Soda Lakes, Flamingoes, and Scientific Literacy: student explorations of the Great Rift Valley

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ABSTRACT While current science policy documents suggest teaching and learning strategies that might lead to students becoming scientifically and technologically literate, little is known about how classroom teachers interpret the documents and how they actually incorporate the use of instructional technology in their teaching for scientific literacy. This paper evolved from a study designed to develop a richer understanding of how one elementary teacher, Ms Brook (pseudonym), utilized instructional technology to teach for scientific literacy. Using qualitative methodology, I examined the integration of instructional technology into the science curriculum, focusing on how the teacher used instructional technology to advance students’ scientific literacy. In this paper, I first provide a theoretical background for scientific and technological literacy. I then describe the Flamingowatch electronic fieldtrip, its focus on scientific literacy, and students’ reactions to the fieldtrip. Next, I describe the qualitative methodology and data collection issues. Finally, I describe the findings of the study and implications for teacher educators.

Theoretical Background

Americans, and citizens worldwide live in a society that has become increasingly technological in nature. Apparently straightforward questions such as ‘Paper or plastic?’ force citizens to interact with scientific and technological issues that affect the well-being of their personal lives as well as the health and well-being of nations as a whole. From the classroom to
the workplace, various forms of technology have become more and more integral in peoples' lives. Increasingly, jobs require more advanced skills, including knowledge of how to use technology in the workplace. Workers need to be able to think critically and creatively, make decisions and solve problems (NRC, 1996). Thus, it is becoming vital that teachers, students and the global populace in general achieve a higher level of scientific literacy. The National Science Education Standards (NSES) define scientific literacy as follows:

Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities. In the National Science Education Standards, the content standards define scientific literacy. (NRC, 1996, p. 22)

This definition of scientific literacy argues that specific knowledge and abilities are needed in order to be scientifically literate. Thus, teaching for scientific literacy is central to science education reform and should be a goal of all schooling.

Why is scientific literacy important? Science for All Americans (AAAS, 1990) argues that the world's economic and environmental destiny is dependent on how wisely humans utilize science and technology. Through science, citizens can learn not only how to make decisions about the use of technology, but also to assess the applicability and effects of new technologies as they emerge. While many global problems exist as a result of the misuse of technology, the use of technology to generate solutions to problems is vital to the survival of the human species.

The literature on instructional technology is abundant, despite the relatively recent emergence of instructional technology in schools. Fulton (1993), Viau (1994), Itzkan (1994-95), Max (1994), David (1990), Cuban (1993), Grejda & Smith (1994) and others offer definitions and rationales for technological literacy and its role in education. Because of the recent emergence and rapid expansion of the forms of instructional technology, many in academe link the implementation of instructional technology across the disciplines to the process of school reform. In other words, widespread use of instructional technology in schools is not the traditional paradigm. Thus, it is useful for researchers to identify and study situations in which instructional technology has moved from the fringe to the center of curricular efforts.
Electronic Fieldtrip: Flamingowatch

The potential of electronic communication is related to its potential audience: it is worldwide. Where students are given access, they can ignore the walls of the classroom and make direct contact with others across the world for collaborative work and in doing so appreciate the differences in culture and yet the similarity of people (Davis, 1994, p. 643).

This passage is uncanny in the accuracy with which it simultaneously describes the educational power of instructional technology and the ways in which Ms Brook and her students utilized it in their scientific inquiries. Instructional technologies currently available to teachers and students offer significant potential for supporting active learning and adventurous teaching (Sheingold, 1990).

