivation	Technology Literacy
Technology Integration	Appropriation

CATEGORIES

Teacher-Directed	Constructivist

THEMES

Teacher-Directed	Constructivist
Constraints of the teaching environment and prior experience influence preferred teaching and learning style	Technology and technology integration training are adapted and appropriated becoming part of the teacher's teaching and learning style.

ASSERTION

Access to educational technology and professional development in technology integration promotes constructivist teaching.

SUB-ASSERTIONS

1a: (Motivation) Technology innovations positively influenced constructivist pedagogy.	1b: (Belief & Practice) Technology beliefs predict technology implementation
1c: (Prior Experience) Confines of the traditional classroom structure shift instruction to more teacher-directed pedagogy	1d: (Future Practice) Successful technology innovation promotes technology literacy

Figure 2. Research Codes, Themes, and Assertions

The two themes were: 1) Constraints of the teaching environment and prior experience influence preferred teaching and learning style, and 2) Technology and technology integration training are adapted and appropriated, becoming part of the preferred teaching and learning style of the instructor. From these two themes, a general statement was advanced in the form of an Assertion for this case study. In order to present and support these two themes and the case study assertion and four sub-assertions, this chapter provides statements about each of the assertions with evidence to support them.

Technology Literacy

Assertion #1. Access to educational technology and professional development in technology integration promotes constructivist teaching.

Personal beliefs and educational practice were influenced by the teaching environment and the tools and materials that were present. Teaching in environments with ready access to technology increased the quality of the learning experience. The teacher in this study used positive language and constructivist, student-centered pedagogy when she was using technology as a tool and teaching aide. This fact was also true when the teacher employed technology as part of the teaching on field trips and for special projects.

In the more traditional classroom setting, her teaching was observed to be more traditional and used teacher centered pedagogy. Teaching practice included more management and routine. Students received less praise, and there were more teacher reprimands. When technology was occasionally employedin the traditional classroom teaching, the students and teacher displayed more energy and used positive exclamation.

Motivation

Sub-assertion #1a. Technology innovations positively influence constructivist pedagogy.

Anne was personally motivated by technology. She "fell in love" with technology as it unfolded from the creative minds generating the first World Wide Web pages in 1994. She described the emergence of the Internet as a powerful and exciting learning tool that would help raise the level of learning: "there was so much there . . . and I kept thinking . . . I can really . . . need to use this . . . I have to get it into my classroom."

In the first interview she explained how she worked her way into a technology training class in 1995. Technology and the Internet were viewed as potentially dangerous teaching tools, according to the school administration. Disregarding these obstacles, Anne pushed to get Internet connections into her classroom as she pursued her passion for technology. Despite the fact that her classroom had no computers, the school administration had strong reservations about technology and they did not think technology integration would work with primary learners, she persevered. In a rush of words, she described a time when private schools were getting grants and computers, while public schools were holding back.

> I signed up for a grant we got with a talented and gifted partnership with a private school. They [her administration] didn't think it would be very beneficial to primary students so I was bumped off the list the first year. I was mad . . . the district had still bought me the equipment so I had all the equipment in my classroom so it was kind of like "well here is the equipment and I don't exactly know how to use it", but I thought . . . "I have one computer that is Internet capable and four that are not but I can still make some of this stuff work and" . . . I took everybody's old and abandoned equipment and I tried to make it work [laughing and talking quickly with enthusiasm] and hook it up.

Anne followed that success with more enthusiasm. She signed up for almost every class that was offered in the years to come. She built her technology integration skills, along with the evolving technology she pursued and acquired through grants and school initiatives.

> The district was leery about the Internet . . . so you had to have a class and 30 hours of training on the Internet before they would even let you...before they would even make your computer . . . the one computer that you had Internet capable, before they would even attach it . . . so I signed up for Cyber Savvy training."

Anne continued to add tools and skills in an effort to transform how her students learned and to inspire the way she taught. She observed other teachers' attempts to incorporate new methods that might work for her students, always asking, "well what are you doing and how are you doing this and how can I tweak that idea and make it work for me and . . . I see it working really good for fifth graders and I am teaching third graders, how can I make that work?"

Anne adopted and adapted technology of all kinds the moment she saw it. Even abandoned technology offered an opportunity for her to be creative and more student-centered. This was evidenced when she developed a student-focused constructivist learning opportunity while teaching her kindergartners their alphabet. Using abandoned keyboards, with no monitors, she created an effective learning process that transformed a routine teaching activity into a fun teaching and learning experience for her and her students.

> My kindergartners learned their alphabet so much quicker on a keyboard and using a keyboard . . . I mean we didn't have Alpha smarts we just had these old keyboards that nobody used or wanted anymore so I took the keyboards . . . "here everybody find the A . . . everybody ding the W . . . everybody find the P . . . the

> letters on your keyboard are they upper case or lower case? How do you know?" Just little goofy games like that and they loved it.

She appropriated technology and technology training, adapting it to her teaching style. Technology was described more than seven times as a tool in the two interviews. But it was clear from her voice, and the way she used technology, that it was much more than a tool; it was a part of her life.

> It's a tool, it's a jumping off place it's an enrichment place. I can use it for drill and kill if I need to . . . I can use it for enrichment activities. I can use it for supplement I can use it for assessment and as a diagnostic. It is just another tool, it is part of my . . . life . . . it's there . . . [Laughs]

She recognized technology integration as a way to engage hard-to-reach learners. Beyond being a fun resource, technology was a support piece and an enrichment piece. She articulated several times the gradual process teachers must go through incorporating technology into the classroom and into their teaching, "It's a process, it's not something that happens all at once . . . you have to give yourself a chance to fail and succeed, reevaluate and plan and retry and it's not something that happens all at once, it's a gradual process."

