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Preservice teachers' responses to an interactive constructivist model for web-based learning

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Preservice Teachers' Responses to an Interactive Constructivist Model for Web-Based Learning

by

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Dedication

To David and Rachel… Thanks for making it possible for me to pursue my dreams. Without your patience and help, I would have never realized the possibilities. I love you both.

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ABSTRACT

College and university teacher education programs are not, and should not be, exempt from the growing demand for distance education opportunities. Science teacher education is no exception to this growing demand. While there are some distance-learning courses and even complete programs for teacher education, the majority of these are offered as continuing education or post-graduate education opportunities. The number of programs offered specifically in science teacher education (either undergraduate or post-graduate) is extremely limited. Those distance-learning classes that are available for teacher education rarely reflect the instruction expected from teachers by the National Science Education Standards when they enter the K-12 classroom.

With the demand for distance education rising, it is important to determine if it is possible for the distance-learning format to be an effective form of delivery for quality preservice science teacher education programs. The research herein took the form of a qualitative case study of two sections of a Science Technology and Society Interaction (STS) course offered via a distance-learning format. (For the purposes of this study, distance-learning courses are defined as those that are offered using online delivery.) The research investigated the extent to which the course incorporated the principles of science education reform. The study took the form of an evaluative case study and provided a rich description of the course itself as well as the nature of the interactions and meanings constructed by students. The course was determined to be an example of a distance learning opportunity that exhibits the desired ideology. Insights gained here were used to illuminate some guiding principles for developing courses for distance delivery that exhibit principles consistent with science education reform.

Chapter 1: Introduction

Science Education Reform

The crisis in science education, originally popularized by the National Academy of Sciences in 1982, prompted the development of reform documents such as *Science for All Americans* (American Association for the Advancement of Science, 1989), *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), and the *National Science Education Standards* (Council, 1996). These documents were generated as a means to guide the needed reform. They provide what was called a “new vision of science education for K-12 students” (Sparks, 1997). Principles of reform which were set forth in these documents were in keeping with current research into how people learn as presented in works such as the National Research Council’s book entitled *How People Learn: Brain, Mind, Experience, and School* (Council, 1999). In response to the declared crisis in science education and the subsequent call for systemic reform, college and university teacher education programs are finding a need to reevaluate preservice science teacher education. Further, the guiding documents indicate that colleges and universities are expected to make changes consistent with current understandings of how science is learned and should be taught.

The guidelines suggest that several changes must be made in the way in which science is taught in order to meet the needs of all American students. Johnston (Johnston, 1989) has suggested that the best way to break what he or she has described as the “cycle of ineffective teaching” is to improve the quality of teachers entering the profession. He goes on to state that, despite this need, America's colleges and universities had not, at that point, met the challenge. Rather, teacher education programs continued to offer the same conservative programs using the "it's always worked" philosophy (Haugen et al., 2000). In a keynote address at a 1993 NSF Workshop on the Role of Scientific Disciplines in the Undergraduate Education of Future Science and Mathematics Teachers, Dr. William Kirwin stated:

> A strong case can be made for the university as the best place to begin this reform effort. Not only do the universities train the teachers for the K-12 classrooms, it is the universities that provide the final phase of the education for the Nation's technological workforce. It is the job of the colleges of education to challenge their traditional teacher education programs and 'reinvent' them (as cited in Mason, 2000).

While the reform documents offer guiding principles for effective science education, there are minimal examples of best practices of reform in action documented in the educational experiences of preservice teachers. The books *Exemplary Science in Grades 5-8: Standards-Based Success Stories* (Yager, 2005a) and *Exemplary Science in Grades 9-12: Standards-Based Success Stories* (Yager, 2005b) and *Exemplary Science: Best Practices in Professional Development* (Yager, 2005c), all edited by Robert Yager are the first national studies to address how these practices are implemented in the classroom. *Exemplary Science: Best Practices in Professional Development* (Yager, 2005c), provides examples of some of the ways professional development is meeting the needs of science education reform. Of the sixteen essays in the book, only two deal with formal courses for preservice teachers. Included among these is a chapter about the course that was studied here. In the time since the study contained herein was completed a national search conducted by a 30 person advisory board of science educators chose this course as an example of a program which meets the needs of science education reform.

In the introduction to the Professional Development monograph, Robert Yager states

> Among issues on the college level is the fact that although 50 semester hours of course work in science certainly indicates a strong background in traditional science, there is no indication of someone's ability to teach. And, too often, science methods courses are taught in the same way that science is taught: Instructors define terms, provide lists of ways to teach, offer their own ideas, and expect students to take notes and repeat what they say for tests. This approach is no better than what typically happens in science classrooms and laboratories (Yager, 2005c).

There is currently a need to develop ways to express the principles of science education reform in the implementation of a teaching/learning experience. In order to prepare teachers of the future to teach according to what is known about how science is best learned and taught, teacher education must change and become consistent with the national standards.

Distance Learning

In addition to direct calls for changes in teacher education programs, changes in technology and in market conditions are also causing colleges and universities to offer educational opportunities for different audiences, using new and evolving technology.

However, these innovations are occurring without increasing budgets. With these factors in mind, more courses, and even entire degree programs are being offered through distance learning avenues (Willis, 1994).

Distance education has been called the “fastest growing form of domestic and international education” (McIsaac & Gunawardena, 1996). It appears that distance learning is being viewed as the means that can revolutionize education and learning of all types. This includes all types of educational experiences ranging from corporate training and seminars through university courses and even entire university programs (Spooner, Spooner, & Algozzine, 1998). Distance education has a history that began with the early correspondence courses and has now employed several forms of delivery including print materials, radio, television, computer conferencing, interactive video, satellite telecommunications and currently the Internet and multimedia computer technology (McIsaac & Blocher, 1998). More interactive courses may include graphics, video, and audio components prepared and collected by the instructor (Jones, 2003). However, despite multiple formats for delivery, the Internet is currently the most popular and accepted form of delivery for distance education (Porter, 1997; Sopova, 1996).

The 1996 Technology Survey reported by the American Association of Colleges for Teacher Education (AACTE) and the National Council for Accreditation of Teacher Education (NCATE) found that colleges and departments of education do use contemporary technologies (with room for improvement). The survey concluded that education students, faculty, and institutions are moving forward, and in some cases, are leading the way in the uses of these avenues for education (Beck, 1998).

Teacher education programs are not exempt from the demands for distance education opportunities. It seems obvious that teacher education programs should lead the way in the integration of available technology into their programs. In fact, distance education technologies are beginning to affect teacher education programs. Colleges and universities offering teacher education programs are moving forward in offering programs using the available technologies for distance education. It should be noted that, for the purposes of this study, the use of the term technology in education does not include the integration of technology into classroom teaching (i.e. virtual laboratories, computer graphics programs, presentation software, and projection microscopes). The only discussion of this type of technology in education will be in the context of the course described in this study. Integration of technology to improve science teacher education (in this case, the use of distance delivery via the Internet) may include classroom technology demonstrations and usage, but this is not the focus of the study described here.

While there are courses and indeed, complete programs available in teacher education, it is more prevalent in continuing teacher education and post-graduate education than it is in undergraduate teacher preparation programs (Hacker & Sova, 1998). In the paper “Teacher Training Programs Turn to Cyberspace”, Blair (2001) reports that about a dozen colleges and universities offer online teacher preparation programs. These programs are, in general, designed to appeal to adults who are interested in career changes or advanced degrees. The 2006 version of the online book *Distance Learning Online*, lists only seven accredited colleges or universities that offer online bachelor’s degrees in education. None of these is specifically in science education. Of the four science education degrees listed, all are offered at the master's level (M. Wilson, 2006). According to Peterson's *Guide to Distance Learning Programs* (Peterson, 2005) several other colleges offer a limited number of undergraduate courses in education via distance delivery. Modes of delivery for these distance programs range from printed material to full internet-based courses. In the publication *Get Your Degree Online*, Helm and Helm (2000) list fifteen certificate programs from nine universities which are intended to be add-on programs for people with existing degrees and in careers other than education. The publication further lists twenty-six complete post-graduate programs in education offered by eighteen colleges or universities. Of these, only two offer programs in science education specifically.

Although some classes and programs for distance learning in education are currently available, these rarely reflect what is expected from teachers when they enter the K-12 classroom. Currently few, if any, guiding principles are available for developing distance learning courses in any field, including science education. The lack of available science education courses and programs for preservice teachers is apt to lead to higher demand for science teacher education programs to enter the distance learning arena. These, yet to be developed, distance learning opportunities must reflect and reinforce current best education practices along with reflecting science education reform.

Constructivism

The principles of science education reform are based upon the theories of constructivism. Constructivism encompasses a group of theories of knowledge and learning. These theories, influenced by the works of Dewey, Piaget, Bruner, Vygotsky, and von Glasersfeld among others, take into account the nature of knowledge, and how we come to know what we know.

John Dewey proposed that students should participated in what he classed directed living. He believed that knowledge emerged from situations that were meaningful for the students. As he stated:

> The essentials of method are therefore identical with the essentials of reflections. They are first that the pupil have a genuine situation of experience – that there be a continuous activity in which he is interested for its own sake; secondly, that a genuine problem develop within this situation as a stimulus to thought; third that he possess the information and make the observations needed to deal with it; fourth, that suggested solutions occur to him which he shall be responsible for developing in an orderly way; fifth, that he have opportunity and occasion to test his ideas by application, to make their meaning clear and to discover for himself their validity (Dewey, 1916).

Jean Piaget's beliefs about how children learn are based on his views of psychological development. In his work, *To Understand is to Invent*, (Piaget, 1972) Piaget expressed the belief that teachers must understand the stages of psychological development and that discovery is the basis for learning. He stated that "To understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition."

According to Jerome Bruner, learning is an active process. Through this process, new ideas are constructed based on existing knowledge. He believes that there are four components essential to instruction: 1) predisposition towards learning, 2) the intended learning should be structured in such that it is readily grasped by the learner, 3) the sequence of presentation must be effective, 4) rewards and punishments must be of an acceptable nature and paced correctly. Bruner also believes in the social and cultural nature of learning

Russian born Lev Vygotsky felt that students learning in the sciences was enhanced by the opportunity to explain and interpret their works for others. He described learning as taking place due to tension between their own understandings and adult concepts. The learner must make a connection between the information presented and their previously held understandings (Van Der Veer & Valsiner, 1994; Vygotsky, 1978).

As a guide for science education, Ernst von Glasersfeld is in the forefront of constructivist thinking. According to von Glasersfeld, “knowledge is the result of an individual subject’s constructive activity, not a commodity that somehow resides outside the knower and can be conveyed or instilled by diligent perception or linguistic communication (von Glasersfield, 1990).” He goes on to state that the facilitation by teachers “necessarily remains tentative and cannot ever approach absolute determination.” This is due to the fact that knowledge is constructed by individuals and there is more than one solution to any problem. Further, individuals arrive at solutions through different pathways (Boudourides, 1998).

Knowledge, according to constructivist theories is constructed by an individual through interactions with the environment. “Constructivism does not claim to have made earth-shaking inventions in the area of education; it merely claims to provide a solid conceptual basis for some of the things that, until now, inspired teachers had to do without theoretical foundation (von Glasersfield, 1995)."

According to von Glasersfeld (1995) "there are as many varieties of constructivism as there are researchers". These range from the theory of radical constructivism (influenced by Piaget) to the theory of social constructivism as supported by the works of Russian psychologist Lev Vygotsky and others. As defined by von Glasersfeld, radical constructivism sees information as being actively received through communication and the senses. Based on this information, knowledge is actively constructed. Cognition is the act of organizing the experiential world and not the act of discovering an objective reality (von Glasserfeld, 1989). Bonnstetter (1994) describes radical constructivism as a situation "in which learning takes place due to interpersonal deliberations and inner speech, leading to personally valid interpretations that are internally assessed for personal consistency. Sort of a 'self fulfilling prophecy'."

On the other end of the spectrum, social constructivism emphasizes a situation in which multiple interpretations are resolved in a group setting by social negotiations. The result is a consensus and common understanding among members of a group. The range of theories labeled as constructivism is vast. In his work "Beyond Symbolic Processing: Expanding Horizons in Educational Psychology", Derry (1992) notes that the theory of constructivism has been defined by "various epistemological camps" whose members are far from "theoretical comrades."

Despite the differences in emphases among the various theories of constructivism, there is some consensus as to how the basic constructivist understanding of learning underlying these theories should be reflected in educational practices and learning opportunities. In developing a model for science teaching, we can draw upon the works of many constructivist theorists and researchers. Several of these theorists and researchers, including Jonassen (D. Jonassen, 1991, 1994), Wilson and Cole (1991), Ernest (1995), and Vygotsky (1978), have provided overviews of implications for teaching and learning which encompass the theories of both radical and social constructivism. Further, these design principles have been applied to the development of some constructivist science teacher preparation programs (Barman, 1998; Hammrich, 1998; *National Science Education Standards*, 1996 ; Richardson, 1997). Implications for the role of the teacher, the role of the student, the environment in which the learning opportunities take place, the "tone" of activities and assessment are all evident. The following is a summary of characteristics present in constructivist learning opportunities (adapted from Murphy, 1997). This summary informed this researcher about essential elements to examine when assessing the extent to which the distance learning course studied here reflects constructivist science teaching practices.

Table 1

Characteristics of Constructivist Learning Opportunities

Learning Opportunities
Provide multiple prospectives
Are authentic in nature (represent the real world)
Use primary sources of data
Facilitate construction of knowledge
Encourage collaborative and cooperative learning
Build upon prior knowledge and experiences
Emphasize deep understanding
Provide opportunities of action and exploration
Build upon previous activities with increased complexity of skills and knowledge
Include a transdisciplinary emphasis
Facilitate alternative viewpoints
Encourage metacognition and self-analysis
Occur in an environment of trust and mutual respect (a community of learners)
Encourage questioning and reflection
Provide opportunities for discourse
Facilitate the construction and reconstruction of the learner's cognitive map
Role of the Teacher
Facilitate student learning
Coach student learning opportunities
Monitor student progress
Share control with students
Roll of the Student
Control own learning environment
Take responsibility for own learning experiences
Learn actively
Participate in self-analysis and metacognition

Learn collaboratively and cooperatively
Become reflective practitioners
Assessment
Authentic
Negotiated
Rewards intrinsic motivation
Includes self-analysis and metacognition

Note. Adapted from "Integrating distance education technologies in a graduate course," by K. Murphy S. Cathcart, and S. Kodali , 1997, *TechTrends*, 42,1.

The science education reform documents noted earlier were developed with these characteristics in mind. The National Science Education Standards (National Research Council, 1996) highlight several areas in which the emphasis in science education needs to change. These areas include science teaching, professional development, assessment, science content, science education programs, and science education systems. In looking at the syntheses of changing emphasis it is obvious that the shift is toward a more constructivist approach to science teaching. Many of the characteristics of constructivist educational opportunities can be identified in the more emphasis areas found in these standards. Due to the nature and objectives in the course studied herein, this investigation concentrated on the teaching, professional development, and assessment areas only.

Table 2

Changing Emphasis on Teaching Standards

Less Emphasis On	*More Emphasis On*
Treating all students alike and responding to the group as a whole	Understanding and responding to individual student's interests, strengths, experiences, and needs
Rigidly following curriculum	Selecting and adapting curriculum
Focusing on student acquisition of information	Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes
Presenting scientific knowledge through lecture, text, and demonstration	Guiding students in active and extended scientific inquiry
Asking for recitation of acquired knowledge	Providing opportunities for scientific discussion and debate among students
Testing students for factual information at the end of the unit or chapter	Continuously assessing student understanding
Maintaining responsibility and authority	Sharing responsibility for learning with students
Supporting competition	Supporting a classroom community with cooperation, shared responsibility, and respect
Working alone	Working with other teachers to enhance the science program

Note. From *The National Science Education Standards*, National Academy Press, 1996.

Table 3

Changing Emphases in Professional Development Standards

Less Emphasis On	*More Emphasis On*
Transmission of teaching knowledge and skills by lectures	Inquiry into teaching and learning
Learning science by lecture and reading	Learning science through investigation and inquiry
Separation of science and teaching knowledge	Integration of science and teaching knowledge
Separation of theory and practice	Integration of theory and practice in school settings
Individual learning	Collegial and collaborative learning
Fragmented, one-shot sessions	Long-term coherent plans
Courses and workshops	A variety of professional development activities
Reliance on external expertise	Mix of internal and external expertise
Staff developers as educators	Staff developers as facilitators, consultants, and planners
Teacher as technician	Teacher as intellectual, reflective practitioner
Teacher as consumer of knowledge about teaching	Teacher as producer of knowledge about teaching
Teacher as follower	Teacher as leader
Teacher as an individual based in a classroom	Teacher as a member of a collegial professional community
Teacher as target of change	Teacher as source and facilitator of change

Note. From *The National Science Education Standards*, National Academy Press, 1996.

Table 4

Changing Emphases on Assessment Standards

Less Emphasis On	*More Emphasis On*
Assessing what is easily measured	Assessing what is most highly valued
Assessing discrete knowledge	Assessing rich, well-structured knowledge
Assessing scientific knowledge	Assessing scientific understanding and reasoning
Assessing to learn what students do not know	Assessing to learn what students do understand
Assessing only achievement	Assessing achievement and opportunity to learn
End of term assessments by teachers	Students engaged in ongoing assessment of their work and that of others
Development of external assessments by measurement experts alone	Teachers involved in the development of external assessments

Note. From *The National Science Education Standards*, National Academy Press, 1996.

Statement of Intent

There are few, if any, online learning opportunities for preservice science teachers. The question that must be explored is whether it is possible to offer online educational experiences (either individual courses or complete programs) for these students. What is evident is that colleges of education need to explore options for alternative types of instruction that meet the needs of the present-day student (Paulsen, Higgins, & Miller, 1998; White & Walker, 1999). With these things in mind, the ultimate goal must be to create or maintain quality programs for preservice science teachers.

One problem that remains is that instructors have little, if any, research to help identify the best way to develop distance learning experiences. There is a need for qualitative empirical studies associated with different styles of delivery. Currently there are few studies being done to determine if the outcomes of distance education opportunities reflect the stated goals of the programs or courses. It may be that distance education can reflect reform in science education and therefore serve a dual purpose. First, these programs could be beneficial to the colleges and universities in reaching more students. Further, these programs may be a way to implement the practices that are crucial to reform. They may provide future teachers with opportunities to participate in educational experiences that mirror the teaching styles that need to be implemented in the classroom (Hacker & Sova, 1998; Hurlburt, 2001).

Perhaps it was best stated by White and Walker in the paper "Technology, Teacher Education, and the Postmodern: Encouraging the Discourse"

> Teachers have been trained to fit into modernism's educational and school goals for training our children. Teachers typically have gone through a higher education institution, engaging in a program whereby liberal arts, steeped in the Western classics, and education courses, heavily influenced by the tenets of modernism were mandated. The prospective teacher then endures a semester long student teaching experience and is magically transformed into a professional teacher…The goals and objectives of education require rethinking and reconceptualizing to meet the needs of students and society in a postmodern world…education and technology should then be designed to facilitate a critical

thinking and problem solving focus that allows for a variety of perspectives (White & Walker, 1999).

Purpose of the study. The purpose of this study was to determine if a reform-based science education course can be taught through a distance-learning format. One example of a constructivist, undergraduate science education course taught via distance learning (specifically through the use of the Internet) was examined. The format and delivery of the course along with interactions and relationships developed between student-student, student-teacher, and student-material were examined. Some guiding principles for developing Web-based science teacher education courses, grounded in these data, emerged from this study.

It appears that distance education can facilitate the needed changes in teacher education programs and through these changes, further encourage the reform needed to address the crisis that now exists in American science education. One might expect that many of the aspects of constructivism (a guiding principle for science education reform) can be encouraged through the use of Internet-based learning experiences. Students in this learning environment can participate in sustained inquiry, work collaboratively, participate in authentic practices in areas of relevance, and be exposed to many different aspects of science and the scientific community. Through the use of computer-mediated communications, students can actively participate in scientific discourse. This discourse can encourage creative and critical thinking skills and help students to develop an understanding of Science Technology and Society issues as well as issues of the Nature of Science. In order for this to be possible, guiding principles must be in place to facilitate the development of distance education opportunities that can help to bring about needed changes in teacher education programs and further advance the process of reform in science education. This study led to the generation of such guiding principles. The information gained from the study can be used to speculate about what will, or can, happen in the future, and what is needed to develop effective distance learning courses for science teacher education.

Guiding Research Question

The study addressed the following question:

> To what extent does the distance learning format of the science education course, described here, incorporate the principles of science education reform?

Chapter 2: Research Plan

This research took the form of a qualitative case study of two sections of a Science Technology and Society Interaction course offered via an online distance-learning format. The emergent design study used the constant comparative method as a means of developing grounded theory.

Research Question

The following is the research question investigated through this study was:

To what extent does the distance-learning format of the science education course, described here, incorporate the principles of science education reform?

The Researcher as an Instrument for Data Collection and Analysis of Data

As stated by Merriam (2001), the primary goal of all qualitative research is, in part, to elicit understanding and meaning, with the researcher serving as the primary instrument of data collection and analysis. This analysis leads to findings that are richly descriptive.

Researcher Role

As the researcher, the lens I used to collect and interpret the data derived from, and was influenced by, many experiences throughout my career in education. As a graduate with a degree in education from a university offering a traditional education experience, I spent seven years teaching in the public schools using traditional science education methods. I then did graduate work and taught in a college level biology program for seven years. During this time, I had the opportunity to be exposed to scientists and science teachers who were not well informed about (or were new to) science education reform. I then had the opportunity to study science education reform and to participate as part of a team carrying out research involving the implementation of reform in a face-to-face setting. Along with the courses offered using reform methods, I also participated in many traditional classes (both face-to-face, and in distance learning formats). From these experiences I became aware of, and came to understand and appreciate the differences in interpretation and implementation of the principles of reform between those individuals (both scientists and science teachers) who were new to, or resistant to, reform and those science educators who were involved in developing the reform. I came to realize that there is definitely a continuum of interpretations of reform.

I have recently taught science education courses at the college level in a class that modeled and implemented reform in a face-to-face setting. Further, I was involved in a cooperative learning experience as an instructor in a university learning community. This community used several of the principles of reform in the design and implementation of the courses. (Again I saw the continuum of interpretations of reform.) In the learning communities we used the available technology, including bulletin board and email in the Blackboard shell, for asynchronous class communications. As an assistant professor in a university department of elementary and early childhood education for one year, I have noted that my own students are predominantly dependent learners. This has made me even more aware of the need for shifting from the dominant reductionist paradigm in which student function commonly and leading them, through my course structure, to become autonomous learners functioning within the holistic paradigm.

These past experiences and understanding of the concepts of reform in science education provide me with an appropriate lens for, and qualify me, to carry out this study.

I have worked with Dr. Spector, the STS course instructor, since entering the Ph.D. program at the University of South Florida in August, 1998. She and I have collaborated on several research projects. While working with Dr. Spector in various research groups, I gradually became comfortable in the role of colleague and co-learner as opposed to the role of student with a teacher. Dr. Spector and I are able to discuss our differences. Neither she nor I take offense when we disagree. I feel extremely comfortable disagreeing with her on interpretations of issues and findings. We have always been able to use these disagreements to initiate discourse and to elaborate on our findings grounded in relevant data. I do not perceive Dr. Spector to be judgmental and I know she sees our discussions as opportunities to learn, clarify, and make valuable changes to programs and ideas. The relationship that developed between me, as the researcher and Dr. Spector, the course instructor allowed me to develop a clear understanding of the course and the intentions and understandings of the instructor as the course progressed. I feel we can both saw this as an excellent opportunity to initiate changes to the course studied here in order to make this a model course for science teacher education courses delivered on-line.

