The use of technology in meeting science reform criteria: Can web-based instruction promote scientific literacy?

Karen Fay Vogt

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THE USE OF TECHNOLOGY IN MEETING SCIENCE REFORM CRITERIA:
CAN WEB-BASED INSTRUCTION PROMOTE SCIENTIFIC LITERACY?

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Interdisciplinary Studies

by
Karen Fay Vogt

June 1999
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Approved by:

Dr. Bonnie Brunkhorst, Chair,
Science, Mathematics, and Technology Education

Dr. James Monaghan

Dr. David Maynard, Chemistry
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ABSTRACT

Science educators are currently facing the challenge of reforming the practices of science education. Publications of various science and educational organizations have established new criteria for accomplishing this goal. The new goal of science educators is scientific literacy for all. It is thought that this task can be accomplished through scientific inquiry. Research studies have been conducted that demonstrate the effectiveness of using instructional technologies to promote learning, including inquiry learning.

This project investigated if the Web-based Integrated Science Environment (WISE) could be used at the 6th grade level to promote scientific inquiry. An integrated unit of study, which focused on the Solar System, was constructed using the WISE software. The project was piloted with 6th grade students with the intention of discovering whether they were able to use scientific inquiry to acquire, construct, and apply new knowledge toward a design task. Results revealed that 6th grade students were able to acquire new content knowledge, but were not successful at constructing and applying that knowledge toward a meaningful design task. Additional research needs to be conducted to determine why students at the 6th grade level were not able to demonstrate higher levels of learning such as synthesis and application.
ACKNOWLEDGMENTS

I wish to acknowledge the two instructors from California State University at San Bernardino who made this project possible. Dr. Bonnie Brunkhorst is an outstanding member of the science education community. She is an encouragement and an example for all who desire to make science education authentic. Dr. James Monaghan challenges and prepares his students in the area of instructional technology, and is able to identify the interests of his students. Dr. Brunkhorst helped me to focus my goals in science education, and Dr. Monaghan introduced me to the WISE project. Their involvement in my education has led me toward an exciting path of using instructional technologies in science education.
DEDICATION

I dedicate this project to my husband, Rick, and my daughter Kierstin. Thank you, Rick, for all your encouragement and support which have enabled me to juggle being a mother, wife, student, and teacher all at the same time. Your ability to be an awesome dad has allowed me to pursue professional career interests. Thank you, Kierstin, for being understanding and patient when Mommy has been busy with school. Now that this work is completed, we will have more time for the park! I love you both very much.
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CHAPTER ONE

Past History of Educational Reform

Throughout history, major events have occurred which have triggered significant changes in American society. As a direct result, changes within the realm of education, particularly science education, also became critically important. Two major issues for science education that have changed due to the societal flux in history have been what is to be learned, and why students are to learn it.

A review of science education history reveals that there has been three major ideas of what science should be learned (Bybee & DeBoer, 1994). These three goals included 1) acquiring and understanding scientific knowledge, 2) learning the processes of science, and 3) understanding the personal and social applications of science. Science knowledge includes accumulated information such as facts, theories, laws, principles, and concepts. Science process is a method of investigating an object of study. Science application is relating science to the impact it has on our world.

The what of science learning is directly related to the why. Both reasons and goals of learning science can be likened to the swing of a pendulum, swaying back and forth throughout history. “These three goals have been repeated, with continuing variation, through the 200-year history of science education in the United States” (Bybee & DeBoer, 1994, p. 380). The 19th century why of science was based on the needs to discipline the mind and for personal development. The 20th century bases its why in the need for problem solving and improving our society as it faces a need for economic and national well being.
In the early 1800’s, the goal of science education was scientific knowledge. This was primarily due to the need to support theological ideas. The goal of personal and social development was also seen in education’s attempt to ‘develop the child’ and ‘develop faculties’. Toward the middle of the 1800’s a shift occurred in the goal of scientific knowledge. Huxley and several others introduced the concept of acquiring knowledge through the use of a scientific method. The goal of science education included mental discipline and purposeful learning of science concepts. In the late 1800’s, as a result of post civil war activity and increasing industrialization, educators felt the need to return to a primary goal of scientific knowledge. This goal was approached differently again, with a need for broader scientific ideas. Also during this time frame, the scientific method was revived for personal and mental development. It was practiced in school laboratories through observations and experiments.

The Depression had a significant impact on the changes in science education in the 1900’s. The goal of scientific knowledge at this time was focused on understanding concepts that were organized into units of study, or themes. This was referred to as a generalization approach. During this period, Dewey brought into prominence the use of the scientific method as a means for solving societal problems. The mid 1900’s also brought awareness of problems in society, and there was a strong shift towards the goal for scientific knowledge. The focus turned towards developing conceptual ideas within particular science domains. Bruner, during this time turned to using the scientific method for acquiring scientific knowledge.
Now, at the eve of the twentieth century and the dawn of the twenty-first century, science education is once again facing the need for reform. The Third International Mathematics and Science Study (TIMSS), released in June of 1998, revealed that American high school seniors are among the poorest performers in science. Out of 20 industrial nations that were tested, American ranked 18th, followed only by Cyprus and South Africa (Fisher, 1998). The United States, currently a world leader in the area of technology and economics, is facing a serious crisis; our children are not scientifically prepared to enter the age of information. In order for our nation to deal successfully with rising issues such as space exploration, environmental deterioration, health care, and national safety, science education is being called upon to achieve possibly the most significant reform in recorded history. “In the 1980s, more than 300 reports called for a reform of education. There is no precedent in history for such widespread reform efforts in education” (Bybee & DeBoer, 1994, p. 382).

As our nation continues to grow more and more technologically advanced, ongoing changes in science education become necessary. Based on the results of the TIMSS report, it can be concluded that current practices in science education are not enabling our students to succeed. Reform in science education for the next century needs to address two critical issues, scientific literacy and technologic literacy. “The industrial model of education that served reasonably well in preparing workers for completing discrete tasks falls short of answering the new questions about complex phenomena and collaborative work processes that define the high-tech workplace” (UC Regents, 1997, chap. 3). The methods of the educational system need to be able to help students develop
skills that will allow them to become scientifically literate and solve the open-ended type of problems they will encounter in the 21st century workplace. Additionally, the practices within an educational setting need to reflect the practices of society. Students need to become technologically literate and be able to use and have access to the same tools and information that practicing members of society have.

Just knowing the what and why of science education will not allow us to meet our objectives in science education. We must now extend ourselves beyond these two issues and address the more critical one of how students can achieve the goals which we as a nation establish. The issue of how students learn science must now be at the forefront.
The Call for New Science Education Reform

Over the past decade, many state and national science and educational organizations have researched scientific teaching and learning. Based on their findings, they have established criteria that is needed to reform science education. These criteria include the what, why, and most importantly, the how of science learning. It has been determined that new programs need to be developed which represent the new goals for science education. The ultimate goal of science education (the why) is to promote scientific literacy among all individuals, not just future scientists. “In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone” (National Research Council, 1996, p. 1). In order for this to be accomplished, educators must also evaluate and implement programs that address the what and how of science education. Various publications have been put forth to guide and assist educators in accomplishing this tremendous task.

In the late 1980s, the most current reform in science education began. F.J. Rutherford created Project 2061 at the American Academy for the Advancement of Science (AAAS). Project 2061 calls for the restructuring of the goals for science education with the aim of improving the scientific literacy of all Americans. Science for All Americans, a publication of the AAAS, was produced in 1989. The main premise of this work was that schools should teach less content at a greater depth. Instruction of scientific concepts must be dealt with differently than they were in the past. Boundaries between content areas must be weakened. The amount of facts that students have been required to know in the past need to be lessened and a shift toward conceptual knowledge
and thinking skills should occur. This new concept development needs to happen in coordination with practicing the process of science and relating personal-social applications.

A second publication of the American Association for the Advancement of Science, *Benchmarks for Science Literacy* was created in 1993. Like *Science for All Americans*, this work challenges educators to make changes in current teaching practices. A new focus on scientific literacy would allow students to develop the ability to live informed, productive, and responsible lives:

> In a culture increasingly pervaded by science, mathematics, and technology, science literacy requires understanding and habit of mind that enable citizens to grasp what those enterprises are up to, to make some sense of how the natural and designed world works, to think critically and independently, to recognize and weigh alternative explanations..., and to deal sensibly with problems… (p. XI).

*Benchmarks* (1993) promotes the use of inquiry-based education, constructivism, and discourse as means to develop scientific literacy. “Students will have many opportunities for hands-on activities and, equally important, for the reflective thinking that enables them to make sense of their experiences – including connecting ideas...” (p. 385). Laboratory investigations should be designed to help students understand and practice the nature of scientific inquiry. Activities need to provide opportunities for students to engage in scientific talk and enable them to understand discussions of scientific issues.

Another driving force in the reform of science education is the *National Science Education Standards* (1996). This publication was the product of many science, education, and research organizations. The Standards call for a change in science
education that will allow all students to become scientifically literate. "Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (National Research Council [NRC], 1996, p. 22). The goal of the Standards is to educate students who are able to know and understand the natural world, use scientific processes to make decisions, engage in discourse about scientific and technological topics, and increase productivity and career skills. The task of producing scientifically literate students, according to the Standards, can be accomplished through the use of inquiry-based education, constructivism, scientific discourse, technology, and the consideration of other factors that influence teaching and learning.

Scientific inquiry is the process by which students are able to study the natural world and develop knowledge and understanding of scientific ideas:

Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information...; reviewing what is already known...; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (p. 23).

Activities in a science classroom that are inquiry based may include observations, data collection, analysis of first hand phenomena, or the analysis of secondary sources of various texts and media.

The National Standards also promote the theory of constructivism in trying to develop scientifically literate students. "Learning science is something students do, not something that is done to them" (p. 20). Learning becomes an active process where
students engage in hands-on as well as minds-on activities. Students should conduct investigations that allow them to make connections to their prior knowledge and apply their learning to a new situation of understanding.

Scientific literacy is also obtained through the practice of scientific discourse and contemporary science practices. "An important stage of inquiry and of student science learning is the oral and written discourse that focuses the attention of students on how they know what they know and how their knowledge connects to larger ideas..." (p. 36). Communication is one important aspect of science, yet in addition to communication, students need to also develop competencies of modes and rules and become active members of the scientific society.

Another concept posed by the National Standards in developing scientifically literate students is allowing students to take responsibility for their own learning and pursue their own ideas and questions. "Teachers give individual students active roles in the design and implementation of investigations, in the preparation and presentation of student work to their peers, and in student assessment of their own work" (p. 36). This process allows students to participate more fully in their education and develop a better understanding of science.