Personal motivation supported her willingness to participate in the one TICG grant and become a NS Ambassador for another TICG grant at the same time. The beliefs she held were influencing her own technology literacy. Her emerging constructivist approach to teaching was strengthened as she pursued more and more understanding and application. Increasingly she identified herself as a technologically literate person, *Belief and Practice*

Sub-assertion #1b. (Motivation) Technology beliefs predict technology implementation.

Anne's belief in technology and her experience implementation of it as a teacher and technology coordinator influenced her action and efforts as a professional. This was demonstrated when she was she was forced to give up her role as Technology Coordinator and return to the classroom. This change coincided with the end of her role in first TICG project and the active phase of the NS Ambassador program. In response she, was able to innovate and restructure the delivery model for second grade at her school. She maintained her role of technology coordinator and mentor for at least one grade level.

At the second grade planning session, teachers deferred to Anne as plans for technology application of the upcoming units were discussed. She was still recognized by colleagues as the "techie" and routinely contacted to give help and provide ideas. Teachers throughout the school commented on her support of technology integration. She was involved in their technology efforts despite her new job as classroom teacher.

Anne was humble about her skills and achievements using technology in teaching saying, "I am always learning and always trying to do better or be better or do something different and better for my students . . . which in turn helps me. Not that I am perfect by any means [laughs]." At the same time that she consistently separated herself from average teachers, she seemed to understand their perspective.

In the interview, she responded to a very open-ended question about NS, revealing her thoughts about NS and the abilities of her colleagues: "The average teacher asks why weren't there more student projects or student examples . . . and they miss the whole discovery and the whole exploration piece that was there." She acknowledged the effort it takes to be good at integrating technology. Her words revealed something about her own efforts to grow as a professional as well as for teachers as a whole.

> You have to have the time to look and see what is there . . . and the time to plan . . . and use it effectively . . . [pause] and the time to fail and reevaluate and re-plan so you can correct your mistakes. You still have to have the willingness, the willingness to do that as well.

Based on actual experience implementing NS in her school, Anne explained why many teachers she mentored did not fully understand and utilize NS. She differentiated between her constructivist teaching approach from that of the average teacher when in an exasperated tone she noted that the typical teacher would say, " So here are all these wonderful resources, where are the ready-made materials that go with it?"

She concluded that lack of understanding and lack of time were big factors in failure to implement NS, "but the average teacher looking at it...they don't have the time to do what they are looking at like . . .'Ok this has this and this has that and let me down load the lesson plan and I can do it.' . . . So I think they are looking for more ready made materials and resources."

Although she had difficulty describing the NS model herself, she had a complete understanding of it. Again, she differentiated between her understanding of NS and how other would understand it. "There are two ways to describe it . . . one way is the way I would use it and then there is the way you would describe it to a teacher or a parent or another teacher who is not familiar with it . . .because so much of it is exploration and self discovery . . . but there are tremendous resources there."

Her beliefs about NS were strong. She could speak of its value but when asked to speak about the underlying goals, she had difficulty articulating her understanding. She had internalized it so well that she recognized it as her own teaching.

> I don't know if I actually remember what the goal was but I got that "Here are . . . we have compiled all these resources for you, we have led you on some journeys and some explorations now, use these resources use these examples and create your own journey, your own exploration, something that you can use with your students. Umm . . . Use these resources, copy what we have done but modify it for you...explore, learn."

When discussing her own lesson for the NS Ambassador implementation, Anne simultaneously apologized for deviating from NS, while providing a perfect example of a NS constructivist learning experience. Her Wounded Hawk Exploration had followed a constructivist learning path that implemented all four parts of the model. Students began with an online exploration of Wounded Hawk's world where they learned about survival and Sahnish traditional technology and agriculture. Anne referred to the Web Adventure as a great "anticipatory set," another example of her application of her own vocabulary.

This Wounded Hawk Web Adventure prepared students for a Real World adventure when they traveled to a local historical site. Here learners used cameras to create a virtual reality movie of a pit house, collect images of technology, and write down questions. When asked about how she used Wounded Hawk, she "confessed" that she had deviated from the Web site.

> Well I liked the anticipatory set, where you know we imagined ourselves there and you didn't give us a whole lot of information but just close your eyes and imagine and draw the picture and then we got the real scenario. And it was such like such an eye opener. And I kind of liked that for the opening and you know do all that stuff. We chose not to do the shield [voice goes down].

She had implemented every step of the model and demonstrated the major goals of NS: engagement, higher order thinking, a high level of learning, relevant use of technology, and a connection to society and community. Students had taken the Real World adventure back to the classroom and conducted investigations that culminated in a student technology product that they shared with their families.

As she got farther into description of the exploration, her language switched to her own vocabulary and she was very excited about the outcome. What interested me was how she appropriated NS and blended it with her two other technology favorites, Project Venture and Cyber Savvy Teaching, "And I thought the three of them kind of overlapped . . . especially like a lot of the um . . . they had a lot of good which blended in so nicely with . . . it was just the perfect match!"

Cyber Savvy Teacher, Project Venture, and NS were blended into her professional constructivist approach. These three innovations were what she identified with and what she recommended to help other teachers.