The sample. This study focused on two sections of a five credit hour, interactive Science Technology and Society Interaction courses offered during two different semesters. Both sections were presented via distance learning using a Web CT course shell. The course was designed as an open-ended inquiry in which students were expected to answer the question “What is STS, and how does it relate to science teaching?” The

Web site provided students with access to a virtual resource center. Within the resource center there were three bins that contained information about the nature and history of STS, examples of STS, and teaching STS. The sample was composed of students who participated in either of the two sections of the course. These students were upper level undergraduate students who had been accepted into the college of education. For the purpose of this study, data gathered concerning both sections of the course were treated as separate data sets and then combined.

Data Sources

Electronic data sources included the Website as well as communications preserved in Web CT, including students' journals and projects, and student-student, and student-instructor interactive discussions. Other data sources included reflections from notes and interviews with the Web designer and the course instructor. Sources for member checks included interviews and written communications with the instructor, designer, and students who participated in the classes.

Research Design and Data Analysis

The study used qualitative research techniques. According to Merriam (2001), "qualitative research is an umbrella concept covering several forms of inquiry that help us understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible." Terms for qualitative research include naturalistic inquiry, interpretive research, field study, participant observation, inductive research, case study, and ethnography (Merriam, 2001). Patton (1985) describes qualitative research as an effort to understand situations in relation to their context and the interactions that occur in a specific setting (as cited in Merriam, 2001). The goal of this type of research is to understand the specifics of a certain situation and the nature of the setting, what it means for participants to be involved in the situation, what is going on for participants, and what meanings they gain. The analysis should be a search for deep understanding and communication of the understandings to others with interest in the situation under study.

Format of the Study

This was an emergent design study in which the data directed the research procedures. The *Dictionary of Qualitative Inquiry* by Thomas A. Schwandt (Schwandt, 2001) draws upon the works of Lincoln and Guba (1985) as well as others to describe emergent design research as a situation in which researchers

> …adjust their inquiry plans and strategies in response to what they are learning as their study unfolds… By both allowing for and anticipating changes in strategies, procedures, questions to be asked, ways of generating data, and so on, the (researcher) seeks to make his or her plans (i.e., design) attuned and responsive to the circumstances of the particular study.

Schwandt goes on to describe the design and process as one that is circular, rather than linear, in nature. An emergent design study has a theoretical structure at the onset. Questions are developed that give the research procedure focus and purpose. Further, decisions are made about the kinds of data sources and procedures to be used to generate relevant data. The actual analysis, however, is not tightly structured but takes the form of discovery. Schwandt (2001) continues,

> Analysis unfolds in an iterative fashion through the interaction of the processes of generating data, examining preliminary focusing questions, and considering

theoretical assumptions. Analysis thus becomes a process of elaborating a version of or perspective on the phenomenon in question, revising that version or perspective as additional data are generated and new questions asked, elaborating another version, revising that version or perspective, and so on (Schwandt, 2001).

The study described here took the form of a case study. Smith (Smith, 1978) notes that case studies are different from other types of qualitative studies in that they focus on a single unit or bounded system. Merriam (2001) describes this type of study as "an intensive, holistic description and analysis of a single entity, phenomenon, or social unit". This study focused on the one semester Science/Technology/Society Interaction course taught as a distance learning experience. The course was delivered via the World Wide Web using a Web CT course shell.

The interest for a researcher carrying out a case study is in "process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation. Insights gleaned from case studies can directly influence policy, practice, and future research" (Merriam, 2001).

This study took the form of an evaluative case study. This type of study requires "involved description, explanation, and judgment" (Merriam, 2001). According to Guba and Lincoln (1981), case study is the best form to use for reporting evaluations. It allows for information to be considered with an eye toward making a judgment. This portion of the investigation required the course being studied be judged as it represents one example of a distance learning teacher education experience using reform principles as described in the current reform documents and consistent with the researcher's view of science education reform. The principles of constructivist teaching, as applied in the National

Science Education Standards (1996), were the sensitizing screen for this study. These principles include evidence that the course is inquiry-based and uses authentic practices. The course should be student-centered and student-driven as opposed to teacher- and text-driven. Students should have opportunities for leadership, collaboration, research, and action. Student thinking, experiences, and interests should drive lessons. This would include allowing and encouraging students to initiate ideas and ask questions. These ideas and questions should be used to design educational activities. Cooperative learning strategies should be an integral part of the learning environment. It should include open-ended questions and encourage elaboration of ideas. Further, students should be encouraged to challenge the ideas of others. This elaboration and challenge should be used to make predictions and suggest causes. An important part of the course should be opportunities for reflection and analysis as well as self-evaluation.

Insights gained through the evaluation of this course and the interactions between participants in the classes were used to illuminate some guiding principles for developing science education courses taught via distance learning formats. The process that was used to carry out the case study took the form of an emergent design study using the constant comparative method as a means of developing grounded theory (Glasser & Strauss, 1967). Since little research is available dealing with science teacher distance education specifically, this type of study is appropriate for this portion of the study. It should be noted that none of the steps in the research design, as described here, happen in isolation.

Design and Analysis

Initially, the course syllabi and contents of the different portions of the Web site delivered via a WebCT shell as well as interviews with the Web designer and the course instructor were used to develop a comprehensive description of the course. Following this, the communication database was transferred from WebCT to the QSR NUD.IST (1997) software program for qualitative data analysis. This program was used for management of the data throughout the research process. At this time, messages were separated into line-by-line units and extraneous information (such as names and dates) was deleted. The remaining data represented an exhaustive compilation of all communications between and among students and the instructor during the semester.

All of the compiled data were read as a means of gaining an overview of the data and to help generate initial impressions of things that might be important in the coding process. The data was then read line-by-line and a tentative coding scheme was developed as common concepts were realized. (Each new coding concept is referred to as a free node in the NUD.IST program). Constant comparison throughout the process led to adding, changing, replacing, or deleting nodes. As terms or phrases were repeated and emerged as important ideas, a string search for these terms was performed. In other words, a search for any noteworthy string of characters was done to find any references to a certain concept or point. (This is a NUD.IST function similar to the "find" procedure in any word processing program.) Once a term was identified, the researcher assigned it to an existing node, placed it in a new node, or ignored the term, as was indicated by the context of the string.

Free nodes were grouped into categories. These categories were grouped in the program using the formation of index trees. These trees offered a method of grouping nodes into categories with common themes. Again, this was an iterative process and required constant comparison with previously coded data. Trees were altered as new categories emerged and others were merged into previously existing categories. As indicated by Merriam (2001), these categories reflect the purpose of the research, are exhaustive, are mutually exclusive, are sensitizing, and are conceptually congruent. Categories were described according to properties. This information was used in the development of hypotheses. Various related hypotheses led to the development of theories. The appendix contains more indepth description of the process used for analysis of the data and includes examples from this study.

As theories were developed, findings were checked by reviewing the database, and member checks. The findings are herein reported in a written report detailing them and include quotations from the students and instructor. The information gained from the study was used to speculate about what will, or can, happen in the future, and what is needed to develop effective distance learning courses for science teacher education.

Following the development of hypotheses and preparation of the report of findings, a comprehensive literature search was conducted. In the book *Research Design: Qualitative and Quantitative Approaches* (Creswell, 1994), John W. Creswell notes that, while there are different criteria and methods for using literature in qualitative studies, the "inductive" process used for these studies lends itself well to completing the literature search at the end of the process. By using this method, "the literature does not guide and direct the study, but rather becomes and aide once patterns of categories have been identified." The author further explains that this approach is most popular with grounded theory studies. Researchers use the literature search as a means to support or negate theories that evolved through the study with those reported in the current literature.

Summary

The study described here provides a review and evaluation of a science teacher education course delivered via distance education. The focus of the project was on the course design and implementation as it models and incorporates the concepts and ideals of science education reform. The study includes an investigation and description of the nature of interactions that took place during the course and relationships that were developed between student-student, student-instructor, and student-materials. Information gained was used to suggest guiding principles that should be incorporated when developing distance-learning courses for science teacher education.

Chapter 3: The Course

The course syllabus provides an in-depth view of the course as a whole. As an evaluative case study this project requires "involved description, explanation, and judgment (Merriam, 2001)." It is of value for this study to provide an exhaustive description of the course syllabus and study guide. These materials provide a window through which the course can be evaluated. Included here is a description of the course as the researcher understands it from the material contained in the virtual resource center in WebCT as it was provided to the participants in the class. Further understandings were gained as a result of interviews with the course instructor and the course designer. Reflections and responses to the course are addressed in subsequent chapters.

The course described here was a five-credit hour Science Technology and Society Interaction (STS) course that was designed to be consistent with the paradigm shift from transmission teaching/learning to constructivist teaching/learning in science education. It was structured as an open-ended inquiry into the question "What is STS and how does it relate to science teaching?" The design of the course represented an opportunity to empower learners to take charge of their own meaning making by enabling them to make choices consistent with their own cognitive frameworks, learning styles, interests, and decision making relevant to their own learning. The course was delivered via a Web CT course shell. The Web CT site was developed as a virtual classroom. The virtual classroom was divided into four areas including the syllabus and study guide, a virtual resource center, student headquarters, and a communication center.

The Syllabus and Study Guide

The syllabus and study guide section of the website provided students with an interactive document that included a course description and objectives for the course as well as basic directions and definitions for use of the website. Further, a content outline, descriptions and organization of the learning activities, and grading criteria were included. Students were also given access to written assumptions for the design of the course.

Course Overview

The course overview included a course description, site organization and philosophy of the course. The course was described as follows:

> This course develops students' awareness of science and technology as human enterprises that take place in a social, environmental, and historical context. Various interactions of science, technology, and society are explored in the context of STS issues relevant to the learners. The learner constructs a grounded theory about the nature of the interaction of Science, Technology, and Society and its role in science education reform. The instructor models constructivist teaching strategies. The goal of the course is to enable learners to construct a historical and philosophical understanding of (1) the nature of the scientific enterprise, including the interaction of science, technology, and society; (2) the multiple dimensions and complexities of sample STS topics; and (3) how to teach STS to diverse audiences.

The site organization statement informed students about the organization of the material and the artificial and arbitrary nature of the divisions. A part of the site organization statement is reproduced here.

> The major portion of this site is organized to serve as a resource center for students' investigation into the interaction among science, technology and society. The resources are organized into three bins. It should be recognized, however, that the division into separate categories (bins) is artificial and arbitrary. It is done for the convenience of study. The separation does not exist in reality. Thus there is much overlap among the bins. Each bin is represented by a triangle with science at one point, technology at another point, and society at still another point. One triangle addresses the nature of and history of STS interactions. The second triangle provides examples of STS issues. The third triangle addresses teaching STS.

The course philosophy stated the following:

> the course is designed for students to 'do' science, to do systematic inquiry to generate an understanding of STS. People in science usually expect to be taught through a deductive approach, that is for a generalization to be stated followed by examples. In daily living, however, people encountered examples and induce a generalization from them. This course has potential to meet the needs of students trained to learn deductively and those inclined to learn inductively. The site is non-sequential and exploratory to enable learners to make interpretations, communicate interpretations periodically, develop criteria for making choices, and design teaching materials. It makes no difference exactly which experiences

people have or in what order they have them. The intent is for learners to have enough experiences to create a personally meaningful understanding of the interaction of STS. Pages can be accessed in several ways, what ever makes sense to a student. Products are due by the end of the course, but not with any particular prescribed order or deadlines. The intent of the course is to provide a holistic concept of STS.

Course Goals and Objectives

Goals and objectives for the course as they were presented to the participants in the course are listed below.

The participant will be able to:

1. describe the nature of science from both current and historical perspectives;
2. describe the nature of technology from both current and historical perspectives;
3. describe the interaction of science and technology with each other and society;
4. construct an understanding of the nature of the scientific enterprise including the role of the interactions among science, technology, and society, and generate a grounded theory of STS;
5. use STS as the context to help learners construct basic science concepts;
6. use a constructivist approach to teach diverse student audiences about the nature of the scientific enterprise and the interaction of science, technology, and society;
7. explain the role of STS in the science education reform movement
8. use computers and other communication technologies to teach STS.

Required Learning Activities

The portion of the syllabus labeled learning activities included a list and descriptions of the activities. Prior to listing these requirements, students were provided with some suggestions to help with time management. These suggestions included allotting sufficient time during the week to participate fully in the course, reading all directions prior to and upon completion of any assigned learning activities, using notes on readings and resources to trigger journal entries, studying all resources related to an assignment before attempting to complete it, and reading any glossary entries linked to terms in the readings to insure interpretation of the term was consistent with the use of the term in the course. Finally students were advised of the value of keeping track of specific due dates using the Web CT calendar provided for student use.

Participants in the course were required to complete thirteen assignments throughout the semester. The assignments were described in this section along with a statement as to the intention of the assignment as it was designed. Descriptions of the assignments are reproduced below. Please note that since information concerning the mechanics of how to post information for the class has no bearing on the study, it has been omitted. Also, information concerning changes in assignments to meet the needs of non-education majors has also been omitted. The following section (pages 35 - 50) is extracted from the syllabus.

Biography. Create a homepage containing the following information: (a) Your Name, (b) Level of computer expertise, e.g. novice, usually functional, expert; (c) Regional location, e.g. South Tampa, Tampa Palms; (d) Phone number; (e) Major and Career Directions, e.g. secondary education, middle school teacher, other; (f) Hobbies, Avocations, Talents; (g) Color label for description that is most like you, and (h) anything about your background that might influence your perceptual screen, e.g. lived in many countries, second career, etc. This assignment is intended to provide information to (a) determine cooperative learning groups and (b) facilitate communication and transportation among community members. (Note: Personal information listed in sections a, c, and d was deleted for the sake of this study.)

Study plan. Use your first study time block to scan all the materials on the web site in the virtual resource center to ascertain what things are available to you, how long each item is, and in what order you might like to experience them. Write a potential plan indicating the path you will follow and a tentative time line for doing so. This plan may be altered as you generate questions in the process of constructing meanings for STS. Put your time line on your personal Web CT calendar in the appropriate boxes. Each time you examine a resource and each time you complete an assigned task, write the date on your Self-Assessment Check List. This assignment is intended to (a) empower you to build on your personal prior knowledge in a way that makes most sense to you, and (b) give you practice in designing learning pathways, a skill you will need to help others learn.

Exit memos. After each face-to-face class meeting, please write a memo in which you answer this question. What would you say to your friends as you walk to the parking lot or to a person when you get home, about the experience during the class meeting? This assignment is intended to provide a spontaneous response giving insight to your experience in a class meeting.

(Note: Classes met a maximum of three times during the semester. Class meetings will be discussed in relation to each class studied.)

Journals. Keep an extensive reflective journal/learning log integrating the meanings you are constructing from your various experiences related to STS. Include a list of resources examined during the week at the beginning of each reflection. Describe the way the date in the resources relate to other readings, videos, field experiences, and your daily life experiences. Identify prior knowledge upon which you are building and how you added, deleted, and, or, rearranged information in your cognitive framework. Questions that emerged for you and your speculations about answers to those questions are also important. Remember that “learning” involves thinking, feeling, and acting (Novak & Gowin, 1984). All three aspects are appropriate inclusions in your learning log. If you indicate your opinion about something, please provide the evidence you used to substantiate your opinion. (Each reflection is not just a listing of statements from the reading, or viewing, or a summary report of its contents, nor is it just isolated comments just indicating you agree or disagree.)

(Note: At this point a link was provided to give more information about writing a journal entry.)

The course is iterative and recursive. The learner chooses resources and other experiences; explores and reads to gather, organize, and analyze data; creates interpretations and shares interpretations and reflections in the journal; receives comments from this community of learners; explores and reads more and revises interpretations. This assignment is intended to (a) serve as a learning log to let you and others understand how you are making sense of STS experiences, and (b) be a stimulus for discussion among this community of learners.

Concept maps (C-maps). Map your understandings of STS as they emerge using Inspiration software. As your maps expand, small sections of your map may be posted if you are working on one section only. Your base line maps should be done before examining any resources. They should answer these questions: What is the nature of science? What is the nature of technology? What are the interactions among science, technology, and society? Write a narrative about the thinking you experienced in developing the map. This is a way of reflecting that may be covered already in your learning log. The succession of maps document the way you are enriching the meaning you have about STS as you gather more data throughout the semester. This assignment is intended to help you (a) think through the many ways concepts can be connected to each other to construct meaning and (b) see how idiosyncratic cognitive frameworks are.

Media watch. Report on one STS event from the media each week…Be sure to include a broad variety of media sources. Write the following: (a) name of the event of topic, (b) brief description of the item, (c) why you perceive it to be an example of STS interaction, and (d) a minimum of one basic science concept inherent in the event. This assignment is intended to (a) demonstrate the extent to which you have developed a perceptual screen that sensitizes you to how ubiquitous STS is, (b) determine your ability to analyze an event for the basic concepts of science one must understand to make reasoned decisions related to the event, and (c) serve as a database from which you can design learning opportunities that help learners understand the relevance of specific basic science concepts to their lives.

Videos. View the video series Connections and The Day the Universe Changed (total 20 hours). Identify one historical trail including four linkages that you observed in each video you watch. Write one question per tape that you could ask someone to find out if the person watched that particular video…In your weekly journal, post your reactions, interpretations, and commentary for each video relating the contents to other learning opportunities. This assignment is intended to increase your ability to construct patterns relating seemingly disconnected events to the historical progression of science, technology and society.

School site visits. Observe and interact with teachers and students in secondary schools for a total for 15 hours. Use the concepts in the Order Out of Chaos… paper as one of your analytical frameworks to understand and describe what you observed in the schools. This assignment is intended to increase your awareness of the paradigm shift as it is occurring in schools in your area.

Community site visits. Conduct at least one site visit to a business, industry, or government organization in the community from which you can learn about STS. Create a presentation about the site and your learning from the visit. You may elect to pair with a partner for this project. This assignment is intended to increase your awareness of (a) STS in the world of work, and (b) the richness of the community as a resource for teaching STS to any audience.

STS issue. Investigate an STS issue of interest to you. Write a report, or construct a presentation, that explicates the science, the technology, and the societal aspects of the issue. This assignment is intended to actually teach someone about the STS issue enough so the learner would feel confident in his/her understanding of the STS issue enough to be willing to teach about it. Be thorough enough so that those who have not investigated the same issue can speak intelligently about the particular example of STS to their future audiences. This is an individual assignment. This is intended to demonstrate the degree to which you can analyze the complexities involved in an STS issue and present them in a coherent story.

Electronic project. Apply technologies you experienced in this course. In particular, the use of internet web pages, and NASA/science resources found on the internet, as well as other electronic and non-electronic media including PowerPoint, Excel spreadsheets, other software programs from CDs, audio or video applications, databases, etc. This is a group task. Each group will be comprised of up to 4 members with the following possible roles: (1) Project manager (2) Technical manager (3) Data specialist and (4) Curriculum/Standards specialist. This project is intended to demonstrate your ability to work as a research team to locate, review, evaluate and organize electronic media into an STS resource base on a computer that others can use to design learning opportunities about a specific STS issue or topic for an audience of their choice.

One of the strengths of electronic media is the ability to tailor instruction to important student characteristics. There is no one best educational treatment for everyone and electronic media in science education may act as a supplement to the overall curriculum program. Therefore, this is a project that should be functional, applicable and relevant to your group's goals as instructors. Each group will leave the course with their presentation, in addition to access to other presentations for future use. This is intended to be a linked and organized resource collection arranged to help a teacher make decisions about what materials to use, where to find them and explain how using them will help to accomplish state and national standards.

Teaching/learning opportunity. Develop and present a teaching/learning opportunity that involves an STS issue and learners taking action relating to this STS issue. This is a planned learning opportunity for a target audience of your choosing in which learners conduct inquiry related to the chosen STS issue. The learners will take action to mitigate the problem of concern based on the data they have acquired. Identify specific Sunshine State Standards and, or National Science Education Standards to which this unit contributes. This assignment is intended to demonstrate your ability to design STS learning opportunities. This may be a group project.

Final project. Develop an original format to assess the degree to which you have integrated information from the experiences in this course into your conceptual framework. You may get some ideas for unique formats by calling upon your avocations, hobbies, talents and interests.

Of particular interest in this section (Assignment descriptions) were the links provided to students concerning length of projects, writing a journal, concept mapping strategies and descriptions and an explanation of media watches. These links provided information to students as aids to completing required sections.

Assessment and Evaluation of Student Outcomes

Assessment of student work was embedded in instruction. Data for assessing students and thus determining grades for the course were collected from the assignments required for the students. These assignments, or learning opportunities described previously included, reading both electronic and print material, watching required videos, site visits, processes, and products. Included also was a written statement concerning the intent of the assignment. This provided the framework for assessment and evaluation of student outcomes.

Participants in the course were provided with a detailed description of the grading criteria as well as a grading scale to be used for evaluation of students upon completion of the class. Three criteria for assessing quality of work were described. The criteria included the following: (1) The quality and quantity of class, field, and Web CT participation; (2) The quality and quantity of presentations; (3) The quality and quantity of journal assignments. Quality of work was assessed according to analytic, conceptual, and creative thinking as expressed through oral and electronic communications and written assignments. Quality was also assessed according to the "degree to which you demonstrate that you have 'tried on' the teaching paradigm put forth in this course and have come to understand it form the perspective of someone who acts within the paradigm.

One requirement for the class was the completion of a self-evaluation based on students' progress at the mid-term point of the semester. Students were provided with a chart on which to record information about the various learning activities associated with the course. In some cases students were asked for a number to indicate how many, how often, or what percent. In other cases students were required to answer a question that asked to what extent something happened. For these, students rated their participation on a scale of 1 to 5. Students were expected to provide evidence to show the extent to which their work provided data for the listed item. Items for assessment and self-evaluation dealt with all aspects of the course including journals, media watches, responses to others work, concept maps, videos, site visits, participation, and overall course concepts.

Instructions that accompanied the mid-term self-evaluation and self-assessment explained that this was

> one option for evaluating a holistic endeavor embedded in an institution governed primarily by a mechanistic paradigm. In the spirit of using yourself as a learning laboratory, this exercise provides an experience with a reductionist/mechanistic tool to assess and evaluate the holistic endeavor. In the current climate of accountability, administrators often ask, 'what did the syllabus say was required and did the student execute the required number of actions?' This quantitative result does not provide opportunity to express the depth of understanding made by a learner who has constructed meaning through analysis and synthesis of information from a variety of sources. This may serve you as a teacher in a traditional school.

The explanation goes on to note that students will be practicing analysis of the data, which is a step in scientific inquiry, and that analysis of data requires that judgments be made.

Assumptions

Assumptions that were considered during the development of the course were made available to the students. The assumptions addressed a variety of issues related to this STS course. Included in this section were assumptions about education reform, the audience for the course, cognition, teacher education, and STS. Also included in this section was a chart comparing the fundamental principals underlying the dominant reductionist paradigm and the holistic paradigm (Spector, 1993). Those assumptions have been reprinted below.

Assumptions about education reform. The paradigm of education must be consistent with the paradigm of society. There has been a visible paradigm shift in North American society in the past thirty-five years (Toffler, 1990). It has shifted from a reductionist and mechanistic to a holistic paradigm. Effective functioning in our society, therefore, requires that the education enterprise shift its paradigm to make it consistent with the paradigm shift in the rest of North American society. The purpose of education should shift from transmitting information to empowering learners to make meaning (Novak & Gowin, 1984).