Flamingowatch was an ‘electronic fieldtrip’ in which students from schools worldwide traveled to the Kenyan savanna in East Africa. For three consecutive days, students viewed an interactive telecast which was broadcast live from Kenya. Following is a description of the technology and science subject matter focus of the project, provided in a faxed memo to schools throughout the viewing region:

Delivered to the classroom via TCI Cablevision, and produced by Turner Adventure Learning, this new electronic fieldtrip, Flamingowatch: Natural History in the Rift Valley of East Africa, transports students to a region where geologic and climatic forces combine to create an environment singularly hostile to life, yet breathtaking in its biodiversity. Using two-way interactive cable, fax, and computer modems, students will be able to communicate from their classrooms with historians, scientists, and other students locally and around the country to ask questions and share opinions about Kenya and the annual convergence of three million flamingoes in Kenya's Great Rift Valley. In this way, the teachers and Turner Adventure Learning combine a live event with interactive publishing, voice and video interconnects, and a variety of teaching tools that take learning beyond the four walls of a classroom. (TCI Cablevision, January 30, 1995)

During these three days, students learnt about the people of Kenya, the geology and the flora and fauna of Kenya, paying specific attention to the Great Rift Valley. The fieldtrip broadcasts were hosted by Peggy Knapp of Turner Adventure Learning, and included presentations by and interactions with CNN correspondents and local Kenya experts. Two features separated the electronic fieldtrips from typical use of video programs by schools: 1. the broadcasts were live, in real-time; and
2. the broadcasts were interactive – students from schools across the world interacted with the program’s experts in the field in Kenya, as well as with each other.

These unique features situated the learning experience for thousands of school children in a real-world context. To support teachers and students on the electronic fieldtrips, Turner Adventure Learning (TAL) provided an extensive curriculum guide which was organized thematically, integrating science curricula with mathematics, geography, literacy and art.

**The Flamingowatch Curriculum Guide**

The curriculum guide was supplemented with a series of CNN video clips and an on-line text and graphics library. The interactive portion of the fieldtrip occurred in two forms:

1. students had the opportunity to interact with fieldtrip moderator Peggy Knapp and experts in Kenya in real-time by phoning the TAL number in Kenya;
2. students throughout the world interacted with each other after each broadcast through an electronic forum on America On-line (AOL).

Implementation of the Flamingowatch electronic fieldtrip was complex, requiring much organization of different resources. The resources that supported teachers’ planning and organization, as well as providing background information on the subject matter in the curriculum, were the CNN video clips which focused on the fieldtrip’s major curricular themes; a monthly newsletter which contained updates to all on-line resource material; and a teacher training tape which oriented teachers to the teaching strategies and resource materials created for Flamingowatch.

One way to represent science curriculum is to integrate the different sciences together (MDE, 1991). Another way to represent science curriculum is to integrate science with other subjects (NRC, 1996; Roberts & Kellough, 1996). The Flamingowatch curriculum was interdisciplinary, and organized around the following themes: constancy and change, observation and inquiry, and the independence and interdependence of communities. Each day of the three-day fieldtrip consisted of a one-hour live broadcast from Kenya. The broadcasts served a dual purpose: presenting information related to the curricular themes, and real-time question and answer sessions in which students used school telephones to call in questions to the host, Peggy Knapp. Ms Knapp answered some of the students’ questions and referred some questions to Kenya residents and experts. Other questions were...
directed to CNN correspondents in the field. Following is a brief analysis of the curricular content and subject matter of each fieldtrip.

**Day 1**

On day one, students explored the geology of the Great Rift Valley, the rich biodiversity found in varying habitats, and how species respond and adapt to a very hostile physical environment. The theme *constancy and change* was emphasized. Major topics explored in this theme included:

- volcanism in the Rift Valley;
- the geology of soda lakes;
- geologic processes;
- biodiversity; and
- flora and fauna.

The topics in this theme correlated to three major curriculum connections: earth shaping processes, matter and energy cycles, and systems. In focusing on the physical setting and the living environment, students learnt that:

> The inhabitants of the soda lakes often live quite literally on the edge. Through drought and flood, tectonic upheaval, and animal and human migrations, the historic ebb and flow of communities within the area presents a fascinating picture of the balancing act that accounts for the survival of a wide variety of species as they respond to this ever-changing environment. Flamingowatch Curriculum Guide (1995, p. 3)

**Day 2**

On day two, students focused on the geography of Kenya and the Great Rift Valley. The flamingoes of Lake Nakuru were used as a case study of species’ adaptations to harsh physical environments. Students also learnt about the soda lakes of the Great Rift Valley, examined the culture of the Masai people, pastoral nomads of East Africa, and explored the impact of ‘ecotourism’ on the environment. The theme of observation and inquiry allowed students to ponder the many mysteries that surround the flamingo population of the Great Rift Valley.