> So that it would actually get used and become natural and comfortable with the teacher. Here is more wonderful resources [NS] . . . here's a bunch of how to's for teachers [Cyber Savvy Teacher] take the time, explore – develop and . . . then [Project Venture] here are your mentor teachers to help support and encourage and keep you on track and balanced and work it all in with everything else.

She had appropriated all three different technology resources and applied them to her way of teaching. I asked her to consider what teaching would be like if she had no access to technology. Her reply says it best.

> I would be at a loss. [laughing] I would beg, borrow and steal [funny voice, talking very rapidly] "Oh you are not using that computer . . . haven't seen you use it much . . . could I have it and use it in my classroom and you can come in my room to use it for your little teacher stuff."

Prior Experience

Sub-assertion #1c. Confines of the traditional classroom structure shift instruction to more teacher-directed pedagogy.

Anne's teaching style while using technology was different than her style when teaching without technology. There was a distinct switch in several areas while teaching in the traditional classroom. The high number of field notes associated with the code of management and routine indicated that much of what went on was teacher-directed. The code "reprimand" was used to identify field notes dealing with student misbehavior. This code was found 16 times in the school day field notes, but was not applied to any of the field notes during the technology class.

Field notes in the one-hour technology session indicated a back-and-forth dialogue between the students and the teacher. Students responded with more excitement expressing "oohs" and "ahhs" over what was being shown or explained. While using technology, Anne confirmed student answers by consistently repeating them to check for understanding, and then asking the next question, "What finger do we use to hit the return?" The student replied "pinky" and Anne started the second question with the reply "Pinky...and what finger do you use for the space bar?"

Although this dialogue is not indicative of a highly constructivist conversation there was an obvious teacher-student connection during those teaching times. I had a sense that students were on task, following her, and she was connected to them.

This constructivist pattern of teaching and instruction was absent during most of the teaching day. The one exception was during a lesson on stars, when she got out the projector and shared images from space. During this interaction, I observed a constructivist dialog. In that same session, technology was used as a reward as illustrated by these words: "Hannah you are doing such a wonderful job, could you please come up here and hold my computer for me?"

Anne fell back on more traditional teaching techniques that were almost entirely teacher-directed when technology was not readily accessible. Good teaching was still witnessed and students were well respected, but Anne's language and body energy were less animated. A move from behind the desk to the Internet and projector shifted the lesson onto the learners. When the connection was shut down, the students returned to their desks and traditional teaching resumed.

Future Practice

Sub-assertion #1d. Successful technology innovation promotes technology literacy.

Over the past ten years, Anne attended numerous technology in-service sessions, workshops, institutes, and conferences. She taught and led workshops on technology integration and gained and demonstrated considerable technology literacy. She identified the personal importance of Cyber Savvy Teacher and Project Venture independently in several different contexts and twice in connection with NS.

These three innovations were appropriated, redefined, and added to her understanding and use of technology. She identified the components of the model but used her own words to describe it.

> So I think at first until they are ready for the discovery part, I would introduce it as excellent resource, there are lots of materials, lots of things there to pick and choose and what's there, what's available to what you need it for, and when you are ready to use it as a springboard for discovery, and then all the tools and resources are (there) for you as well.

Anne recognized NS as different from other Internet Web sites. She defended it as more than online curriculum. When I compared it to a few name brands in Internet education, she interrupted with an emphatic statement, "NS **is different** . . . it's an excellent resource for both teachers and students, and yet at the same time it evokes ideas, it gives students the idea to go further or explore this one piece further or do something a little more with it."

She described her Wounded Hawk implementation and the value it had as a spring board, taking the concept of invention and technology past and present and applying it to a study of the Hohocom Indians who had 1,000 miles of irrigated farms in Arizona 7,000 years ago. As she described her lesson, her language shifted completely away from NS terms and references to the Wounded Hawk module. With excitement she shared stories of ways the students tied the learning into their community. She described the fun and excitement the second graders displayed while videotaping inside the pit house. She commented on the success of the unit and ways parents were involved in learning from their children, "Wow I never knew all this was here, I never knew how neat all of this was. And just to see how it impacted their life there."

Anne had followed the NS model effectively and used many aspects of Wounded Hawk Exploration just as intended. But she viewed the NS implementation as her own lesson plans despite the fact that it had followed the Wounded Hawk module perfectly and achieved the highest goals of NS. Anne appropriated and incorporated the ideas to such a degree that she no longer identified with the NS program, and yet it was still there. She could not describe the model, nor could she describe many components of the module, yet she was implementing a perfect example of precisely what Wounded Hawk and NS were trying to accomplish.

Anne was a good teacher by all accounts. She constantly reflected, planned, cared, and changed. She was always thinking of the individuals of the class and her own needs as a teacher as illustrated by these words: "I don't know, I think it goes back to the teacher and what's appropriate and what's valuable. You know it needs to be a balance of everything." She downplayed her integration of technology but seemed happiest when she was sharing technology with her students or incorporating it into the lesson. "I think, what do I need to do to incorporate that, and how can I make it work for me."

As for the future of technology literacy for teachers and children, she recognized it as a moving target: "it is always kind of changing and evolving and it isn't . . . so I can't ever really say that it is the same from year to year because it is always changing. " She did acknowledge her own growth and suggested that each teacher needs support, starting from where they are as a learner by saying: " I don't know, I think it goes back to the teacher and what's appropriate and what's valuable. You know it needs to be a balance of everything."