The California State Framework (1990) is another, more local, force in science education reform. (A more current version of the State Framework was in the draft stage when this project was being constructed. Since a final version was not yet available, only the 1990 edition was consulted). The Framework was established by the California Department of Education. The State Department’s goal in establishing the Framework
was also to develop scientific literacy. "We want our students to be actively engaged in
learning about the natural world in which they live. We want our students to grapple
with the ideas of science as they learn the inner workings of the counterintuitive
universe" (p. vii). Similar to the National Standards and Benchmarks, the Framework
promotes the use of inquiry-based education, constructivism, discourse, and instructional
technologies in establishing scientific literacy.

In reviewing the California Science Framework, Benchmarks for Science
Literacy, and the National Science Education Standards, the criteria for science reform
can be clearly distinguished. The why of science education today is to promote scientific
literacy. The what of science education includes conceptual knowledge, thinking skills,
and science process skills. The most significant criteria address the issue of how students
are to learn. New methods that are based upon what we know about how students learn
include inquiry-based learning, constructivism, and scientific discourse.

When evaluating the type of reform necessary and how to approach it, it is also
vitaly important to consider the tools that will allow us to accomplish the reform.
Today's society is highly technological. The technological tools that are used in the
private and public sectors of our society should also be extended to the educational arenas
so that students will be well prepared for their futures. "Computers and other
technologies are an increasingly important part of the world in which students live" (Peck
and Dorricott, 1994, p. 13). They are the lifeline for the business and industry
communities. Without technology, many companies would not exist. If students are to
become competent users of these technologies in the future, they must practice and
develop their skills now. “Today we have to ensure that everyone has a realistic opportunity to develop the intellectual skills required to prosper in an information age” (Poole, 1995, p. 2). This task includes creating an educational environment that provides each student with the best possible learning opportunities. It also includes preparing students to approach the future with necessary technological skills and abilities.

Several science reform documents call for the use of instructional technologies in changing the practices of science education. The National Science Standards (1996) is one of the reform documents that describes how the use of instructional technologies can change the way students learn and be used to promote scientific literacy. The use of instructional technology, “…provides students and teachers with exciting tools-such as computers-to conduct inquiry and to understand science (p. 24). The use of technologies such as computer databases, video, film, and computer simulations allow teachers to take an inquiry approach to acquiring and interpreting information. Electronic communication can also promote scientific discourse. “Teachers provide the opportunity for students to use contemporary technology as they develop their scientific understanding” (p. 45).

The California State Framework (1990) also stresses the value of instructional technologies in developing a science program to enhance science learning. “As newer technological devices, such as scientific calculators, computers, videotapes, and videodisks, become less expensive and more significant as mechanisms for teaching and learning, their role should be constantly evaluated for their contribution to an effective science program” (p. 178). According to the Framework, scientific investigations need to utilize materials in an inquiry approach. “Instructional materials should not be
dogmatic...(but), should direct the students toward inquiry rather than conclusions” (p. 206). Questions should be posed that allow students the opportunity to explore and come to an understanding. Instructional materials should also be used as tools for constructivism. “Programs should encourage active learning on the part of students in which they are actively engaged in the doing of science…” (p. 207). This active learning allows students to make connections between new ideas and prior conceptions and creates understanding. Additionally, instructional materials should be used to encourage scientific talk and discussions. “Science should be portrayed as a vital, changing endeavor with controversy and competing lines of intellectual discussion…” (p. 206).

In the case of technology, its integration into education is not only appropriate, but it now seems to have become necessary. Outside of the classroom, technology manifests itself everywhere. However, in the realm of education, the use of technology remains uncommon. “Even though the pace of technological innovation continues to accelerate in our society as a whole, in schools such innovation lags far off the pace” (Hancock & Betts, 1994, p. 24). The use of instructional technology is an absolute necessity if the needs of our students are to be met. “If our students (our future work force) are to be prepared for their adult lives, it is imperative that the system that provides their education be ready and able to redesign itself to keep up with the fast pace of change that surrounds us on every side” (Braun, 1993, p. 12).

School systems need to provide students with opportunities to use instructional technologies. Paper, pencil, and book learning will no longer suffice in science education, and will not adequately prepare our students to meet challenges ahead. “An ‘I
tell you, you tell me, and I'll grade you' model of education will not prepare students to
take advantage of these resources" (Peck & Dorricott, 1994, p. 13). Dwyer (1994) feels
that experiences with technology will, "provide the skills that will enable students to live
productive lives in the global, digital, information-based future they all face" (p. 4).

It can clearly be seen that the process of reform in science education must address
both of the above issues. Educators must change their approach to teaching science to a
way that reflects how students learn best. Educators must also provide opportunities for
students to develop technological skill that will be vital for their future. "The need for
widespread scientific and technical literacy extend to every potential employee (UC
Regents, chpt. 1). Since the goals for scientific literacy and technologic literacy seem to
have the same objective, producing capable individuals for the 21st century, it is a sound
practice for educational systems to integrate the two.
CHAPTER TWO

Research on Instructional Technologies

Since its introduction into classrooms, research has been conducted on how the use of various instructional technologies affect different aspects of the educational system. As instructional technologies changed, and as researchers gained new knowledge of teaching and learning, the types and focuses of research projects have also changed. The most current research results support the following hypothesis: The integration of technology into the classroom is not only needed to develop a technologically literate society, but the use of technology in the classroom also promotes scientific literacy. Computers and other technologies can be used by teachers to promote inquiry-based learning. They can be used by students in the application of the constructivist theory of learning as well as the practice of scientific discourse.

Most of the earlier studies conducted on the use of instructional technology in education (in the 1970s and 1980s) were traditional comparison studies (Gabel, 1994). Results of instruction without a certain technology were compared to instructions with a certain technology. Since that time period, a myriad of additional study results show that the use of instructional technologies provide positive benefits over other traditional methods and tools. Several areas where benefits have been documented include motivation, interest, and attitude.

Lumley and Bailey, in their study, found that technology rich classrooms increase student motivation (1991). At Skowhegan Area Middle School in Maine, teachers have found that integrating computers into the classroom increases student interest in their
work (Muir, 1994). In a study where videodiscs were used in science classrooms, students showed an increase in enthusiasm, attitude, and self-confidence (Rock & Cummings, 1994). Braun (1994) found that, “A visit to any school which uses technology in intelligent ways reveals a high level of excitement among all participants…” (p. 12). Researchers of the Apple Classrooms of Tomorrow SM program observed that computer use in the classroom improved student attitudes toward learning and that the use of technology increased student motivation (Dwyer, 1994). Peck and Dorricott (1994), through their study, also found that technological tools such as video productions, “can produce high levels of motivation and accomplishment” (p. 13).

Many other comparison studies have addressed the question, “Does the use of instructional technologies improve efficiency in learning?” Efficient learning can be described as learning more in a given amount of time or learning the same amount in less time (Berger, et al, 1994). Several research studies have demonstrated that technology has a significant impact on student learning. Videodiscs are one type of technology that helps to improve student learning. Rock and Cummings (1994) reviewed the results of using science videodiscs by two New York schools. Students in the classes that used the videodiscs were observed as achieving more, having a greater growth rate, and scoring higher than students whose classes did not use the technology. Computers are another type of technology that allows students to improve their performance. In reviewing the success of the Apple Classrooms of Tomorrow SM program, Dwyer (1994) noted several advantages of computer use. Student scores on the California Achievement Test were higher in students involved in the ACOT program than those who were not. ACOT
students made improvements in their writing, and an overall increase in student productivity allowed them to finish units of study sooner. The greatest impact, however, seemed to be in the methods that these students used to complete their work. "Routinely they employed inquiry, collaborative, technological, and problem-solving skills..." (Dwyer, 1994, p. 8).

The more current research regarding the use of instructional technologies addresses this issue of methodologies. The revised research question has become, "Does the use of instructional technologies change the way students learn?" Research studies have been conducted which demonstrate that the use of instructional technologies can help meet reform criteria and improve science education.

Berger, (1994) in their review of current research have found that studies show a change in how students learn. Learners actively working with technology construct their own knowledge. Technology provides more visualization of learning than other medium. Eight major shifts in learning and instructions were found to occur through the use of instructional technologies.

1) from whole-class to small-group instruction
2) from lecture to coaching
3) from working with better students to working with weaker students
4) towards more engaged students
5) from assessments based on tests to assessments based on products
6) from competitive to a cooperative structure
7) from all students learning the same thing to different students learning different things

8) from primarily verbal thinking to the integration of visual and verbal thinking

The use of technology changes the way teachers teach and the methods they provide for students to learn. The focus in the classroom shifts from the teacher to the students. "Students will be taking more control over their learning, taking control away from the educator" (Betts, 1994, p. 21). The role of the teacher is more like a facilitator or coach (Means and Olson, 1994; Hancock and Betts, 1994). In the Apple Classrooms of Tomorrow \textsuperscript{SM} program, "teachers reported and were observed to interact differently with students - more as guides or mentors and less like lecturers" (Dwyer, 1994, p. 6). The use of presentation software was observed to, "reduce the amount of time teachers spend lecturing to students, and increase hands-on interdisciplinary instruction (Hancock & Betts, 1994, p. 26).

Some pedagogies emphasize learning facts through prescribed activities. Teachers who practice this view learning as the acquisition of information. Other pedagogies, such as constructivist-oriented, emphasize students engaging in problem solving activities that allow students to build their own meanings. A constructivist-oriented pedagogy is more conducive to the process of inquiry-based learning. With the increasing utilization of the computer in the classroom comes a wide opportunity for students to engage in computer-based scientific inquiry. A study by Dorit and Taylor (1995) investigated the influence of teacher pedagogy on the use of a computerized learning environment to promote scientific inquiry and higher level thinking.
Observations of the constructivist teacher’s classroom included student independence, teacher-initiated discussion and problem solving, student-initiated discussion, complex investigations, and creative questioning.

The researchers believe that in order for computer-based instruction to be based on scientific inquiry and promote higher level thinking, teacher epistemology needs to reflect a constructivist approach. Computers offer a great potential in the development of students’ higher level thinking skills. Maor and Taylor (1995) conclude that, “transmissionist epistemologies are likely to subvert the aims of inquiry-based teaching by controlling students’ interactions with computerized instructional programs too closely and providing too few opportunities…” (p. 852). They also conclude that, “…teachers who adopt constructivist pedagogies…are more likely to enable students to better exploit the potential of computerized data bases for developing the higher-level thinking skills associated with scientific inquiry” (p. 852).