Assumptions about the audience for the course. This course serves two audiences: (a) Students throughout the university who are taking this course to fulfill the general education requirement under major issues and major works, and (b) Students who are learners enrolled in a preservice science teacher education program. They are completing, or have completed the equivalent of a major (about 50 semester credit hours) in one of the traditional science disciplines and are seeking secondary (middle and/or senior high school) certification from the state in a single science, or in integrated science. The science courses, and usually the methods courses, they have completed are taught traditionally. Both content and delivery reflect the dominant paradigm, which is reductionist and mechanistic. As traditional students, learners act as recorders and memorizers of information from lectures presented by the professors. These learners subsequently believe that teaching science is about transmitting the accrued body of information produced by normal science (Kuhn, 1970) in the way that it is structured by researchers and traditional textbooks. Further, they believe that the teacher's job

Table 5

Comparison of Paradigms

Dominant Reductionist Paradigm	*Holistic Paradigm*
There is one objective reality independent of a person that can become known to an individual.	Reality is constructed by individuals within their own minds. Therefore there are multiple realities.
Truth is correspondent to the objective reality	Truth is what a group working in a field at a given time agrees to call reality (socially constructed).
The whole is equal to the sum of its parts.	The whole is greater than the sum of its parts.
Parts are discrete, each having their own identity.	Pieces are altered when they interact to become part of the whole.
Cause and effect are linear and immediate.	Cause and effect relationships involve multiple factors, are complex, and may be difficult to distinguish.
Hierarchies are the prevailing model organizing information, people, and things.	Networks dominate the organization of information, people and things.
One can know the world by analyzing isolated smaller and smaller pieces	One can know the world by examining the whole.
Science, using this reductionist approach, is the legitimate way of knowing	Science is one of several equally valid ways of knowing.
	The wholeness of the person, the union of the physical, spiritual, intellectual, and emotional aspects of the individual is acknowledged
	Process is product

Note. From "Order out of chaos: Restructuring schooling to reflect society's paradigm shift," by B.S. Spector , 1993, *School science and mathematics,* 93, 1.

is to cover the material prescribed by some outside authority (e.g., a textbook or a school district's scope and sequence). These students have not yet had field experiences (a practicum or internship) in secondary schools.

Assumptions about cognition. Human beings construct their own meanings. Knowledge, therefore, is socially constructed. The process of constructing meaning requires an integration of thinking, feeling, and acting (Novak & Gowin, 1984). The meanings constructed are stored in the brain as cognitive frameworks. People continually alter their cognitive frameworks through assimilation. This assimilation of information into cognitive frameworks alters the meaning people construct for themselves, their understanding of the world, and decisions they make.

A person's cognitive framework serves as the perceptual screen, or lens, that filters what the person is able to perceive in any given situation. "You see what you are prepared to see" (Pasteur cited in Hurd, 1991). The perspective an individual has on an object or event depends on the person's personal perceptual screen. People respond to their perceptions of the world, not to some objective reality. Varied pathways are needed to access the idiosyncratic frameworks of learners. Different perspectives held by a variety of individuals about a situation can serve as pathways to access different frameworks. Each perspective may be thought of as a key to unlock a different door, a different framework.

Assumptions about teacher education. Teacher education needs to demonstrate effective ways to access the idiosyncratic framework of each learner. It must provide multiple perspectives about an object or event. This can be done through diverse teaching-learning experiences. Teacher education needs to be iterative because learners can construct more detailed meanings and develop richer understandings each time they encounter new data about an object or event.

The amount of data and the usefulness of these data increase with the number of diverse situations learners encounter. The more data they have, the more likely they are to find patterns emerging from which to induce concepts. The more concepts they induce, the more likely they are to see connections and generate theory (Spector & Gibson, 1991).

The Team assumes most teachers teach the way they were taught. If teachers experience an alternative to traditional didactic teaching, they may choose to emulate the new approach. Thus, teacher education should model how teachers should teach science in secondary schools as recommended by the *National Science Education Standards,* (1996) *What Teachers Should Know and be Able to Do,* (Dykman & Mandel, 2000) and *Science for All Americans* (American Association for the Advancement of Science, 1989). It is assumed that experiencing teaching-learning procedures consistent with the desired approaches for secondary schools helps prospective teachers construct an understanding of the way different learners in their future classes may experience the integration of thinking, feeling, and acting. These insights heighten preservice teachers' awareness of, and sensitivity to, the needs of their future students. These insights can guide the teachers to design instruction that is meaningful to students.

Additionally, it is assumed that teacher education must focus on meaningful learning (meaning making) in contrast to memorizing. An environment that promotes trust is essential for learners to take the intellectual risks necessary to construct meaning. A class structured as a community of co-learners has potential to encourage trust. In addition, the 5E’s-engage, explore, explain, extend, and evaluate (Bybee, 1997) provide appropriate scaffolding to organize teaching-learning experiences for prospective teachers.

Assumptions about STS. The interaction of science, technology, and society illustrates the nature of the scientific enterprise, because it engenders understanding the nature of science, the nature of technology, how they interact with each other, and how each separately and together interact with society. STS requires decision making, problem solving, and action. STS, as used here, is the emerging paradigm for science education and is consistent with a holistic worldview. The current paradigm shift encompasses what we teach, how we teach, and why we teach science (including a shift from science for the elite few who will be career scientists to science for all Americans.).

The Team does, however, recognize other interpretations of STS, and that STS is defined and implemented in a multitude of different ways in schools. These manifestations of STS in Schools vary from STS being defined as a topic added to the end of a chapter or syllabus, to an instructional strategy using a traditional scope and sequence for science content, to an organizing template for an entire curriculum. The latter includes building on constructivism as an epistemology, a learning theory, and a teaching-learning approach (Spector & Simpson, 1996).

Virtual Resource Center

The students were expected to conduct a self-planned investigation using a virtual resource center on the Website and the community beyond the university. Resources were intended to provide opportunities for students to be immersed in a variety of STS interactions. Students were expected to determine their own pathways for exploring the resources using their own time plan and sequence.

The virtual resource center for the course consisted of approximately 275 Web pages including print matter, videotapes, graphics, interactive media, and links to Web sites. It was arranged into three bins (1) the nature and history of STS, (2) teaching STS, and (3) specific examples of STS.

The nature and history of STS. The bin labeled the nature and history of STS was intended to address the following questions: (1) What is the nature of science?; (2) What is the nature of technology?; (3) What is the nature of society?; (4) What is the nature of the interaction among all three?; and (5) How does the history of STS provide insight into the nature of each of its components. Resources were divided into groups dealing with the nature of science, the nature of technology, the nature of society, and historical perspectives. Each of these included pertinent chapters from the current reform documents *Science for All Americans* (American Association for the Advancement of Science, 1989) and *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993). The nature of science and the nature of technology sections also included readings from *Science and Technology as Human Enterprises* (Spector & Lederman, 1990). The nature of science section also included a paper entitled "The Biological Evolution as a Basis for Science." Each of these resources was a print selection to be read by the students.

The historical prospectives section included four different series of videos. Two of the series were sets of ten videos from the "Connections 1" and "Connections 2" series (Jackson & Kennard, 1990). "Connections 1" and "Connections 2", hosted by James

Burke, guided viewers through a sequence of interconnected historical events and inventions. The videos were intended to help illustrate the connections between history, science, and technology. Another series of videos, “The Day the Universe Changed”, (Lynch, 1995) also hosted by James Burke, provided an overview of the evolution of Western thought beginning with the Greeks. Students were expected to view the entire series “The Day the Universe Changed” as well as 20 hours of video selected from the “Connections 1” and “Connections 2” series.

Also included in the historical perspectives section were written selections from “Science 84” (Hammond, 1984) and “Science 85” (Hammond, 1985). “Science 84” dealt with twenty discoveries over the previous century that changed people’s lives. “Science 85” was devoted to twenty five discoveries that could change people’s lives in the future. These selections were intended to give students some understanding of advances in science over the past century as well as an idea of the forward thinking nature of science and future possibilities. Further, through these readings students could gain some insight into the extent of the advancements in science over the past fifteen or twenty years.

Teaching STS. The teaching STS portion of the virtual center was divided into four sections: (1) What and why?; (2) Sample events; (3) How to strategies; and (4) Resources. This bin was intended to address the following questions: (1) What is the concept of STS in teaching?; (2) Why is science education today equated with STS education?; (3) How has the societal paradigm shift impacted science education?; (4) What are strategies to teach STS?; (5) What are examples of events and materials available to teach STS?; (6) What is the relationship between STS teaching and the nature of science?.

The resource available for addressing "What and Why" was the video "The Business of Paradigms" by Joel Barker (1990). This video explains the importance of being aware of, and open to paradigm shifts using real-world examples. The other resources in this section were papers dealing with paradigm shifts in society and the schools' needs (and/or attempts) to restructure in response to these shifts.

The "Sample Events" section of the teaching STS resource portion included a wide variety of resources for students to explore. These included examples of local STS events, such as a description of marine science at a local marine aquarium and a draft of a middle school curriculum. Further, many of the sample events were interactive programs, available either on laser discs, online, or as CD ROMs for use by students. These interactive programs included "The Adventures of Jasper Woodbury" (Center, 1992) and the Tom Snyder Production entitled "Decisions, Decisions" (Docklerman, 1991). The Jasper series, developed by the Learning Technology Center at Vanderbilt University, was designed as adventures with embedded teaching and opportunities for problem identification and problem solving while providing common content, authentic tasks, and opportunities to solve authentic problems. The "Decisions, Decisions" series provides role playing opportunities to study and solve real-world problems while being asked to support their decisions and consider the consequences.

Another resource included in the "Sample Events" section was a Web site called the Why Files (www.whyfiles.org). This site contains a broad range of articles related to current, real world science events and concerns. The articles are timely, accurate, and broad in scope. Yet another resource for students to experience was a written transcript of a conference presentation made by the course instructor on MADD (Mothers Against

Drunk Drivers) as an ideal STS topic. Also included in this section were samples of student products from past courses. These products provided students with more examples of STS events in the "real world".

The "How To Strategies" section was composed of eight reading assignments. These included chapters from *Science for All Americans* (American Association for the Advancement of Science, 1989) and *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993). These chapters are devoted to science teaching and learning. Other readings emphasize STS as a topic for science teaching and as a curriculum organizer, science and technology as human enterprises, and STS equated to instruction. One reading also focused on the use of community resources as a path to meaningful learning.

The fourth and final section under teaching STS was intended to introduce students to organizations for educators as well as the national and state science education standards.

Examples of STS. STS examples were the third broad area in the Virtual Resource Center. This section contained four sub-areas. These were designed to show the interrelationships between science, technology, and society. This section was intended to illustrate the interactions between science/technology/society stemming from changes in technology. It included written selections dealing with hazardous waste, sick buildings, and movement deficits caused by the use of technology.

The example provided for the effects of changes in society to technology was a written description of the issues facing the city of Key Biscayne when the newly formed city faced replacing flora that was wiped out during Hurricane Andrew as well as a sewage pipeline perilously close to rupturing and polluting the recently reclaimed Biscayne Bay.

An article entitled “The Impact of Technology on the Neurosciences” (Strong, 1999) was the only example relating changes in technology to science. A paper entitled “The Cost of Not Knowing” (Holm, 1995) was the example provided to show the relationship of changes in science to technology. The author describes one example of a situation in which understanding a problem in a hospital’s duct work could have saved tens of thousands of dollars a year. The AIDS situation was the topic for both assigned experiences under the society to science section. Students were required to read a paper entitled “The AIDS Dilemma” (Strong, 1995) and to view a video “And the Band Played On: Politics, People, and the AIDS Epidemic” (Shilts, 1999). There were no examples provided for the section on the relationship of science to society.

Student headquarters. The student headquarters portion of the Website was essentially a help area for participants in the course. Help, links, and advice for required activities such as designing Web pages, downloading material from the Web, and changing passwords was available. Further, students were provided with help in tracking their progress through the inquiry process. A checklist for recording which resources had been experienced and activities completed was included for student use along with the self-assessment and self-evaluation form in this section.

Communication center. The fourth bin on the Web CT site was the communication center. This contained an asynchronous bulletin board on which students were expected to each post a reflective journal entry once per week as well as comments on and analysis of postings made by fellow students. Course participants also posted in-progress and final products on the bulletin board.

The communication center also contained an email forum. Messages delivered via the Website were available to participants in the course only. This email was used for one-to-one communications as well as delivery of products to the instructor prior to posting them for the entire class to view.

Chapter 4: Characteristics of Constructivist Learning Opportunities Exhibited in the STS Class

Characteristics of Constructivist Learning Opportunities Exhibited in the STS Class

Learning Opportunities

The learning opportunities for the students in the STS class described here exhibited many of the characteristics of constructivist learning. It should be noted that the opportunities presented through learning activities does not imply that students reached the intended goals of the course. Student responses to the constructivist learning environment and success (or lack there-of) in reaching the goals of the course will be addressed later in this study.

Provide multiple perspectives. The resources in the virtual resource center that were made available for students to experience throughout the course were from a wide range of perspectives and a wide range of authors. Activities for the course gave students many opportunities to experience STS issues from multiple perspectives. These included the constant discourse between students in the form of journal entries and responses. Also, students were required to comment on media watches from a variety of sources and a variety of topics. School and community site visits also provided multiple perspectives. Students were required to visit schools for a minimum of 15 hours during the semester. In most cases, these hours were spent with multiple teachers. While they visited only one community site, experiences at these community sites were presented to the other members of the class and thus gave members of the class exposure to many different sites. Projects for the course including the STS issue investigation; electronic project, teaching/learning opportunity, and final project were all presented to the class and made available for each member to investigate. Further, with the exception of the STS issue assignment, these tasks were group activities. Working with other members of the course also provided students with multiple perspectives when preparing presentations.

Authentic in nature (represent the real world). Many of the resources and learning activities represented "real world" issues. That is to say that the learning activities represented authentic events outside of the classroom that were not artificially staged. Issues addressed through these learning activities were connected to the world in which the participants lived as opposed to the explanatory issues that are currently incorporated into the science education process. Written materials dealt with real events such as those described in the Key Biscayne issues, "The Cost of Not Knowing" and those resources centered around the AIDS issues. The resources dealing with teaching STS provided students with real world examples and information on how to teach STS and dealing with the need for a paradigm shift in education (in relation to the paradigm shift in society). The required learning opportunities also exposed students to many "real world" situations. These included the media watches that were reports and discussions of issues that were currently being discussed in public forums. Site visits to schools and community organizations also presented authentic situations and allowed students to interact in theses settings. The project designed to present an STS issue gave students yet another opportunity to experience STS in an authentic situation. In this case, projects were based on actual issues that were relevant for each student. Students were given freedom to choose issues of interest to them. Other projects, including the electronic project, and the teaching/learning opportunity, also gave students the opportunity to experience STS in authentic situations. Not only did students select topics that were of interest and relevant to them, they chose the audience for which to prepare the project. Directing the projects to an audience of choice allowed the participants in the course to explore issues in a setting beyond the classroom and with an authentic audience in mind as opposed to directed toward the teacher and his or her expectations.

Allow for construction of knowledge. The course offered opportunities for students to construct their own knowledge. The design of the course to be an inquiry into the question "What is STS and how does it relate to science teaching?" allowed students to develop their own study plan. This allowed students to build on prior knowledge in ways that made sense to them. Journal entries and exit memos gave students opportunities to explore experiences and to formulate explanations of how these opportunities fit into and changed their understanding of STS. Further, the discourse that accompanied journal entries allowed students to verbalize and defend their reflections and understandings. Examples and a discussion of this will be presented in chapter 5.

Throughout the course, students were expected to develop three concept maps that illustrated their understanding of STS as they emerged during the course. These maps built upon each other and were intended to show the idiosyncratic nature of cognitive frameworks.

With the exception of the use of media, the resources for the course were highly text driven. This is an obvious inconsistency with the principals of constructivist science education. This was, however, an intentional reversion to traditional teaching methods.

The instructor and designer for this course knowingly made compromises as a means of bridging the gap between the holistic learning opportunities and the traditional learning opportunities to which the students were accustomed. Students in this course were enrolled in a traditional institution and were thus, for the most part, unfamiliar with constructivist learning opportunities. The use of some traditional methodology here allowed them to participate in the opportunity with some initial level of comfort and understanding.

Beyond this text driven portion of the course, there was little evidence of the characteristics of traditional classes. There was no requirement for memorization, no lectures, no competition, and no traditional assessment. The video series, however, did seem to force students into more traditional roles during the time spent watching and reporting on the videos. While a few examples of these videos may have been effective, students spent 20 hours during the semester watching videos. Students were required to comment on the videos by tracing one pathway and asking one question about the video (a method to check to see if students had indeed viewed the videos). This was not required for other resources as they were experienced by the students.

Encourage collaborative and cooperative learning. The design of this course supplied many opportunities for collaborative and cooperative learning. These opportunities included discourse through journal entries and responses, and several group activities. These group activities included site visits that could be done with a partner if desired as well as the teaching/learning opportunity that could be done in a group. Also, the electronic project was designed as a group task with suggestions given for roles for the individuals in the group.

Build upon prior knowledge and experiences. The design of the course allowing students to design their own study plans was the first evidence that students would build upon their own prior experiences and knowledge. The fact that students could decide where to start and which direction to go in their study allowed students to base their plan on their own backgrounds. Information revealed in journal entries and responses were another opportunity to express prior knowledge and describe experiences as a means of building on these. Further, the students constructed an initial concept map in order to give them a base on which to build their representations of their understanding of STS. These maps, theoretically, provided a visual representation of this building process.

Emphasize deep understanding. The overall design and intent of this course were to emphasize deep understanding of STS and how it relates to science teaching as opposed to emphasizing memorization and repetition of information. Journal entries were intended to allow students to explore all of their experiences throughout the course. Leading questions asked in response to journal entries directed students toward more intense exploration of comments made in response to different aspects of the course. Further, four activities, the STS Issue activity, electronic project, teaching/learning activity and final project, were designed to help students complete in-depth studies of different aspects and issues involved in STS.

Provide opportunities for action and exploration. While there were many "assigned" readings and video viewings for this course, there were also many opportunities for action and exploration. Despite the fact that readings and videos were assigned, students were encouraged to explore them in their own order and their own pace. Further, students were expected to visit sites (school and community) and be aware of STS issues through media watches. Projects such as the teaching/learning opportunity were intended to be developed (exploration) around an STS issue and learners taking action related to the issue. Further, the electronic project, STS issue, and final project were all designed as in-depth explorations of different STS issues.

Build upon previous activities with increased complexity of skills and knowledge. This course was intended to be iterative and recursive. While students developed their own learning paths, they were expected to build current activities upon previous ones. Information and skills gathered from one aspect of the course were expected to be represented in future projects. Examples of activities that emphasize this are the concept maps, and electronic projects. The concept maps were supposed to be a way to illustrate these increases in knowledge and understanding and to build upon earlier maps. The description of the electronic project states that students are to “apply technologies you experienced in this course” to “locate, review, and evaluate, and organize electronic media into an STS resource base.”

Include a transdisciplinary emphasis. In order for an educational opportunity to exhibit a transdisciplinary emphasis it must exhibit interconnectedness between different disciplines. Resources provided in the virtual resource center did encompass a variety of disciplines within the sciences, education, and society in general. Further, site visits, media watches, and required projects allowed students to experience STS from a variety of viewpoints and disciplines.

Allows for alternative viewpoints. The design of the course was intended to encourage alternative viewpoints to be expressed, debated, and valued. Journal entries and responses provided a forum in which students were expected to express differences of opinion and understanding and explain their alternative viewpoints. Choices for media watches and subsequent discussions (via the journals) also provided for alternative viewpoints so far as what constituted an STS issue and responses to issues discussed. Further, projects allowed students to discuss their viewpoints about different STS issues. Authentic assessment used for the course was designed to allow for alternative viewpoints as well. Students were not expected to “guess what the teacher was thinking” in final projects or evaluations.

Encourage metacognition and self-analysis. The simplified definition for metacognition that is often heard is thinking about thinking. The Strategic Teaching and Reading Project Guidebook (Laboratory, 1995)states that metacognition consists of three basic elements. These elements include developing a plan of action, maintaining the plan and evaluating the plan. This course is designed to allow students to participate in each of these steps in the self-regulation of cognitive processes. Planning their own path to completing the tasks associated with the course is the initial step in this process. It was further aided by continuous discourse and description of activities and actions in the journals and by the building and rebuilding of the concept maps. Further, self-analysis was aided by the use of the self-evaluation process that students were required to complete as part of the requirements for the course.

Occur in an environment of trust and mutual respect (a community of learners). One of the apparent obstacles in teaching a distance class that represented one example of a constructivist course was the issue of developing a community of learners in the absence of face-to-face meetings. Students did have common goals and tasks to complete which gave them some common experiences on which to construct relationships. Also, in an attempt to help overcome the lack of face-to-face interaction, biographical pages were developed by students which included statements about their background, current situations, and personalities through the assignment of color labels to themselves. Further, students participated in ongoing discourse about the class and current events and were encouraged to express opinions but to back up any opinions expressed. Another way of building a community was through participation in group projects. Participants did not necessarily meet face-to-face, but they had to communicate among themselves to complete these group projects.

Encourage questioning and reflection. A large percentage of the requirements for this course were based on student reflections. These included reflections on all aspects of the course in the journal discourse. Students reflected on required experiences from the virtual resource center as well as on media watches and site visits. Further, students prepared exit memos following any face-to-face meetings and created concept maps that contained reflections on their understandings. Students were encouraged to ask each other questions as part of the reflections for the course.

Provide opportunities for discourse. Again, a major portion of the course was based on student discourse. Students were encouraged to respond to reflections in the journals and presentations with questions and comments. The instructor also interjected questions to help facilitate the discourse. Students were expected to comment on others reflections and this was intended to lead to discourse.

Allow for the construction and reconstruction of the cognitive map. The basic idea behind this course was to construct and reconstruct the cognitive map based on activities and opportunities presented throughout. Students were not only allowed to do this, but were encouraged and expected to be aware of and report on the “reconstruction” as it occurred. The ultimate goal of the course was to develop a cognitive framework that exhibited understanding of STS and how it relates to science teaching. Concept maps, journals, and projects all were intended to show evidence of students undergoing this reconstruction.

Role of the Instructor

The opportunities for the instructor of the STS class described here exhibited many of the characteristics of constructivist learning. It should be noted that the opportunities for the teacher to exhibit the characteristics of a constructivist learning environment do not imply that the instructor in this course capitalized on the opportunity.

Facilitate and coach student learning. The instructor for this course had many opportunities to serve as a facilitator of learning for the students. The format of the class, that of allowing the students to design their own learning pathways and explorations into the topic of STS, put the instructor in a situation in which traditional classrooms methods (lecture, tests, etc. either in person or through distance learning) could not be the predominant mode of delivery of information. Further, the designed learning activities were not based on traditional methods of assessment. The instructor instead was in a position to help students to develop their own learning experiences and to offer suggestions and guidance for enhancing the experience. Opportunities for teacher interaction (which could offer time for facilitation and coaching) included participation in the journal discussions and the posing of leading questions to help guide student discourse and work on required activities. Emails and instructor comments on projects and presentations also offered opportunities for interaction.

Monitor student progress. Throughout the course, the instructor had ample opportunity to monitor the progress of students. One of the most striking means for monitoring student progress toward attaining the goals of the course was through the use of concept maps. Through these, the instructor had access to a visual representation of connections made and rearranged throughout the course. This could allow the instructor to gain a better understanding of student progress or lack there-of. This included participation in or monitoring of the discourse through the journals. Further, assessment of student projects and presentations allowed for further monitoring of student progress.