When speaking of the value of TICG initiatives, Anne visibly expressed her personal concern in this way: "somebody else in a couple of years is going to reinvent the wheel and think they have this brand new thing, and I'm gonna say . . . people are gonna say **nooo** we had this back then and look at all this stuff that is here." She had appropriated NS and Project Venture as her own and described her concern over the future of these initiatives,

> I am kind of scared to **thiinnnk** what's going to happen to them because I see so much value and benefit and I guess because I was a part of them and I used them and they are valuable to me and I see their value and importance. I really hate to see them go by the wayside and at the same time I have that nagging feeling that maybe that's not going to happen.

Recommendations for Further Research

This teacher was fascinated by educational technology. It motivated and inspired her teaching. When educational technology was readily available, whether it was in the technology room or part of a learning experience on a field trip, the teaching became livelier.

A visible connection occurred between the teacher and the learners when technology was employed. The amount of dialogue and instruction increased in those situations. Praise was used more often with the teacher's voice ending sentences in an upswing of affirmation. The teacher's descriptions of learning while using technology were all highly constructivist. Her examples of technology implementation affirmed the constructivist approach she employed.

Understanding what sparked interest and grabbed this teacher's attention long enough to consider the value of educational technology integration will provide insight into how to find the hook for others. Finding the hook that gets teachers started will help increase and support technology literacy.

A great deal of research has focused on discovering the barriers to technology literacy. These barriers are fully documented. We know lack of time, fear of losing control of the learning, lack of equipment, lack of technical support, and lack of training are all barriers to using technology in teaching, but what are the motivators?

It is now necessary to spend more time talking to teachers who are committed to technology integration and finding out why they use it, why they spend the time, money, and effort to include it in their teaching. It will be necessary to watch them teach and see how they use the technologies and how they talk about and recommend teaching with technology.

The intrinsic rewards this teacher gained from technology integration could not be fully documented in this case study. This study points at the powerful commitment to technology that is demonstrated by a teacher and how the use of that technology changes the teacher-student interaction.

This study did not explore the students' feelings and understanding of teaching with technology. Relatively more research has been conducted on student outcomes using educational technology and student attitudes towards technology. It is known that students expect technology to be part of their learning and that they enjoy using technology as part of the learning process. Research indicates that the enjoyment and degree of learning is dependent on the teacher efficacy and may not be the result of the technology alone. More research on the relationship between teacher efficacy and student outcomes could provide a better understanding of technology literacy.

The 110 TICG grants offer a wealth of research data and a tremendous opportunity to respond to the questions of technology literacy. These projects and their creators represent a high degree of technological efficacy. Evidence used by evaluators to write annual reports could provide ample data for a retrospective analysis or a qualitative meta-analysis if we could observe, and interview, and learn from the creators of the projects.

TICG Educators who dedicated five years of their lives to promote technology literacy in a variety of iterations would perhaps be willing to share what they have learned. Their understanding might provide answers to the questions of what inspires some teachers to integrate technology into their classrooms and teaching.

CHAPTER V

TECHNOLOGY LITERACY IN THE 21ST CENTURY

Synthesis

The quantitative study presented in Chapter III and the qualitative study presented in Chapter IV are summarized in this chapter. The synthesis of the two studies, offered here, presents overall conclusions as well as suggestions for further research on educational technology integration and technology literacy.

Introduction

NatureShift! *Linking Learning to Life* (NS) was the focus of this research. In order to understand the impact and effect this Technology Innovation Challenge Grant project had on teachers and learners, two approaches were taken. A quantitative study examined the products of teachers and learners who had participated in a NS implementation. Student pre/post test scores of content knowledge and technology application, as well as scores from student and teacher products, provided the data for quantitative analysis. A qualitative investigation, in the form of a case study, examined a participant teacher's beliefs, attitudes, and understanding of NS in specific, and technology in general. The qualitative study of NS and the teacher who used it provided data from which themes and assertions about NS emerged.

NS goals were central to these two studies. These goals informed the questions used for pre/posttests and the rubric used to evaluate products. The same goals offered a starting place for conducting the qualitative research in an attempt to discover how a teacher understood NS and what happened to her teaching as a result. NS goals were based on the principle of constructivist teaching and learning aimed at providing tools that help teachers and students operate within their own personal world. When the process of learning with NS became more than a storage of "truths" and shifted to the construction of useful personal knowledge (Grabe & Grabe, 2001), thereby linking learning to life, NS was judged to have succeeded. The two studies and two methodologies were chosen to determine to what degree students and teachers achieved increased technology literacy through NS.

Teacher and Student Outcomes

The quantitative study investigated five measures related to technology literacy that were demonstrated to varying degrees by the teachers and students participating in a NS implementation. NS external evaluators created the actual instruments used as part of the NS program to measure teachers' and students' technology literacy. Literacy was demonstrated by student pre/posttest comparisons of content knowledge and technology use and rubric scores of student summative projects and teacher lesson plans. These student and teacher projects were evaluated in five dimensions, and rated by level of demonstration.

The findings and conclusions from this study could be of interest to NS partners in the project, other TICG project directors, the U.S Department of Education and to educators at all levels who are interested in effect of technology integration on teaching and learning. In addition, the study adds to the existing body of literature in the field of technology and education.