Pea (1991) also conducted research in the realm of inquiry-based education. His focus was on the use of discourse with computer-based education:

The pedagogical goal is to have students become better able to engage in appropriate conversations about the conceptual content they are investigating. Such inquiry-focused discourse is a fundamental part of learning environments in authentic practices outside schools; our aim is to examine ways for augmenting such learning conversations in schools (p. 313).

Pea defines his theory of learning in relationship to communities of practice, or social constructivism. His belief is that learning is a process that enables individuals to become a member of a community and sustain it. The factors involved in this include using the language and tools of a community and also sharing its beliefs and views. Learning is
not simply a transfer of information, but it is a process of participating and collaborating within the community. A major component of this collaboration is the use of the community's language in sense-making activities. Learning conversations enable a member to construct meaning about a particular subject through back and forth talk. This provides opportunity for meaning to be negotiated, changed, re-shaped, and integrated. Students need to be able to talk science and not just hear it. In the practice of scientific discourse, the learner becomes an active participant. Computers, "can be effective agents for directly teaching the language games of science" (p. 321). Technology provides learners the opportunities to collaborate, construct, and discuss scientific concepts. The computer becomes a tool that allows for learning conversations to occur. A truly effective learning situation is one that allows for technological tools to be integrated into a social/constructivist environment.

Soloway et al. (1996) conducted case studies of Learner-Centered Design. The premise of the studies was that computer software must be designed according to current learning theories. The two learning theories addressed in LCD include constructivism and socioculturalism. Constructivism focuses on learner assimilation, organization, and management. The learners acquire knowledge and skills which allow them to organize and use information in a way similar to experts. Socioculturalism focuses on learners becoming collaborative meaning-makers through the use of the language and tools of the science culture. Their learning is situated and contextualized. If learning theories are considered when software is designed, students will have a more successful learning experience.
Devitt (1997) also believes that instructional technologies can be used in accomplishing reform demands. “Are American teachers keeping up with scientific learning?” (p. 41) This is the question that Devitt feels is plaguing science education today. He is concerned with the efforts to reform science education, for students to think and investigate the way scientists do. He believes that one way to accomplish this is through the use of technology. His premise is that instructional technology should become an integral part of science instruction. Current science reform stresses the need for a fundamental change in science teaching. Students need to be immersed in inquiry-based learning where curiosity and creativity are encouraged. “By immersing students in inquiry-based learning, as outlined in the National Science Education Standards developed by the National Academy of Science, ... educators can provide students with a set of learning skills with application far beyond the classroom” (p. 42). The use of instructional technology allows students to act like scientists by allowing them to use hardware, software, and probes that actual scientists would use. These technologies also allow students to frame questions, manipulate data so they might develop conclusions and understandings in their investigations, and communicate the results.

Research has also been conducted on one of the most current instructional technologies, Web-based instruction. Duchastel (1996-1997) proposed a model for Web-based instruction that would meet current reform requirements for learning. The Web model proposes that the students should organize their own learning and be guided to the end result, not directed to it. This reflects the criteria of inquiry-based education. The model also promotes the use of open-ended questions that will allow students to
communicate their acquisition of knowledge in a way that enables them to synthesize what they have learned. It also states that the evaluation of learning should require the students to perform a task or produce an item that requires them to utilize, synthesize, and apply the knowledge that they have acquired. Duchastel believes that, "...learning through knowledge production is the goal in education" (p. 226). These objectives meet the criteria for constructivism. Additionally, the model stresses cooperative learning and collaborative learning across the globe. In the business/commercial world, teamwork is the norm rather than the exception. Group interaction allows for discussion and the opportunity to change and integrate knowledge into prior experiences. The use of the Web allows students to break down the constraints of the walls of the classroom. It also provides the opportunities to interact with professionals in their fields of learning. Students become co-scholars with practicing individuals. This aspect of the model addresses the criteria of scientific discourse and practice.

Other researchers have also concluded that the Internet can be a valuable tool for constructivist and resource/inquiry-based learning. "The Internet presents many possibilities for enhancing instruction and learning in a resource-based environment" (Rakes, 1996). Greening (1998) believes that, "the World Wide Web provides a medium that is readily accessible and potentially well aligned to the tenets of constructivism." Based on their review of research, Silva and Breuleux (1994) also state several justifications for the use of K-12 networks. The use of computer networks fosters collaborative learning. Networking, in its nature, is collaborative. Also, the emphasis of education shifts from teacher-centered to student-centered learning. Teacher and student
become partners in the learning experience. Networking promotes social interaction and active involvement, two integral parts of the learning process. Additionally, networking allows students to contextualize their learning. Work has more meaning and significance when it is situated and has real life applications and responses. Networking is another use of the computer that will build upon student learning.

The previous research information has shown that instructional technologies, including the Internet, are effective tools that can be used to meet the reform criteria of inquiry-based education, constructivism, and scientific discourse. Its use in education is also a vital way of insuring the development of technologic literacy. Instructional technology needs to be an integral part of science education because of this. If the integration of technology does not occur, the future generation of workers may not be prepared with the skills needed to meet the challenges ahead of them. With this in mind, the question should no longer be whether the use of instructional technology can make a difference for students, but what needs to be done to make the integration of instructional technology a reality instead of an experiment or a case study.
Research on KIE/WISE Web-based Technology

The World Wide Web is entering our classroom environments at an astounding rate, providing even the remotest schools with an overwhelming abundance of information. As this access to information becomes available, the need for appropriate learning environments and tools becomes critical. Unfortunately, as demonstrated by historical cycles, the development of the technology often precedes the pedagogy and tools. Current models of instruction and tools for web use have been found to be lacking and inadequate. "Yet, models of instruction that are appropriate for the Web are sorely lacking" (Duchastel, 1997, p. 221). "At present, Net resources are underutilized and tools are inadequate..." (Bell, 1995).

The National Science Foundation has provided funds to organizations for the development and implementation of new science curricula that characterize new reform criteria. Headed by Marcia C. Linn, the Graduate School of Education at the University of California, Berkeley has been developing and testing a software curriculum that enables educators to meet the goals of science education reform through web-based learning.

The Knowledge Integration Environment (KIE) project seeks to provide a tool that allows science educators to successfully experience the educational potential of the Internet. "Relying on KIE, teachers can provide students with a pedagogically sound approach to using Internet resources in the science classroom" (Linn, 1997, p. 2). The KIE project also focuses on developing students’ abilities to use the Internet as a resource for lifelong learning.
The pedagogy/learning theory that drives the KIE is referred to as the Scaffolded Knowledge Integration framework. The objective of this framework is to help students make connections between scientific concepts and problems and situations that are personally relevant. "Our instructional goals are to foster integrations - where students expand and refine their existing repertoire of models, make sense of new evidence in personally meaningful ways, and learn important knowledge integration skills (Linn, 1995, p. 3).

Students come in to science learning situations with preexisting knowledge referred to as models. These models may be incomplete or have various misconceptions attached to them. Knowledge integration aims to add new models, alter existing models, and accurately restructure their knowledge. This framework provides opportunities for students to use their models to solve problems and provide scientifically sound explanations for various phenomena.

Scaffolded Knowledge Integration frameworks is comprised of four component goals: (a) identifying new goals for learning, (b) making thinking visible, (c) encouraging life long learning, and (d) providing social supports.

The new goals for learning are reflective of the new science reform criteria. "We (SKI/KIE) advocate a curriculum that emphasizes opportunities for students to evaluate scientific evidence according to their own personal understanding (inquiry), to articulate their won theories and explanations (scientific discourse), and participate actively in principled design (constructivism)" (Slotta, 1997). Scientific thinking is made visible when students see computer representations, sort information, and actively experience the
exchange and debate of ideas. Life long learning abilities demonstrate themselves in the application of information. When students use acquired information to create products or evaluate information, they are demonstrating skills that can be utilized throughout their lives. Social support (discourse) is a vital skill that provides the opportunity to collaborate and exchange information, which ultimately leads to the acquisition of new or revised ideas.

The Knowledge Integration Environment utilizes three types of activities, theory comparison, argument explorations, and design. Theory comparison allows learners to examine their ideas, argument exploration allows learners to evaluate validity and bias of information, and design projects provide students with the opportunity to synthesize information for problem solving.

The Knowledge Integration Environment software is comprised of various components that work together to provide support for student work. The Evidence Database contains collections of scientific evidence that exist on the Web or that have been created by project developers. Information regarding the piece of evidence is available to project developers. Such information includes keywords, age appropriateness, and expected time needed for students to evaluate the evidence. Each piece of evidence is prefaced with a cover page. This page contains information that will guide a student in the use of the evidence; it serves as an advanced organizer. On-line Guidance provides students with support in identifying information in the evidence. Hints are given in the form of questions. These questions help to focus the students’ attention on critical information. The KIE Tool Palette provides links to all the student
components of a project. The Activity List provides a series of activity steps for the students to complete. Each activity provides students with specific instruction about what to do. This frees up the teacher to be a facilitator for concept development. Activities may include analyzing evidence, creating designs, searching for evidence, participating in discussions, or creating reports. The SenseMaker allows students to sort and organize evidence information into frames. This provides students with visual organization of how they interpreted the evidences. The SpeakEasy is an on-line discussion tool. Discourse is an integral part of knowledge integration. Electronic discussion provides students the opportunity to ask questions, answer questions, and comment on or debate information. This tool allows students to go beyond the classroom walls and hold discussions with members of the scientific community.

The KIE software also includes a developer-friendly project production tool. "The multi-paneled interface guides project developers through successive stages of project planning, including high level planning (e.g., the activity structure), activity details, evidence and guidance, and other documents associated with the project" (Linn, 1997, p. 9).

Marcia Linn (1997), in a report to the National Science Foundation, summarized the research that has been conducted regarding the utilization of KIE software. Results of research on the use of guidance/prompting showed that the use of prompts (for planning and reflecting) increase knowledge integration. These prompts encouraged students to complete each activity and develop an integrated understanding of the topics. Research conducted on the use of advance organizers showed that organizers that offered cognitive
and procedural strategy hints enabled students to formulate better questions in their attempt to integrate knowledge. Research that investigated the impacts of using the SpeakEasy for discourse shows a dramatic increase in the percentage of students who participate in discussions. Research also revealed that females participated more in the electronic discussions than males which is directly opposite from traditional class discussions. Results of evaluating evidence rankings show that students will give evidence pieces higher value if it includes some type of media-enhancement. Pieces with text only do not appear to hold as much credit. When analyzing the evidence rankings, researchers noticed that the source/author of the evidence did not impact how students viewed the validity of the information presented. Researchers determined that students who held a more dynamic view of scientific principles created more scientific claims and more unique categories for evidence. Students who use the guidance were able to develop more scientific bases for their arguments. When allowing students to do their own web searches, researchers found that the use of a Collaborative Search Page, where students are able to list important web sites that they have found, enables students to locate more useful web sites than through the use of a general search engine.