Share control with students. The description of the course studied here clearly shows intent to share control with the students. Throughout this course students are expected to design their own learning pathway. There are opportunities to change the syllabus according to the needs of the students. Further, students are able to determine topics and formats for presentations of some of the assigned activities and to determine if they will be done individually or in a group. Examples of this will be presented and discussed in Chapter 5.

Role of the Student

As with the role of the instructor, the STS class described here provided the students with the chance to experience many of the characteristics of constructivist learning. It should be noted, however, opportunities for the student to spend time in a constructivist class do not imply that the students took advantage of the opportunity nor that they attained the stated goals of the course. The students' responses and outcomes will be addressed later in the study.

Control own learning environment. The description of the course studied here clearly shows intent to allow students to control their own learning environment. The very fact that this is a distance learning course allows students to choose a place and a time that is convenient for them. Choices of topics for learning activities and sites for visits are left up to the student. Throughout this course students are expected to design their own learning pathway. There are opportunities to change the syllabus according to the needs of the students. Also, students are able to choose to what extent many of the learning activities are individual or group work.

Take responsibility for own learning experiences. Again, the fact that this is a distance course forces students to be responsible for learning experiences. However, the question to be addressed is whether students go beyond the assigned learning opportunities. The course is almost entirely self-paced; students must choose when to experience all of the learning opportunities and when to complete the required activities. Further, students were responsible for determining appropriate sites for community and school visits, topics for media watches, and issues to be addressed in other projects and presentations

On the other hand, suggested due dates were posted for most required activities. While this is an obvious contradiction, this is a holistic course set in a dominant setting and students are conditioned to respond to the dominant paradigm. When dates are not given students responded to pressures from other courses and left this work until too late in the semester. As the course progressed the students could not use the activities as scaffolding to construct their knowledge.

Learn actively. The concept of active learning suggests that students are doing something as they gain knowledge and act upon it. This course was designed to provide many opportunities for active learning. All of the learning opportunities are designed to be active processes as opposed to passively taking in information. Active learning includes reading, writing, discussion, problem solving, analysis, synthesis, and evaluation. The sole example of passive learning in this course may be the reading and viewing of the many components of the virtual resource center. However, the use of journals for comment and examination of these resources serves to move the students toward acting on the material and thus become more active in their own learning.

Participate in self-analysis and metacognition. This course is designed to allow students to participate in each of these steps in the self-analysis and metacognition. Planning their own path to completing the tasks associated with the course is the initial step in this process. It is further aided by continuous discourse and description of activities and actions in the journals and by the building and rebuilding of the concept maps. Further, students were required to complete a self-evaluation tool as part of the requirements for the course. Part of this self-evaluation was an assessment of the students' work for each assigned learning activity.

Learn collaboratively and cooperatively. The design of this course supplied many opportunities for collaborative and cooperative learning. These included the opportunity for discourse through journal entries and responses, and several group activities. These group activities included site visits that could be done with a partner if desired as well as the teaching/learning opportunity that could be done in a group. Students posted assignments before they were to be finalized to obtain suggestions for improvement from other members of the class. Also, the electronic project was designed as a group task with suggestions given for roles for the individuals in the group.

Become a reflective practitioner. Reflection was a major component of this course. Entries in the journals as well as exit memos and the concept maps were all based upon reflection on the process that the students were going through in completing each of the activities. Additionally, class members reflected on the content of the course, other students' understandings, and the effect of STS on science teaching.

Assessment

Again, as noted in other areas, the opportunity for assessment that is consistent with constructivist teaching is not intended to suggest that the participants in the course were exposed to this type of assessment. That issue will be addressed at a later point in the study.

Authentic. Students were advised that assessment was embedded in each task performed throughout the course. These required activities were of a "real-world" nature. Authentic opportunities included site visits, teaching/learning opportunities, STS issues, and media watches.

Negotiated. Students were offered the opportunity to make changes to the syllabus before it was considered a final document. Changes in the evaluation and assessment criteria were open to negotiation as well. Further, students were required to complete a self-evaluation form as a part of the course requirements. This allowed students to not only evaluate themselves by means of a grade for the course, but to give evidence to support their evaluation. A discussion and examples of this will be presented in chapter 5.

Rewards intrinsic motivation. Intrinsic motivation is described by John Marshall Reeve in Motivating Others (Reeve, 1996) as “the innate propensity to engage one’s interests and exercise one’s capacities, and, in doing so, to seek out and master optimal challenges”. Further, in the book 150 Ways to Increase Intrinsic Motivation in the Classroom(Raffini, 1996), James Raffini states "Intrinsic motivation is choosing to do an activity for no compelling reason, beyond the satisfaction derived from the activity itself--it’s what motivates us to do something when we don’t have to do anything."

The design of the required activities, by allowing students to choose the format for the presentations did reward intrinsic motivation to some extent. Beyond this, however, intrinsic motivation does not appear to play a key role in the assessment component of the course described here. The two criteria for assessing quality work were “analytic, conceptual, and creative thinking as expressed through …communications in class and in other written assignments”, and the “degree to which (the students) demonstrate that (they) have worked in project development and demonstration”. These seem to emphasize participation and completion of the assigned activities only. (It should be noted that intrinsic motivation is not evident in the course. Further, lack of consideration of intrinsic motivation in the stated assessment criteria should not imply that it was not encouraged throughout the course. This will be considered at a later point in this study.)

Included self-analysis and metacognition. As noted previously, this course is designed to allow students to participate in each of these steps in the self-analysis and metacognition. Planning their own path to completing the tasks associated with the course is the initial step in this process. It is further aided by continuous discourse and description of activities and actions in the journals and by the building and rebuilding of the concept maps. Further, self-analysis students were required to complete a self-evaluation tool as part of the requirements for the course.

Summary

There are a few contradictions between the design of this course and the characteristics of a constructivist learning opportunity. These included the requirement to list the connections and pose one "factual question" about each of the videos, specific due dates for learning activities, and assessment that emphasized participation and completion exclusively. While these contradictions do exist, it would appear that these cases were accommodations made to help students succeed in this course atmosphere. Since students taking this course were, for the most part, experiencing a constructivist course for the first time, some adjustments were made to help maneuver the paradigm shift.

Chapter 5: Student Responses and Recognition of Their Responsibilities in a Constructivist Online Course

Students Control Their Own Learning Environment

The distance learning format of this course led students to expect to have control over their own learning environment**.** Students understood that they would decide where and when they would complete the work for the course. However, there were some students in both sections of the course (sections a and b) who did express concerns over this control. Some where surprised at the extent to which the control was relinquished by the instructor. The amount of control given to students in this class seemed to be contrary to other distance or face-to-face classes that they had experienced. One student in section A mentioned a discomfort with the lack of structure and meeting on-line as opposed to face-to-face.

> In life, I am not usually such a structured person but when it comes to my classes I enjoy the constant face-to-face interaction and daily feedback from quizzes, exams, and the professor! I do agree that it is rather refreshing to have a self paced program where we learn at our own rate and by interacting in the forums. However, on the other hand I still really miss the extra perks of being in the good old-fashioned classroom.

Other students in this same class expressed concern that they were not doing the assignments “right”. Comments in the journals included “if this isn’t what the journal was supposed to be please let me know, and I'll try to do it right next time", and "well, here it is, I hope I am on the right path or at least in the right forest. Please be honest. Thanks for the help."

One student in section B expressed her concerns as "I am not quite sure how I feel about this class. Mostly nervous and scared…I like being in a classroom setting and I'm afraid that by taking a web class I will get lost." Some of the concern in this class seemed to stem from some confusion about the initial expectations for the class. Comments made by students early in the course often voiced this confusion. One student wrote, "I am in my senior year, but I have never had a class set up like this one. If you could just let me know what I need to do by this Saturday at midnight, I would greatly appreciate it." Another wrote, "I have done my best to carefully read everything I can on the web site, and I still do not exactly understand what is expected from me to turn in … I would greatly appreciate your help in this matter."

Despite the concerns about the nature of the course, some were able to see the value of the course design in the learning process. One student wrote (quoting another student's journal entry)

> 'effective learning often requires more than just making multiple connections of new ideas to old ones; it sometimes requires that people restructure their thinking radically.' This quote explains exactly what I feel I have to do for this class. I have to restructure my thinking radically. I am a hoop jumper and that is how I thrive, not by working for the grade or working to impress the teacher but working for myself, to do the best I can do. To follow instructions and think things through and now in this class I cannot do any of that. The instructions are

> so open ended that I feel like I am trying to get somewhere I have never been without a map or directions. In short I have been feeling lost. I have had to restructure my entire study basis to fit the new mold this class has for me. Will I be able to do it? I really don't know. Right now all I know is that I may not make an A or a B, or even a C but I will learn something new, I will learn how to operate outside the box and I will do the best I can. Maybe I will simply crawl under the hoop or maybe I will soar over it but right now I only know that there will be no hoop jumping here.

One student expressed an understanding of the student control and lack of comfort with it when he described a conversation during a class meeting. The student said

> at our last class meeting it seemed everyone was lost as to what to do with the assignments. Some started to belittle the program. I said to the group that some people like to be told exactly what to do and some people don't want to be told. This really stunned them and got their attention. Then, --- (name omitted) said that he was afraid to do the assignment wrong. And they all agreed that they didn't trust that they were allowed to have the freedom offered by such open-ended assignments. They thought there was some hidden criteria that would give them a bad grade. I reassured them that it was ok to be creative and make their own decisions regarding the assignments. But, I am still amazed at the distrust they had and most likely still have. You said trust was a problem, but I guess I didn't believe it until I seen (sic) it myself.

Yet another participant expressed her understanding when she wrote

> this is my first on-line class and I have to say I understand why people drop out of them more so than regular classes. I think the reason is because you are in control of your own learning and when you have been brought up in a system in which the teachers generally direct your learning it becomes difficult to switch.

While student concerns over the control seemed to be consistent for both of the classes, there were some differences in the extent of the concerns. Despite the fact that the course outline and content were the same for both sections, the students in section A seemed to be less confused and less concerned about the perceived lack of structure in the course. Several of the students were comfortable and excited about the opportunity for control over their learning experiences. This comfort and excitement seemed to help those students who were less comfortable with the situation to relax and be more open to this new experience. Many students expressed this excitement. One student wrote "I'm looking forward to the rest of the semester and the path I'll create." Others said, "I enjoy the flexible nature of this course and after all we should arrive at the same level of knowledge no matter if we went through the front door or took a detour around the back," and "I feel that being given freedom to choose our own path is refreshing. I actually look forward to pick and choose where I'll go next and at my convenience."

Over time students in both of the classes did begin to understand the control and to even appreciate the opportunity. In fact, there were some cases in which students helped to encourage fellow participants in developing an understanding of the process. In commenting on the required reading entitled "Factors Contributing to Preservice Teachers' Discomfort in a Web-based Course Structured as an Inquiry" wrote "I'm really not uncomfortable with our class design but I still really enjoyed the article. It helped me to see what kind of reactions/problems I might be faced with when I start to teach. Also, when I read this article, I reflected on how this class is an inquiry." One participant wrote in response to a fellow classmate's comment about on-line courses being an extreme amount of work,

> I don't think it's a trade-off. I think it's the difference between being an autonomous learner versus being spoon fed. In a class like this you have to take action to learn. In a class that meets twice a week for lecture, most often you get a feel for what is on the test and you review it a couple times before that test. Big difference between learning and passing a test.

Many of the students seemed to grow to really enjoy the nature of the course and the control of their own learning environments. Some participants began to reflect on why their attitudes changed over the course of the semester.

> I was a little skeptical at first, as most people are with something new, but as time wore on I began to thoroughly enjoy it. I feel that I've learned here, in a semester, what I've learned during 3 semesters in a traditional educational curriculum. The ability to mold the material to my preferred learning style, I believe was key.

Another student stated,

> The trepidation that each and all of us had at the start of this course was that it had a start, it had an end, but there was no 'map' to guide from one to the other. We truly became 'travelers' of the mind. I think we all learned a lot, but perhaps more than anything we all saw that abstract methods of teaching can have a greater impact than what would normally be considered the 'norm'. The interaction

among all of us was amazing, I've never been involved in a class that held so much discussion among so few students. It was great!!!

Other comments included, "This class allowed me to delve into the topics I desire, and did not force me to memorize information to regurgitate on a multiple (no-brain) test" and "the scariest part of this class, was the beginning, when I sat there and said 'Oh s***, what do I do now?' But it all worked out, very well in fact!"

Students Take Responsibility for Their Own Learning

All of the students who completed the two sections of this course took responsibility for their own learning environments to the extent that each student completed the required learning activities within the semester time frame. Some, however, went beyond the required learning opportunities as well as encouraging others to do the same. For example, one student in the 2000 class worked part time at a local Museum of Science and Industry. She suggested that her fellow students might like to go there to just see how it was organized and what was going on or that she could arrange for them to participate in a program offered through the education department at the museum. Another student in the same class suggested that her classmates read a book that reinforced a concept presented in one of the required readings for the course. She wrote, "Have you ever read 'Silent Spring' by Rachel Carson? If this article interested you, I think the book will also." In section B, there were several incidences in which students were obviously going beyond the required learning activities. At one point a student described a discussion that she had with her husband (not a participant in the class) about a required video. She described the understanding she had developed through this conversation and it became an important part of the group discussion. Several students related the fact that they had done some outside research on topics of interest or as a follow-up to required learning activities. One student did some outside research on constructivism because it was of great personal interest. The student wrote in her journal

> I'm currently doing some research on the constructivist approach. (It's part of our objectives.) I've found that if you get the students into the topic and allow them to inquire and explore it first, then you can introduce the vocabulary because they will have something that they can connect it to. This approach also emphasizes the importance of making the material relevant to the students. I think this approach is great. I can't stop reading about it.

Yet another student wrote "after watching the video NSF presentation, 1994, I thought I would see how things progressed since then."

Further, there is evidence that students were taking responsibility for their own learning in that they were willing to question the value and format of the learning activities and to even suggest changes that might be beneficial for the class participants. For example, during section A, there were some problems getting one of the required sets of videos. Many of the students expressed frustration with having to come to campus (since it was a distance course) to get the videos and then they were not available. One participant in the class took the responsibility of reading the book instead of the videos since he did not live in the city and the videos were not available in his local library. Still other students suggested to the instructor that these videos should not be required and suggested reasons why this was the case and how the format of the class should change. Comments from students generally reflected this frustration such as

> the purpose of a distance learning course is to free the student from having to make a trek into a classroom/school location. These videos force the student into doing this, which is in complete opposition to the concept of distance learning.

Many students also suggested that the two sets of videos ("The Day the Universe Changed" and "Connections") were so similar that there was no real value in viewing both sets. The instructor pointed out her perspective on the differences between the two sets of videos. Following this explaination of the reasoning behind the assignment, the decision was made to keep the assignment as originally developed.

The required videos also were an issue in section B and were an example of a situation in which students took responsibility for their own learning environments in that they questioned the format of the required responses to watching the videos. In this case, students did not comment on being required to watch both sets of videos, they were concerned with the required written response to the videos. Students initiated and participated in a discussion of the value of being asked to trace one pathway through the video and to present one question that might show that a student had viewed the video. A portion of the on-line discussion follows:

> I thought the reason I was required to read these messages was so that I could learn something from them. This is not happening; and I feel that reading the messages in regards to the videos are a waste of my time. I am trying to see what changes could be made so that I might benefit from it. I'm only trying to make the most out of my time and education.

Another student responded

> This isn't grade school. And the syllabus is not written in stone either. We are going to be teachers ourselves and be writing up our own syllabus one day. Doesn't this give us an additional right to voice our opinions about such? Sooner or later we are going to have to decide what activities are most beneficial for our class and what activities could be left out or modified.

Eventually the discussion led to a suggestion for a modification of the syllabus. The suggestion was

> for each of the videos give the title of the video and describe what was the most interesting part of it and why you think so. Does this video relate to any other course materials you've read so far? If so, tell which ones and how it relates. Since the nature of science involves asking questions and in order to be an autonomous learner one must know how to ask questions, write at least three 'what if' type questions that relate to the video but promote further/deeper thinking.

The response from the instructor was "The questions are to fulfill the assignment I gave. It asks for questions you could ask someone to demonstrate the person watched the video. It is what I refer to as 'cop' assignment- playing police." After further discussion, changes were not made to the syllabus. In this case the instructor was pointing out that this assignment was indeed consistent with the old paradigm. One thing that is of note here is that journal entries early in the course were often merely responses to the "cop assignment". However, as time and understanding progressed, journal entries began to be more reflective and to incorporate issues and learning that were beyond the videos and the given assignment. This demonstrated that eventually the students did get to the point where they were taking responsibility for their own learning and these traditional type assignments became unnecessary after a time.

Other examples of students taking responsibility for their own learning included discussions of different topics that were of interest and led to further research and discussion. These issues included political issues, pet sports drinks and a discussion of the safety of drinking large amounts of diet soft drinks containing phenylalanine (among other topics). It was obvious from the discussions that these were topics that were relevant to the students and driven by their needs and interests. Participants in these discussions were motivated to do the research on topics of interest and to report on their findings to their fellow classmates.

Active Learners

Active learning is a process. Throughout this process, learners are actively involved in their own learning. The process can include activities such as reading, writing, discussing, solving problems, analysis, synthesis and evaluation. The course was set up so that students had to be actively involved in the learning process. There was very little opportunity to be a passive learner. The only requirement for the course that could be considered passive in nature was viewing the video series. And, even in these cases students were expected to incorporate these into their discussion and synthesis of the material for the class. Journal entries, student discussions, concept maps, and projects do reflect the fact that students were actively involved in their own learning. Journal entries often were much deeper than simply repeating information gleaned from the resource material. Often reflections led to active discussion among students in the class. These discussions and reflections revealed that students were making attempts to use the information available to them, integrate multiple sources of information, and draw conclusions in order to formulate deeper and more comprehensive understandings. For example, one media watch that was reported by a student in section A was about deaths caused by defective tires. This report led to a discussion of blame for the problems. One student wrote,

> Now that I have had a chance to think about it, I view the situation a little different… Firestone is being blamed in over 150 deaths due to their tires tread peeling off the tire. The thought of 150 people dying over such a small error like a tire design is tragic. In this case a small error in the interaction between science and technology had terrible consequences. I would hate to see the results of a major error in some of the technology that society depends on. When I thought about the error with the tires I realized that neither science nor technology are to blame for the mistake. The blame falls on society for misusing the science (research) and or technology when developing the tire.

Another discussion in the class centered around the effects of developing technologies on our society. A participant in the class wrote

> You have a great point that technology will not doom us, we will doom ourselves for what we have created. I do not think as an entire society people will change their ways of thinking, look how hard we liberated college students had with this course and its different ways of doing things which makes us have to think differently about our whole learning process. I'm sure we have not totally accepted this way, we have to do it (at least for this semester) but that does not mean we all changed our ways of thinking and possibly our ways of doing things.

Journal entries prepared by students in section B also reflected students' active learning processes. One particular discussion which stemmed from a student's comments about the videos "The Day the Universe Changed" was an active discussion on the evolution of thinking. The discussion included students expressing their own ideas and understandings as well as bringing in other sources that supported these understandings. One student stated he/she thought that human beings had gone from never questioning to always questioning. Several students responded to this line of thinking. One student wrote,

> You said, 'We went from not ever questioning to always questioning.' I don't agree with this. I feel as the article 'The Biological Evolution of Humans as a Basis for Science' suggested that curiosity is natural for humans. It's inherently natural for us to question things. It may seem like what you said is true only because now we have more to question. The more you know the more questions you can have. What you said about teaching students that science don't (sic) have all the answers is so important. It's even stated in the SAA under the nature of science. Science can't answer all questions because science is progressive. Answering one question always leads to more questions. And as knowledge increases it may change some of our answers.

Another student responded with

> I see this in both ways that you two explain it. In the beginning, we questioned through curiosity but kept the information internal. But as time passed with the increase in humans moving (traveling) the information began to be shared and we began to question in more of a public arena. It is true that we have always

questioned through curiosity and always will but what is to be controlled by the structure of society is whether we will always share and question each other in the public.

And yet another student commented “I think you hit the nail on the head.
We have always questioned, but today we seem to voice and look for the answers more openly.”

Throughout the course, students were expected to produce three concept maps. These maps built upon each other and reflected the students actively participating in the learning process. Figrues 1,2, and 3 below show typical examples of concept maps produced by participants These represent students’ understanding of an STS issue, as well as the nature of science, the nature of technology, and the interaction among science, technology, and society. In each case students demonstrate an understanding of the issue as well as the interactions which contribute to the issue. For example, figure 1 shows an understanding of global warming, evidence that it is an issue of concern as well as interactions contributing to the problem and possible solutions. Figure 2 shows one student’s understanding of the nature of science. Through this map, the student demonstrates the understandings that science is changing and seeks to explain the world. Further, the student represents an idea that science and new understandings lead to changing paradigms and new discoveries. Figure 3 demonstrates one student’s conceptions of the nature of technology and its constant change. Further the student expresses an understanding of the relationship of technology to science and society. In each case, these maps help students to visualize their understandings of the issue of interest. By producing these maps, students were actively involved in the learning process as opposed to the traditional lecture, notes, and tests.