Standard statistical methods were used to answer the research question: What relationships existed between use of NS and engagement in learning, level of learning, demonstration of higher order thinking, appropriate use of technology, and developing understanding of the natural world, as indicated by evaluation of student and teacher projects? Findings indicated a positive relationship between use of NS and all of the five dimensions. Students' content knowledge and understanding of technology application increased significantly after a NS implementation. Student and teacher projects overall were above average in all five dimensions, and over 80% of the students' products demonstrated an above-expected level of engagement and learning. The teachers' lesson plans showed a comparable level of achievement. Students integrated three or more technologies into 69% of the projects, despite the fact that only 1/3 of the teacher lesson plans suggested use of three or more. It appeared that students were able to outperform what was required of them in the teachers' lessons.

The quantitative study pointed to an increased technology literacy for students and teachers involved in a NS implementation. Results further indicated that not all dimensions presented in the NS Web site and program were equally well understood by teachers and students.

A Teacher's Understanding of Technology Innovation

The qualitative study examined an experienced teacher's understanding of all aspects of NS, the NS Ambassador Program, and the role technology played in the classroom. Data were gathered through classroom observations and interviews. All data were transcribed and coded following standard qualitative research practice in order to answer the research questions: What happened when a teacher attended NS

Ambassador professional development training? How did the teacher understand the NS program, Web site, educational model, and technology two years later, and how did she integrate them into her teaching?

Overall, the NS Ambassador teacher described technology of all kinds as a tool and a resource, an enrichment piece, and a support piece to reach students. Technology appeared to be a personal motivator for this teacher, as she actively sought out new technologies and appropriated innovations, adapting them to her own teaching style. Of special interest was clear difference in teaching style the teacher displayed when technology was a part of the classroom teaching and when it was not.

The traditional classroom was run like an efficient small business, complete with an in-basket, agendas, work centers, and a set routine of activities. Instruction changed dramatically from teacher-directed to learner-focused constructivist teaching when technology was employed. The pace and dialogue shifted with supportive conversation going back and forth between all the participants followed up with regular checks for understanding.

NS clearly informed and inspired the Ambassador's teaching, even though she did not identify it as the source of her teaching. She had difficulty consciously articulating the components of a model that she was in fact following. It was especially striking that she perceived her implementation as deviating from the NS model, despite the fact that she was following it closely as she planned and implemented a perfect example. Apparently, the NS exploration model was internalized and combined with her other technology integration knowledge to such an extent that she no longer recognized its source. Overall, results indicate that as this teacher adapted and adopted technology, she appropriated it and identified it as her own. Despite a high degree of technology literacy and competence in constructivist learning methods, she fell back on more traditional teacher-centered approaches when technology was not involved in the teaching.

Implications for Educators

Teachers in these two studies committed large amounts of time, personal effort, and money to participate in technology training and conduct NS implementations in their schools. It appears that some intrinsic rewards were present that inspired these teachers when integrating technology into their classroom routines. In turn, teaching with technology enhanced student and teacher performance in several areas. A great deal of research and attention has been given to the obstacles that inhibit teaching with technology. Perhaps it would be more beneficial for researchers to direct their energies into investigating the motivations of those who succeed at the task.

This study suggests that when teachers are provided with clear objectives they are able to build them into a specific teaching task associated with the objectives. Long term appropriation of the technology integration methods and models, evidenced by the Ambassador teacher, indicates that teachers, like all learners, construct learning that is personally meaningful for them. If this is the case, it may be helpful to consider ways we can build technology literacy into the teaching repertoire of teachers and preservice students.

Research indicates that training and professional development do support teacher technology literacy. Further, research indicates that positive teaching experiences using technology increase teacher efficacy. As their competence in using technology increases, most teachers increasingly employ constructivist-teaching methods. When technology is employed, the learning process becomes individualized, for at least two reasons. One explanation lies in the multiple learning paths available to the learner that may lead students off in different, equally valid directions; another is found in the fact that numerous technology problems require individual, personalized attention. Due to the nature of the medium, the teacher gives each student more one-on-one attention when technology is employed.

The most effective technology integration appears to be conducted by teachers who are personally involved in constructing the activities that integrate technology into lessons they choose to teach. When teachers simply implement pre-made lesson plans, the results are less satisfactory. With proper support from school administrators and sufficient technology tools and time, teachers are more willing to use technology in their teaching. Other research and the findings from this study indicate that the more success teachers have in using technology, the more constructivist their teaching style becomes and the more they utilize technology in their teaching. Examining teachers who use technology in conjunction with a constructivist teaching style will help clarify this observation further.

Implications for Researchers

Two studies cannot decisively answer all the questions surrounding technology literacy, but they can open up new lines of thinking. Implications drawn from these two studies raise interesting questions and provide opportunities for further research. It certainly seems that the very process of using technology in teaching and learning encouraged, or even required, a teacher in this study to employ constructivist practices.

If this process applies in a more general way to a wide range of other teachers, then it is certainly worth investigating closely.

When teachers put the learning tools in the hands of the students, the students are in control of the learning. Action becomes individualized as users' skills and interests take them in different directions. The same assignment when supported by technology offers multiple directions and choices for the learner and more demands on the teacher than its non-technology supported counterpart. Demands take on the form of problem solving and trouble-shooting or may go to a higher level of learner /teacher interaction.

A search for the most constructivist schools and technology literate classrooms, and technology literate teachers would serve as a great starting place for a research study. Observing the interactions in these environments and analyzing what students and teachers say about their learning would give us more ways to support the technology literacy that the modern world requires. Here are some sample research questions that might be pursued:

1. What are the intrinsic rewards that motivate teachers to pursue technology?

2. What about teaching with technology supports teachers' constructivist style of teaching?

3. What are the conditions (school climate, technology support, technology access, administrative attitude, technology training, socioeconomic level) of the schools and classrooms that integrate technology into teaching?