The KIE software is still in the process of being developed. It has already shown promise of increasing the scientific literacy of students while also improving their technologic literacy of computer and Internet use. With continued testing and revisions, it will become a significantly important tool in the education of students in the 21st century.
CHAPTER THREE

Web-based Research Problem

During the course of my graduate studies at California State University at San Bernardino, I had developed an interest in the new science standards that were being developed and the increasing focus on using instructional technologies in education, specifically the Internet. After reviewing many research studies, I became convinced that the use of instructional technologies in educational settings has significant positive impacts. In August of 1998, I was fortunate to be introduced to the KIE project at the University of California at Berkeley. At this time, the name of the project and software became known as Web-based Integrated Science Environment (WISE). During a summer session, I was able to meet with the designers and researchers who were investigating the development of web-based software for the purpose of scientific learning. I became one of the teachers involved in the project and adopted it as the focus of this Master's Project. The WISE software is still being developed and is not currently accessible to teachers outside of the Berkeley project. The Solar System Expedition project is therefore not available for other teachers to use at this point.

The research question that this project was designed to investigate is, “Can web-based instruction be used at the 6th grade level to promote scientific literacy?” This broad question was investigated by looking at several more narrow questions that addressed the various aspects of scientific literacy. Does web-based instruction provide students with age appropriate inquiry-based learning experiences? Can students, through the use of the WISE software, construct their own knowledge? Does scaffolding of activities allow
students to build up their knowledge repertoire in a way that allows them to successfully synthesize their knowledge and apply it toward a real world situation? Also, does the WISE software provide students the opportunities for discourse? Does this discourse encourage students to revise their models by addressing misconceptions and reformulating their ideas to draw accurate conclusions?
Project Design

Description

The Solar System Expedition was constructed to be a “Design” project. The project began with the students being introduced to the problem of possibly having to establish a colony on another planet. It concluded with students designing a model of a colony that would be able to support life on another planet. The project consisted of the following seven scaffolded activities:

1) Consider This – Students were instructed to brainstorm what living things need in order to survive.

2) Class Discussion – A class discussion was held to discuss/debate which items were vital to supporting life. From this discussion, a class list of necessities was created.

3) Research Earth – Students reviewed web evidences that explained how Earth provides the necessities for life.

4) Research Planets – Students investigated the conditions of each of the planets in our solar system.

5) Make A Decision – Each group determined which planet would most likely be able to support life. Students hypothesized what a colony on that planet might look like and what things it would need to consist of.

6) Life Support – Students researched self sustained life support structures that have been or will be tested. They identified all the component parts of several systems and described the importance of their functions.
7) Design A Colony – After reviewing the life support structures, students needed to synthesize and apply their new learning and revise their colony model. After making any needed revisions, they performed the authentic task of designing a final version of a colony that would support life on another planet.

The WISE software allowed these activities to be organized in a way that would scaffold student learning. Each activity set was prefaced with an advanced organizer that instructed the students on what the goal of the activity was. The advanced organizer page also provided directions for completing the task. Several of the activities were divided into sub-activities which were also prefaced with advanced organizers. These sub-activities presented groupings of web pages for the students to access in their attempt to acquire information, organize their thoughts, and work towards solving a problem. The web pages are referred to as “evidence.” The web sites that were used in the project as “evidence” were pre-selected and incorporated based on their content and level of difficulty.

As web evidences were presented to the groups, they were required to access their “Notepad.” Here they would respond to questions about the evidence page. Each note page consisted of a prompt and a hint which were provided to help students focus their responses and filter out any unnecessary information. Occasionally students were required to complete “Activity Support Worksheets.” The purpose of these activity sheets was to provide further guidance towards the content information that the students should be acquiring and adding to their repertoire of knowledge.
Method

The Solar System Expedition project was run with two 6th grade classes of students age eleven and twelve. The study included 59 students; thirty-two students were male and twenty-seven were female. Three of the students were designated as “Gifted and Talented,” and another three of the students were designated as “Resource.”

The study, four weeks in length, spanned an eleven-week time period. This issue will be discussed in the limitations section of the project analysis. Students did not participate in the project every day. As with the nature of a middle school, special events arose and some block scheduling occurred. Students spent the equivalency of 20 class sessions of 50 minutes each working on the project. This time does not include the days used to review after students returned back on track.

Student groups consisted of 3-4 member teams. Each group member performed one or two of the four group roles. The options included 1) Activity Director – this student was in charge of previewing the tasks and directing the group’s approach, 2) Reader – this student was responsible for reading any evidence and assisting other students in their understanding of it, 3) Recorder – this student had the task of writing down responses to questions and prompts, and 4) Project Supervisor – this student had the ultimate responsibility of making sure that each activity was completed and that the group worked together to accomplish it.

Due to the lack of computers and Internet access, only one group of students in each class period ran the actual ‘computer’ version of the project. Each of the other groups had the ‘paper and pencil’ version of the project. This issue will also be
addressed later. Due to the lack of computer availability, the primary tool utilized was the “Notepad.” Off-line versions of the SpeakEasy and the SenseMaker were also adapted and applied at various points in the project.
Data Collected

Several types of data were collected based upon differing objectives. Pre-assessment and post-assessment scores were compared and evaluated for growth in the students' content knowledge repertoires. The "Notepad" and "Activity Support Worksheets" were evaluated to determine if the students were able to use inquiry learning to acquire knowledge from web evidence on their own and if they could interpret the information accurately. The "Colony Design" was assessed to determine if students were able to accurately construct knowledge from the web information and successfully demonstrate the application of learning by designing a product that reflects a real-world situation. It was also used to analyze if students were able to identify misconceptions in their original models, reformulate their ideas and make improvements to demonstrate a more accurate understanding. I assessed and interpreted each part of the project according to the rubrics that I established. Each rubric is described in the following section.
Data Collection and Analysis

Method

Before the unit began, each student completed a pre-assessment that was composed of twenty-one open-ended questions which addressed the topics that the unit was going to cover (see Appendix C, pg. 64). After the unit was finished, each student completed the same assessment that was designated as the post-assessment. The assessments were scored on a zero to three point rubric. Points were assigned according to the following criteria:

3 = No misconceptions, accurate response, thorough explanation
2 = Few misconceptions, partially accurate response, some explanation
1 = Major misconceptions, attempted a response, no explanation
0 = No response attempted

As the project was run, students completed two types of tasks, note-taking and support activities. After each piece of evidence was presented, students were provided questions about the information contained on the web page. The questions, along with prompts for guidance, were displayed on the “Notepad” (see Appendix C, pg. 65). Student responses to the questions were evaluated on a zero to three point rubric according to the following criteria:

3 = Accurate response, thorough explanation
2 = Partially accurate response, some explanation
1 = Attempted a response, inaccurate explanation
0 = No response attempted

During the activities, students were also required to complete “Activity Support Worksheets” (see Appendix C, pg. 67). These worksheets asked questions to help clarify evidences or asked students to complete other tasks. The responses to the “Activity
Support Worksheets” were also graded on a zero to three point rubric. The criteria was as follows:

3 = Accurate interpretation of information and correct response
2 = Partially accurate interpretation and response
1 = Inaccurate interpretation of information, attempted a response
0 = No response attempted

The culminating activity was to design a colony on another planet that would provide all the necessities for living things. Students were to list each component of their design and explain why that part was necessary to support life. This task required students to synthesize what they had learned and apply their knowledge to solving a real-life problem. Students were evaluated for including components that would address the original class list of things that living organisms need as well as having components that they learned about from their web inquiries. The components of the student designs were assessed based on the following rubric:

3 = No misconceptions, accurate synthesis and application, thorough explanation
2 = Few misconceptions, partially accurate synthesis and application, some explanation
1 = Major misconceptions, inaccurate synthesis and application, no explanation
0 = No response attempted
Results

The rubric scores of the pre-assessment and post-assessment were compared to analyze the change in students' content knowledge. The results show that content knowledge increased. The amount of zero scores dropped from 456 (36.8%) in the pre-assessment to 113 (9.1%) in the post-assessment while the rubric scores of three increased from 228 (18.4%) to 527 (42.5%).

Table 1. Pre-Assessment Rubric Totals and Percentages

<table>
<thead>
<tr>
<th>Rubric Score</th>
<th>Pre-Assessment Totals</th>
<th>Pre-Assessment Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>456</td>
<td>36.8%</td>
</tr>
<tr>
<td>1</td>
<td>357</td>
<td>28.8%</td>
</tr>
<tr>
<td>2</td>
<td>198</td>
<td>16.0%</td>
</tr>
<tr>
<td>3</td>
<td>228</td>
<td>18.4%</td>
</tr>
</tbody>
</table>

Table 2. Post-Assessment Rubric Totals and Percentages

<table>
<thead>
<tr>
<th>Rubric Score</th>
<th>Post-Assessment Totals</th>
<th>Post-Assessment Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>113</td>
<td>9.1%</td>
</tr>
<tr>
<td>1</td>
<td>225</td>
<td>18.2%</td>
</tr>
<tr>
<td>2</td>
<td>374</td>
<td>30.2%</td>
</tr>
<tr>
<td>3</td>
<td>527</td>
<td>42.5%</td>
</tr>
</tbody>
</table>

The rubric scores of the "Note Pad" and "Activity Support" tasks were used to analyze whether the students, at the 6th grade level, were able to acquire knowledge from web evidence on their own and if they could interpret the information accurately. The results demonstrate that students were able to interpret the information presented in the web evidences. In both types of tasks, when students were asked to read and respond to
questions or activities regarding the evidence, over 80% of the scores were at the rubric level of two or three.

Table 3. Note Pad Totals and Percentages

<table>
<thead>
<tr>
<th>Rubric Score</th>
<th>Note Pad Totals</th>
<th>Note Pad Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>27</td>
<td>6.5%</td>
</tr>
<tr>
<td>1</td>
<td>34</td>
<td>8.2%</td>
</tr>
<tr>
<td>2</td>
<td>112</td>
<td>26.9%</td>
</tr>
<tr>
<td>3</td>
<td>243</td>
<td>58.4%</td>
</tr>
</tbody>
</table>

Table 4. Activity Support Worksheet Totals and Percentages

<table>
<thead>
<tr>
<th>Rubric Score</th>
<th>Activity Support Totals</th>
<th>Activity Support Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>13</td>
<td>6.8%</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>10.9%</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
<td>38.5%</td>
</tr>
<tr>
<td>3</td>
<td>84</td>
<td>43.8%</td>
</tr>
</tbody>
</table>

The rubric scores of the Project Design were used to analyze if students were able to synthesize their content knowledge learning and apply it to a real world problem. More specifically, the scores were used to determine if there was progression in students’ model revision and development. Activity 5C was used to analyze the hypotheses, Activity 7A was used to evaluate the revisions, and Activities 7B&C were used to further evaluate revisions and the final products. At each of the three stages, students were assessed for including and explaining the function of necessary component parts. These component parts included the items decided upon by the class in Note Pad Question A2B as well as the items included in the Note Pad Questions 6B/E4 and 6B/E5 from NASA.
The results show that students were not able to significantly improve the rubric scores of their designs. The decrease of the number of zero scores was only 19.4% and there was only a 3.4% increase in the amount of rubric scores of three. Students were not able to revise their original models and demonstrate the abilities of synthesis and application.