Through inquiry activities, students addressed the following questions: Why do these colonies of birds migrate from lake to lake and even sometimes from Africa to Europe? What governs the ‘decision’ to nest and produce young? Why are they pink and how does this adaptation influence their survival? The topics in this theme correlated to six major curriculum connections: the nature of science, scientific habits of mind, the living environment, adaptations, habitat, and diversity.
Day 3

On day three, students focused on the theme independence and interdependence of species, specifically examining the communities of greater and lesser flamingoes inhabiting the shores of the soda lakes. Students learnt that:

The food chain created around each lake is often fragile and tightly linked so that if one link is broken or weakened, the effects are quickly felt by the entire community. Flamingowatch Curriculum Guide (1995, p. 5)

Major topics explored in this theme included:
- communities of flamingoes;
- food chain/web;
- species adaptations; and
- human influences on the environment.

The topics in this theme correlated to five major curriculum connections: energy transformations, earth shaping processes, interdependence of life, social behavior of organisms, and systems. This overview of the curricular connections in the fieldtrips is consistent with the view of Science for All Americans (AAAS, 1990) and Benchmarks for Science Literacy (AAAS, 1993) that science curricula should be thematic and focus on larger concepts that are interconnected.

Students’ Use of Instructional Technology

Students utilized a variety of instructional technologies both during and after Flamingowatch. After each live fieldtrip broadcast, students worked in small groups at computer stations to compose messages and questions about the fieldtrip and send the messages to global peers via America Online. Students also sent questions to content experts in Kenya that were part of a chat forum in America Online dedicated specifically to Flamingowatch. Ms Brook attended to computer access and logistical issues by dividing the class into four groups of six students each. Each group rotated to four ‘technology stations’ following each fieldtrip. One group went to Computer Station 1 to send and receive messages to peers worldwide via America Online. Other groups were working at Computer Station 2 (word processing), the school’s computer lab (HyperStudio projects), and Computer Station 3 in the library (working with graphics software packages). After about twenty minutes of work, each group rotated to the next station. While working at the computer stations, students collaborated in small research groups to learn more about the large game animals of the East African savanna. Utilizing hypermedia tools, electronic atlases and
encyclopedias, online databases, and traditional text materials, students compiled electronic reports of their research. Each group then reported their research findings to students in another elementary school via a live videoconference. Because students in the other school had also participated in Flamingowatch, students were able to compare what they had learnt in the fieldtrips and through their research projects.

**Students’ Perspectives on Flamingowatch**

To determine students’ perspectives on using instructional technology in the Flamingowatch project, I made anecdotal notes from classroom observations, informally discussed technology use with students during the fieldtrips, and formally interviewed students. Following are students’ views on the Flamingowatch project.

Vern: It was a technology project and one you do using computers and through television and through your ability to use different equipment. And I’d also describe it as something that like, um, it’s, well...(thinking). It is a project you’d do as a group, cause it wouldn’t be as interesting if you just did it by yourself or one other person. You have questions that you don’t have the answers to or if others have questions, you may have the answer to it and you can share your ideas with other people and it’s just more interesting but, uh, um, with a group and I think it’s pretty interesting that we can go from one classroom to another by just using technology... It was an electronic fieldtrip because, it’s electronic, and it’s through computers... (inaudible) and we’re watching them, and hearing them, and talking to them, by electronics so I think that’s why its called an electronic fieldtrip.

Vern focused strongly on the technological aspects of Flamingowatch, explicitly stating ‘it was a technology project.’ He gave an overview of the technology used in the project, describing the role of technology. Vern also expressed the view that the project was more interesting because it was a group project. He reinforced a theme that emerged from the students’ perspectives: that collaborating and sharing information were important aspects of their science learning.

In trying to elucidate students’ views on the technological aspects of Flamingowatch, I conducted several interviews with them. The following quotes capture the spirit of students’ responses to questions about their use of technology to pursue scientific inquiry:

- We used microphones, video cameras, televisions, satellites - all sorts of technology and without it we would be stuck... ;
- I mean when we were communicating with our friends in Lincoln School, that was electronics and that gave us a lot of information;
- We probably wouldn’t even be able to have partners with people in
Lincoln without using technology;
Then we worked as a big group, together ... it was fascinating!;
It was just fun presenting our information to other people
(electronically);
It’s fun being on camera and you can see yourself;
It’s good to share information because when you get older you can use
the technology... ;
I don’t think it’s ever given me wrong information on MY computer, but
it did a little on that computer;
We both used Encarta but we had different information;
You can double check your stuff by using books and stuff;
Yeah, it felt like you were really there! (in Kenya during the fieldtrip);
Technology is really helpful but sometimes it can really get in your way;
So if you have on-line or Netscape then if one place doesn’t have what
you need you can just hook up to another place and they’ll probably
have it.

In the quotes above, students indicated knowledge of how they used
technology to facilitate collaboration with colleagues at Lincoln Elementary
School via their research project. They described their group work as
‘fascinating,’ and the use of video technology as being ‘fun.’ Students also
discussed how instructional technology allowed them easier and quicker
access to information while doing their Flamingowatch research projects.
However, they also indicated that information found through electronic
resources could also be outdated or contradictory, necessitating confirming
information by using other sources such as books in the library. Students
unanimously indicated that working collaboratively with peers at Lincoln
school would be almost impossible without instructional technology. Vern
commented that while technology is extremely useful in facilitating learning,
it can also ‘get in your way.’ Vern explained at length that while
instructional technology had many good purposes and was very motivating,
technical problems with its use sometimes created problems in the learning
process. Vern’s analysis of his technology use demonstrates how
sophisticated students‘ understanding of instructional technology is.
While students generally praised the role technology played in their
learning, none held it as the ultimate arbiter of ‘correct information.’
All related that even information from electronic sources such as
CD-ROM encyclopedias could be outdated or incorrect. Therefore,
verifying information from a variety of sources was sometimes neces-
sary in order to be as accurate as possible. This type of critical think-
ing about their use of instructional technology correlates to the ‘habits
of mind’ dimension of scientific literacy that educators and policy-
makers are so strongly advocating (AAAS, 1990; NRC, 1996).
The phrases above indicate how students thought about the technology itself, the role technology played in their learning, how technology use intersected with science content, and technology-related issues.

**Flamingowatch and Scientific Literacy**

Scientifically literate students should be able to use, construct, and reflect on scientific knowledge (MDE, 1991). The technology-based Flamingowatch curriculum guide contains many activities, tools and resources that correspond to the dimensions of scientific literacy described in reform documents such as the Michigan Essential Goals and Objectives for Science Education K-12 (MEGOSE) (MDE, 1991), and the Benchmarks for Science Literacy (AAAS, 1993). Table I illustrates the components of scientific literacy found in the Flamingowatch Curriculum Guide:
Table I. Dimensions of scientific literacy: Flamingowatch Curriculum Guide.

Given that the authors of the Flamingowatch curriculum based their work on the Benchmarks for Science Literacy (AAAS, 1993), one would expect the Flamingowatch curriculum guide's activities to promote scientific literacy. Document analysis of the Flamingowatch Curriculum Guide (Table I) indicates that the using, constructing, and reflecting on dimensions of scientific literacy (MDE, 1991) are well-represented. Flamingowatch correlated closely to the dimensions of scientific literacy outlined above. The Flamingowatch curriculum also represented a good example of interdisciplinary curriculum. The passage below describes the interdisciplinary nature of Flamingowatch and its design which was framed by the Benchmarks for Science Literacy (AAAS, 1993):

Social studies, science, language arts, problem solving, and study skills objectives are integrated into suggested activities. The underlying structure on which Flamingowatch is based is the Benchmarks for Science Literacy of the American Association for the Advancement of Science, published by Oxford University Press (1993). The content themes, overarching goals of the fieldtrip and all activities focus on competencies outlined in this excellent reference. Flamingowatch Curriculum Guide (1995, p. 6)