4. Of those classrooms, to what degree do they utilize constructivist pedagogy?

5. What are the attributes of teachers who integrate technology into the classroom?

Overall Conclusions and Recommendations

A great number of research questions can be suggested from this research. A research emphasis on why teachers do use technology and constructivist teaching will perhaps give educators more to work with than a battery of studies that examine why teachers do not or will not.

Student-centered teaching with technology may allow a teacher to respond to and engage in student's unique learning process. Students' discoveries and related questions offer opportunities for the teacher to support independent construction of personally useful knowledge. This type of teaching and learning can be a rewarding, or it can be overwhelming.

Research has indicated that when teachers feel supported and successful using technology as part of the learning process their teaching becomes more constructivist and learner-centered. A shift from constructivist teaching using technology to traditional teaching could represent a retreat, an opportunity to rest and recharge before taking on another freewheeling student-directed adventure. Taking a closer look at when teachers use technology in a constructivist manner and when they do not might shed light on what conditions support the student-centered approach. Classroom structure, the number of students, or type of equipment all may influence technology integration. Factors could include room design, access to the outdoors, size of class, ready access to state-of-the-art technology, and a good sink and a whiteboard.

Finally, this research has implications for teacher-educators. It is essential that teacher-educators model technology integration in preservice classrooms and raise their level of technology literacy in order to inspire and prepare future teachers. Above all, it is necessary to provide preservice teachers with opportunities to build technology integration into their student teaching repertoire and experience success using technology in their field experience. Technology literacy is not an option; it is a requirement for life and learning in the 21st century. When educators fail to integrate it into the elementary, secondary, and college classrooms, learners duly accept the absence, and then regard school as completely disconnected from the technological world we live in.

Reflections

Students are admonished to pick a dissertation topic of interest because they will be with it for a longtime. This certainly proved to be true. I worked as an educational developer for NS from 1998–2003, writing, testing, training teachers, and refining the program. The research and writing for this study took another two years. Fortunately, one cannot tire of examining an endeavor that took $5 million dollars and six years of concerted personal effort to build.

Chapter I proved to be the most challenging. Sitting down to write the literature review resulted in continual research into the research behind the research. Spending six years creating something did not mean that I had ready knowledge of current literature and research to back up the creation. The most current research on the topic of technology integration was conducted while we were in the process of implementing emerging technologies into our project. This realization led to a year of reading about theories that had supported the NS innovation, a review of past projects and studies addressing similar goals, and general research on: Web learning, teaching with technology, teacher attitudes, student learning with technology, technology integration, and all the goals that had been incorporated into the NS project.

The two-article dissertation format had benefits and drawbacks. It appeared repetitive at times, since the literature, methods, and findings were described in several chapters. On the plus side, it provided a context and an audience to write to, with professional journal examples to follow. Considering quantitative and qualitative research questions about the same project provided an interesting balancing effect, making it impossible for my thinking to fall too deeply into one method or the other. At times I found myself viewing things from a more quantitative perspective, only to find that qualitative questions forced me to think differently about what was going on. When the qualitative research left me doubting the efficacy of NS, the quantitative findings reassured me, and I was able to let go of my bias and look between the lines at what the NS Ambassador teacher was expressing.

From a NS point of view the two dissertation format was a more authentic task which can immediately be applied to the real world, as journal article proposals, as soon as the dissertation process is complete. Writing a dissertation is a burden and an indulgence. The process has given me confidence as a researcher and a writer. My abstract/random learning style has been improved by some newly acquired concrete/ sequential skills. I have many ideas for future studies and have vowed that I will never start another major initiative without doing my research homework first. The luxury and discipline of the dissertation process was a life changing experience, and definitely linked the learning to my life.

APPENDICES

APPENDIX A

SEVEN OBJECTIVES FROM THE NATURESHIFT GRANT

Objective 1 – Living with Nature

- Increase student knowledge and understanding of Nature's effect on human and wild populations.
- Increase student knowledge and understanding of the interdependent nature of location, people and history in the region.

Objective 2 – Rural Isolation

- Increase rural and reservation communities' access to the internet.
- Increase rural and reservation communities' use of non-local resources.

Objective 3 – Science Literacy & Standards

- Incorporate national standards and state frameworks for content and processes in science, history, and environmental education curricula.
- Incorporate problem-solving and authentic learning opportunities into educational curricula.

Objective 4 – Preparing for the World of Work

- Incorporate five SCANS and abilities into science, history and environmental educational curricula.

Objective 5 – Gender and Cultural Issues

- Increase teacher awareness of educational research and teaching implications in the areas of gender and cultural diversity.
- Incorporate in the modules and teacher training sessions, topics, knowledge and skills relevant to gender and culture into science, history and environmental education curricula.

Objective 6 – Effective Use of Technology

- Increased demonstration, while using technology, of problem-solving skills by teachers, students and community members.
- Technology use corresponds to, and integrates with (instead of being peripheral to), curricular goals.
- Technology users are able to integrate multiple technologies such as text, graphics, capturing visual images and videos in constructing and demonstrating their understanding of Objective 1.

Objective 7 – Teacher Preparation

- Prepare teachers to use technology as a tool for promoting problem-solving skills in the areas of science, history and environmental learning.
- Develop a corps of community evangelists to serve as mentors to local community members concerning the use of technology in daily living.
- Train and prepare teachers to use technology in ways that create a learner-centered and hands-on environment.

APPENDIX B

NATURESHIFT GOALS AND OBJECTIVES

Overall Goal of the NatureShift Project
To use innovation technologies to change the nature of learning experiences to emphasize learner-centered and hands-on interactions between the natural world and human society.

Objective 1 – Living with Nature
- Increase student knowledge and understanding of Nature's effect on human and wild populations.
- Increase student knowledge and understanding of the interdependent nature of location, people, and history in the region.

Objective 2 – Gender and Cultural Issues
A. Increase teacher awareness of educational research and teaching implications in the areas of gender and cultural diversity.
B. Incorporate in the modules and teacher training sessions, topics, knowledge and skills relevant to gender and culture into science, history and environmental education curricula

Objective 3 – Effective use of Technology
- Increased demonstration, while using technology of problem-solving skills by teachers, students and community members.
- Technology use corresponds to, and integrates with (instead of being peripheral to), curricular goals.
- Technology users are able to investigate multiple technologies such as text, graphics, capturing visual images, and video construction and showing an understanding of objective 1.

Objective 4– Teacher Preparation
A. Prepare teachers to use technology as a tool for promoting problem-solving skills in the areas of science, history and environmental learning.
B. Develop a corps of community evangelists to serve as mentors to local community members concerning the use of technology in daily living.
C. Train and prepare teachers to use technology in ways that create a learner-centered and hands-on environment.

Objective 5 – Higher Order Thinking and Learning Level
A. Teachers and students are able to understand and employ higher order thinking to problems and projects.
B. Teachers implement relevant learning tasks that demonstrate and require a high level of learning, and student engagement to investigate and share with others.

APPENDIX C

PRETEST/POSTTEST TEMPLATE

NatureShift! Partner Implementation Project Evaluation Template

This template is designed to help you create the Pre and Post-test for your NS Project evaluation. Delete instruction boxes and fill in your questions and answers based on your content and objectives. Please follow the evaluators' instructions for assigning numbers to student papers. Names should be removed. Completed assessments should be mailed to Dakota Science Center, 308 5^{th} St. South, Grand Forks, ND 58201.

Step A: Sample Content Question
Example: Subject = Clouds
What are the clouds called that look like big heaps of white cotton candy?

- cirrus (distracter answer)
- cottony (close distracter answer)
- cumulus (correct answer)
- thunderbolt (off-track answer)

Title of Unit
Part A

1. Your question.

   a) Distracter b) correct answer c) close distracter d) distracter

2. Your question.

   a) Distracter b) distracter c) correct answer d) close distracter

3. Your question.

   a) close distracter b) distracter c) correct answer d) correct answer

4. Your question.

a) correct answer b) close distracter c) distracter d) distracted

5. Your question.

a) Distracter b) distracter c) close distracter d) correct answer

Step B: Guide lines for Technology Questions
Include questions 6-8 in your pre and post-test. Add two questions that match the types of additional technology you will integrate in your NatureShift implementation. For instance if your students are using digital cameras or Kid Pix as tools in their learning include these questions about those technologies. Your pre-test should have only 5 technical questions. The same questions should be used **for your pre and your post-assessment**.

Part B

6. If you wanted to look for information on the Internet on a certain subject, you would want to use:

   a) A web browser
   b) A search engine
   c) A TCP/IP number
   d) A CD

7. If you wanted to make a digital drawing on a computer, you would use:

   a) A digital camera
   b) A drawing pen
   c) A notebook
   d) A software program

8. A computer mouse is used for:

   a) Actions on the computer
   b) Drawing
   c) Writing in a word program
   d) Speaking into a computer

Write your own 2 technology questions or choose from the samples below those that fit **your** NatureShift Project:

9. Your question.

    a) Correct answer
    b) Distracter
    c) Close distracter
    d) Distracter

10) Your question

    a) Distracter
    b) Close distracter
    c) Correct answer
    d) Distracter

Sample Technology Questions:
Digital Camera

One good reason to use a digital camera instead of a regular camera is because:

1. You don't need a power cord
2. The pictures are already digitized for the computer
3. The pictures have higher digital quality.
4. You can put the pictures on the computer.

Movie Camera

Movie Cameras are a great choice for a project when you want to:

1. Capture a live action for immediate reporting to the class
2. Keep track of your assignments
3. Capture the color of an unusual flower for botany class
4. Store documents

Adobe Photo Deluxe

Adobe Photo Deluxe would be most useful if you wanted to do which of the following?

a) Capture a picture
b) Change an image
c) Create a web site
d) Convert slides to digital pictures

Hyper Studio

Hyper Studio is really useful for:

a. Finding resources on the Internet
b. A software that creates interesting multimedia shows
c. A software designed for mind mapping, idea generating, and idea organization
d. A software to record sounds and movies

Web Pages

When you are creating a document to use as a Web page, you would save your document with which extension?

a. .JPG
b. .DOC
c. .HTM
d. .BBC

Kid Pix

Kid Pix is most often used:

- For searching on the Internet as a search engine
- To create web ready .html pages
- To create multimedia projects using pictures, drawings, movies and sounds
- A favorite website for kids to do fun things

Imatrix

On the World Wide Web, images and information and multimedia creation tools can all be found by looking at:

a. IMatrix
b. Blue WebN
c. WebQuest
d. Ask Jeeves

Scanning
Scanning is most useful when you want to:

a. Create digital copies of original documents and photos
b. Capture an action shot or data from an experiment
c. Create a QTVR movie
d. Create a multimedia project

Step C. Content and Higher Order Thinking Essay Create two questions that allow students to think and write responses. The first thinking and writing covers the content of your NatureShift Project and the second writing session prompts higher order thinking. Start sentences for the second question with words like: Compare, Create, What if? Design, Compose, Invent, Describe what would happen if...? How would you devise? How many ways can you?

Part C

1) **Think and Write**

   Take two minutes to think and in the space below: (list, describe, identify, tell....)

2) **Think, Analyze, and Write**

   Take three minutes to think and two to write in the space below. (Compare, create ...tell ...what if....)

APPENDIX D

RUBRICS FOR EVALUATING STUDENT AND EDUCATOR PRODUCTS

These rubrics are designed to judge the level of attainment for each of the following dimensions. These rubrics measure the impact of an implementation of the NS program on student and educator products. Each rubric can be used to generate a score ranging from 0-4 for the dimension it measures. These cores for the individual rubrics can be added or averaged to generate a total score for all the rubrics applied to a single product and for each rubric across projects.

Engagement in Exploration

- Negligible engagement in exploration
- Minimal engagement in exploration
- Moderate engagement in exploration
- Substantial engagement in exploration
- Extensive engagement in exploration

Illustration of the interactions among the natural world, human society, and/or history

- Negligible illustration of interaction
- Minimal illustration of interaction
- Moderate illustration of interaction
- Substantial illustration of interaction
- Extensive illustration of interaction

Level of Learning

- Below grade level
- Low learning for grade level
- Typical learning for grade level
- High learning for grade level
- Above grade level

Demonstration of Higher Order Thinking Skills (HOTS)

- Negligible
- demonstration of HOTS
- demonstration of HOTS
- demonstration of HOTS
- demonstration of HOTS

Use of Technology

- No use of technology
- Effective use of computer
- Use of computer and one other technology
- Use of computer and two other technologies
- Use of a computer and three other technologies

APPENDIX E

CONSENT FORM

Participant Consent Form for:
Technology in the 21st Century: Teacher and Student Outcomes of a Technology Innovation Project

Dear NatureShift Ambassador,

Thank you for agreeing to let me observe you teaching and ask you questions about your teaching in terms of technology integration and the NatureShift Model. I am a student at the University of North Dakota, completing my doctorate in Teaching and Learning. Because of my affiliation with the NatureShift project, model, curricula, and dissemination, I am very interested in how you and other NatureShift Ambassadors are using technology in your teaching.

I would like to fly to your town and observe you in your classroom, on a day of your choosing. During the time I am in your class, I will sit in a spot you designate, and take informal notes periodically during the day. If you find that my presence poses a difficulty for you, or any of your students, please let me know and we can stop the observation.

In addition to the classroom observation, I would like to interview you twice during the study, once after the teaching experience and once by phone later in the year. I will tape these interviews. In this way I may pay full attention to our discussion while you are talking and transcribe your responses later so I get your comments stated accurately. Tapes will be destroyed after the transcription is complete. Please note that you are free to drop out of the study at any time. There is no penalties or loss should you decide to do so.

All observations, interviews, and comments are confidential; no names will be associated with the study. These observations will be incorporated into my dissertation on Technology in the 21st Century: Teacher and Student Outcomes of a Technology Innovation Project, and I will be happy to send you a copy of your comments and my notes if you would be interested. I look forward to seeing you in action and gathering your thoughts on the role technology tools play in education today. If you have any questions please call me at 701-746-6343, or contact my advisor, Dr. Richard Landry at 701-777-3582. If you have any other questions please call the University of North Dakota Office of Research and Program Development at 701-777.4729.

Sincerely,

Mary Beth Kelley-Lowe

____________________ ____________________
Observer Date

I have read this consent form and agree to the above conditions.

____________________ ____________________
Teacher Date

APPENDIX F

QUALITATIVE TEACHER REVIEW

1. Tell me about your teaching style, philosophy, and classroom. Thinking back on your classroom and teaching of ten years ago, how would you describe your classroom then and now? In what ways is similar and in what ways different?

2. How would you describe your style of teaching then and now?

3. How would you/have you described NatureShift program to someone?

4. I am going to give you some Cue Cards. As you turn each one over respond with what ever comes to mind. You may respond in, as many words as you feel are appropriate.

Learning	NatureShift	Wounded Hawk
Exploration	Teachers	Lost something
Technology	Worried	Angry
Engagement	Students	Student Projects

5. When you think of engagement in exploration and learning what comes to mind?

6. Based on your experience with NatureShift, how would you rank the 7 objectives for the NatureShift program (appendix I)?

7. Could you comment on ways you feel NatureShift promotes students' understanding of the role of history in human society and issues outside of the classroom?

8. *How would you characterize the level of learning in your classroom using* NatureShift? Is it more, the less or the same than with other units?

9. What are advantages of integrating technology into teaching? What are some of the limitations or drawbacks of integrating technology?

10. What do you see as the future of NatureShift in your classroom? Which aspects do you feel are most beneficial and which are less helpful to your teaching?

11. If there were no limits on spending, budget, facility and you could establish the ideal teaching environment what would it look like?

12. How would you describe the Wounded Hawk Module? What aspects of the module did you find most useful and effective? If you could add or take away one thing from the module what would that be?

13. How would you describe/define the ultimate goal of NatureShift/Wounded Hawk?

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