Table 5. Project Design Totals

<table>
<thead>
<tr>
<th>Rubric Score</th>
<th>Hypothesis Design Total</th>
<th>Revision Design Totals</th>
<th>Final Design Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>102</td>
<td>91</td>
<td>68</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>29</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 6. Project Design Percentages

<table>
<thead>
<tr>
<th>Rubric Score</th>
<th>Hypothesis Design Percentage</th>
<th>Revision Design Percentage</th>
<th>Final Design Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>58%</td>
<td>51.7%</td>
<td>38.6%</td>
</tr>
<tr>
<td>1</td>
<td>28.4%</td>
<td>29.5%</td>
<td>29.5%</td>
</tr>
<tr>
<td>2</td>
<td>11.9%</td>
<td>16.5%</td>
<td>26.7%</td>
</tr>
<tr>
<td>3</td>
<td>1.7%</td>
<td>2.3%</td>
<td>5.1%</td>
</tr>
</tbody>
</table>
Analysis of Results

This project examined several questions in the attempt to identify whether or not Web-Based instruction can be used to promote scientific literacy at the 6th grade level. Various data was gathered to address each particular question.

The pre-assessment and post-assessment comparisons were used to determine if the WISE software enabled students to use inquiry-based learning to increase their content knowledge. The results showed a significant increase in knowledge levels. The pre-assessment results revealed that only 18.4% of the questions were answered in a way that demonstrated no misconceptions. Only an additional 16% of the questions had answers that demonstrated some understanding. 67.6% of the questions were either not answered at all or had responses that were completely inaccurate. Refer to the Pre-assessment Rubric Results graph in Appendix D, page 71. In contrast, the post-assessment results showed that 42.5% of the answers reflected no misconceptions, an increase of 24.1%. Another 30.2% of the answers demonstrated some understanding. Only 27.3% of the questions on the post-assessment were answered incorrectly or not at all. Refer to the Post-assessment Rubric Results graph in Appendix D, page 72.

The “Notepad” and “Activity Support Worksheet” data were used to see if the WISE software provided students with age appropriate inquiry-based learning experiences. The results would tell if students were able to acquire knowledge from web evidence on their own and if they could interpret the information accurately. On the notepad, 58.4% of the tasks or questions were responded to with accurate understanding and another 26.9% of the responses showed only some minor misconceptions. Less than
15% of the tasks were answered incorrectly or not at all. See the Notepad Rubric Results graph in Appendix D, page 69. On the activity sheets, over 80% of the responses were mostly or completely accurate. Less than 20% of the questions were not answered or answered incorrectly. See the Activity Support Rubric Results graph in Appendix D, page 70.

The "Colony Design" data was assessed to determine if students were able to accurately construct knowledge from the web information and successfully synthesize and apply what they had learned to a real-world situation. Specifically, the data was used to analyze if the use of scaffolding and discourse assisted students in identifying misconceptions in their original models, and allowed them to reformulate their ideas and make improvements to demonstrate a more accurate understanding. The data did not reveal positive results. The conceptual models that the students' held in their hypotheses did not significantly change. Originally 1.7% of the models at the hypothesis stage showed understanding without misconceptions. This percentage only grew to 5.1% at the final stage. The models that showed minor misconceptions also only improved a small amount from 11.9% to 16.7%. Refer to the Colony Design graphs in Appendix D, pages 74 - 77.

Even after exposure to visual models from web evidences from NASA sites, they were not able to identify their misconceptions and revise their models to reflect a more accurate understanding. It is interesting to note that the notepad questions and activity support tasks that required interpretation of the web evidences that included the models of life support environments had relatively high scores. 84% of the notepad questions
were responded to in ways that demonstrated understanding with little or no misconceptions. Similarly, 98% of the responses to the activity support worksheets earned rubric scores of 2 or 3. Students seemed to be able to acquire knowledge and understand the functions of the life support models that were presented in the webpage evidences, but they were not able to synthesize that knowledge and apply it towards revising their hypothetical models.
Conclusion

Discussion

The results of this study are shown to be both positive and negative. First, it can be concluded that web-based instruction does provide 6th grade students with limited age appropriate inquiry-based learning experiences. Sixth-grade students were able to use web-based instruction for acquiring knowledge. They were able to read and understand web material and demonstrate learning at the knowledge and comprehension levels of Bloom's Taxonomy. As the students worked through each activity they did not seem to experience difficulty with the level of material and seemed to be able to understand and accomplish each task. The majority of these scaffolded activities required the students to define, list, label, tell, name, choose, and sketch. These are narrow questions aimed at cognition and memory.

In contrast to the scoring relatively high on the scaffolded activities, students were not able to score as high on the tasks that required convergent and divergent thinking. Students were unable to take their new content knowledge and advance to the levels of synthesis and application. Although they demonstrated understanding of the design problem they were to solve, students had difficulty separating scientifically possible solutions (as presented in the web evidences) and fantasy solutions. The students were not able to focus on basic life support functions and wanted to design colonies that leaned more toward science fiction. Some final design projects included items such as a bank vault, a weapons facility, and a clothes store. Several samples of student products can be seen in Appendix E, pages 78 - 82. Also, when the students were allotted time for
discourse regarding revisions of their models, many students were unable to evaluate their designs and identify problems; they were unsure of what they should be discussing. They had trouble with the tasks of rejecting and defending components of their hypothetical designs to create a more scientifically accurate final version.
Limitations

When looking at the results and the analysis of this project, several considerations need to be noted. The school district that this project was run in had a multi-track year-round schedule. The science curriculum is also textbook driven. Since there are just enough books for three classes (there are nine classes on track at any given time), a schedule for each teacher to teach each topic was established. Problems arose with the curriculum schedule which impacted the time at which this unit was taught. Students started a study on astronomy, were switched to a unit on the animal kingdom, and then came back to this project on the Solar System. The unit was unfortunately taught the last month that the students were on track. It should be noted that this is not the best instructional time for the students.

The project could not be completed before the end of the track and had to be completed after students came back from their four-week break. This situation may have affected the pre-assessment and post-assessment scores since the post-assessment was not completed until after the break. Before the post-assessment was issued, students spent two weeks reviewing what they had learned. The days for review were not included in the actual count for the project length. The fragmented schedule may also have affected the design scores. The tasks of model revision and final design had to be rushed in order to be completed before students went off track.

Another consideration is the lack of computer technology available to run this project. The WISE software was designed to be used on-line. Unfortunately only one computer with Internet access was available in the classroom. The computer was
connected to a scan converter and two television monitors. This allowed the ‘paper and pencil’ groups to experience the multimedia components of the project but not directly interact with it. Since each group of students did not have access to a computer, the SpeakEasy and SenseMaker were not utilized. Instead, group discussion time was provided and scaffolded activities allowed students the opportunities to organize information. Each ‘paper and pencil’ group had binders that included printouts of each web site as well as copies of all the other activities and instruction pages. The content and methodology was the same among all groups. The only difference was that one group was actually able to run the computer and type in their responses instead of writing them on paper.

Unfortunately, as with any new technology, problems did arise with the WISE software and the Internet access. Prior to running Activity 4 – Research Planets, minor changes were made to the SSE master program. These changes did not translate successfully to the student version of the project. Some evidence pages were mixed up, rearranged, and even not accessible to the students. Students had to forfeit the two class periods that were designated to research web evidence for planetary data because the planetary data evidence pages could not be located anywhere in the project. Their research became limited to the two CD Roms that were available. Additionally, the computer group was unable to access the Internet on two of the days. The district server was down. This group had to complete their activities using the printouts from the web sites just as the paper and pencil groups were doing.
Limitations of the research tool also need to be discussed. Some of the questions that students were evaluated with were very specific while some of the activities were general. These questions and activities allowed for only a limited amount of things to be evaluated. Students may have learned additional things and/or held other misconceptions that were not within the scope of this research to evaluate. Additionally, the judgement for each rubric score was determined by me. Since I designed the project, and ran it with my students, I also evaluated each response. Results may have been different if the project had been run with a different group of students or evaluated by another teacher.
Further Research Questions

The results of this study expose the need to ask several new questions. The main question is why students were not able to synthesize what they had obviously learned at a knowledge level and apply it to their problem of designing a colony. Two hypotheses exist for this question. First, it is possible that students at the 6th grade level are not developmentally ready to function at the higher levels of Bloom’s Taxonomy. This theory could be tested by running the same project with students at the 8th grade level to see if they were able to make more progress on their model revisions. If 8th graders were able to produce significantly higher scores, then the results of this study could be explained according to developmental readiness. Another hypothesis is that 6th grade students may be developmentally ready, but have not been exposed to higher level thinking and learning opportunities in their past educational experiences. This hypothesis could be tested by utilizing a different design project with 6th grade students each trimester. If students are able to make better design revisions over the course of the year, then the results of this study could be explained by the lack of exposure to higher level thinking.

Another area that could be investigated is how teachers with limited classroom technologies can and should utilize this web-based instructional tool. Unfortunately, the scope of this study did not allow for the comparison of the computer version and paper and pencil version of the project. Since only one group of students in each class used the computer version, the data sampling would not have been sufficient for accurate interpretation. A further research question could investigate if students who use the on-
line version of the project of the project demonstrate more success than the students who used the off-line version.
CHAPTER FOUR

Looking Ahead To the Future

Since the 1960’s educators have been attempting to revolutionize education through the use of electronic instructional technologies. In the 1960’s television was expected to change the course of education. Later, video technologies were also expected to make a significant impact on school systems. In the 1980’s, microcomputer technology was introduced into classrooms and thought to be the most transforming tool yet. Instructional radio and television, as well as other technologies, were viewed as panaceas for learning. Seemingly educational reform, through the use of these tools, did not occur (Cuban, 1993). Fortunately, over the course of time, educators have begun to realize some of the reasons why these new technologies had failed to meet their full potentials.