In the next section, I describe sample activities that illustrate the interdisciplinary nature of Flamingowatch and how the activities correlate to dimensions of scientific literacy.
Flamingowatch Curriculum Guide Activities

The activities in the Flamingowatch Curriculum Guide contain several of the dimensions of scientific literacy. These activities are organized on Student Worksheets which the teacher may or may not distribute to students. Many of these worksheets also provide science subject matter in some way. For example, student worksheet T1a – The Big Picture: Constancy and Change, provides students with a summary paragraph on the science subject matter related to this particular theme. It also provides a list of resources to assist students in learning about the theme, and it provides a Questions for Discussion section. Following are specific questions from this worksheet that correlate to the dimensions of scientific literacy:

Describe the forces within the earth that have shaped the Great Rift Valley.

Read one or both of the famous stories by Dr Seuss, Horton Hears a Who, or The Lorax. What do these modern fables have to say? How does it apply to the Great Rift Valley? Explain.

Worksheet T1b – ‘The Big Picture: Observation and Inquiry’ is similar to worksheet T1a but asks students to compare and contrast, predict, and design in addition to describe and explain. Following are specific questions for discussion illustrating these dimensions of scientific literacy:

Compare and contrast the viewpoints of science and magic or ancient religious tradition. What does each viewpoint have to offer human beings? Is each a valid way to observe and seek understanding? (Explain)

After reading about the flamingoes, visualize or imagine the actual bird, not the plastic figures people use to decorate their lawns. What do you think a flock might look like from an airplane? From under the water? (both questions ask for predictions) Draw quick sketches, preferably appropriately colored, to show each idea. (design)

In addressing the questions in number one above, students would also implicitly be engaging in the habits of mind (AAAS, 1993) dimension of scientific literacy because they would be evaluating claims and arguments, thinking critically, and organizing and expressing ideas.

Methodology and Data Collection

This study took place in a heterogeneous fourth grade class in Jefferson (pseudonym), a suburban school district located in the upper Midwest of the United States. In examining how Ms Brook integrated instructional technology into her science curriculum, I gathered data focused on the insiders’ perspectives. The study’s participants included Ms Brook and five
students in her class. The students' role was to provide student perspectives on their use of instructional technology in pursuing scientific literacy in their classroom. The student group was chosen with Ms Brook's assistance and consisted of two males and three females. The student group was chosen based on these criteria:
x a high to low range of academic ability;
x a demonstrated interest in using instructional technology in the classroom;
x an almost equal ratio of males to females.

As a participant observer, I collected data in Ms Brook's classroom almost every day for five months. This type of site-based research required that I conduct extensive, observational fieldwork (Erickson, 1986; Bogdan & Biklen, 1992). Erickson (1986) specifically described fieldwork as involving:
x intensive, long-term participation in a field setting;
x careful collection of fieldnotes and other evidence;
x analytic reflection using narrative vignettes and direct quotes.

To establish baseline data on how Ms Brook perceived scientific literacy, I conducted two interviews with her in the first month of the study. This data allowed me to compare her conceptions of scientific literacy with the ways in which she utilized instructional technology in pursuit of scientific literacy. The interviews, combined with classroom observations and document analysis, also enabled me to compare Ms Brook's conceptions of scientific literacy with the dimensions of scientific literacy used in the study's coding schema for analysis. Finally, the interviews contributed to the development of a case study of Ms Brook as an exemplary science teacher.