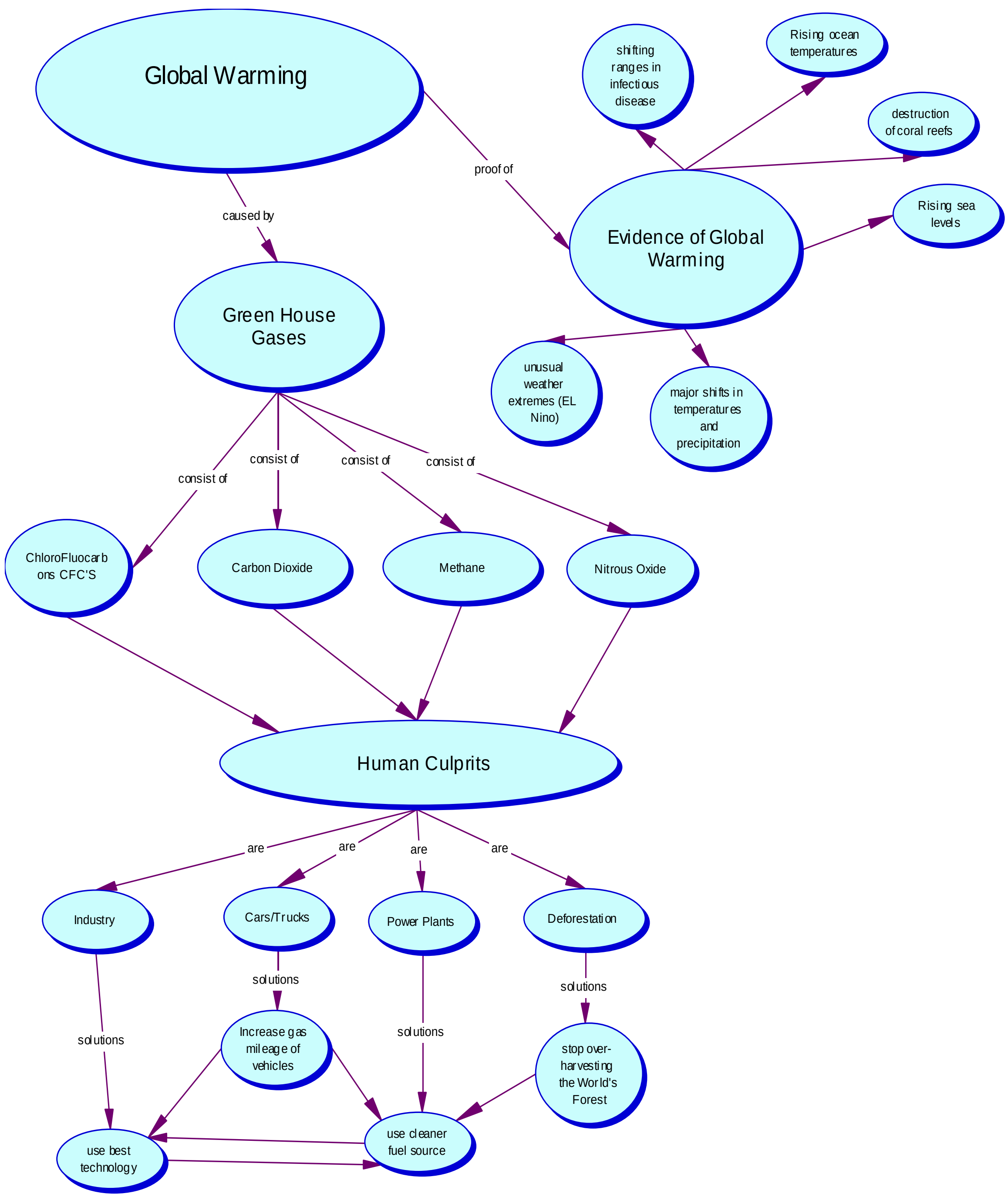

Figure 1. Example of a Concept Map Showing Student's Understanding of an STS Issue

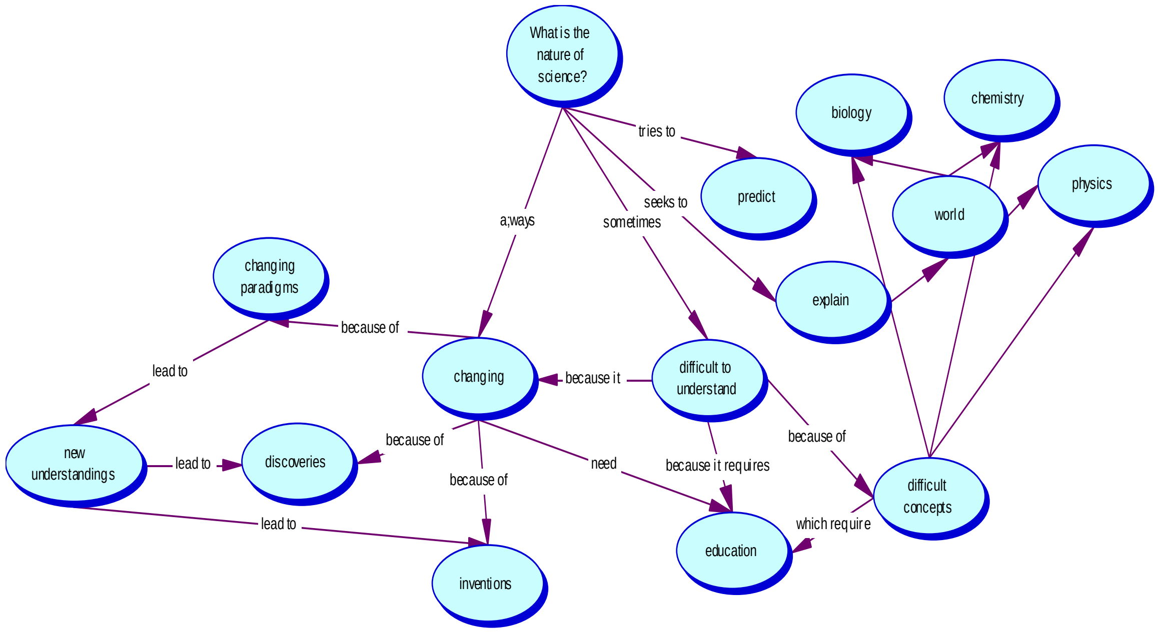

Figure 2. Example of a Concept Map Showing a Student's Understanding of the Nature of Science.

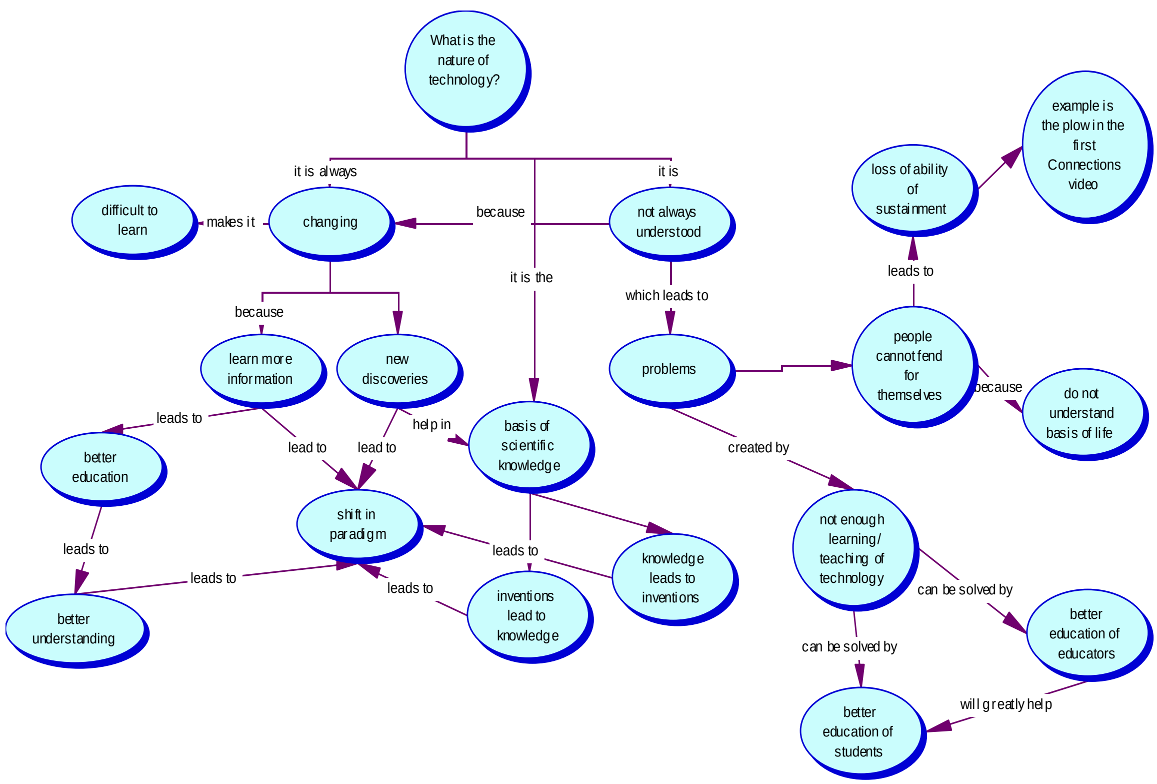

Figure 3. Example of a Concept Map Showing a Student's Understanding of the Nature of Technology.

Discussions of site visits to local schools and current educational situations were another area in which students were obviously working with the information they had gained (as opposed to simply going through the motions to fulfill the class requirements). Students were required to report on the visits. Many, however, went beyond the requirement to consider how the situations in the classrooms reflected (or did not reflect) how students learn and the best way to teach. Further, participants in the STS class often used the experience as a starting point to reflect upon how the experience could be used to influence their own future teaching. Many of these comments took the form of frustration over the current system and concern that their own teaching experiences would be difficult due to various issues including lack of support for constructivist teaching, the need to help students to think for themselves and to be creative and curious (since traditional educational practices tend to discourage these), and time to implement practices in the classroom that reflect what is known about how best to teach science. One student stated

> To this day I don't think I have observed a single science class conducting "inquiry". However, I HAVE specifically heard a teacher say that he knew about inquiry-based learning years ago but didn't have the time to implement it, so he never did.

Another student related, "Creativity and curiosity are natural. However, by the time they get to middle and high school they have packed these away. You almost have to teach them how to be creative." Some were encouraged by what was going on in the classrooms that they visited and reported on these, as well. One participant in the course stated, "…I see that the reward is the learning of exploration of education, and not the extrinsic candy or pencils. The schools I have been in today seem to be attempting to move into the right direction."

One result of the discussion of our current educational system was a call to action for bringing about change. Comments included, "Once you figure out how to push this reform faster, let me know and I'll help you. You're right. I've heard some big-wigs talking the talk; but I don't see much in the way of actions;" and "…society's paradigm is changing. So businesses either have to be willing to change also; or be left behind. So, why don't the school systems wake up and get with it?"

Students seemed to realize the responsibility was falling to them as future science teachers. Comments from students reflected this feeling. One student expressed her concern when she wrote "What happens if a really good teacher is trying to implement the latest scientific discoveries of human learning and even the latest technology to help her but, the society surrounding her is rebuffing and reprimanding her every effort?" Students responded to this realization through many observations about their futures as teachers. One student wrote, "I do agree with --- when she said, 'As long as the ideas were welcome and the newer teachers do not fall into the ways of the old paradigm of their colleagues.' To me it seems to be the biggest obstacle for new teachers." Yet another comment was

> …it would be very hard to completely change the school system right off the bat. I think that we are slowly changing to a more productive system. The way in which our teachers are being taught now (IE: us…) is the way that we should be. I think that is one of the first steps to changing the system. But it will take time. It is also hard to coordinate such a vast span of schools to change at one time,

> especially since we do not have a national standard for our schools. But I think that we are just at the beginning of that change. I also believe that it will be our job to help form that change when we become teachers and redirect teaching in the right direction. That is one of the main things that has fascinated me about his profession, is that we are going to become some of the leaders for the next generation of teachers.

Despite the frustration with the current educational system, students did seem to be optimistic about their role in bringing about change. One participant in the class wrote, "One day, some of the future teachers of tomorrow may be the future administrators of tomorrow and hopefully, we can all work together to make a better school system." Another student said "You have to be strong enough to go against the tide and not tire out. That's why we really should keep in touch with one another. If nothing else then to encourage each other and hear each other's experiences."

Self-Analysis and Metacognition

The idea of "thinking about thinking" and self-analysis were clearly foreign to many of the students in both sections of the Science, Technology, and Society course. Early reflections tended to be simple reports of what students read or saw or experienced. For example, one student's early media watch was simply a description of the FIRST program.

> FIRST ("For Inspiration and Recognition of Science and Technology") is a non-profit organization. The program works to increase the interest of today's youth in science and engineering. They have an annual robot competition (since 1992) which exposes high school students to the world of engineering. The competition

> also helps build a sense of community among schools, universities, and business. Sponsors include big businesses such as, Baxter International, Daimler Chrysler Corporation, General Motors, Johnson & Johnson, Motorola, Xerox, and more. Not only does this program help students learn and build community spirit, it gives students many more opportunities for their future. Students who compete in this competition have opportunities to receive scholarships. For more information, check out the web site www.usfirst.org/.

Later reflections on readings or experiences reflected much more emphasis on meaning making and understanding as opposed to reporting. Further, there was evidence that students were relating current readings and experiences with previous ones. One student watched a television documentary on two tribes in the Amazon basin of Brazil that did not use modern technology. As opposed to earlier media watches, this one included little information about the program itself, but included a great deal of reflection on how this related to our society and lifestyles. The student wrote,

> I started to think how our civilization would react if something catastrophic happened. We had the big blackout but everyone knew that was only temporary. This last week there was a big solar flare that threatened communications and power grids but like Y2K is was just a threat. I got to wondering if maybe there were huge and maybe permanent solar flares on our sun that permanently disrupted our power systems how would we as a society react. If the air was ionized enough where we could not communicate via electronics, what do you think would be the results to our society? If we lost our power grids, could we adapt back to the pre-electric days?

This prompted the class to engage in an in-depth discussion of what would happen if our society did lose its electricity.

As students became more comfortable with the idea of metacognition, there was evidence that they were actually asking themselves (and answering) why they thought something and where the thinking could lead. Further, they seemed to enjoy the process of digging into the why and how behind the thoughts they were experiencing. In discussing the video "The Business of Paradigms", one student wrote

> This video was very interesting. For those of you who have not seen it I highly recommend it. It clears up the term 'paradigm' and gives great examples of how paradigms affect people and the world around us. I had learned about this concept previously, but the professor termed 'paradigms' as 'terministic screens'. People fit and see things in the world the way they think they should or the 'right' way. This concept definitely gives you stuff to think about and perhaps evaluate some of the ways of thinking we have.

Another student described her thinking about paradigms as "my paradigm of the way science education should be taught and learned is constantly shifting. I feel like I am trying to incorporate two discourses to overlap in a meaningful and productive way. Wow, this really makes me think!" Many comments from students exhibited the fact that they were thinking about the thinking process itself. Comments included, "one thing that story made me think of as well are the comfort zones of thinking people might get into;" "misconception of the things that surround us, I believe, is caused by constricted thinking processes;" and "He got me thinking of how the connections were not direct and neither is the real world yet in the traditional school the way subjects are taught makes topics seem as though everything is so linear and direct." One student even joked, "Now I have to go to bed before I become another basket case from thinking about this too much." The development of concept maps was beneficial in helping students to evaluate their own thinking, understanding, and meaning making. One student wrote the following in a journal entry, "I must say as I was creating and recreating my web this week, it is truly amazing how far you can go with it. I felt like I could sit there for hours and add and change and connect ideas. Once you put one idea down there is something else to connect it to then add a million more ideas."

Self-assessment proved to be much more difficult and uncomfortable for the participants in the classes. Throughout the class, students expressed a feeling of not knowing how they were doing. They were obviously used to having the instructor provide the assessment and feedback. Comments like "I think the thing that aggravates me most is that I do not really know how I am doing", "it unnerves me a bit not to know where I stand" were common at all times during the semester. Many comments reflected the fact that students were looking for approval of their work. Some students did, however understand that assessment did not have to come from the instructor. One student wrote "it's almost as if we don't need a professor to tell us how we're doing because it is obvious in the interactions among us."

Students as Collaborative and Cooperative Learners

The nature of this course and the associated learning opportunities naturally put students into collaborative groups. Beyond the required group work, however, there is evidence that students were building learning communities and support groups within the class and as a class group as a whole. Section A may have built a community more quickly due to the fact that one student in the class was extremely proficient with computers and was able (and willing) to help fellow students with problems that arose that were associated with the computer based format of the course. He was always willing to either print out directions, or post assignments for students who sent them to him. For example, at one point a student was having a problem posting a PowerPoint on the web. He responded to the student "email your PowerPoint to me as an attachment, I'll turn it into a WebPages for you. Yours did exist, I saw it, yep it was all gobbly-goop because it was a PowerPoint and not html." In another situation he was willing to write out very explicit directions for posting something in the student presentation section of the website. Many of the comments from other participants in the class reflected their appreciation for the work of this computer expert. Common types of comments included, "you are a lifesaver, and a wonderful teacher," "I can't imagine taking this class and not having you around to help…Thanks so much for all your help!" Another student wrote, "How in the heck do you find the time to be so awesome!!! You have done a lot for this class and a lot to help those of us who are not quite computer geniuses yet! Thank you!" This student's willingness to help fellow students as well as his openness about himself and his family seemed to help other students to open up more and build a relationship with the members of the class.

Openness among the students in the course also seemed to help build the trust that is critical to building collaborative learning groups. In each class there were students who were willing to be very open with the class. This seemed to help open up other students to be a part of the class and not just look in from the outside. The same student in section A that was the computer expert also shared an experience with the class that he was going through while participating in the class from New York. His wife was serving as a kidney donor for his sister-in-law. He kept the class updated on their progress and the class seemed to be truly concerned for them all. Students sent messages such as “I wish your wife and sister-in-law all the best!” and “My prayers are with your family. Hopefully both your wife and her sister will have speedy recoveries from the surgery.”

One participant in section B of the course also shared a life-altering experience with the class.

> I guess the most life changing experience I had was a little over a year ago when I was involved in a major car accident in a 15 passenger van which took the life of my husband and one other young girl. I had suffered the same type of injuries that they died from, but with major brain surgery, I surprisingly survived. I was told that I would never be able go to college again. After about six months, I had a neuropsychologist tell me that it would be very difficult but if that was what I was determined to do, that I could pursue a degree in chemistry. I suffered frontal brain damage, but God has brought me this far, and now I am in my final semester of classes before my final internship.

Fellow students expressed their appreciation of her strength and perseverance. One student wrote,

> I just wanted to say I think you're a remarkable person. I know of many people that look for excuses not to pursue their dreams (goals). It takes a special kind of person to be determined not to let circumstances or what others think stop you and get you down. I am really looking forward to getting to know you better and working with you in class throughout this semester. Never give up!

As the classes progressed, there was evidence that the students felt bonds with fellow participants in the class. At one point, students began to discuss their future plans. One student was interested in moving to Colorado to teach in the future. It was almost as if it became a class project to help her determine where in Colorado she should plan to relocate (if at all). Other students discussed their activities with friends and families and other issues that were of a more personal nature than just the “business of the class”.

Throughout the class students worked to encourage each other to complete the learning activities required for the course. For example, early in the class when there was still confusion over what students were expected to do, one student offered the following:

> I have taken (this instructor) for the middle school science class and have a good idea about what kinds of things we are doing and what is due. If you need any help on what we are supposed to be doing I may be able to help.

Another student wrote about one of the assigned readings, “…If you haven’t read this one, do it next.”

By the end of the course, many students expressed the fact that they really felt close to the members of the class. One student in section A wrote in a final journal entry, “Thank you everyone in this class. The interactions we have are wonderful. Even though we are not in a physical meeting I do feel that we have made a good learning community.” Another participant in the section B expressed the same in the comment “I actually somewhat know the students in this class. Probably more than I would know them in a regular classroom.”

There was one telling discussion between students in section A in which they examined the reason for the large amount of discussion among the students via the online journal postings. The initial comment that started the discussion was

> this class has more interaction than any class I've ever been involved with. Some figures: This class has 12 or fewer students, yet there have been 989 posts to the bulletin boards. In another class I'm in, one that demands interaction, there are 53 students with a total of 354 posts. 4 times the students, 1/3 the posts.

Students responded to this comment attempting to explain the reason. One student wrote,

> I think that we have so much interaction among us because we are such a small group of students, like a close community even though we are not all close geographically. Everyone participates in lending support and insights into each other's postings. I have learned so much from everyone, which is something that I could never get from any textbook. We are all in the same boat since this is a new web-based course. It helps a great deal to hear from your peers about their experiences and thoughts about the course. I feel more confident and better informed about the course than I have in any other web course.

Another student stated the following, "I agree that this is one of the best web courses I have taken, and it is the result of our interactions. The conversations help keep me motivated." And yet another student stated

> I have to say that it is not only the interaction that brings us closer it is also the support that we have given to each other as well. For example, trying to figure out how to post projects, etc. There is always someone there to help to guide you

along. Also to give you insight to a topic or give more knowledge on it is great.

Thanks!

Students as Reflective Practitioners

Reflection is a critical part of learning. Going beyond repeating what is read, reviewed, or experienced to address the why and how associated with these experiences assures that learning is taking place. The requirement that students complete journal entries and concept maps for this course gave them ample opportunity for reflection. Early in the course, students tended to post more reports than reflections. But with the help of comments and guiding questions from the instructor as well as discussion from fellow class participants, students tended to move toward being more reflective practitioners as opposed to reporters.

Comments and guiding questions from the instructor fell into three categories. Categories included explanatory, expanding, and encouraging. Through these comments and questions there was evidence of the instructor exploring her perceptions of the students' understandings and exploring her own understandings.

Explanatory comments were intended to explain the class structure and learning activities or to explain concepts that came up during the discussions. Examples of explanatory comments and questions included the following: "Can you rewrite the directions for the syllabus to accomplish what you want? Or, maybe write a list of criteria for the assignment or even a rubric that will accomplish what you are thinking about?" "The syllabus, with all its attached items is not a one time read. Whenever you have questions about what you are doing, please remember to check back in the syllabus." "Let's look at the purpose of the assignment. In order to see how much your ideas change as you progress through your data collection, you need to have a record of where your understandings were to begin." "Does this help interpret the ideas you folks have been sharing?" "Assumptions about constructivism: The following are assumptions about human constructivism, the theoretical basis for the design of this course." (This was followed with a passage that described human constructivism taken from a previous publication.) "We need to differentiate between 'hands-on' and 'inquiry activities' that are hands on. The robotics demonstrated an inquiry activity. Most 'hands-on' activities in schools today are still just cookbook." When asked for tips on completing an assignment, the instructor responded "no I do not have any tips. This is entirely your creativity and what you WANT to do to share about your learning. If you can find a way to relax and think about the project, I think you will find it can be fun. Above all, don't stress out."

Many comments and leading questions from the instructor were meant to encourage students to expand more upon their own thinking and develop deeper understandings.   Comments and questions included "your thoughts touch on the nature of science. How has technology and the current societal paradigm affected the way you came to these conclusions?" Following the explanation of a lesson presented to young students, the instructor asked "Have you tried that lesson with older kids? What does the teacher normally do for science and how does it compare with the STS paradigm?" Following a student's comments about a reading on faulty pipes in a building the instructor asked "can anyone identify any physic principles involved understanding why the engineering was faulty?" Many comments encouraged the students to dig deeper into what they were learning and how it related outside of the course itself. One such comment was “what are you learning about the way your mind makes connections when left free to do whatever? What does this suggest for the way different students may learn in a class you teach? How alike and how different are the learning pathways are all taking?”

Encouraging comments from the instructor were common. One comment was “you are not expected to nail down everything now for the rest of the semester. No reason to hyperventilate. Relax and enjoy the adventure.” Other comments included “what you did here is a wonderful example of how this course is supposed to work,” and “AMEN! That is what is supposed to happen if this course is working correctly.” However, as a result of the feelings of camaraderie that developed in these classes, the majority of the encouragement for members of the class came from fellow participants. Student journal entries often included statements like “I know you can do it,” “hang in there,” and “you are doing great work.”

Guiding questions and comments helped students to be more efficient reflective practitioners. There are many examples of reflection throughout the journal entries. A few sample entries are presented here. Some of these reflect students’ realization of the importance of reflection as part of teaching and learning. “I now understand the purpose of some of the activities we do. We must be writing these journals (or concept maps) because it has been found that self reflection helps build on our prior knowledge.”

> I see that this is what this class is, we are learning what we can learn so we can make good decisions later in life. Choosing things/events from the real world that students can relate to will certainly help them be more interested in science, rather than saying Ok read 25 pages and we’ll talk about it tomorrow.

> We lead such busy lives that we forget to leave time to reflect and I think schools often reinforce this for teachers and students. Yet without the reflective time to appreciate what we have experienced, it may be as if things never happened.

> I don't think people are born good teachers or not good teachers. The only teachers I know of that teach well and don't have a teaching degree are ones that have gone out of their way to learn new teaching skills. Teaching is more of a skill than a gift.

> The word connections in your journal made me think. In this class we are trying to connect how science, technology, and society interact. We watch the videos on connections to help with this. We have to connect the inquiry of this course and how it is going to help in the classroom. Even if I am learning just plain facts like micro or something I have to 'connect' it to something like make up a story or something. I don't understand how someone could just read it and be able to remember the stuff without connecting it to different words or stories. I guess what I am saying is that 'connections' is a very key word to learning. Kids and adults that aren't able to make these aren't going to do well usually.

Students Feelings about Distance Learning Opportunities

Participants in these on-line courses expressed a variety of feelings toward distance learning in general. Some had participated in several online courses and felt comfortable in the setting. Others, however, either had bad experiences in previous courses, or had not participated in on-line courses prior to this experience. Some of the comments were made early in the semester and reflected students concerns about the upcoming course. One student wrote,

> I really do not like on-line courses. I can not function in this type of forum so I am very concerned about how I will do in this class. If I knew that this class was going to be online only, I would not have taken it but, unfortunately, I have no choice.

Yet another student stated, “I do like the interaction and feedback you get from others in a classroom. I think you can learn so much more from others being there discussing and exploring together.” One of the concerns was the lack of ‘body language’ associated with face to face communication.

Others comments about distance learning were in response to a discussion of dropout numbers in on-line versus face-to-face courses. In this discussion the instructor wrote,

> I think the reason for the dropout in Internet courses is that students don’t realize how much effort has to be put into making meaningful sense of the material (in order for) the student… to grasp the information. Most students in the traditional classroom just rely on memory of what the instructor said to get by in class. I agree with online classes, it does seem you get to know your classmates better, especially when there is a communication requirement component of the course. Because the students are required to write about how the information relates to them and their cognitive framework (sic). And of course everyone’s own little personal stories end up coming out in the course of the dialogue.

Another comment indicative of student attitudes toward the online class was;

> What you said about online courses may be true for this class but certainly not for all. I’ve had many ‘never to repeat’ experiences with on-line courses. Not that the

material was difficult, but that the layout/design was inconvenient, frustrating, and boring. This is the best on-line course I've ever taken.

To some extent, statements about feelings toward the online courses were a function of time. Early in the course, many students expressed this frustration. However, as time passed and participants became more experienced with this type of learning and were able to create a picture of what they were supposed to do, they expressed more comfort with distance learning opportunities.

Chapter 6: Literature Review

Constructivism

In light of current understandings of how people learn and how teachers could most effectively teach, Lunenburg (1998) suggests that the most significant recent trend in education may be constructivism. Constructivism's origins can be traced to the Neapolitan philosopher Giambiattista Vico. Vico argued that only God can know the real world since God created it. Humans construct their own realities and thus can only know the reality that they construct. The only thing that humans can know is the constructed reality. This reality does not represent external reality (Von Glasserfeld as reported in (Vrasidas, 2000)

According to Vrasidas (2000), there are five "major philosophical and epistemological assumptions of constructivism." These are:

1) There is a real world that sets boundaries to what we can experience. However, reality is local and there are multiple realities. 2) The structure of the world is created in the mind through interaction with the world and is based on interpretation. Symbols are products of culture and they are used to construct reality. 3) The mind creates symbols by perceiving and interpreting the world. 4) Human thought is imaginative and develops out of perception, sensory experiences and social interaction. 5) Meaning is a result of an interpretive process and it depends on the knowers' experiences and

understanding (Cobb, 1994; D. H. Jonassen, 1992; Phillips, 1995 as reported in Vrasidas, 2000)

Constructivism is not one single theory, but rather several schools of thought that exist across a continuum. Three broad categories can be identified across the continuum. These categories included cognitive constructivism which is associated with the processing of information and the component processes of cognition. A second category, know as radical constructivism, contends that reality is unknown and there is an internal nature of knowledge. According to radical constructivists, internal knowledge is not the same as external reality. Rather, internal knowledge represents a variable model of any given experience. The third category of constructivism has been labeled social constructivism. This theory emphasizes the social nature of knowledge. Truth is not an objective reality (as is the theory behind cognitive constructivism) or experiential reality (as is the theory behind radical constructivism). Truth, according to social constructivists is a socially constructed and agreed upon truth (Doolittle, 1999). Candy (1991) stated that different learners will most likely perceive external reality differently and that a common meaning is constructed through social negotiation.

Online Distance Learning

Over time distance learning has assumed many variations ranging from mail order correspondence-type courses to the currently predominant format, online courses. Despite the method of delivery, distance learning has developed from a need to allow all students equal access to education (Bordeau & Bates, 1997). Of those institutions reporting the availability of distance courses during the 2000-2001 academic year, 52% offered thirty or fewer courses, 15% reported offering between 31 and 50 courses, 19% offered between 51 and 100 courses, and 15% offered more than 100 courses through distance learning avenues. The number of postsecondary degree and certificate programs offered totally through distance education has increased dramatically over the past decade. According to the U.S. Department of Education, National Center for Education Statistics, the number of degree programs offered in 1994-1995 was 690 and had increased to 2810 by the 2000-2001 academic year. The number of certificate programs offered totally through distance education had risen from 170 to 1330 over the same period (Lewis, Snow, Farris, & Levin, 1999; Watts & Lewis, 2003)

Online courses encompass a variety of methods for delivery of the material. These methods range from classes which are totally text-based to those which provide opportunities for interactions between the students and the instructors as well as interactions between the students and other students and the students and the course materials. These more interactive courses may include graphics, video, and audio components prepared and collected by the instructor (Jones, 2003). In the most recent survey, the U.S. Department of Education, National Center for Education Statistics reported the percent of institutions using "primary technology" for delivery of at least one distance education course for the 1997-1998 year and for the 2000-2001 year (see table 1 below). Institutions using technology for distance delivery of courses reported using multiple methods of delivery. However, the majority of the institutions reporting the delivery of distance courses were using asynchronous Internet courses by the 2000-2001 academic year. The increase and predominance of this type of delivery may be due to the desire for student control of time and location for participation in these courses. Student requirements for distance courses will be discussed later in this report.

The course studied here represents an undergraduate course for preservice teachers who are taught using asynchronous Internet for delivery. As with the majority of institutions delivering distance courses, other courses are offered through more traditional face-to-face methods.

Table 6

Primary Delivery of Distance Education Courses

Delivery Method	*1997-1998*	*2000-2001*
One-way prerecorded video	48%	41%
Two-way interactive video	56%	51%
Asynchronous Internet courses	60%	90%
Synchronous Internet courses	19%	43%

Note. From U.S. Department of Education, National Center for Education Statistics.

Who Takes Online Courses?

In 2002, the National Center for Education Statistics reported that the actual number of students who chose to participate in distance education was below the expected number. The center found that in 1999-2000 8% of undergraduate students and 10% of graduate students took at least one for-credit course via distance education

(Sikora, 2002). Qureshi et. al. (2002)report “it appears that students who choose to enroll in distance education courses are motivated adults, age 18-40, mostly females, who because of their family and work commitments, lack time to participate in on-campus studies.” Rogers (1989) and Cranton (1989) suggested seven characteristics that describe the majority of distance learners. These characteristics include adult age, valuing learning as a continuing process, experienced, motivated, realistic, often holding competing interests and possessing pre-developed patterns of learning.

More recent studies have suggested that the distance education population is shifting toward younger students. Often these younger students combine distance education courses with on-campus courses (Wallace, 1996). The main reasons that students reported taking distance education courses were location and interest. Other reasons included the desire to earn a degree and the importance of the course in the students’ chosen careers (MacBrayne, 1995). A study of distance education in trade and industrial education found that “students wanted to pursue degrees without relocating to retain their current employment or because of family responsibilities (Zirkle, 2002)”. Wallace (1996) reported that control of time, place and pace of learning were most important in motivating students to register for distance learning opportunities.

Levenburg and Major (1998) suggest that online courses support certain personality characteristics. Students exhibiting these characteristics tend to be self-directed learners, efficient communicators, good at problem solving and comfortable with collaboration. Deal (2002) states that “not all learning styles and personalities are suited to a distance learning format. Special skills necessary to be successful in a distance learning environment include writing and communication skills, time management, organizational skills, and the ability to work independently." Further, Regina G. Chatel in the paper entitled "Testing the Waters of Distance Learning: A Case Study in Constructivist Learning and Teaching" (Chatel, 2001) states "students taking online courses are risk-takers who do not appreciate the 'sage on the stage' in the traditional classroom and are open to change…"

Participants in the course described here were of varied ages and personality types. Students ranged from traditional college age to substantially older. Most of the participants did live off campus, and some were living in different states than the university through which the course was offered. All were pursuing a degree (most education degrees) and were taking this course for the completion of requirements toward that degree. This may have had an effect on the variety of students taking the course. The mixed responses to the distance course suggest that not all of the participants were of the personality characteristics described above. However, it did appear that most students became more self-directed learners, efficient communicators, good at problem solving and comfortable with collaboration.

Student Satisfaction With Distance Learning Experiences

There are several factors which help to determine student satisfaction with a distance learning experience. These factors include the use of high quality visuals as a part of the instruction, the use of different instructional strategies to aid in instruction, prompt and high quality feedback from the instructor, encouraging student participation in class sessions, ability to access the instructor outside of class time as well as materials needed for the class and clear communication of expectations for the course (DeBourgh, 1999).

Most studies of the effectiveness of online courses have found that students report high satisfaction with distance learning courses regardless of the technology used for delivery of the course (Leonard & Guha, 2001; Phipps & Merisotis, 1999; Smaldino, 1999). This is the case with the STS course described. Students did report satisfaction with the course offered through the WebCT course shell. The accessibility and feedback from the instructor as well as the materials for the class did play a role. While reports of dissatisfaction were minimal, they were most often associated with the need to access materials that were not readily available.

Distance Learning Versus Face-to-Face Learning

While there is a call for more research to determine the effectiveness of distance learning as compared to face-to-face learning (Liebowitz, 2002), the bulk of the available research suggests that the two types of delivery are comparable. A literature review of 248 research reports, summaries, and papers found that there was no significant difference in the outcomes of distance learning opportunities and traditional face-to-face opportunities (reported in DeBourgh, 1999). Overall, distance learning has been found to be as effective as face-to-face instruction. This seems to be especially the case when students perceive timely teacher feedback (Marquart & Kearsley, 1999). In one study which used a "Can-Do-Cannot-Do survey" to determine if students in an organizational behavior course taught both face-to-face and online felt they had accomplished the course objectives, "the online students believed that they had achieved the course objectives to, at least, the same extent (98 percent) as the face-to-face students (Liebowitz, 2002)."

In some cases, students and instructors perceived that online courses were even more effective than face-to-face courses. This seems to be due to the ability to reflect on concepts before commenting. Chatel (2001) stated

> the physical absence of the teacher seems to force students to reflect more on problems and concerns before asking any questions because there will be no immediate response as there would be in a traditional classroom…students have time to reflect on the problem and often arrive at a solution without the assistance of the teacher or peers.

An instructor new to distance learning stated “what impressed me the most about this format was the thorough, insightful, analytical, and well-written paragraphs and posts that the students posted on the bulletin board. I could tell that ‘the wheels were turning’!(Liebowitz, 2002).” The instructor went on to explain

> my perception was that being able to wait a few seconds before typing what they would say allowed the students to put some thought into their responses…before reacting to the other students’ typed statements. Being able to slow down the dialogue seemed to help the students learn to apply their new people skills...(Liebowitz, 2002).

Fran McCall, a 44 year old student at the University of the District Columbia stated “it’s the typing…that often forces mature discussions. When people write their comments they pay more attention to detail and get to the meat of the subject…it’s even honed my ability to agree to disagree (Boser, 2003).”

As was the case in the studies mentioned here, students and the instructor for this course did seem to feel that the format for this course was as effective, if not more so, than face-to-face courses. Students felt that they really built a sense of community and were able to more deeply explore new learning and understandings.

Constructivism and Online Distance Learning

Many have expressed the need for more research to determine the effectiveness of distance learning in general as well as the possibility of delivering distance courses using constructivist learning principles. According to Diaz and Cartnal, (1997) "research is indeed needed to determine the effectiveness of distance learning versus face-to-face learning." The Institute for Higher Education Policy report entitled "What's the Difference? A Review of Contemporary Research on the Effectiveness of Distance Learning in Higher Education" concluded that "despite the large volume of written material concentrating on distance learning, there is a relative paucity of true, original research dedicated to explaining or predicting phenomena related to distance learning (Phipps & Merisotis, 1999)." Several key shortcomings and gaps were identified in the extant research. A discussion of these follows.

The concerns over the research (or lack there-of) have reinforced some ongoing reservations about distance learning in general. The American Federation of Teachers passed a resolution that stated that an undergraduate degree earned entirely through distance learning avenues is not as high in quality as one earned in a face-to-face setting (Carnevale, 2000). Further, in a report for *The Tallahassee Democrat*, John D. McKinnon suggested that "even at Florida Gulf Coast University, a university 'built as a testing ground for Internet-based instruction', faculty expressed serious concerns and reservations regarding the effectiveness of distance learning (McKinnon, 1998)."

It stands to reason that if the research is not available concerning the impact of distance learning courses in general, then there is an even greater void concerning the possibilities for constructivist pedagogy in distance learning environments. As Gail Marshall stated in the work “Models, metaphors and measures: issues in distance learning” (Marshall, 2000)

> at present, work in distance learning situations is based on pragmatic applications of one or another epistemology, behaviorist or constructivist but we have little systematically collected evidence of any deep or lasting impacts. We cannot point to well-done models because few models exist which have been thoroughly subjected to rigorous analysis/evaluation.

The question that arises is whether online distance courses support pedagogy that is based on these constructivist components. Those few studies of the presence of constructivist principles in distance learning environments that have been conducted found that these principles were not present in most cases. As part of a study to identify the characteristics of constructivism and their presence in face–to-face and distance learning courses, Tanenbaum and others (Tanenbaum, Naidu, Jegede, & Austin, 2001) identified seven components of constructivist teaching and learning. These included room for arguments, discussion, and debates; conceptual conflicts and dilemmas; opportunities to share ideas; problem solving opportunities; reflection and investigation of concepts; meeting the needs of individual students; and opportunities for meaning making. This study found that, despite the intentions of the instructors in both settings, these components were not present to any great extent in either. According to Marra and Jonassen (2001), “very few online learning environments that we have examined throughout higher education engage learners in solving problems. Rather, most online learning that we have examined replicates in structure and function of traditional classroom instruction."   They deduce that the reason that these constructivist approaches to learning are not predominant in distance learning is that the "affordances of online course development, delivery, and management systems do not support constructivist learning."

There are however, those who believe that the technology that exists for delivery of online distance learning does lend itself to constructivist principles and that online courses can embrace constructivist philosophies. Some researchers feel that there are many aspects of the available technology which support and even enforce the interactions necessary to help students in the construction of knowledge. These include the use of synchronous and asynchronous communications such as email and threaded discussions, hypertext to allow for debate, and the availability of information on "real life problems" (Chatel, 2001; D. Jonassen, Collins, Campbell, & Haag, 1995). Wagner and McCombs (1995) believe that students participating in online courses must work more independently, creatively, and actively than in many of the traditional face-to-face courses.

The course described here does exhibit the principles of constructivist science education. There is evidence of each of the seven components of constructivist teaching and learning as described by Tabenbaum et.al. (2001) Student participants in this course are given room for arguments, discussion, and debates; conceptual conflicts and dilemmas; opportunities to share ideas; problem solving opportunities; reflection and investigation of concepts and opportunities for meaning making. Further, the course seems to meet the needs of individual students by allowing them to determine their own course of study and to select issues of personal interest as the focus of the learning activities.

While the literature noted indicates that the use of WebCT could be a barrier for learning. In this case the WebCT shell was used in such a way that it did allow for learning in a constructivist atmosphere. The way the course was designed using the WebCT shell did not hinder the experience. In fact, the format of the course using the WebCT shell seems to lend itself to these constructivist principles. While other types of technology such as streaming video and hypertext and threaded discussion capabilities, may enhance the experience for participants, the format here did not seem to hinder the experience for the students.

Barriers and Problems for Online Learning

One study on four students that participated in online distance learning and student strategies identified four main themes that emerged as the course progressed. These themes included "web site design flaws, cognitive and coping strategies, the effects of virtuality and learning differences (Sullivan & Lucas, 2001)." Galusha (1998) identified five categories of access barriers to distance education.

Cost motivators. The first of the five categories identified by Galusha was labeled cost motivators (Galusha, 1998). This suggests that cost was a factor in limiting student access and satisfaction to distance courses. However, a study reported by Zirkle (2002) found that neither cost nor individual financial situations as significant barriers. As was the case reported by Zirkle, cost was not found to be a barrier for this course. However, since this course was studied beginning at a point after students had decided to participate, there is no way to know if cost had an effect on students who did not elect to take the course through a distance avenue.

Feedback and teacher contact. Another category identified by Galusha was the need for feedback and teacher contact (Galusha, 1998). Jones of Southwest Missouri State University School of Teacher Education suggests that faculty participation in online course delivery may have to “include a retooling of your skills to become a facilitator of discussions and new strategies for deepening online dialogue in order to enrich learning opportunities rather than general questions often asked in traditional face-to-face classrooms (Jones, 2003).” Further, in a study of instructor’s participation in Internet-based instruction, Wang-Chavez and Branon found that one of the major difficulties experienced by instructors was finding the time to facilitate online discussions and provide quality feedback (Wang-Chavez & Branon, 2001).

The course syllabus for any online course may be a crucial element in maintaining contact with students. Providing an in-depth understanding of the course structure and expectations may be one way to help to facilitate learning and help students to feel that the instructor is providing needed guidance for the learning experiences (Chatel, 2001). Cyrs (1997) feels that the syllabus is the “single most important communication device” for students participating in distance education experiences. Susan Jones (2003) suggests that instructors should provide students with “accessible information in order to function within the online community… (The information) can be written in a detailed syllabus and placed online for anytime, anyplace access. This syllabus should contain many of the same components of traditional syllabi with some additions but greater detail.”

The syllabus for this course was an integral part of the learning experience. This extensive online document provided students with the information and guidance for completing the course. Information was not limited to the traditional list of class dates and assignments but also included instructions for using the technology, links to required materials, and guidance in planning a course of study among other things. Further, the instructor for this course had the ability to guide the class through the online format. She found the time needed to successfully facilitate the online discussions and provide feedback as needed.

Need for student support services. The third category of access barriers was the need for student support services (Galusha, 1998). This includes the need for technological support services as well as other services related to the course. Technology that was inadequate, not working, or expensive also presented obstacles to successful completion of online distance courses ("A view from the trenches: E-learning entrepreneur Matthew Pittinsky talks about the latest trends", 2004). There is definitely a need for an effective network of technical assistance for students participating in online courses (Kiser, 1999; Zirkle, 2002). Beyond the need for technology support was the need for access to other types of materials and tools (Marra & Jonassen, 2001). Many students express frustration over problems around library materials required for the courses. The student felt that the materials were either unavailable, or they were uncertain as to how to obtain the needed materials (Garland, 1993; Zirkle, 2002).

While technology problems were present for students in these two sections, they did not seem to be debilitating. After the initial period of getting used to the system and the technology, problems were rare. The course instructor and designer were both instrumental in avoiding the need for support services for the students. The instructions for many technology requirements for the course were included in the syllabus. These instructions were in-depth and written in easily understandable terms. Thus, the need for assistance was reduced. When assistance was needed, students were told where they could call or contact on campus for technical assistance. Since most problems that were mentioned were only mentioned once, the technological support for students seemed to be sufficient. In one case, a particularly technologically savvy student was able to help others in the class with any assistance needed. This easy accessibility of help did seem to relieve this barrier, and indeed students in that particular section of the course did not perceive the technology as a barrier at all.

Alienation and isolation. Alienation and isolation were also identified as access barriers (Galusha, 1998). Early expectations for "instructorless education" were never realized and in fact those courses with limited personal contact and text-only type instruction via the Web suffered from dropout rates of as high as 60% (Boser, 2003). As stated in "E-learning: Working on What Works Best" (Boser, 2003) "…perhaps E-learning's biggest irony, even with the best technology, (is) it will always need the human touch to be effective." A review of the literature shows that the feelings of isolation are a predominant problem for participants in online courses. Social interactions that occur in traditional face-to-face courses are missing from courses taught through distance avenues. Students do not feel that they belong to a scholarly community (Fast, 1999; Galusha, 1998; McIsaac & Gunawardena, 1996; Zielinski, 2000; Moore, 1989; Wagner, 1994).

Simpson and Galbo (1986) defined interaction as:

> behavior in which individuals and groups act upon each other. The essential characteristic is reciprocity in actions and responses in an infinite variety of relationships: verbal and nonverbal, conscious and nonconscious, enduring and casual. Interaction is seen as a continually emerging process, as communication in its most inclusive sense.

Sorensen and Baylen conducted a survey of students participating in online courses and found that concerns over lack of interaction actually had two facets. Students expressed lack of teacher-student interactions as well as student-student interactions (Sorensen & Baylen, 2000). Learner-learner as well as learner-instructor interactions are extremely valuable and can help students deal with complicated situations for learning related to factors such as cultural differences, age, experience, and learner autonomy (or the lack of autonomy) (Belanger & Jordan, 2000; Moore & Kearsley, 1996). Actually, Moore (1989) identified three types of interaction in distance education. The three types are: learner interactions with the instructor, learner interactions with the content, and learner interactions with other learners. Hillamen Willis, and Gunawardena (1994)suggested a fourth type of interaction; that between the learner and the medium (or learner and the interface). Fulford and Zhang (1993) suggest that the perception of interaction by students in distance courses was an important indicator of student satisfaction.

Students participating in online distance learning may need to develop new “study skills.” Skills which seem to be prominent in reports from students involved in distance learning are time management, task management, and “electronic team skills” (Deal, 2002; Phipps & Merisotis, 1999; Vrasidas, 2000). It would appear that development of these skills would alleviate the barriers. The “electronic team skills” would help students develop relationships with fellow students and allow for collaborative and cooperative work as a part of the learning experience.

In addition to student's developing new skills to ensure the needed interactions, course designers can help to facilitate interaction by organizing courses that offer opportunities for all types of interaction and planning instructional activities that provide the appropriate type of interaction for that specific activity. Designers need to take into account the appropriate type of interaction for a specific learning goal or activity as well as the stage of growth and needs of individual students (Murphy, Cathcart, & Kodali, 1997; Zheng & Smaldino, 2003).

There are possibilities available through the courseware packages which do facilitate the social interactions necessary for successful online course presentation. "Electronically mediated communications, computer-supported collaborative work, case-based learning environments and computer-based cognitive tools" all help to provide the necessary interactions (Chatel, 2001). One student who participated in an online distance course actually reported that "she felt like she got to know the students in the online class in a way that she seldom did in a face-to-face class (Sullivan & Lucas, 2001)."

For those students who do not feel a connection with fellow students, instructors may find it necessary to provide opportunities for different types of interaction which are appropriate for the specific tasks in a learning opportunity. This may be made more difficult by the fact that, in many situations, only one medium is used for delivery of the course (specifically the type of media with which the instructor is comfortable or familiar). Instructors need to consider using a variety of media (Moore & Kearsley, 1996). According to Beverly Bower (2001)it is clear, however, that to create an equivalent experience in the distance education environment requires more planning on the part of the instructor and more effort on the part of the student.

Students participating in this course did not express feelings of alienation or isolation. In fact, many expressed more of a feeling of community than they had felt in previous courses taught in a face-to-face environment. As a result of participation in this class, students seemed to be comfortable with “electronic team skills”. While the delivery medium for the course was for the most part, text driven, students had many opportunities to interact with fellow participants. The class offered many varied opportunities for interactions with fellow students beyond the online discussion through the use of collaborative and cooperative group projects.

Lack of experience and training. The final barrier identified by Galusha (1998) is the lack of experience and training. There are some basic skills that are crucial in order for students to be successful in online courses. Nunes et.al. (2000) identified four basic skills that are necessary to succeed in the online learning environment. These skills include at least a low level of understanding of computer mediated technology, online etiquette, web navigation, and web searching. In the studies that have been carried out concerning online distance learning, one of the most frequently mentioned issues that affect success in distance learning courses is the technology skills required for participation (Chatel, 2001; Deal, 2002; Murphy et al., 1997). These studies suggest that the frustrations, anxieties, and negative attitudes toward the online courses as well as student dissatisfaction are caused most often by technical aspects of the courses (Chatel, 2001; Thomerson & Smith, 1996).

The technical aspects of this course did not seem to be a barrier. Participants seemed to have the basic skills necessary for success in an online course. While some students had to learn how to use new software or how to create web-based products, the basic skills were not of issue.

Faculty Concerns

Design and implementation of online distance courses that provide students with constructivist learning experiences lies directly on the shoulders of the teaching faculty. In the paper "Distance Education: Facing the Faculty Challenge", Beverly Bower states, "faculty have specifically expressed concern for the adequacy of institutional support, the change in interpersonal relations, and quality" of distance education (Bower, 2001). With this in mind, there is also a need to conduct research which investigates faculty perceptions about distance education and how these perceptions affect their participation in these courses (Gannon-Cook, 2002).

It should be noted that "a good traditional professor doesn't automatically become an effective distance learning professor (Chatel, 2001)." Willis (1994) suggests special challenges which are present for distance learning instructors. These challenges include the ability to understand the needs and characteristics of the students despite the lack of face-to-face contact, changes in teaching style and course content according to the needs of the students, understanding the technology used for delivery, and a shift from a transmitter of knowledge to a facilitator and "guide on the side". In describing the factors that influence the success of an online course, Chatel (2001) states that in order for a course to be successful, the instructor must accept the fact that he or she is no longer in complete control of every aspect of the course.

Willis (2000/2001) points out that classroom instructors can depend on visual cues in order to make adjustments in the course delivery. Distance instructors he notes do not usually have access to visual cues. Further, with the use of online delivery, the spontaneous nature of the discussions is lost. This changes the complexion of the course and presents a different set of obstacles which must be maneuvered by the instructor.

In the paper "Limitations of Online Courses for Supporting Constructive Learning", Marra and Jonassen (2001) state that the many barriers facing distance learning faculty

> include the amount of faculty time required to patch the course together, the frequent lack of faculty technical competence, administrative pressures to use a particular course delivery package because of licensing agreements and technical support, not to mention the compromises in course effectiveness and communication problems resulting from these patches.

UCLA's Higher Education Research Institute (HERI) found that 2/3 of college and university faculty rate the stress of keeping abreast of information technology above the stresses associated with research and publishing demands, teaching loads and the tenure/promotion process ("Faculty survey", 1999). These stresses could be reduced with the design of a "support model for faculty endeavors that will encourage the brightest, best and busiest faculty to seriously consider Web-basing their coursework (Crawford, 2002)."

In the 2000/2001 ASTD (American Society for Training and Development) distance learning yearbook, Willis (2000/2001) lists five issues to which distance educators need to pay attention. First he suggests a variety of presentation methods including discussions, presentations, and student-centered activities. Second he suggests the use of many relevant and local examples to help students relate content to the “real world”. Next, he suggests that statements and questions be short and direct in order to compensate for the increased time for students responses related to the use of technical equipment. He also suggests the use of email, phone and other strategies to reinforce, review and provide remediation for students. Finally, Willis urges the instructors to relax and allow students to become comfortable with the format. Once they have become comfortable, effective teaching and learning will be possible.

The course studied here would suggest that the faculty concerns are valid. Faculty members who develop online courses need the support of the college or university in a variety of ways including time considerations, financial considerations, and technological support. Further, the instructors and developers for these courses must appreciate the differences in delivery and requirements as compared to face-to-face courses. These instructors must also have the ability to facilitate learning in this non-traditional format.

Courseware Concerns

As Web-based instruction becomes more and more common for delivery of courses, concerns about the capabilities of the available courseware packages are becoming more prevalent. As stated previously, the choice of courseware is often dictated by the college or university, and faculty members are locked into a specific package for delivery of online courses. Firdyiwek (1999) reviewed three online course packages including WebCT, TopClass, and Web Course in a Box. He concluded that all of the packages are capable of supporting “competency-based teaching of discrete information and processes” and thus support the behaviorist pedagogy. However, these packages were not capable of supporting more constructivist type instruction. The Center for Curriculum Transfer Technology (CCTT) reviewed 46 software packages for online course delivery. The reviewers concluded that none of the packages provided support of assessment that could provide evidence of meaningful learning. Assessment tools were limited to quizzes, multiple choice, long and short answer, true/false, matching and ordering (reported in Marra & Jonassen, 2001) claim "three major limitations of these systems create significant barriers to implementing constructivist learning principles in online courses." These limitations were: 1) "The ability to efficiently and effectively accommodate multiple, alternative forms of student knowledge representations…online course systems support only quizzes, online discussions (with no evaluative support), and the submission of word-processing documents;" 2) "The ability to provide and support authentic assessment (either with tools for the instructor or tools to help communicate these assessment data to students)…The over reliance on single forms of assessment (especially quizzes) precludes the assessment of meaningful learning;" 3) "The ability to support distributed tools for meaning making…online course developers who require this functionality to support learning find it difficulty to provide access to tools and to support the learning of the tools."

While reports that the delivery systems for online courses are insufficient for delivery of constructivist learning opportunities, the WebCT system used here did seem to be sufficient for delivering a Web-based constructivist science education course. It appears that the lens through which these courseware packages have been reviewed is more traditional in nature and does not view the courseware through the constructivist lens. While the courseware does not support the constructivist principles for a learning experience, the design of the course can. For example, many different forms of attachments can accompany the courseware and provide a variety of experiences for the participants. Students were able to use other software in order to elaborate and elucidate meaning making. Computer-based presentations and concept maps were developed and attached to the discussion and email delivered through the course system. Further, many links to streaming video and other Web-based material were available.

More traditional aspects of the courseware (such as the support of online quizzes or other assessment tools) were not used as a portion of this course. Rather, assessment was embedded in the instruction and evaluation was based on this, and not on more traditional means. Those components of the courseware that did not support constructivist principles were simply not included as part of the course design.

Guidelines and Suggestions for Developing Online Constructivist Courses

Despite the lack of research concerning on-line courses and even less on constructivist online courses, there is no lack of written suggestions for developing these educational opportunities. One theme that seems to run through all discussions of online distance learning is the need to avoid some very common mistakes in presenting courses online. According to Schieman, Teare, and McLaren (1992) designers must avoid a "standby approach where traditional on-campus courses are re-worked slightly" and then offered as online courses.

In 1999 The Institute for Higher Education Policy (IHEP) was commissioned to evaluate benchmarks which had been developed to ensure quality distance education. IHEP conducted a three phase study which consisted of a comprehensive literature search, identification of institutions with a great deal of experience in Internet-based distance education, and a study of six of the institutions with the experience. The study resulted in the identification of forty five (45) benchmarks which were combined to produce a list of 24 benchmarks that are essential for the delivery of quality Internet-based courses. These benchmarks are categorized into seven (7) specific categories. The categories include benchmarks for institutional support, course development, teaching/learning, course structure, student support, faculty support, and evaluation/assessment ("Quality on the line: Benchmarks for success in internet-based distance education", 2000)

Traditionally, development of face-to-face instruction employed a linear model of curriculum development. This model is based upon objectivist philosophy and behaviorist learning theory. “All learners are expected to achieve those objectives and behaviors in the same manner (Vrasidas, 2000).” The linear model consists of four steps which are rigid and sequenced. The steps are: “1) Identify the objectives of instruction. 2) Select the useful learning experiences. 3) Organize the learning experiences in the best possible manner. 4) Evaluate learning (Vrasidas, 2000).”

In order for distance learning to employ a constructivist philosophy, the model for course development must change. Vrasidas (2000) suggests that a constructivist approach to distance education course design would have no distinct phases but the phases would be overlapping and ongoing. Jonassen (1992) suggests that the traditional imposition of goals and objectives would be replaced with negotiation. There can be no simple, best sequence for learning material. Further, the system design process would not focus on determining specific instructional strategies to bring about specific behaviors. Finally, evaluation would become less criterion referenced and more authentic and embedded in the instruction.

When developing distance learning courses, several questions must be considered. These questions include: What are the characteristics of the learners? What content, goals, and objectives are critical? What are the best learning/teaching strategies and type of technology? In what environment will learning occur? And, how will learning be assessed and evaluated? (Simonson, Smaldino, & Albright, 2000; Zheng & Smaldino, 2003). These questions represent five common themes that arise in discussions of distance education design; learner considerations, content organization, instructional strategies and technologies, and evaluation. With the exception of the technology, these match general instructional design issues (Zheng & Smaldino, 2003). It seems that in today's college class climate, however, technology issues are often of concern even in face-to-face situations.

Several groups have guidelines for developing distance learning opportunities. Suggested guidelines include: 1) Develop courses and consider the logistics well in advance; 2) Clearly articulate class assignment expectations and requirements; 3) Provide opportunities for collaboration; 4) Group students with different technology expertise in the same groups; 5) Provide students with training in the necessary technology; 6) Encourage and facilitate all types of interactions; and 7) Provide reasonable access to other resources such as library, and technical expertise (Biner, Dean, & Mellinger, 1994; Daines, Egan, Jones, Sebastian, & Ferrais, 1994; Murphy et al., 1997; O'Connor, 2002; Shneiderman, 1994; St. Pierre, 2002; Zirkle, 2002; Thomerson & Smith, 1996). Gibson (1998) feels that all distance courses should include content that meets the needs of the learners, clear directions for required actions, learner control of the pace of the learning, means for communication of concerns, prompt and clear assessment and evaluation, and access to materials that are relevant, and interesting.

The need for structure is crucial for students to succeed in distance learning situations.

> Structure, however, does not necessarily suggest an objectivist approach to instructional design. Good planning is a characteristic of good teaching regardless of philosophical paradigm. Clearly defined activities, student role, homework submission guidelines, course expectations, and evaluation procedures are characteristics of any well-prepared course (Vrasidas, 2000).

Web-based instruction has been defined as the “application of a repertoire of cognitively oriented instructional strategies implemented with a constructivist and collaborative learning environment using the attributes and resources of the World Wide Web” (Patton, 1985 as reported in St. Pierre, 2002) Perhaps it was best stated by Matthew Pittinsky, cofounder and chairman of Blackboard Inc. (one example of E-learning software) when he said, “the distinction between totally online learning and in-class learning is going to go away, and it’ll just be teaching and learning” ("A view from the trenches: E-learning entrepreneur Matthew Pittinsky talks about the latest trends", 2004).

Charles Dzinbam, director of the Research Initiative for Teaching Effectiveness at the University of Central Florida stated that “what works online isn’t very different from what works in a traditional classroom…Students need to be actively involved…It’s true in traditional classes, and it’s more true online (Boser, 2003).” Schneider (Schneider, 1998)asked the questions “are the new models built on earlier learning? Or are educators putting online a 'lecture-and-listen' model that never worked for most students in the first place?" He went on to state "We know students of the new providers (i.e. those taking courses offered via distance avenues) are getting credit hours; are they getting an education?" These and many other questions remain unanswered. The need for research on the possibilities and effectiveness of online constructivist learning opportunities is evident and should be addressed.

Summary

Current literature, while limited in amount and scope does support and is supported by the findings from this current study. This is an online science teacher education course that incorporates the principles of science education reform.

Findings from this study support and are supported by the literature in that students perceived it to be as effective, or even more effective, than face-to-face instruction. As suggested by the current literature, the make-up of the class (i.e. the age and situation of the members) as well as the opportunity to reflect on concepts before presenting them to the class and the availability of feedback from classmates prior to formal assessment seemed to increase students' perception of a "successful class".

Student perception of success and satisfaction with the course may be due, however, to other factors including the constructivist nature of the course and the extensive syllabus provided as a part of the Website. The fact that this class was a constructivist science teacher education course helped to encourage autonomous leaning and may have led students away from dependency on authority and the need for constant approval. Students in this setting would be more inclined to accept and be comfortable with more intrinsic rewards. This switch may have led to a perception of success based on a paradigm shift. More autonomous, self-motivated learners can enjoy the value of the varied learning opportunities for the sake of learning and not for the grade alone.

As noted here, there is a need for more research on the possibility of delivering online distance courses using constructivist learning principles. What research that is available found that most online learning replicates traditional instruction. Since most courses studied that are available as online distance learning opportunities were developed under the dominant paradigm, it is not surprising that there are few that exhibit the principles of constructivism. The course studied here does, however, offer one example of a constructivist online distance learning opportunity. The course is a science teacher education course, but it would appear that the findings here will translate to other areas as well.

The fact that few constructivist distance learning opportunities are available and the difficulty developing online constructivist courses have been attributed to the lack of current technology for delivery of instruction that embraces constructivist philosophies. The course delivery system used here (Web CT) did provide the necessary attributes for delivering this constructivist science teacher education course. Other currently available technology (available both commercially and as freeware) can even offer opportunities for face-to-face interactions. This can serve to help ease the need to overcome the perception of lack of interaction that may be present for some participants in online courses.

This study reinforced the fact that there are several barriers and problems that accompany online learning which may not be present in traditional classroom settings. However, the constructivist nature of the course and emphasis on autonomous learning, as well as interaction among participants seems to have helped learners overcome or compensate for these barriers and problems and thus minimize the extent to which they were realized. While cost may remain a barrier, other issues such as need for support services and training, isolation, and feedback concerns were not debilitating problems for class members. This is not to say that a strong mechanism for support for students and faculty through the college or university is not essential for success in distance learning opportunities. In fact, this support is essential in order for these programs to survive.

Some issues that remain of utmost importance in developing and delivering constructivist online courses are those concerning faculty. Those involved in online courses must understand the learner, the learning, and the available technology for delivery using constructivist principles. Further, it is important to understand that lack of face-to-face interaction time does not decrease (and indeed increases) the time needed for facilitation of the course.

Overall, it would appear that the course studied here does represent one example of an online distance learning science education course that incorporates the principles of science education reform. Further, it would appear that the lessons learned here can help in the development of other distance learning opportunities which exhibit the principles of constructivism.

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Appendices

Appendix A: Data Analysis

Initially, the course syllabi and contents of the different portions of the Web site delivered via a WebCT shell were used to develop a comprehensive description of the course. Following this, the communication database was transferred from WebCT to the QSR NUD.IST (1997) software program for qualitative data analysis. This program was used for management of the data throughout the research process. At this time, messages were separated into line-by-line units and extraneous information (such as names and dates) was deleted. The remaining data represented an exhaustive compilation of all communications between and among students and the instructor during the semester.

All of the compiled data were read as a means of gaining an overview of the data and to help generate initial impressions of things that might be important in the coding process. The data was then read line-by-line and a tentative coding scheme was developed as common concepts were realized. (Each new coding concept is referred to as a free node in the NUD.IST program). Constant comparison throughout the process led to adding, changing, replacing, or deleting nodes. As terms or phrases were repeated and emerged as important ideas, a string search for these terms was performed. In other words, a search for any noteworthy string of characters was done to find any references to a certain concept or point. (This is a NUD.IST function similar to the “find” procedure in any word processing program.) Once a term was identified, the researcher assigned it to an existing node, placed it in a new node, or ignored the term, as was indicated by the context of the string. Table 7 below reflects many of the initial nodes that emerged from the student communications database. Nodes were not all identified during the initial process. The iterative nature of this process led to changes and rearrangements as the research continued. Each node that is listed below housed a variety of entries from the database which reflected the nature of that node as it related to the students' communications during the course.

Table 7

Free Nodes that emerged from the student communications database

Free Nodes from student communications	
Reflection	Willingness to disagree
Collaboration	Paradigm shifts
"I get it"	Reason for direction of study plan
Feelings about distance learning in general	Ideas from students
	Disagreements among students
Comrades	The students
Frustration about design of the course	Excitement about activities
Metacognition/Assessment	Answers to questions
Frustration about current education system	Relief about expectations
	Frustrations about assignments
Understanding of goals of class	Questions for instructor
Control and responsibility	Examples of STS
Frustration about assessment	Computer help
What learning looks like	Basic concepts in media watch
What schools can look like	Teacher as facilitator
What students today look like	Feelings about instructor
Relationship to teaching	Society in media watch
Seeing beyond the class	Confusion about issues in readings/activities
Going beyond assignments	
Insecurity about expectations	Misconceptions about ideas
Relating experiences outside of this class	Problems with Web site
Active learning	Allowing the students to drive the class
Scientific discourse among students	
Students drive the class	Feelings toward the class in general

Free nodes were grouped into categories. These categories were grouped in the program using the formation of index trees. These trees offered a method of grouping nodes into categories with common themes. Again, this was an iterative process and required constant comparison with previously coded data. Trees were altered as new categories emerged and others were merged into previously existing categories. As indicated by Merriam (2001), these categories reflect the purpose of the research, are exhaustive, are mutually exclusive, are sensitizing, and are conceptually congruent. Categories were described according to properties. This information was used in the development of hypotheses. Various related hypotheses led to the development of theories. Table 8 below is a list of the categories that emerged as free nodes were grouped.

Table 8

Categories that emerged as free nodes were grouped

Grouped free node catagories	
Frustrations and Insecurities	Understandings
Interactions	General Student information
Beyond the class	Reflections
Feelings of independence and control	Responses to the Class

Figures 4 through 10 below are examples of the trees that emerged as a result of categorization of free nodes. Due to the iterative nature of this process, the trees changed throughout the process. The trees represented in these figures are ones that evolved early in the process. Many of the trees branched further as the process continued. For example, control of responsibility (figure 5) evolved to include both positive and negative responses to the control. Further, the willingness to disagree (figure 5) included disagreements with the instructor, with fellow students, and with the course materials.

Not all of the free nodes that emerged were represented in the tree development. This is due to the fact that the iterative nature of the process led to changes in the nodes and assignment of sections of the database to those nodes. Included in each figure are a few sample entries that were included in the node. These are not intended to be comprehensive listings of the entries included in each node. Rather, they are intended to be representative samples to help provide a clearer understanding of the process that was employed during the study.

Following each tree is a brief description of the findings that emerged from each category. A more comprehensive reporting of the findings can be found in chapter 5. It should be noted that the characteristics of constructivist learning opportunities as summarized previously informed this researcher about essential elements to examine when assessing the extent to which the distance learning course studied here reflects constructivist science teaching practices.

Findings associated with frustrations and insecurities (figure 1) included the following: 1) the instructor for this course was serving as a facilitator as opposed to a lecturer; 2) control was shared with the students; 3) participants in the class were engaged in questioning and reflection; 4) students were rearranging their preexisting cognitive maps; and 5) students were engaged in active learning as opposed to passive absorption of information.

The findings developed in response to the understandings category (figure 2) were that students were actively engaged in their education, were constructing knowledge, were developing deep understanding, were participating as reflective practitioners, and were indeed undergoing a paradigm shift.

Interactions between students (figure 3) led to the findings that this course had indeed been conducted in an environment of mutual trust and respect. Due to this, students felt comfortable expressing alternative viewpoints. Further, it was found that students were working collaboratively and cooperatively and had many opportunities for discourse. Topics addressed during interactions show evidence that students were engaging in reflection as well as self-analysis and metacognition.

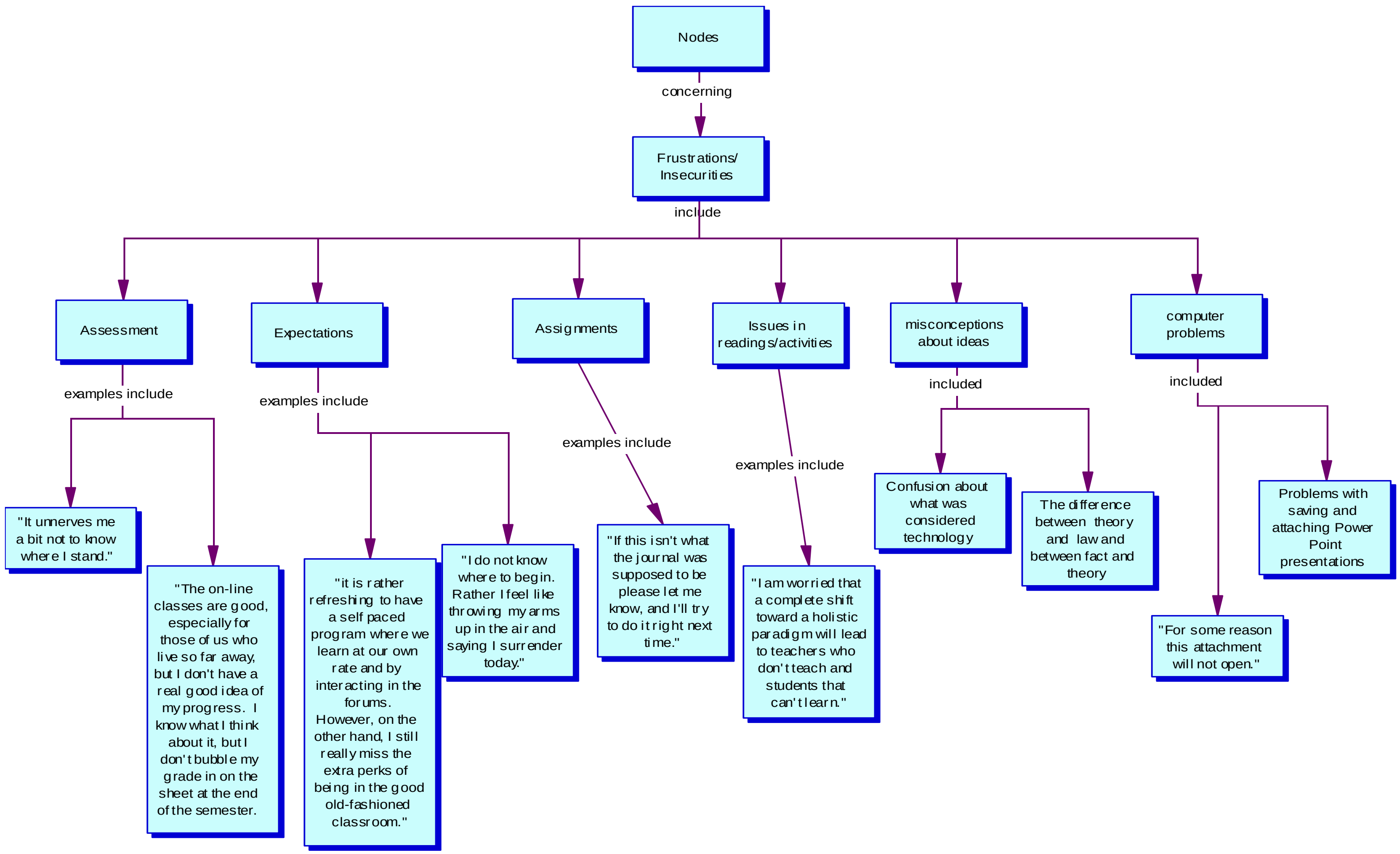

Figure 4. Frustrations and Insecurities Tree as it Emerged from Student Communication Database Including Some Sample Entries.

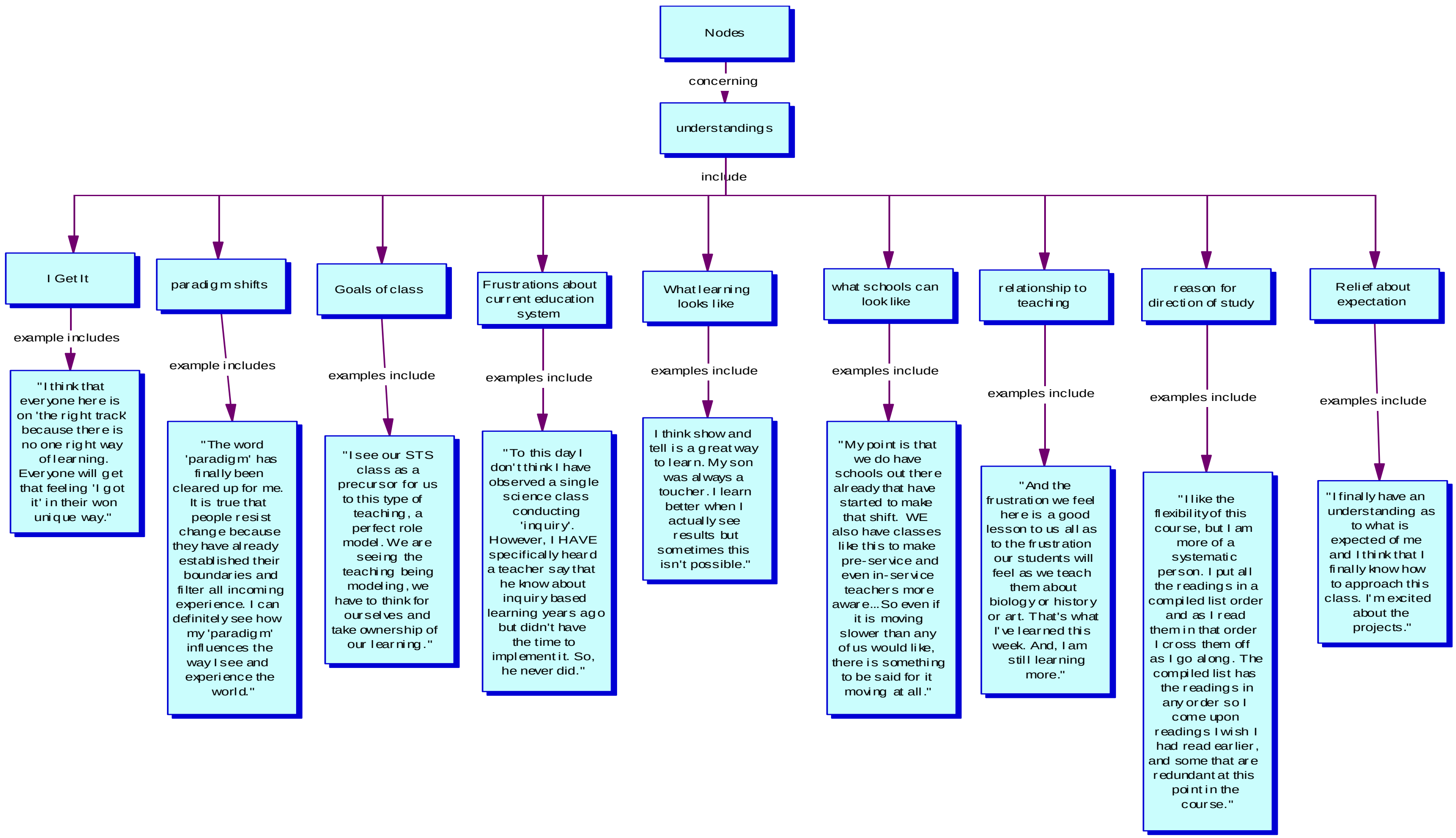

Figure 5. Understandings Tree as it Emerged from Student Communication Database

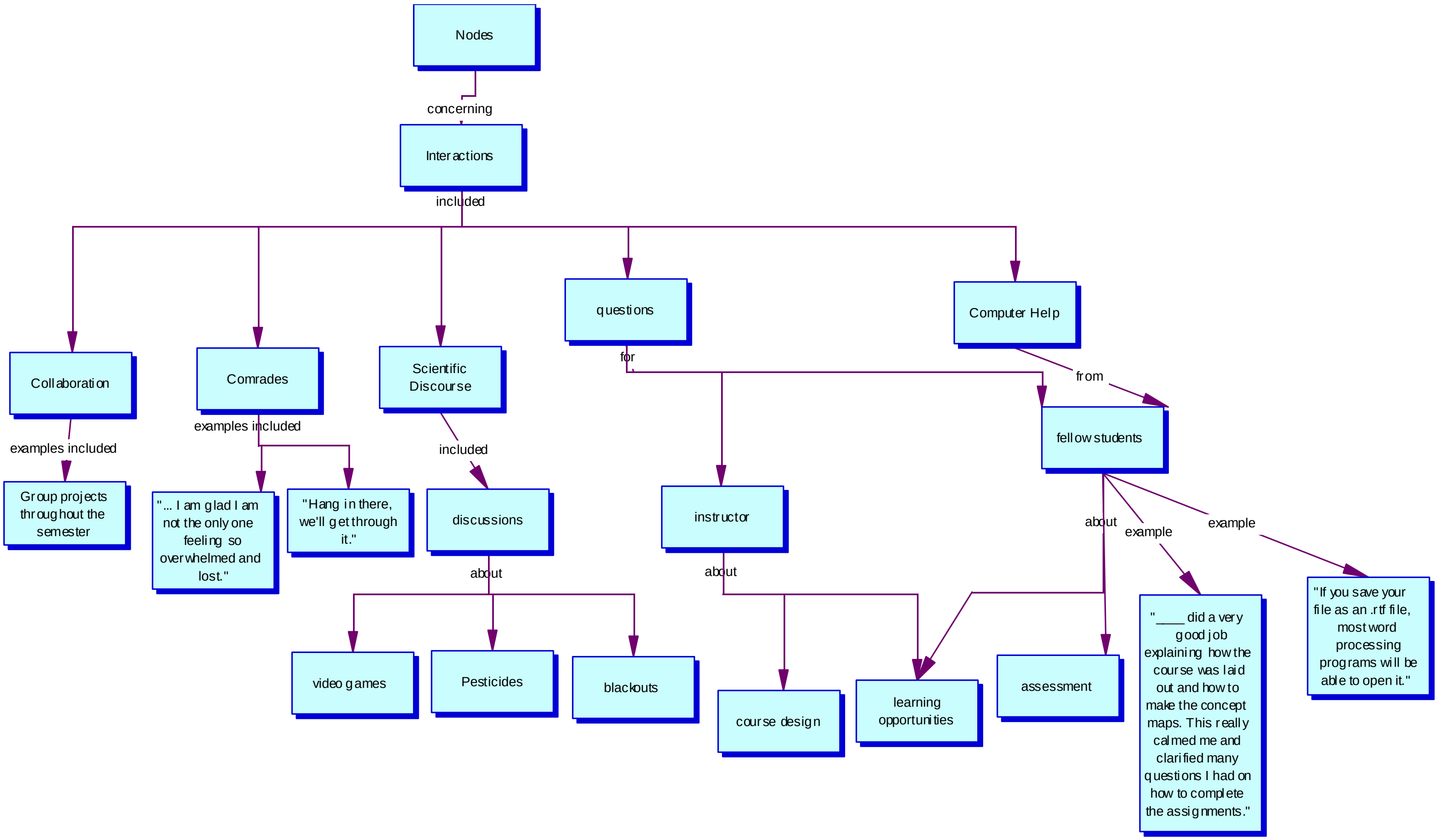

Figure 6. Interactions Tree as it Emerged from Student Communication Database

Appendix A (Continued)

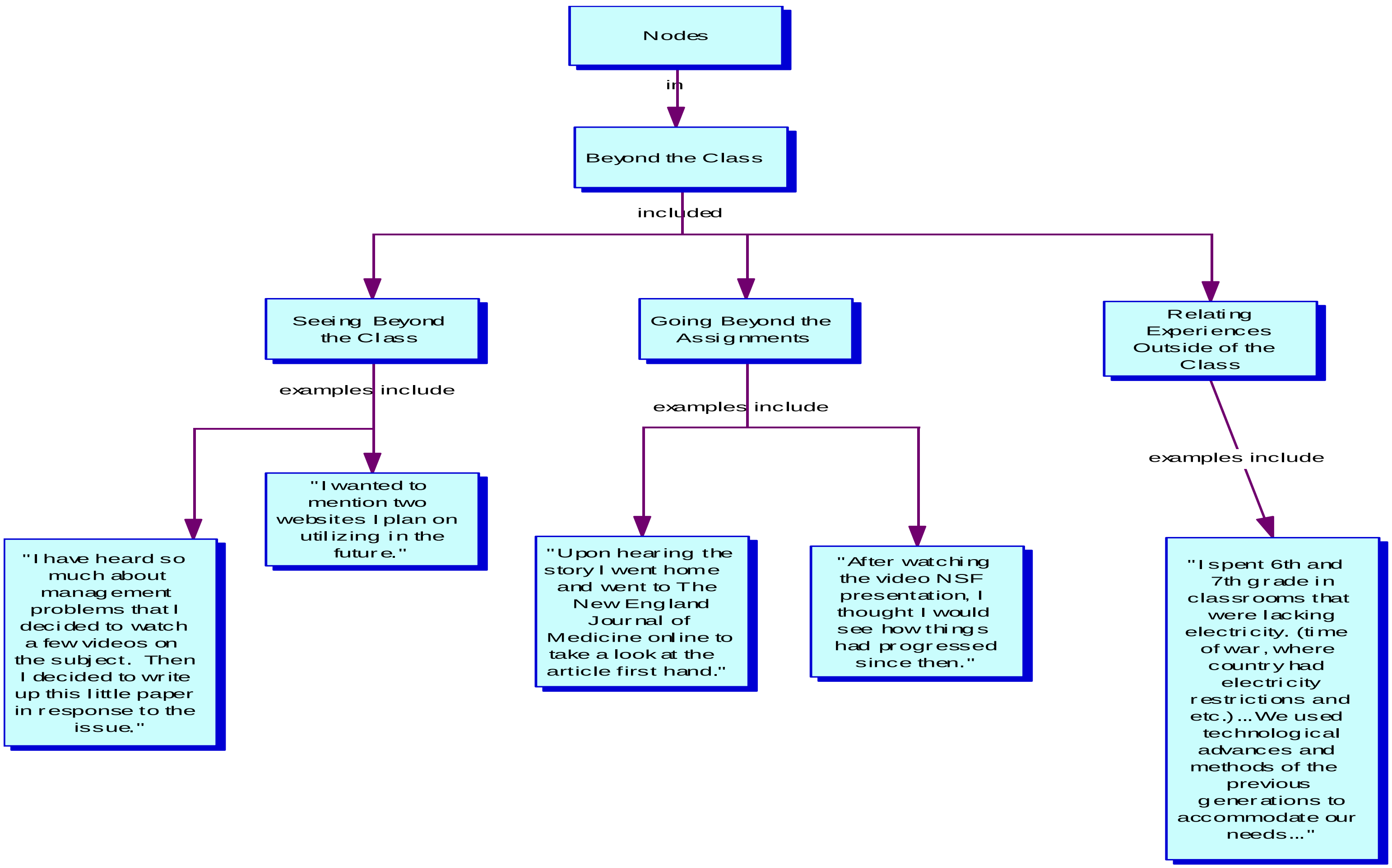

Figure 7. Beyond the Class Tree as it Emerged from Student Communication Database

Appendix A (Continued)

The category labeled "beyond the class" (figure 4) brought to light the finding that students were taking responsibility for their own learning. Further they were questioning their learning and the connections they were forming as a result of participating in the course. Experiences reported outside of the course requirements also reflected that students were constructing their own cognitive maps as they built on their prior experiences.

Students felt that they were in control of their own learning environments and they took responsibility for their own learning (figure 5). Further, there is evidence that they were comfortable with questioning the course make-up and requirements as well as expressing disagreement with the course and with information presented by participants in the class.

Appendix A (Continued)

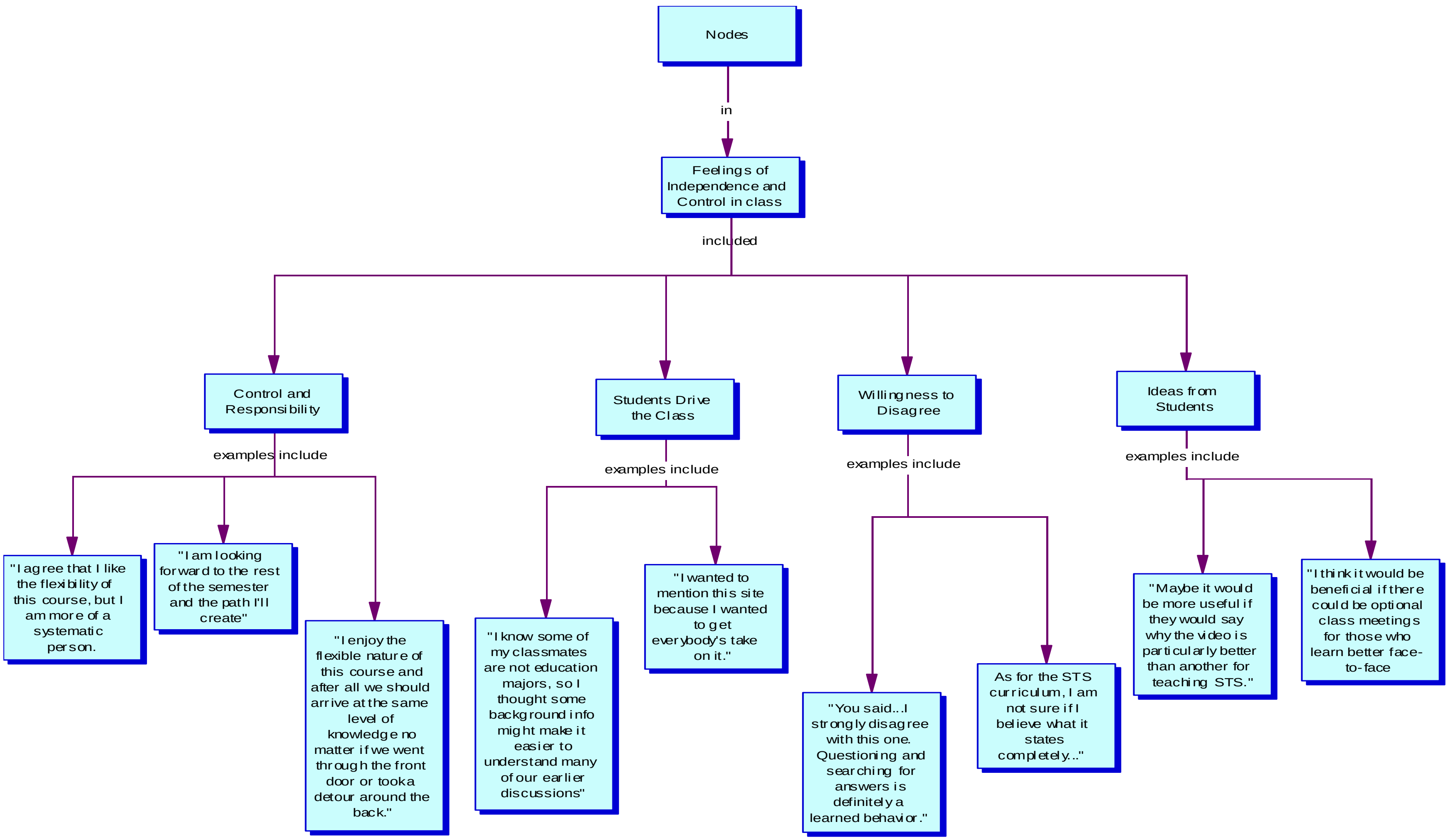

Figure 8. Feelings of Independence and Control of the Class Tree as it Emerged from Student Communication Database

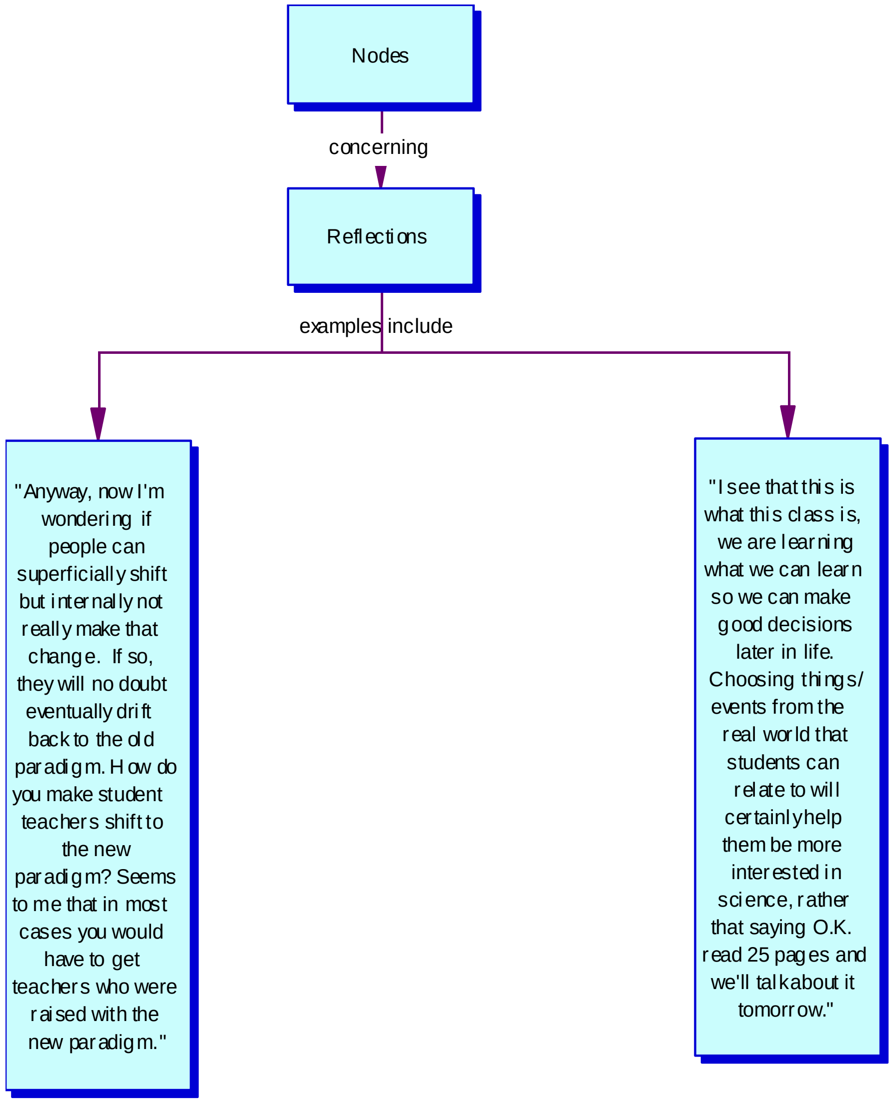

Figure 9. Reflections Tree as it Emerged from Student Communication Database

Reflections from students indicate that students were participating in self-analysis and were reflective practitioners throughout the course.

Appendix A (Continued)

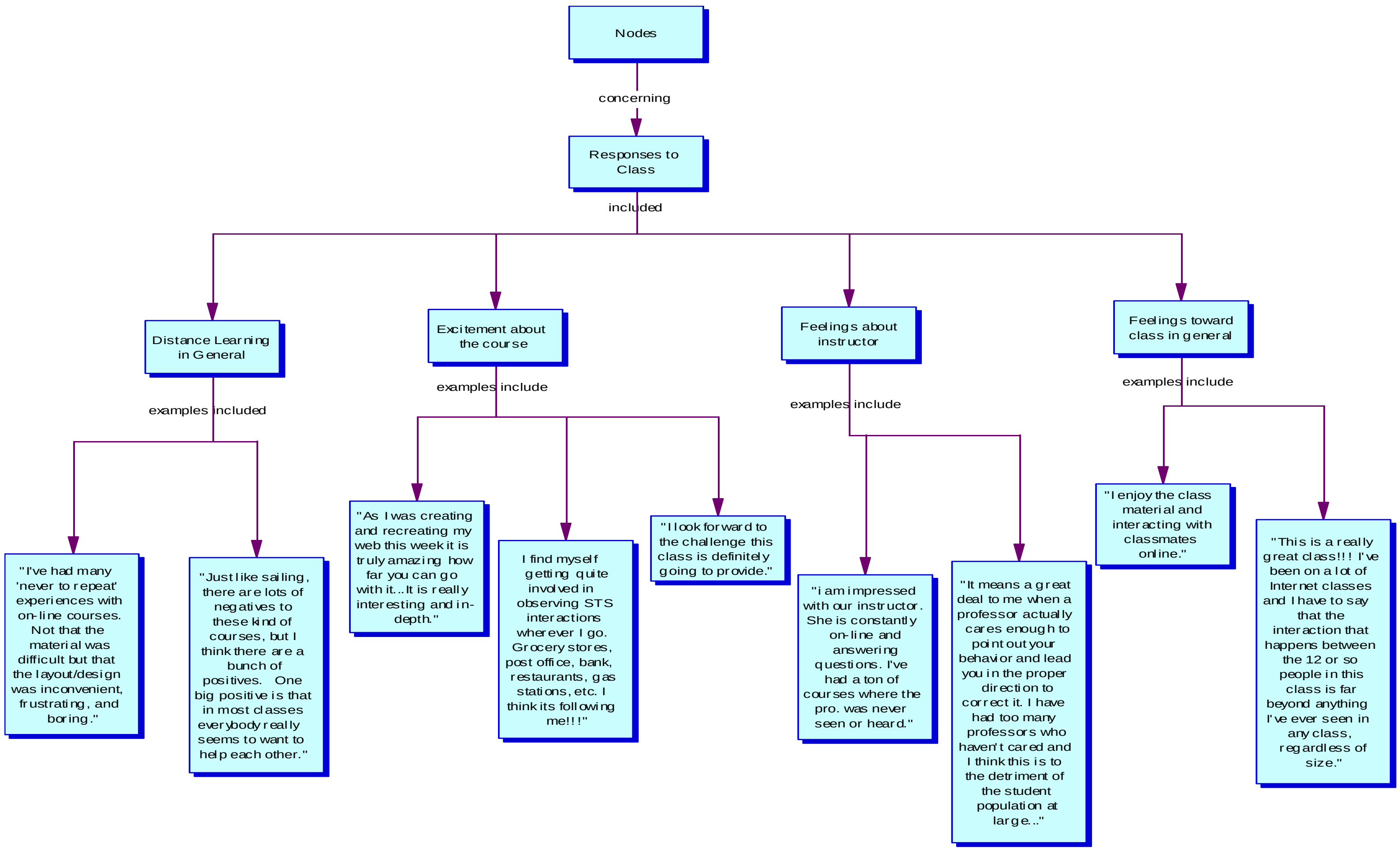

Figure 10. Responses to Class Tree as it Emerged from Student Communication Database

Responses to the class showed that students were actively involved in the class despite the distance. Further, they were able to work as collaborative and cooperative partners and even felt a strong sense of community as a result of participation in this course. There was some feeling of disconnect with the instructor, however.

As theories were developed, findings were checked by reviewing the database, and member checks. The findings are herein reported in a written report detailing them and include quotations from the students and instructor. The information gained from the study was used to speculate about what will, or can, happen in the future, and what is needed to develop effective distance learning courses for science teacher education.

About the Author

Cherry Orr Steffen holds a bachelors degree in elementary education from the University of Richmond, in Richmond Virginia. She taught sixth and seventh grades in Kilmarnock, Virginia and Fredericksburg Virginia before moving to Tampa, Florida to complete a master's degree in Botany at the University of South Florida. During the time she was completing her Ph.D. she worked as a marketing director for a partnership between the University of South Florida, The Museum of Science and Industry in Tampa, Florida, and the Hillsborough County School District. Her work with this partnership centered on the recruitment of science and math teachers. Since leaving Tampa, Cherry has been an assistant professor of elementary and early childhood science education at Kennesaw State University in Kennesaw Georgia.