One factor was the lack in understanding of how the educational system is embedded within a much larger system, society:

The history of our efforts to bring electronic technology into schools is full of failures...because of a variety of public relations and other non-technical errors made by advocates who did not understand that successful technological change in education is always linked to events, attitudes, and values in the society at large (Maddux, 1997).

A second factor was the failure to utilize new technologies in the presence of sound theories and pedagogies. Technologies have previously been integrated into old transmissionist learning environments that did not maximize the use of the technologies. In order for the capabilities of the Internet and other technologies to be fully experienced, major changes in education will need to occur. “The future of the sensible use of
technology to provide an environment for meaningful learning cannot be described as narrow or confined, and suggests exciting developments in pedagogy and transformations to the concept of education” (Greening, 1998). Educational philosophies and pedagogies will have to be redefined. The use of educational technology “...is only as good as the skills and the attitudes of the people who use it and the educational methods and strategies they devise and implement” (Maddux, 1997).

Once again, the educational system has been introduced to a new technological tool. The newest and fastest expanding technology in education today is the Internet. And, once again, educators are presented with the challenge of utilizing it in a way that will reform science education. “We are currently entering a new wave of science education reform with the introduction of the computers and the Internet into the classroom. The trick is to insure that the products of today’s design experiments don’t go the way of instructional television and other closeted innovations” (Hsi, 1997).

Educators need to determine which factors will enable the integration of the Internet to reach its maximum capabilities. Various research projects have focused on how to make the utilization of instructional technologies effective. The following research stresses the importance of teacher participation and staff development in the successful integration of instructional technologies into the science curriculum.

The success of using technology in the classroom is significantly dependent upon the instructor. Teachers must, “…learn how to use technology as a pedagogical tool in the context of their classroom.” (Maddux, 1997, p. 179). Teachers must feel comfortable with the use of technology. They need to understand how to use technology and why to
use it. Because of the important role of teachers in the use of technology, it is important to have adequate staff development and teacher involvement in curriculum development.

Parke and Coble (1997) believe that teachers need to be involved in the research-based design of curriculum. Their research showed that when teachers are involved in curriculum development they are more likely to use an inquiry approach and have their students involved in hands-on activities. Teacher involvement in the process of curriculum development leads to intrinsic motivation and purpose for using new methods and technologies, and developing curriculum with reference to current research allows for the needs of the students to be successfully met.

Mehlinger (1997), in his report, comes to the conclusion that staff development is a vital factor in the vision of technology reform. "A major obstacle to the integration of technology across grade levels and the curriculum is the lack of a sufficient number of teachers who are comfortable using technology" (p. 3). Mehlinger (1997) noted that although most U.S. businesses spend billions of dollars training their employees, the majority of U.S. teachers said that they are almost completely self-taught. In order for teachers to attain the skills needed to use technology as an instructional tool, there needs to be a major emphasis on training.

Silva and Breuleux (1994) believe that K-12 networking has a great potential to revolutionize education and that the application of participatory design in developing the integration of networking into our classrooms is necessary if it is to be successful. "Indeed, participatory design may offer the means to fully exploit the potential in new technologies and networking" (Silva and Breuleux, 1994, p. 19). Silva and Breuleux
state five reasons that the concept of participatory design should be tested and researched. First, the introduction of anything new in the classroom is difficult. Secondly, input of teachers allows them to integrate classroom tasks into the use of the internet. It allows them to influence matters that affect their work. Thirdly, participatory design gives educators the opportunity to address any concerns they might have with the design of the materials. Prevention now is better than correction later. Fourth, participatory design allows for the application of the most current trends and theories in education. Finally, participatory design allows the teachers to provide any safeguards they feel necessary.

Other researchers see the need to focus on teaching and learning when deciding how best to integrate new technologies. "The design of software for learners must be guided by educational theory" (Pea, 1991, p. 1). When computer technology was first introduced into the educational arena, it seems that much focus was on the equipment itself and not the learning process. It has been deduced by many educators that in order to have successful utilization of computers in the classroom the program software must meet the learner's needs. The concept of Learner-Centered Design gives educators and program developers a solid example and outline by which we can develop and utilize software that meets the students' needs and also our state and national standards.

Saettler (1990) believes that, "the cognitive approach to educational technology offers the best possibilities of progress for the future" (p. 539). In focusing on how students learn, we are better able to develop programs and utilize technologies to best meet their needs. Saettler also addressed other problems that have hindered the use of
instructional technology including untrained teachers, low quality/inappropriate materials, and equipment problems including costs.

Papert (1980) also addresses several concerns about the use of instructional technologies. The challenge is still to not let "good educational ideas sit on the shelves" (p. 37). Educators need to get rid of conservatism and stop employing certain practices just because that's the way they have always been done. The temptation of using new technologies with old instructional methods must be avoided. “There is a world of difference between what computers can do and what society will choose to do with them” (p. 5). It is important to see the potential of what computers can do in the future and not allow the problems that are experienced today prejudice future views and visions.

Research on one of the most current instructional technologies, the Web, also addresses concern about realizing its full potential. Duchastel (1996-1997) makes the following points:

1) The Web is a new technology that has great potential
2) If the Web is used to support traditional instruction, much of its potential will be lost
3) The use of the Web requires a change in the way we look at teaching and learning
4) Universities will also need to reexamine the evaluation process.

Duchastel addresses the same concerns as Papert (1980) and Saettler (1990). New things come about and they are novel and exciting. Many educators are quick to leap before they look and they do not consider all the factors that need to be considered.
The problem often arises with teachers simply using new technologies in their traditional teaching methods. "In most cases, however, the Web is used in support of a traditional model of university instruction and much of the potential of the Web is lost" (p. 221). New technologies like the computer and the Web require educational processes to be transformed in order for their potentials to be realized.

The effective integration of new technologies demands that new research with new approaches be conducted. "The rapid influx of information technology into all aspects of modern life, now finally including schools, is also a defining part of the new landscape that motivates and supports design experiments" (Hsi, 1997). This new type of research is changing its focus; researchers are now interested in how to develop design partnerships where researchers, scientists, educators, administrators, students, parents, and community members can all be involved in designing curriculum. "Through multidisciplinary collaboration, closer specification of shared goals, and partnerships, we can invent methods that serve to extend fundamental research in cognition as well as provide valid examples of successful educational reforms" (Hsi, 1997). Since the educational system needs to mirror the practices of society, it is important that members from various areas are involved.

Possibly even more importantly, researchers are now interested in the cognitive processes that occur while students are learning with the use of instructional technologies. Studies are teaming research on content learning with metacognition, learning how to learn. Berger (1994) summarizes how new research includes the relationship between cognitive processes and various types of instructional technologies.
Telecommunications, Hypermedia, Microworlds, and various other new technologies have great potential in allowing researchers to discover how students learn and construct their knowledge of science. Continued research will allow science educators to move one step closer to reaching the goal of scientific and technological literacy for all. "If balance in goal emphasis can be achieved and if new findings concerning the psychology of learning can be applied to the educational setting, genuine improvements in the science curriculum will result" (Bybee & DeBoer, 1994, p. 385).
SOLAR SYSTEM EXPEDITION
PROJECT DESCRIPTION

After completing this project, students will have learned to:
• discuss - factors necessary to life
• evaluate - web evidence for explanations of how Earth supports life
• research - web sites and other media for planetary data
• compare and contrast - planetary conditions of our solar system
• analyze - information they have gathered
• decide - which planet would be most able to support life
• hypothesize – what a planetary colony would look like
• synthesize and apply - what they have learned about life support structures
• design - a colony for their planet that is able to sustain life

An optional extension project will allow students to:
• critique - web evidence about life on Mars and changing Mars' environment
• debate - whether life on Mars existed in the past or if it is possible in the future

This project addresses the following middle level content standards:
1) components of our solar system...size, composition, surface features, etc.
2) regular & predictable rotations and movement ... days, years, etc.
3) gravitational forces
4) influences of the sun ... energy sources, seasons, cycles, etc.
5) earth's life sustaining qualities

This project also integrates the following themes of science:
1) ENERGY - Energy for the Earth is provided by the sun. The sun's energy drives cycles such as the water cycle and food webs.
2) EVOLUTION - Man's use of Earth's resources often cause harmful changes over time.
3) PATTERNS OF CHANGE - Periodic motions of planets create patterns in seasons.
4) SCALE AND STRUCTURE - Planet Earth is one planet of our solar system which in itself is part of a galaxy which is part of our universe. Each planet in our solar system is composed of different elements.
5) STABILITY - Earth and objects in our solar system have a set predictable rotation and revolution
6) SYSTEMS AND INTERACTIONS - Earth is a member of the solar system which is composed of other planets, satellites, and other objects that sometimes interact. The solar system is a system of planets with a given scale of size. Organisms interact with each other to form complex food webs. Plants and animals are dependent upon one another.
WEEK ONE & TWO - LIFE FACTORS AND EARTH ANALYSIS

The first segment/week of this project provides students the opportunity to discuss factors/things that living/biotic organisms need to survive and discover how Earth provides conditions that allows those needs to be met.

DAY 1

Students (organized into groups of 4) will discuss the factors/conditions that most organisms need in order to survive. They will compile a list and enter it into their notebook. Each group will share their list with the rest of the class. As each group shares, the other groups will add left out conditions to their original list. The facilitator will conduct a class discussion that enables one class list to be established.

Activity 1 – Consider This (10-15 minutes)
Notepad
Brainstorm

Activity 2 – Class Discussion (20-30 minutes)
Notepad
2A – Group Sharing
2B – Revise your list

DAYS 2 - 10

Students will evaluate pieces of web evidence that explains/shows how Earth is able to provide the life factors for organisms.

Activity 3 – Research Earth
3A – Water, Water, Everywhere (50-60 minutes)
Notepad
Evidence 1-4

3B – Food For Thought (30-40 minutes)
Notepad
Evidence 1-3

3C – What A Great Atmosphere (50-60 minutes)
Notepad
Evidence 1-5

3D – Not Too Close For Comfort (20-30 minutes)
Notepad
Evidence 1-3
WEEK THREE - PLANETARY DATA
The third segment/week will provide students with the opportunity to research planetary data, compare and contrast the characteristics of each planet in our solar system, analyzing the data, and make a decision as to which planet would be most able to support life.