Qualitative Data Analysis Using the Constant Comparative Method

In moving from the data to claims or findings, I used the constant comparative method of data analysis (Glaser & Strauss, 1967; Maykut & Morehouse, 1994). The constant comparative method of analyzing qualitative data combines inductive category coding with a simultaneous comparison of all units of meaning obtained from the data (Glaser & Strauss, 1967). As data analysis progressed, units of meaning that related to the research questions were compared to all other units and grouped with similar units of meaning. Data were analyzed inductively, with frequent examination and analysis of field notes, interview transcripts, curriculum documents, and policy documents (Goetz & LeCompte, 1984). This analysis facilitated categorization of the data. For example, as fieldnotes were organized and coded, statements, descriptions, questions, and comments relating to one unit of meaning, scientific literacy for example, were grouped together and categorized. Categories were continuously refined, with some being discarded, changed, or new ones generated as the analysis progressed.
Maykut & Morehouse (1994) illustrate the constant comparative method of data analysis in Figure 1 below:

![Figure 1. The constant comparative method of data analysis.](image)

I describe this data analysis method as a series of steps, but in reality these steps occur simultaneously, with analysis generating more questions, data collection, and coding (Bogdan & Biklen, 1992). Each section of the study focused on research questions that emerged from the data. Data were then analyzed to confirm or disconfirm assertions that stemmed from the research questions. In beginning this process, I first coded the data by using the number and letter codes in the Michigan Essential Goals and Objectives of K-12 Science Education (MEGOSE) (MDE, 1991) Dimensions of Scientific Literacy Coding Chart. This process facilitated identifying units of meaning from the words and actions of the study's participants as well as from curricular documents and other data. Units of meaning are framed by the researcher's focus of inquiry. For example, anything to do with scientific literacy, use of instructional technology, technology-rich curricula, scientific inquiry, or exemplary science teaching would comprise a unit of meaning as it pertained directly to the focus of the study. Units of meaning in my data consisted of fieldnotes of classroom observations, descriptions from the Flamingowatch curriculum guide and electronic media, and interview responses from Ms Brook. The length of units of meaning range from one sentence to several paragraphs. Longer units tended to emerge from interviews because Ms Brook was encouraged to give full descriptions of her philosophies, teaching strategies, and experiences. Thus, she tended to respond to many questions by telling stories. In the next section, I describe an example of a technology-rich curriculum project that integrates science and instructional technology.
Findings and Implications for Teacher Education

Science education initiatives advocate a paradigm shift from textbook-driven science to activity-based learning in which students are actively engaged with science curricula, ‘covering’ fewer topics but in more depth (MDE, 1991). The authors of MEGOSE (MDE, 1991), Science for All Americans (AAAS, 1990), and the National Science Education Standards (NRC, 1996) also feel students’ science learning must be connected to their real world in order to be meaningful and contribute to scientific literacy in the nation’s populace.

This technology-rich project reached a worldwide student audience, provided a three-day real-time field trip to East Africa’s Great Rift Valley, and was interactive in nature. Students were able to communicate with experts in Kenya in real-time. The project facilitated communication on scientific issues by providing participating students with a forum on America On-line. Following each fieldtrip, students used AOL to communicate with ‘experts’ on the forum as well as with other students. The curriculum was thematic and interdisciplinary, and emphasized problem solving and inquiry. The Flamingowatch curriculum was informed by the Benchmarks for Science Literacy (AAAS, 1993), and thus the activities within the curriculum were designed to promote scientific literacy. Below I describe the study’s findings vis-a-vis the Flamingowatch Project:

Finding 1: The technology-rich instructional units implemented by Ms Brook focused on science content and scientific inquiry. Students utilized the Internet and other instructional technologies to ‘extend beyond the walls of the classroom’ to a global audience.

Finding 2: Ms Brook’s teaching strategies most often involved her facilitation of activity-based student projects. These projects focused heavily on students’ use of instructional technology in scientific inquiry.

Finding 3: Ms Brook utilized existing technology-rich curricula such as Flamingowatch, to supplement her thematic, interdisciplinary science curriculum.

Implications for Teacher Education

Science for All Americans (AAAS, 1990) argues that a clear national consensus now exists for the improvement of science, mathematics and technology education for all students. In order to effect the systemic reform of science education, teachers need to be better prepared, both at undergraduate level, and in their continuing professional development
The preparation of technologically literate teachers should be of interest and concern to teacher preparation programs across the world. Given the rapid expansion of the integration of technology in classrooms in many countries, and the increasing dependence of educators on communication and collaboration via the Internet, projects like Flamingowatch are likely to proliferate on a global basis.

Current reform initiatives call for closer integration of science, mathematics and technology, yet this study indicates that most elementary teachers lack the knowledge necessary to achieve such integration in their teaching. How will classroom teachers acquire the skills necessary to design and implement curricula that promote technology-driven inquiry in students?

The National Science Education Standards (NRC, 1996) state that a teacher’s professional development is a career-long endeavor. In other words, novice teachers will continue to work on their professional preparation throughout their careers. In working with elementary student teachers for the past four years, I have found them to be seriously deficient in their preparation to use instructional technology in their professional work. For many, using instructional technology for anything beyond word processing papers and assignments seems untenable. In many teacher preparation programs, the pedagogical training needed to increase awareness and effectiveness in integrating instructional technology into content areas is nearly absent.

A strong implication of this study is that teacher preparation programs need to begin preparing novice teachers in a meaningful way to use the multimedia technology they will be exposed to in schools. While this study occurred in the United States, its findings and implications are appropriate for any country whose teachers are changing their paradigm to include technology-based inquiry.

Implementation of technology-rich projects such as Flamingowatch will require inservice teachers to participate in long term professional development. Preservice teachers need a well-articulated technology competency embedded in their teacher training program (Coverdale et al, 1998). National science education policies and accreditation agencies are requiring teacher preparation institutions to prepare novice teachers who can:

- pursue their own inquiries, making use of technologies to find, organize, and interpret information, and to become reflective
This type of teacher preparation is a global issue. Ms Brook and her students communicated with teachers and students globally as they conducted the Flamingowatch project. For this type of collaboration to flourish, novice teachers throughout the world will need to address their own technological literacy through undergraduate preparation and inservice staff development.

While each college and university will need to structure programs to suit their particular purposes, models of effective technology education programs currently exist (Dell & Disdier, 1994; Freeouf & Flank, 1994; White, 1994; Bao, 1994; Kortecamp & Croninger, 1994; Pan, 1994). While these programs describe a wide array of approaches to preparing preservice educators to integrate instructional technology into their curriculum, I agree with Kortecamp & Croninger on three major aspects of effective technology training:

- Use of instructional technology in preservice teacher preparation programs should include: modeling and engaging students in technology assisted instruction in all their coursework;
- Placing teaching interns in classrooms where technology is a vital part of every school day; and
- Form a partnership with a local school system so that teaching interns can work with teachers and students in the field in realistic projects which integrate instructional technology (Kortecamp & Croninger, 1994).

Based on the findings of this study, I would add one recommendation to the list above. Given the potential of Internet use in science teaching on a global basis, I recommend that preservice educators have access to and participate in current educational listserves such as KidProj and KidSphere, and Internet-based curricula such as MayaQuest, Journey North, and others. Additionally, using the World Wide Web for science curriculum development is rapidly becoming a critical pedagogical tool. A percentage of science education coursework should be designed to actively engage preservice educators with the real world projects found on these listserves.

**Conclusion**

We do not know how future technologies will effect science curriculum. In this paper, I described how Ms Brook utilized current instructional technology to effect a technology-rich curriculum via projects such as Flamingowatch. The paper also examined students’ reactions to their use of instructional technology in pursuing scientific inquiry. Davis (1994, p. 643) described the power of telecommunications in allowing students to “ignore the walls of the classroom and make direct contact with others across the
world. Flamingowatch epitomized the curricular expansion that Davis (1994) alluded to, and allowed Ms Brook and her students to pursue scientific inquiry by collaborating with students worldwide. Flamingowatch is unique among current technology-rich curricula due to its worldwide audience, its three-day real-time fieldtrips, and its interactivity. Students were able to ask questions of the experts in the Kenyan field in real time, communicate with colleagues through America On-line immediately after each fieldtrip, and follow the progress of Kenyan school children as they traveled through Kenya’s game parks and reserves. The use of technology as a teaching and research tool continues to proliferate in classrooms worldwide. As teacher preparation programs continue thinking about preparing teachers for the 21st-century classroom, collaborative, technology-rich projects such as Flamingowatch may be vehicles for promoting scientific and technological literacy in students and educators.

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