DAYS 1 & 2
Students will research various pieces of web evidence that describe the environmental conditions of the various planets. They will identify the characteristics of each planet and sort the information according to factors that promote the existence of life and factors that prohibit the existence of life.
Activity 4 – Research Planets (60-90 minutes)
   Activity Support Worksheet
   Planetary Data Table

DAYS 3 & 4
Students will research other sources of media that describe the environmental conditions of the various planets. (Media options may include Planetary Taxi CD, Magic School Bus Solar System CD, MacMillan/McGraw Hill Exploring Space videodisc, etc.) They will identify the characteristics of each planet.
Activity 4 – Research Planets (60-90 minutes)
   Activity Support Worksheet
   Planetary Data Table

DAY 5
Students will review the information they have collected on the data table. They will analyze the data and determine which planet has the most factors that promote life and the least factors that prohibit life. They will then decide which planet would be most able to support life. Students will then hypothesize what a colony on that planet might look like.
Activity 5 – Make A Decision
5A – Which Planet (10-15 minutes)
   Notepad
5B – Problem Conditions (10-15 minutes)
   Notepad
5C – Hypothesize (15-20 minutes)
   Activity Support Worksheet
   Hypothesize
WEEK FOUR – LIFE SUPPORT
The fourth segment/week will provide students with the opportunity to evaluate previously designed life support structures.

DAYS 1 & 2
Students will explore Biosphere 2 web evidence and evaluate the components of this previously designed life support structure. They will start forming ideas and take notes about which technologies they might be able to utilize when they design their colony.

Activity 6 – Life Support
   6A – Biosphere Research (30-40 minutes)
   Notepad
   Evidence 1
   Activity Support Worksheet
   Biosphere 2

DAYS 3 - 5
Students will explore NASA web evidence and evaluate previously designed life support structures as well as designs for future research.

Activity 6 – Life Support
   6B – NASA Research (60-90 minutes)
   Notepad
   Evidence 1-5
   Activity Support Worksheets
   Lunar/Mars Project
   BIO-Plex Project
WEEK FIVE - DESIGN A COLONY
The fifth segment/week challenges the students to synthesize all the information they have obtained and design a planetary colony that is able to overcome the factors that prohibit life and allows life to exist. Students will need to construct a model or draw an illustration of the colony they designed. They will be required to provide a list of all the life factors and a brief description of how their colony is able to provide/meet those needs.

DAY 1
Students will revisit their hypothesis. Based on the new information from the life support research, students need to analyze their hypothesis and add to, delete, or modify the original component parts.
Activity 7 – Design Your Colony (20-30 minutes)
   Activity Support Worksheet
   Design Your Colony Parts I

DAY 2
Students will compose a final listing of all the components in their colony design. They need to justify/explain how each part will provide some life sustaining quality.
Activity 7 – Design Your Colony (20-30 minutes)
   Activity Support Worksheet
   Design Your Colony Parts II

DAY 3 - 5
Students will create a color illustration or build a model of their colony design.
Activity 7 – Design Your Colony (1-3 hours)
   Activity Support Worksheet
   Design Your Colony Parts III
EXTENSION FOR FUTURE - CRITIQUE/DEBATE LIFE ON MARS
The sixth segment/week will provide students with the opportunity to critique information about and debate whether life has existed on Mars or if it is possible in the future.

DAYS 1 & 2
Students will critique web evidence regarding the current scientific issues of whether life had existed on Mars and whether or not life on Mars is possible in the future. Students will rate the web evidences for validity and sort the information into categories of 'Supports the theory of life on Mars' or 'Contradicts the theory of life on Mars'.

DAYS 3 & 4
Students will be assigned or chose a particular position. They will prepare to debate the issue by forming arguments that support their position, developing counter arguments for evidence that contradicts their position, and establishing arguments against the opposing position.

DAY 5
Students will conduct a class debate. Each side will present the argument that supports their position and the argument against the opposing position. Each group will then be able to counter argue the evidence that contradicts their position.
# SOLAR SYSTEM EXPEDITION JOURNAL

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<th>DESCRIPTION OF ACTIVITY</th>
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<td>Pre-assessment</td>
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<td>1/7 Day 2</td>
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<td>Activity 1 – Consider This</td>
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<td></td>
<td>20-30 min.</td>
<td>Activity 2 – Class Discussion</td>
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<td>1/8 Day 3</td>
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<td>Activity 3 – Research Earth</td>
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<td></td>
<td>5-10 min.</td>
<td>3A – Water, Water, Everywhere</td>
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<td></td>
<td>5-10 min.</td>
<td>Evidence 1 – Earth’s Watery Surface</td>
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<td>5-10 min.</td>
<td>Evidence 2 – Precipitation</td>
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<td>1/11 Day 4</td>
<td>30-40 min.</td>
<td>Evidence 3 – Water Cycle</td>
</tr>
<tr>
<td>1/12 Day 5</td>
<td>30-40 min.</td>
<td>Evidence 4 – Hydrologic Cycle</td>
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<td>1/13 Day 6</td>
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<td>Water Cycle Lab</td>
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<td></td>
<td>10-15 min.</td>
<td>Evidence 1 – The Food Chain</td>
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<td></td>
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<td>Evidence 2 – Following The Path of Food</td>
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<td></td>
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<td>Evidence 3 – Oxygen/Carbon Dioxide Cycle</td>
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<td>1/14 Day 7</td>
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<td>Photosynthesis Lab</td>
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<td>1/15 Day 8/9</td>
<td>15-20 min.</td>
<td>3C What A Great Atmosphere</td>
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<td></td>
<td>5-10 min.</td>
<td>Evidence 1 – The Atmosphere</td>
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<td></td>
<td>5-10 min.</td>
<td>Evidence 2 – The Earth’s Atmosphere</td>
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<td>5-10 min.</td>
<td>Evidence 3 – Structure of the Atmosphere</td>
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<td></td>
<td>5-10 min.</td>
<td>Evidence 4 – The Greenhouse Effect</td>
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<td></td>
<td>5-10 min.</td>
<td>Evidence 5 – Standard Atmosphere</td>
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<td>1/19 Day 10</td>
<td></td>
<td>3D – Not Too Close For Comfort</td>
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<td></td>
<td>5-10 min.</td>
<td>Earth’s Conditions….Just Right</td>
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<td></td>
<td>5-10 min.</td>
<td>The Four Seasons</td>
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<td></td>
<td>5-10 min.</td>
<td>The Seasons Explained</td>
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<td>1/20 Day 11</td>
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<td>Activity 4 – Research Planets</td>
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<td></td>
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<td>Planetary Taxi CD</td>
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<td>1/22 Day 13</td>
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<td>The Magic School Bus Solar System CD</td>
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<td>1/25 Day 14</td>
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<td>Activity 5 – Make A Decision</td>
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<td></td>
<td>10-15 min.</td>
<td>5A – Which Planet?</td>
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<td></td>
<td>10-15 min.</td>
<td>5B – Problem Conditions</td>
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<td></td>
<td>15-20</td>
<td>5C - Hypothesize</td>
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<tr>
<td>1/26 Day 15</td>
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<td>Activity 6 – Life Support</td>
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<td></td>
<td>45-60 min.</td>
<td>6A- Biosphere Research</td>
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<td>1/27 Day 16/17</td>
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<td>6B – NASA Research</td>
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<tr>
<td>Two Periods</td>
<td>5-10 min.</td>
<td>Evidence 1 – Advanced Life Support Concept</td>
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<tr>
<td>Day</td>
<td>Time</td>
<td>Activity/Assignment</td>
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<tr>
<td>1/28</td>
<td>15-20 min.</td>
<td>Activity 7 – Design Your Colony Part I</td>
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<td>1/29</td>
<td>45-60 min.</td>
<td>Activity 7 – Design Your Colony Part III</td>
</tr>
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<td>1/30 – 2/28</td>
<td>BREAK</td>
<td>D-TRACK STUDENTS WERE OFF</td>
</tr>
<tr>
<td>3/2 – 3/17</td>
<td></td>
<td>Review of Notepad and Activity Support Worksheets</td>
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<tr>
<td>3/18</td>
<td>50 min.</td>
<td>Journey To Mars Video</td>
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<tr>
<td>3/19</td>
<td>60 min.</td>
<td>Post-assessment</td>
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<tr>
<th>Time</th>
<th>Activity/Assignment</th>
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<tr>
<td>5-10 min.</td>
<td>Evidence 2 – Lab-Scale CELSS Project</td>
</tr>
<tr>
<td>10-15 min.</td>
<td>Evidence 3 – CELSS Information</td>
</tr>
<tr>
<td>15-20 min.</td>
<td>Evidence 4 – Lunar/Mars Life Support Project</td>
</tr>
<tr>
<td>15-20 min.</td>
<td>Evidence 4 – BIO-Plex Project</td>
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<tr>
<td>1/28 Day 18</td>
<td>Evidence 2 – Lab-Scale CELSS Project</td>
</tr>
<tr>
<td>1/29 Day 19</td>
<td>Evidence 3 – CELSS Information</td>
</tr>
<tr>
<td>1/30 – 2/28</td>
<td>Evidence 4 – Lunar/Mars Life Support Project</td>
</tr>
<tr>
<td>3/18</td>
<td>Evidence 4 – BIO-Plex Project</td>
</tr>
<tr>
<td>3/19</td>
<td>Evidence 4 – Lunar/Mars Life Support Project</td>
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APPENDIX C: Solar System Expedition Project Questions

Solar System Expedition
Pre-assessment/Post-assessment Questions

1) List four things that living organisms need in order to survive. After each item, describe how earth is able to provide those items.
2) Sketch and describe how day and night are created.
3) How long is one of earth’s days?
4) Sketch and describe how seasonal changes are produced.
5) Two factors that help create seasonal changes include
6) How long is one of earth’s years?
7) List the two main gases in earth’s atmosphere.
8) What force helps to keep an atmosphere on earth?
9) List the four main layers of earth’s atmosphere.
10) Sketch a diagram of the layers of earth’s atmosphere. Label the layers.
11) List the five processes of the water cycle (hydrologic cycle).
12) Sketch a diagram of the flow of water in the water cycle. Label the processes.
13) Explain this statement. Earth’s atmosphere is like a greenhouse.
14) Illustrate the flow of energy by creating a diagram of a food chain that includes a consumer, decomposer, producer, and energy source. Label each item.
15) Where does earth’s energy source come from?
16) Describe the process of photosynthesis. What do plants need for photosynthesis and what do they produce from it?
17) What two gases do plants and animals exchange? Draw a simple sketch that shows the process. Make sure you label everything.
18) List as many of the nine planets in our solar system as you can. Then, give a brief description of the environmental conditions of each planet. Include the planet’s composition, temperature, and atmosphere.
19) Which planet is probably most like earth?
20) Design a colony that would enable earth’s living creatures to exist on that planet. Create a sketch of the colony. Create a list of the components of your colony and explain why that part is important for allowing living things to survive.
21) Create the sketch of your colony on the back of this page. Make sure you label each component part.
<table>
<thead>
<tr>
<th>Note Pad Question #</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A1</td>
<td>What do living things need in order to survive? List and describe as many conditions as you can.</td>
</tr>
<tr>
<td>2 A2A</td>
<td>Did any of the groups mention things that your group did not consider? If so, enter those items on to your notes.</td>
</tr>
<tr>
<td>3 A2B</td>
<td>Now it's time to revise your original list. Create a list that includes all the life factors that your class discussed.</td>
</tr>
<tr>
<td>4 3A/E1</td>
<td>How much of Earth is covered by water? How much of that is actually usable? Where is most of our freshwater found?</td>
</tr>
<tr>
<td>5 3A/E2</td>
<td>If most of Earth's water is in the ocean, how do we get water for drinking and other uses? What forms does water exist in?</td>
</tr>
<tr>
<td>6 3A/E3</td>
<td>If we get our usable water from various forms of precipitation, what process enables precipitation to form? Where does the energy to drive this process come from?</td>
</tr>
<tr>
<td>7 3A/E4</td>
<td>Another name for water cycle is hydrologic cycle. What are the five processes of the hydrologic cycle? After entering your notes, complete the Activity Support Worksheet (3A-Evidence 4-The Water Cycle).</td>
</tr>
<tr>
<td>8 3B/E1</td>
<td>What are the four main components of a food chain? What provides the original source of energy? What category do humans fit under? What group allows humans to obtain the energy from the sun by harnessing it for us? After writing your notes, complete the Activity Support Worksheet 3B – Evidence 1 – Food Chains.</td>
</tr>
<tr>
<td>9 3B/E2</td>
<td>What process do plants use to make their own food? What four items are needed for this food making process? After taking notes, complete the Activity Support Worksheet 3B - Evidence 2 - Photosynthesis.</td>
</tr>
<tr>
<td>10 3B/E3</td>
<td>Besides food, what else are animals dependent upon plants for? Complete the Activity Support Worksheet 3B – Evidence 3 – Oxygen/Carbon Dioxide Cycle.</td>
</tr>
<tr>
<td>11 3C/E1</td>
<td>What is the atmosphere? What are six important things that Earth's atmosphere does?</td>
</tr>
<tr>
<td>12 3C/E2</td>
<td>What gases is Earth's atmosphere composed of? How does its composition help make Earth livable? After taking notes, complete the Activity Support Worksheet (3C – Evidence 2 – Composition of Earth's Atmosphere).</td>
</tr>
<tr>
<td>13 3C/E3</td>
<td>Describe the structure of Earth's atmosphere. After taking notes, complete the Activity Support Worksheet (3C – Evidence 3 – Layers of Earth's Atmosphere).</td>
</tr>
<tr>
<td>14 3C/E4</td>
<td>Why is the Greenhouse Effect beneficial? How does it contribute to making Earth a great planet to live on?</td>
</tr>
</tbody>
</table>
After taking notes, complete the Activity Support Worksheet (3C – Evidence 4 – The Greenhouse Effect).

15 3C/E5 What holds the atmosphere to Earth?

16 3D/E1 What information does this evidence provide about how Earth's location (distance from the sun) helps to make it a nice place to live on?

17 3D/E2 Variety is known as the spice of life. Earth's climate varies and as a result parts of Earth experience seasons. What two factors cause Earth to experience seasonal changes? Describe the seasonal changes that the northern hemisphere experiences throughout the year. What areas of the Earth do not experience seasonal changes?

18 3D/E3 What is the measurement of Earth's tilt that helps to create seasonal changes? Complete the Activity Support Worksheet (3D – Evidence 3 – Seasonal Changes).

19 A5A Review your notes and the Planetary Data Table Activity Support. Which planet would be best to colonize because it seems to be most similar to Earth and able to support life?

20 A5B Now that you have decided which planet would be most capable of supporting life, you will need to determine which conditions of that planet need to be overcome in order to survive on it. Carefully review your notes about the planet and identify the specific factors that make the planet non-livable.

21 6A/E1 What are the nine components that Biosphere 2 contains? As you tour through Biosphere 2, complete the Activity Support Worksheet (6A – Evidence 1 – Biosphere 2).

22 6B/E1 What has the Advanced Life Support program at NASA been examining? What does CELSS stand for?

23 6B/E2 If we were to colonize the Moon or Mars, what system would be required? What is that system able to do?

24 6B/E3 CELSS stands for Controlled Ecological Life Support System. What does that mean? What does this life support system supply? What human wastes must be removed? What basic idea is behind the CELSS concept?

25 6B/E4 The Overview of the Lunar-Mars Project summarizes the systems that were critical components of the project. How many components does the Lunar-Mars Project consist of? After finishing your notes, complete the Activity Support Worksheet (6B – Evidence 4 – Lunar-Mars Project).

26 6B/E5 Future Life Support Systems tests include the BIO-Plex project. How many subsystems is the BIO-Plex designed with? After finishing your notes, complete the Activity Support Worksheet (6B – Evidence 5 – BIO-Plex Project).
### Activity Support Worksheet Questions

<table>
<thead>
<tr>
<th>Question #</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 3A/E4</td>
<td>Fill in the correct processes of the water cycle in the blank spaces above. Use the terms below. evapotranspiration (2x), condensation, water vapor, precipitation infiltration, run off, water, ground water Fill in the table below. List each of the five processes of the water cycle and briefly describe them.</td>
</tr>
<tr>
<td>2 3B/E1</td>
<td>Living organisms are either producers or consumers, depending on how they obtain their energy. Consumers can be either herbivores, carnivores, or omnivores. Label each organism above as a producer, herbivore, carnivore, or omnivore.</td>
</tr>
<tr>
<td>3 3B/E2</td>
<td>Label lines A-D above. Choose from the following terms: chlorophyll water sunlight energy carbon dioxide</td>
</tr>
<tr>
<td>4 3B/E3</td>
<td>Label the picture above. Choose from the following terms. sunlight energy oxygen carbon dioxide plant makes food water chlorophyll in leaves</td>
</tr>
<tr>
<td>5 3C/E2</td>
<td>Label the circle graph with the gasses that make up our atmosphere. Include the percentages of each.</td>
</tr>
<tr>
<td>6 3C/E3</td>
<td>List and describe the five divisions of earth’s atmosphere. Label each layer in the diagram above.</td>
</tr>
<tr>
<td>7 3C/E4</td>
<td>Sketch in the arrows that describe the flow of warm air in our atmosphere. Describe what is happening to create the Greenhouse Effect.</td>
</tr>
<tr>
<td>8 3D/E3</td>
<td>Based upon the position of the earth, label the four seasons as the northern hemisphere experiences them on the solid lines and label the seasons that the southern hemisphere experiences on the dotted lines.</td>
</tr>
<tr>
<td>9 3D/E4</td>
<td>Label the diagram above as it illustrates day and night. Use the terms below. day night north pole south pole equator sun</td>
</tr>
<tr>
<td>10 4/E1&amp;2</td>
<td>Fill in the Planetary Data Table as you learn information about each planet. Outline the boxes of the factors that may promote the existence of life on that planet.</td>
</tr>
<tr>
<td>11 5C</td>
<td>What do you think a colony on your planet would look like? Fill in the chart below and draw a sketch of your colony.</td>
</tr>
<tr>
<td>12 6A/E1</td>
<td>List the nine components of Biosphere 2. Why do you think the designers of biosphere included those nine components? Describe two purposes for the ‘lungs’ of biosphere 2. Describe the appearance of the Biosphere 2 living quarters. What types of</td>
</tr>
</tbody>
</table>
rooms are included?
What does IAB stand for? What does the IAB do?
What type of plants does the Rainforest support?
What purpose was the Ocean designed for? What did the designers use for an example ‘blueprint’?
What type of desert is the Biosphere 2 Desert modeled after?

<table>
<thead>
<tr>
<th>13 6B/E4</th>
<th>Complete the descriptions of the various L-M Project components.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plant Growth System</td>
<td>Plants were used for ...</td>
</tr>
<tr>
<td>2. Solid Waste Incineration System</td>
<td>Solid wastes are burned and as a result, two product gases are produced. These gases are...</td>
</tr>
<tr>
<td>3. Air Revitalization System</td>
<td>ARS provides...</td>
</tr>
<tr>
<td>4. Water Supply and Water Recovery System</td>
<td>WRS provides...</td>
</tr>
<tr>
<td>5. Thermal Control System</td>
<td>TCS controls...</td>
</tr>
<tr>
<td>6. Food System</td>
<td>Food for the test subjects will include...</td>
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<tr>
<td>7. Human Accomodations</td>
<td>Several of the human accommodations include...</td>
</tr>
<tr>
<td>8. Facility Support Systems</td>
<td>The EMS is designed to...</td>
</tr>
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</table>

| 14 6B/E5 | Fill in the missing labels of the subsystem flow chart above. Complete the information for the schedule below. |

| 15 7A | You have just finished your research on several different artificial life support systems and self sustained environments. Before you go on to your final design, revisit your hypothesis of what a colony on your planet would look like. Based on the information you now know, how would you change your design? What would you add and delete? Complete the data table below to help you organize your thoughts. |

| 16 7B | The time has come for the grand design of your planetary colony. Once again, list the component parts of your colony design. Then describe what function it has; tell how it provides some life sustaining quality. |

| 17 7C | Create a colored sketch of your new design. Make sure you label each component. |
Group Results

<table>
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<th>Score of 1</th>
<th>Score of 2</th>
<th>Score of 3</th>
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Appendix D: Rubric Data Results
COLONY DESIGN HYPOTHESIS RESULTS
ACTIVITY 5 C

Score of 0  Score of 1  Score of 2  Score of 3

Proper Temperature  Living/Working Environment  Air/Oxygen  Food/Plants  Energy/Solar  Gravity  Water  Animals  Waste Removal  Control System  Medicine

Colony Component Part
FINAL COLONY DESIGN RESULTS
ACTIVITY 7 B&C

Component Part

Proper Temperature  Air/Oxygen  Food/Plants  Energy/Solar  Gravity  Water  Animals  Waste Removal  Control System  Medicine

Number of Groups

0  2  4  6  8  10  12  14  16  18

Score of 0  Score of 1  Score of 2  Score of 3
COLONY DESIGN SCORE COMPARISON

- Score of 0
- Score of 1
- Score of 2
- Score of 3

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APPENDIX E: Samples of Student Models
BIBLIOGRAPHY


Mehlinger, H. D. (1997, June). The Next Step: Now that schools have technology, it’s time to let the technology transform schooling. *Electronic School [On-line].* Available:


