A DESIGN OF MARS 2076: A STUDENT-CENTERED AEROSPACE CURRICULUM

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NOMENCLATURE

The following are defined as used in this study.

Aerospace Education: The use of aviation, space history, and science to inspire and motivate students to pursue studies, in science, mathematics, engineering, and technology, thereby preparing them to function in the workplace of tomorrow.

Curriculum Enhancement Products: Materials, primarily informational, activity-oriented, or multi-media, which are given out to educators to add dimension to established curricula.

Educational Technology: The use of technologies such as computers, phone lines, modems, communications satellites, cellular services, wireless transmitters, cable television (TV), and other providers of electronically transmitted information to enhance the quality of education.

Hardware: The actual computer and related machines.

Software: A computer program; loosely defined, is a package of instructions to be used on computer hardware.

Virtual Reality: Computer-generated visuals simulating a real or imaginary environment.

ABBREVIATIONS AND ACRONYMS

AESP	Aerospace Education Services Program
CD-ROM	Compact Disk Read Only Memory
ERIC	Education Resources Information Center
NASA	National Aeronautics and Space Administration
TFSP	Teaching From Space Program
URCEP	Urban and Rural Community Enrichment Program

CHAPTER I

INTRODUCTION

Background

The educational community has used many methods over the past centuries to pass along the accumulated knowledge of humankind. Chief among these in formal schooling has been the use of the lecture method. This essentially involves listening to a teacher talk about what he or she knows concerning a particular subject. The student, in turn, attempts to remember the facts sufficiently so that he or she can recall them satisfactorily to do well on an examination. The instructor evaluates how well the student has performed and assigns a grade. At the end of the term of study, the instructor uses the accumulated marks to pass along a final grade. The student has had little involvement in the establishment of the rubrics that contain the parameters for his evaluation. In the end, the student receives very little assistance in acquiring the details he needs to improve upon his own knowledge of the subject except what was right or wrong on specific exams.

This is not an ideal learning environment for a majority of students. Many need different or a variety of methods to make learning more personally beneficial. There have been many attempts to revise and improve upon the lecture method of teaching during the past century. One of the more practical came from the study of science where it had long been acceptable for students to work collaboratively as laboratory partners.

The strength of the laboratory type of study was founded in the idea that students could remember lessons better because they had actually experienced the events or results for themselves. This, compared to the lecture method, where the instructor told the students about his own or someone else's experiences. It appears to be a human characteristic that we remember best what we experience for ourselves.

What we remember or get value from is dependent upon our own personal need to learn information for some practical use. Abraham Maslow (1970) showed in his *Hierarchy of Needs* that humans are not concerned with learning or experiencing the more profound lessons of life unless their personal basic needs of food, shelter, and clothing have been met. Humans who need to spend most of their time each day striving to survive until the following day do not desire to engage in philosophical debate on the existence of heaven or where the universe ends.

When humans first colonized "new worlds," like the United States, their basic needs had to be provided for each day before they became concerned about furthering their own formal education or that of their children. When those needs of consistent food, clothing, and shelter were met, colonists did allow themselves to engage in education that required "higher-order thinking skills." (Bloom, 1956)

In Benjamin Bloom's *Taxonomy of the Cognitive Domain* (1956) he speaks of steps by which humans reason. Much of what we do in everyday life does not require "higher order thinking skills," but those that define history usually do.

This process will be the same when humans begin to explore another "new world" such as Mars. There will be basic differences between Earth and Mars that will have to be realized so those colonists can adapt to their new locale. Much of Earth knowledge will be useful to the explorers, but they will have to be cognizant of the things that are totally new, different, or unexpected. In some circumstances, it will be better for them to disregard their Earth-bound knowledge and think in new ways. True survival may depend upon new ways of thinking.

Educators today are not just schooling children for the present, but the future, wherever that may be. These students need to acquire skills now that will be useful to any future endeavors—even space travel. NASA has been at the forefront of providing educators additional tools that can be used to enhance the science, mathematics, and technology curricula of their schools.

When educators, as well as the general public, think of NASA they envision the future. This is also true of the educational products it distributes. The products need to be innovative.

In the Act of Congress that created the agency in 1958, NASA was directed to disseminate the data from its research in aeronautics and space-related projects to the American public. The agency has sought to accomplish this goal by creating educational products that could be used by teachers in classrooms to enhance the study of science, mathematics, and technology (Bilstein, 1989).

Over the past forty years, NASA has distributed a variety of educational products. Many of these products are demonstrated each year by NASA Aerospace Education Specialists contracted by the agency through Oklahoma State University who travel to individual school districts to perform teacher workshops. The educators in the schools have the opportunity to evaluate not only the materials they are given, but also the method in which the products are demonstrated.

Many of the activities that NASA distributes to teachers are in the form of laboratory modules. Collaborative study by small-group members interacting with each other can potentially gain more value from a particular activity than a student could attempting to learn information by him or herself.

It is the purpose of this study to have educators evaluate an original piece of aerospace science curricula and evaluate it according to its merits as a device to involve students in higher-order learning.

Statement of the Problem

Major disciplinary groups, national commissions, state boards, and local interest groups have recommended reform in the learning process in today's schools. Many standards have been imposed upon the educational community, especially in the past decade.

Educators are seeking ways to form the school curriculum to these new mandates while keeping the students directly involved with the learning process. How does an educator successfully combine the key elements of content knowledge, societal work skills, and student learning interests? What are the most effective educational processes to accomplish these goals?

Purpose of the Study

This study will seek to discover how aerospace science curriculum projects can contribute to the higher-order learning of students in a period of vast education reform.

Objectives of the Study

To accomplish this purpose the following objectives must be met:

1. Sixty educators will participate in the "Mars 2076" activity project.
2. The participating educators must complete answers to the provided questionnaire.
3. Selected educators will be interviewed about the project.
4. Case studies will be made of two interviewees.
5. The qualitative responses will be categorized.
6. Major themes found among the categorized responses will suggest strengths and weaknesses in the project.
7. Improvements suggested by participants will be implemented into the revised small-group, interactive project.

Scope and Limitations of the Study

This study is limited to educators who will be part of a workshop supported by NASA in the summer of 1999. They will be used as a representative group of educators in the evaluation on the aerospace education project "Mars 2076."

The study will not examine student reaction to the project, but will ask educators their impressions on various aspects of the activities and the project as a whole.

Significance of the Study

The significance of the study is that it will be the first opportunity for educators to evaluate the original project "Mars 2076" as a means to involve students in an interactive, small-group, aerospace activity.

Organization of the Study

This research is designed to provide a descriptive evaluation by educators on how well "Mars 2076" could effectively be used as an inter-active, small group aerospace project with their own students. A group of educators from various regions across the United States and Puerto Rico participated in the "Mars 2076" project during a two week workshop of aerospace education sponsored by NASA at Oklahoma State University. Information was gathered from the educators during the summer of 1999 by utilizing a questionnaire. Additionally, selected educators were interviewed to derive more in-depth evaluation of the project. Case studies were made of two participants.

Following this introductory chapter, Chapter II reviews related literature on education reform. This is followed by a presentation of material on teachers as facilitators. Third, a discussion is shown of the use of small-group, interactive projects in education. Fourth, an explanation of NASA curriculum enhancement products is offered as an example of tools in the curriculum. Fifth, examples of important Mars-related literature are provided as background support in creation of the "Mars 2076" curriculum enhancement product. Sixth, student interests in learning are examined. Finally, evaluation is explored both for use with student learning and with the data from this research project.

Chapter III discusses the procedures used to collect the data and analyze it in detail. The development and validation of the instrument are described. Chapter IV explains the results of the answers to the questionnaire and individual interviews. It also describes the analysis on this data and that of the case studies. Chapter V summarizes the major findings and conclusions, and recommends topics for further study.

CHAPTER II

REVIEW OF RELATED LITERATURE

In order to set forth a logical basis for this study, work was reviewed that had been previously written by others in a number of topic areas: First, the researcher will present studies done in the area of learning reform; second, the role of teachers as facilitators will be discussed; third, small-group, interactive projects are examined; fourth, NASA Curriculum Enhancement Products are explained; fifth, Mars-related literature is described as support materials; sixth, student learning interests will be reviewed; and finally, the need for evaluation will be included.

Educational Reform, Goals, and Standards as a Basis for Curriculum Development

The past fifteen years have been one of exceptional scrutiny for America's schools. "We have been enjoying and enduring the most intense period of educational reform in this century. Everyone has gotten into the act: politicians, parents, teachers, taxpayers, teacher educators, social critics, journalists, and researchers—all are passionately involved in school renewal (Zemelman, Daniels, & Hyde, 1998, p. 1).

Two significant reasons for this renewal consist of concern for low student test scores and an apparent loss of American workers' competitiveness in the world market. President Bill Clinton's Assistant for Science and Technology, John H. Gibbons, set forth the necessity for reform in the administration's document, *Science in the National Interest*: "Today we are facing a rapidly changing world and we have the opportunity, indeed the imperative, to examine our science policies and decide how to restructure them to retain America's preeminent position in world science." (1998, p. 1)

Blame has been placed upon a wide number of culprits: TV, video games, single-parent families, ill-trained teachers, urban gangs, and schools of education, among others.

Zemelman, et al. look upon this period as one that schools and educators should take advantage. They feel that American interest in education has never been more intense. Educators should use this unique spotlight to make major changes in the way schools educate students. In *Science in the National Interest,* Harold Varmus, of the National Institutes of Health, offered: "As we respond to increasing demands to plan and justify our investment in science in terms of societal goals, it is crucial to recall that the greatest and most influential discoveries have usually been the products of young minds free to think creatively about the natural world, without consideration of practical purpose." (1998, p. 2)

What is significantly different in this current round of education reform is that we are blending a positive view of children with our commitment to certain curriculum content and our improved understanding of how learning works.

Today we enjoy a rich base of research and exemplary practice that points the way to school renewal through curriculum reform. As teachers are showing in schools around the country, this progressive paradigm is not just a dream anymore, but a real, practical, manageable, available choice. But this new/old model enacts learning and teaching in very different ways from those that most contemporary parents, principals, and teachers themselves experienced in school—and, in some ways, it directly contradicts teachers' professional training. So when teachers, schools, or districts want to move toward this new model, everyone involved in the change needs lots of information and reassurance: They need a chance to construct their own understanding of what the new curriculum means, what research and theory supports it, how it can be implemented, and why it holds so much promise for our children (Zemelman, et al., 1998, p 16-17).

In contrast to reformers who believe that you can simply use the same old methods more intensively for success, we need to focus on the interactions between students and teachers in school. Our current teaching processes don't empower students, don't nurture literacy, don't produce efficient workers, don't raise responsible citizens, and don't create a fundamental democracy (Zemelman et al., 1998, p. 3).

Real reform recommendations have come from many different organizations associated with many academic disciplines. Many of these recommendations are very similar; these include:

- Less whole-class, teacher-directed instruction (e.g., lecturing)
- Less student passivity: Sitting, listening, receiving, and absorbing information.
- Less presentation, one-way transmission of information from teacher to student
- Less prizing and rewarding of silence in the classroom
- Less classroom time devoted to fill-in the blank worksheets, dittos, workbooks, and other "seatwork"
- Less student time spent reading textbooks and basal readers

- Less attempt by teachers to thinly "cover" large amounts of material in every subject area
- Less rote memorization of facts and details
- Less emphasis on the competition and grades in schools
- Less tracking or leveling students into "ability groups"
- Less use of and reliance on standardized tests
- Less use of pull-out special programs
- More experimental, inductive, hands-on learning
- More active learning in the classroom, with all the attendant noise and movement of students doing, talking, and collaborating
- More diverse roles for teachers, including coaching, demonstrating, and modeling
- More emphasis on higher-order thinking; learning a field's key concepts and principles.
- More deep study of a smaller number of topics, so that students internalize the field's way of inquiry
- More reading of real texts: Whole books, primary sources, and nonfiction materials
- More responsibility transferred to students for their work: Goal setting, record keeping, monitoring, sharing, exhibiting, and evaluating
- More choice for students (e.g., choosing their own books, writing topics, team partners, and research projects)

- More enacting and modeling of the principles of democracy in school
- More attention to affective needs and the varying cognitive styles of individual students
- More cooperative, collaborative activity; developing the classroom as an independent community
- More heterogeneously grouped classrooms where individual needs are met through inherently individualized activities, not segregation of bodies
- More delivery of special help to students in regular classrooms
- More varied and cooperative roles for teachers, parents, and administrators
- More reliance on teachers' descriptive evaluations of students growth, including observational/anecdotal records, conference notes, and performance assessments rubrics (AAAS 1989 & 1993; Anderson, et al., 1985, Bybee, et al., 1989 & 1991; Center for Civic Education, 1994; Consortium of National Arts Organizations, 1994; Crafton, 1996; Geography Education Standards Project, 1994; Harst, 1989; Hillock, 1986; IRA & NCTE, 1996; Joint Committee on National Health Education Standards, 1995; National Center for History in the Schools, 1994; National Research Council, 1996; NCTM, 1989, 1991, & 1995; National Council for the Social Studies, 1994; Sanders and Gilliard, 1995; Sierra-Perry, 1996; Smagorinsky, 1996; Wilhelm, 1996.)

Because of their practices, teachers in aerospace science have an opportunity to be in the forefront of the movement. "Science educators have a decades-long tradition of supporting progressive, hands-on, student-centered instruction, but less success with implementation in schools." (Zemelman, et al., 1998, p.7)

The emerging "Best Practice" paradigm includes a series of recommendations that may assist educators to create valuable reform in America's schools. The following are thirteen interlocking principles of Best Practice models suggested by the work of Zemelman, et al.:

Student–centered: The best starting point for schooling is young people's real interests; all across the curriculum, investigating students' own questions should always take precedence over studying arbitrarily and distantly selected "content."

Experimental: Active, hands-on, concrete experience is the most powerful and natural form of learning. Students should be immersed in the most direct possible experience of the content of every subject.

Holistic: Children learn best when they encounter hole ideas, events, and materials in purposeful contexts, not by studying sub-parts isolated from actual use.

Authentic: Real, rich, complex ideas and materials are at the heart of the curriculum. Lessons or textbooks that water-down, control, or oversimplify content ultimately disempower students.

Expressive: To fully engage ideas, construct meaning, and remember information, students must regularly employ the whole range of communicative media—speech, writing, drawing, poetry, dance, drama, music, movement, and visual arts.

Reflective: Balancing the immersion in experience and expression must be opportunities for learners to reflect, debrief, abstract from their experiences what they felt and thought and learned.

Social: Learning is always socially constructed and often interact ional; teachers need to create classroom interactions that "scaffold" learning.

Collaborative: Cooperative learning activities tap the social power of learning better than competitive and individualistic approaches.

Democratic: The classroom is a model community; students learn what they live as citizens of the school.

Cognitive: The most powerful learning comes from when children develop true understanding of concepts through higher-order thinking associated with various fields of inquiry and through self-monitoring of their thinking.

Developmental: Children grow through a series of definable but not rigid stages, and schooling should fit its activities to the developmental level of the students.

Constructivist: Children do not just receive content; in a very real sense, they re-create and reinvent every cognitive system they encounter, including language, literacy, and mathematics.

Challenging: Students learn best when faced with genuine challenges, choices, and responsibility in their own learning. (1998, pp. 9-15)

Rather than discuss Best Practices in all school learning disciplines, this researcher will concentrate on exemplary models in the sciences, the discipline most associated with his research project.

Numerous science educators and, in turn, national science organizations have endorsed principles of progressive education. They call for making science learning experiential instead of lecture-oriented, cognitive and constructivist rather than focused only on facts and formulas, social and collaborative rather than isolating students from one another.

The American Association for the Advancement of Science (AAAS) set the tone in 1989 by asserting "if students are expected to apply ideas in novel situations, then they must practice applying them in novel situations. If they practice only calculating answers to predictable exercises or unrealistic word problems, then that is all they are likely to learn. Similarly, students cannot learn to think critically, analyze information, communicate scientific ideas, make logical arguments, work as part of a team, and acquire other desirable skills unless they are permitted and encouraged to do those things over and over in many contexts." (p. 199)

Along with goals for content learning, the 1989 report, *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology*, included a full section on "Effective Learning and Teaching."

The National Science Education Standards (1996) took several leaps further by starting with a set of teaching standards, moving on to standards for student achievement. Unlike many documents from other fields, rather than just arguing that higher standards for kids would mean higher standards for teachers and school systems, this report recognizes that better learning comes first and foremost from better teaching and better systemic support for good education. Within the content standards themselves, the document turns its asserted values into explicit standards for the classroom. The first content standards are about "Unifying Concepts and Processes." Then, standards for each grade level begin with a standard for "Science as Inquiry" and conclude with one for "Science in Personal and Social Perspectives" and one for "History and Nature of Science." Understanding large ideas and themes and developing inquiring habits of mind, in other words, are the central goals for teaching and learning science.

The National Science Education Standards is an extremely helpful document because it not only provides goals for high quality science teaching and learning and for leading more students to enter science fields, but also shows us how to work toward these goals.

For both the students who will study and use science in their careers and for all students who need to be well-informed citizens, the broad goal of a school science program should be to foster understanding, interest, and appreciation of the world in which we live (Zemelman, 1998, p. 111).

The following are a series of examples of Best Practices that emphasize goals of science education.

In San Antonio, Texas, a school biology teacher gave each of his students 25 acorns at the beginning of the school year. Based upon each student 's initial investigation of the acorns, the students chose their own topic to investigate, designed their own topic to process, pursued it, and wrote up the results. This project continued throughout the school year while the rest of the biology study went on (Zemelman, 1998, p. 112).

In this project, <u>process</u> is paramount. Students learned the importance of inquiry and questioning by encouraging it themselves. If students are asked only to memorize information that is presented as already known, they are not being exposed to this questioning side of the discipline.

The National Science Education Standards asserts: Learning science is something students do, not something that is done to them... emphasizing active science learning means shifting emphasis away from teachers presenting information and covering science topics (p. 20).

Science involves higher-order thinking and comparison and connection of phenomena from a variety of settings. This approach does not negate or minimize the value of factual information in science. Rather, it seeks to ensure that students really understood and retain this knowledge. One of the best practices for an educator is to become a fellow experimenter with his students—in other words, they can be a good model of scientific thinking (Zemelman, 1998, p.113).

A start-of-the-year activity used by Jim Effinger at Naperville North High School illustrated just how a problem-solving approach can excite students about biology. Jim brought donuts to class and asked what sorts of things people might do before they eat their donuts. Possibilities included choosing and inspecting your donut, saying a prayer, and sooner or later, someone mentioned washing hands. "Why do that?" Jim asked. The students decided that *getting rid of germs* was the main purpose...

This practice shows that it is essential to encourage students' natural curiosity, sense of self-esteem, and confidence in approaching science study. Students should see themselves as active, responsible, citizens who use their knowledge to take an active part in public debate.

The 1989 AAAS Report, Science for All Americans: Project 2061 Report on Literary Goals in Science, Mathematics, and Technology emphasized: "Science teaching should also aim to counteract learning anxieties by building on success, provide abundant experience in using tools, support the roles of women and minorities in science and emphasize group learning." (p. 205)

In one Earth Science class, the teacher helped students undo their confusion about the phases of the Moon by using two tennis balls, each painted black on one side (Zemelman, 1998, p.118).

This best practice sought to clarify a commonly held misconception in space science. This was accomplished by having the students investigate actively.

Fourth graders, located in the Great Lakes Region of the United States, studying the desert were encouraged to pursue reading and writing in unique ways: They wrote letters to students in Arizona asking them about how those children experienced desert geography and desert life. They also read stories and poems written with desert themes.

These students utilized a number of skills outside the science discipline—reading, writing, and speaking skills. Math was used in measuring, tallying, graphing, and averaging. Thus, teachers—especially with self-contained classrooms—could readily integrate many parts of the curriculum in order to make time for extended science exploration (Zemelman, 1998, p. 119).

Parents can also be proponents of Best Practices. They don't need to be science experts to encourage their children to investigate. Parents can answer questions from their children thoughtfully. When it is time to give gifts for birthdays and Christmas they can reinforce their children's natural desires to learn by giving microscopes, telescopes, chemistry sets, etc. They can make family outings to science museums or wildlife habitats. They can give non-fiction books on animals and plants. These gifts are valuable in one other way—they are not gender specific. Finally, parents can and should be as active as possible in school/parent organizations. This is especially important for parents who are concerned about the effects of reform on their children. "I do not wish to sacrifice my child on the altar of the future. Talk to me about today. A new program can't be implemented without a year or two of adjustment. The problem is the students have only one chance." (Educ. Leadership, Vol, #7, April 2000, p. 54 & 55)

Teachers as Facilitators

Whether educators like to admit it or not their primary role in learning is to facilitate the process of having school students acquire a certain desired level of understanding of content and application of skills on various topics by using the most appropriate teaching methods they can devise.

They take the curriculum adopted by the school board and attempt to bring enough interest to the topic so that students will want to acquire the knowledge and utilize the learned skills.

In North Carolina a multidisciplinary approach to a middle school science program found that teachers can re-define their role as imparters of knowledge and assume roles as facilitators, questioning and guiding each child. Effectiveness in the program was determined by evaluations on performance-based items that target content and process acquisition.

The following examples are offered as "best practices" which illustrate these goals:

1. World Resources for Integrated Thematic Education (WRITE). Here teachers created a science-based integrated curriculum where science is the "heart" and literary skills central to each outcome.

2. Celestial Simulations. Teachers encouraged higher-order thinking skills when students used astronomy simulation programs.
3. It's More than the Fun Factor. Teachers challenged students to help select effective science activities by having them share in their own words what happened and defend their explanations with data they had gathered through investigations.
4. Library of Conservation: Using Children's Literature to Teach the Concept of Stewardship. Parents and teachers modeled interest in knowing about the beauty of nature taught children the importance of taking care of the planet.
5. Science–Technology–Society: Preparing for Tomorrow's World. Educators encouraged a multidisciplinary approach to problem solving and critical thinking to promote decision-making and problem solving, skills needed to deal with issues in science, technology, and society.
6. Learning from Bad Science—Find My Mistakes. Teachers recognized that although students were not sure of the correct laboratory experiment necessary to test something that interested them, they were experts at pointing out someone else's mistakes, which gently nudged them toward the correct design.
7. HOTS—Higher-Order Thinking Skills Project. The teachers replaced the traditional drill and practice activities and content instruction in compensatory programs with thinking activities designed to generate the gains in basic skills expected from "Chapter 1 Programs." Student thinking abilities and social

confidence were improved in the process (U.S. Dept. of Education, 1994, p. 26).

It was Aristotle who believed that the role of the teacher was to aid students in developing into human beings of moral and mental intelligence by integrating the curriculum with real observations. Teachers can contribute greatly to student-oriented learning by becoming a "partner" in the educational process.

Small-Group, Interactive Projects

Research shows that there are advantages to numerous students in the use of small group, interactive projects as learning experiences. It has been reported that small group instruction produces achievement differences on a variety of student measures, including grades and scores on several types of tests. Student attrition rates (from courses and from institutions) are lower for students exposed to small group instruction relative to their peers taught by more traditional methods. Student attributes toward the subject matter and how skilled they feel about their competence in the discipline are also positively effected by their exposure to small group instruction (Springer, et al., 1997).

It has also been reported that small group, cooperative instruction has a powerful effect on a variety of additional "higher-order (critical) thinking skills," and cognitive development (Brookfield, 1987, p. 91). From the cognitive perspective, small group instruction allows students to cognitively rehearse and relate course material into existing schema or conceptual frameworks, thus producing a deeper, contextualized level of understanding of content (Kurfiss, 1988, p. 58).

More humanistically-oriented theories point to the intrinsically rewarding nature of small group interaction based on the assumption that students have a natural potential for learning that is best fostered in non-threatening groups. These theorists tend to focus on the learning process that they believe is best developed without excessive teacher intervention and control, thus allowing students to find their "voices" via democratic, student-centered learning environments (Belensky, et al., 1986, p. 44).

Some authors in the small group literature argue that, for their types of small group instruction to work, the techniques must be faithfully executed in every detail. Other contributors suggest that any movement in the direction of getting students more actively involved should be commended, not faulted, if one or more elements of a certain technique are not executed according to dogma (Cuseo, 1992, Smith & MacGregor, 1992, p. 69).

There are problems associated with small group instruction. Some appear to be better than others in fostering specific outcomes. Not all techniques work better than the lecture method. For example, badly structured small group instruction leaves strong negative feelings among students regarding the fairness of grading systems, the feeling of unequal distribution of labor, and other issues (Feichtner & Davis, 1984-85, p. 87). A suggestion by Cooper and Robinson (1998, p. 32) is encouraging to this research. "...one area that future researchers may wish to pursue is using small group instruction to foster higher-order thinking skills in science, mathematics, engineering, and technology classes."

NASA Curriculum Enhancement Products

Ever since NASA was created by an act of the U. S. Congress in 1958 the agency has sought to use educators as a means to disseminate the results of its research to the American public. In the past forty years the products that NASA has distributed to teachers and other educators have had many forms. These have been educator resource guides, color lithographs, wallcharts, 35mm slides, filmstrips with audiotape narration, videotapes, and recently, CD-ROMs.

Many of these products have mirrored the changes in educational methods, from lecture-demonstrations to more interactive student project-oriented research methods of study today. The multi-media materials, which are distributed by the agency, show the influence of new technologies on the school classroom experience.

Even the means by which products have been distributed have changed because of the advance of technology. Most of the products are still distributed through the NASA Educator Resource Center Network, which includes the NASA Aerospace Professional Development Center located on the Stillwater campus of Oklahoma State University. Today more and more of the NASA educational products are available on line. They may be accessed by using a personal computer and modem. The site where most of the electronic materials reside is referred to as NASA SpaceLink (http://spacelink.nasa.gov). An evaluation of educator use of SpaceLink was performed by Ellen Hardwick in 1996.

The curriculum enhancement products that NASA disseminates have also changed to include the skills outlined by national standards in science, mathematics, and technology disciplines. NASA has worked with the National Science Teachers'

Association, the National Council of Teachers of Mathematics, the International Technology Education Association, and the National Geographic Society to incorporate skills that have been associated with each of these organizations and the educators they represent.

As an example, the recently updated NASA educator resource guide, "Planetary Geology," lists the following skills in one of the student activities found in the publication:

1. Science Standards:
   - Earth and Space Science
     - Origin and evolution of the Earth system
2. Mathematics Standards:
   - Connections
   - Number and number relationships

It is an important aspect of this project to have the individual activities reflect those skills. NASA has also chosen to show precedent in inclusion of skills outside the traditional science, mathematics, and technology disciplines.

This holds true for curriculum projects which have Mars exploration as its base.

Mars Exploration

Mars as a place has fascinated humans ever since they first noticed that it was a different color than most of the other points of light in the night sky and that it moved in a path among the seemingly fixed stars. As technological advances improved the means by which humans could see Mars in greater detail, interest in the planet grew.

Two scientists who made detailed observations are of note. Giovanni Schiaparelli made numerous sightings of Mars through a crude telescope and was among the first to draw what he referred to as the "canali" of the planet. Percival Lowell is the best known of the Mars astronomers. He viewed Mars most of his life and wrote numerous books about the planet. His works influenced many who eventually made exploration to Mars a reality like Wernher von Braun.

Until recent time, the past 25 years, this was the extent of the research. In 1961 NASA sent the first spacecrafts, Mariners 4, 6, 7, and 9 to fly-by the Red Planet. The data from these missions established the parameters by which the 1976 landings on Mars were planned for the Viking 1 and 2 Landers and the almost complete mapping by their companion crafts, the Viking 1 and 2 Orbiters. NASA had not been back to Mars until July 1997 when the Pathfinder Lander and the Sojourner Rover made trips to the Ares Valles region on the Martian surface. The Mars Global Surveyor also began its more detailed mapping of the planet from orbit. The Sojourner robot was the first human-made object to get close enough to Mars' rocks to analyze the mineral content. It used a sophisticated "sniffer" device that determined the presence of certain elements in individual rocks (Greeley, et al, 1998, and Raekum, et al, 1998).

NASA has plans to send a series of robotic landers, orbiters, and rovers every two years to different regions of Mars. In order to gather appropriate data to assist scientists on Earth to set forth the mission guidelines so that a possible first human landing mission to Mars might happen before Former President George Bush's goal of 2019, the fiftieth anniversary of the first landing on Earth's Moon (Caiden, et al, 1997).

Numerous books have been written that take advantage of the "hype" associated with the eventuality of landing humans on the only other planet known in the Solar System with a semi-suitable environment. In the scientific, non-fiction realm there are many titles. In John Noble Wilford's *Mars Beckons* he gave details of why humans have a fascination with Mars (1990). Peter Zubrin edited a series of seminar presentations in which he and other Mars' experts participated over the past ten years. *The Case for Mars* details how these scientists feel human exploration can be accomplished with technology available today (Zubrin, 1996).

In the areas of fiction there have been a number of excellent science fiction books written with a Mars theme. The most famous is Ray Bradbury's *Martian Chronicles.* This book is actually a series of stories that gives glimpses of what life might have been like on Mars in the past and what humans might experience as a developing civilization on Mars in the future.

Of the newer books being written with a Mars theme the *Red Mars, Green Mars,* and *Blue Mars* trilogy by Kim Stanley Robinson are among the more thought provoking. This set of books enables humans to take a look at the terra-forming possibilities and catastrophes of the future (1993, 1994, 1996). On the same topic, Arthur C. Clarke has produced *The Snows of Olympus,* which shows through computer-generated graphics what a transformed Mars might become.

The influence of Mars on the arts and literature is detailed in books with extensive illustrations and descriptions such as *Beyond the Blue Horizon* by E. C. Krupp and *Destination Mars: In Art, Myth, and Science* by Martin Caiden and Jay Barbee.

The basis for an earlier student curriculum project of this researcher was Robert Heinlein's *Tunnel in the Sky*. The book was intended for the middle school/junior high reader. It centered on a small number of high school students who have to take a final exam for a survival course. They were sent through a travel portal to an alien planet. Each had basic supplies and, supposedly, acquired the skills necessary to survive a two-to-three week stay on the planet. During their visit to the planet the students began to meet each other and help each other to overcome the obstacles placed before them. These included wild creatures and environmental challenges. Eventually, the students realized that something had seriously gone awry. For whatever reason, no one from Earth ever came to bring them home. The students learned to assume authority, delegate responsibilities, and establish their own "civilization."

During the Summers of 1996, 1997, 1998, and 2000, a colleague, David Wright, and this investigator first wrote and then facilitated participation of thirty high school juniors and seniors in a half-day project during a three week aerospace academy at Oklahoma State University funded by the Oklahoma Aeronautics Commission.

In this activity the students were asked to make both scientific and philosophical decisions based within the parameters established for the activity, "Lottery 2076." The activity such as the one related in *Tunnel in the Sky* was on an alien planet, not Earth, but also not Mars. Because of the recent and continuing interest in Mars this researcher chose to re-locate the activity to Mars and re-write most of the activities.

This investigator had interest in two goals for the "Mars 2076" activity. First, the students should become familiar with a planet they will hear much more about during their lifetimes. The study of Mars can also be used to explain the logical steps in establishing outposts for human life anywhere beyond Earth. Second, students should also be able to use what information they learn about how "civilization" and society works to examine Earth civilization past and present and how they can help to make decisions that may take humankind to the best of all possible futures.

Human Learning

One of the most difficult tasks for the classroom educator is to match the curriculum to the needs of each student in his or her classroom. First, the educator must understand why humans need to learn and what factors have to be present for them to be receptive to lessons being offered for study in the schools.

As a basis for making these decisions this investigator has incorporated the use of Abraham Maslow's *Hierarchy of Needs*. In his series of studies Maslow involved various groups from different elements of society in research that proved that humans must have certain elemental "needs" provided in their lives before they are willing to concern themselves with "self-actualization" activities which explore their more creative abilities. Beyond the basic physiological requirements of life, humans also have great needs for safety, social acceptance and self-respect (Maslow, 1970).

When the basic needs of the individual are met they are more likely to incorporate "higher-order thinking skills" into their learning process. Benjamin Bloom established a Taxonomy of the Cognitive Domain which explains that memorization of data is far less desirable in learning than analysis, synthesis, and evaluation of knowledge. Specific facts are more useful to humans if they can be combined, analyzed and produce logical conclusions. Some refer to this end product as wisdom (Bloom, 1956).

D. Graves in *Bring Life to Learning* stated, "If we want to keep the curriculum and learning fresh we have to make it possible for our students to go from outside the subject to inside." (2000, pp.19 &21)

G. DeCoker of Ohio Wesleyan University said that "Developing the mind and hands is education, developing the hands alone is mere training." (2000, p. 62)

K. Sullenger believes "Finding out how scientists think, why they do the things they do, and why they are interested in certain things introduces learners to broader conversations about science taking place outside classrooms." (1999, p. 25)

"Student motivation has been important to teachers ever since the beginning of the profession. A key question is whether it is more motivating to students to emphasize teaching the student or teaching the subject." (A.C. Himes, 2000, p. 80)

In the November 1999 issue of Educational Leadership M. Grace provided ten key considerations for teachers who seek a more student-based curriculum:

1. Garner support and start small.
2. Use library resources.
3. Give up the guides and get ready to model.
4. Develop assessment tools (rubrics).
5. Allow for noise.
6. Schedule record keeping.
7. Don't panic, routine will follow.
8. Become a learner yourself.
9. Communicate unanxious expectations.
10. Gather weekly data (1999, p.49).

Evaluation

How exactly can an educator decide what is specifically on-target for each student in a certain area of study? Traditional belief may be that teacher –based assessment puts emphasis on a student's strengths and provides multiple sources of evaluation that give an accurate view of a student's progress; while critics may say that teachers (using standardized tests) judge a child without providing suggestions for improvement.

John Dewey in 1916 made the statement that "experience was not the sole purpose of education, reflection upon that experience in communication with the teacher was the intent (Democracy & Education). The closest model we appear to have today that meets Dewey's criteria is Authentic Assessment where a student's performance is compared over time. It requires both teacher and student to observe and document the activities, experiences, and achievement that the learner makes over time (M. Ochanyi, 2000, p. 26).

Mary Lee Martens in Science and Children, May 1999, relates her belief that there is an art in productive questioning made by the instructor. Productive questions purport to take a student forward in his or her thinking. They enable a teacher to provide scaffolding for students beginning to build their own understanding. Productive questions enable teachers to create a bridge between activities and students.

John R. Mascozine and Wendy Sherman McCann of Ohio State University suggest these guidelines for authentic assessment:

1. Allow more time to assess student's prior knowledge.

2. Provide opportunities for students to find discrepancies in their own explanations.
3. Allow time for students to critique their working understanding of concepts.
4. Allow concepts to resurface and be reinstated from time to time (1999, p. 24).

There are wide divisions in the educational community over the ideal type of assessment that is of best benefit to student learning. Some believe that assessment can be best achieved when using science standards as a means to create learning goals and assessment tools. They state that it may be an ideal way to decide what is expected at grade level and actually allows for visible evidence that students are meeting expectations.

In contrast, others such as Heide Andrade in February 2000 stated that students should create their own rubrics for assessment. "Data suggests that self-assessment has a positive effect on many students writing." (p. 18)

Qualitative Study Elements: Questionnaires, Interviews, and Case Studies

It is very important to the validity of this qualitative study that the individual elements are created in the most appropriate manner. This investigator sought the assistance of a number of sources to produce elements that can achieve the goal of acquiring the best possible information from the participants while appearing to remain unbiased.

Qualitative research contains a characteristic abundance and "messiness" of data. Qualitative analysis requires that the researcher work with chunks of data. Without data of this character, it is difficult to see which ideas "go" together in the mental universe of the respondents, or the "cultural logic" on which the ideas rest (McCracken, 1988, p. 24).

In the preparation of the instrument for the initial survey to be used with the following were considered:

- Avoiding the use of emotional and biased questions.
- How specific the questions should be.
- Whether the questions will produce credible information.
- Whether respondents are able to answer the questions.
- Whether respondents will be willing to provide the information (Dillman, et al, 1994, p. 77).

The later interviews with the participating educators were intended to gather more in-depth evaluations of the project. Breaking the overall topic into several related questions was done to provide unity to the questionnaire. The wording of the main questions was open enough to encourage interviewees to express their own opinions and experience, but narrow enough to keep interviewees from wandering too far from the subject at hand (Rubin, 1995, p. 146).

In Steiner Kvale's *An Introduction to Qualitative Research Interviewing,* he suggests the following guidelines for developing questions.

1. Introducing Questions: Opening questions may yield spontaneous, rich, descriptions where the subjects themselves provide what they experience as the main dimensions of the phenomena investigated.
2. Follow-Up Questions: The subjects' answers may be extended through a curious, persistent, and critical attitude of the interviewer.

3. Probing Questions: The interviewer pursues the answers, probing their content, but without stating what dimensions are to be taken into account.
4. Specifying Questions: In an interview with many general statements, the interviewer can attempt to get more precise descriptions by asking, "Have you experienced this yourself?"
5. Direct Questions: Direct questions may preferably be postponed until the later parts of the interview, after the subjects have given their own spontaneous descriptions and thereby indicated what aspects of the phenomena are central to them.
6. Indirect Questions: The answer to projective questions may refer directly to the attitudes of others; it may also be an indirect statement of the pupil's own attitude, which he or she does not state directly.
7. Structuring questions: The interviewer is responsible for the course of the interview and should indicate when a theme has been exhausted.
8. Silence: Rather than making the interview a cross examination by continually firing off questions, the research interviewer can take a lead from therapists in employing silence to further the interview.
9. Interpreting questions: The degree of interpretation may involve merely rephrasing an answer, for instance: "You then mean that…" or attempts at clarification: "Does the expression…cover what you have expressed?" (1996, p. 133)

Case studies are a specialized form of interview designed to provide an enriched background of the project participants. This background information may assist the researcher in finding greater or different meaning from the data provided by the participant. This researcher found the case studies done with young people in Patricia Hersch's *A Tribe Apart* were an excellent set of examples of this interviewing technique.

Summary

The knowledge this researcher acquired through this review of literature has assisted him in the creation of a representative piece of aerospace science curriculum that incorporates accepted elements of education reform, yet remains essentially student-centered. The literature has displayed helpful ways to assist the teacher to become an even better facilitator of the reformed learning process. Small-group, interactive projects were explained as logical, integral parts of the student-centered curriculum. NASA education products and Mars literature were included as key elements in the "Mars 2076" project development. Student learning interests were explained as key elements of any student-centered curricula. Finally, evaluation was included as necessary for any realistic student involvement in the learning process and the evaluation of the "Mars 2076" project.

CHAPTER III

METHODOLOGY

Introduction

This study grew from limited success with an earlier educational project "Lottery 2076." That project was performed with juniors and seniors in a high school aerospace academy during five recent summers. The project was inter-active and required the students to work in small groups. "Lottery 2076" required three hours of the students' time. The purpose of the project was to get the students to work cooperatively and to have them use "higher-order thinking skills" to solve problems. In the end, the students were asked to project what their lives would be like in the future according to the choices they had made.

The intentions of the current project "Mars 2076" are very similar. It would be good to have the students work together and compromise on making decisions. The problem solving activities should lead them to realize how different life on a foreign planet might be. It should cause them to evaluate many of their own moral and ethical beliefs. It should also allow them the opportunity to hear differing viewpoints.

Statement of the Problem

Major disciplinary groups, national commissions, state boards, and local interest groups have recommended reform in the learning process in today's schools. Many standards have been imposed upon the educational community, especially in the past decade.

Educators are seeking ways to form the school curriculum to these new mandates while keeping the students directly involved with the learning process. How does an educator successfully combine the key elements of content knowledge, societal work skills, and student learning interests? What are the most effective educational processes to accomplish these goals?

Purpose of the Study

This study will seek to discover how aerospace science curriculum projects can contribute to higher-order learning of students in a period of vast education reform.

Objectives of the Study

To accomplish this purpose the following objectives must be met:

1. Sixty educators will participate in the "Mars 2076" activity project.
2. The participating educators must complete answers to the provided questionnaire.
3. Selected educators will be interviewed about the project.
4. Case studies will be made of two interviewees.
5. The qualitative responses will be categorized.

6. Major themes found among the categorized responses will suggest strengths and weaknesses in the project.
7. Improvements suggested by participants will be implemented into the revised small-group, interactive project.

Core Activities

The following activities will help accomplish the goals of this project:

Activities that provide insight into the environment of Mars and how it compares and contrasts with that of Earth:

1. "Falling Hopes" An avalanche limits the possibilities of escape from the underground cavern. Students will be able to analyze a problem and make a series of decisions on how to rescue themselves.
2. "Fire from Water" A science activity concerning the production of hydrogen fuel through the electrolysis of water. Students will be able to use scientific skills to produce necessary fuel from their water supply.
3. "Foods for Thought" The crops grown in the cavern have special needs. The students will be able to demonstrate how the hydroponics process could sustain farming on Mars.
4. "Legends in the Sky" A lesson in mythology by identifying constellations in the Martian sky. Students will be able to write their own legends about constellations in the Martian sky.

5. "Silent Winds" The winds on Mars have no sound because the air is so thin. Students will develop a warning system to protect their colony from any potentially disastrous sandstorms on Mars.

Project activities that ask students to work cooperatively to make decisions using higher-order thinking skills:

1. "Forming an Opinion" Should terra forming be used to transform Mars into a place more like the Earth. The students debate the morals and ethics of radically changing a foreign world for their own purposes.
2. "Defending the Future" An activity that explores the ethics of using weapons on Mars. The students will discuss the need and use of armaments to protect themselves after someone steals fifty percent of their food supply.
3. "Picture This" How would the Mars environment affect future works of art? The students will be able to create a piece of graphic art that depicts life on Mars. They will also be able to explain how the planet influenced the piece.
4. "Rocky Discoveries" How does the location of a fossil in a Martian rock change the history of the planet? The students will be able to discuss how the possible existence of life on the planet makes the study of the Mars' environment more important than ever to Earth Scientists.
5. "Silver Reflections" In twenty-five years how will the colony that we've established on Mars be different than today? A culminating activity; students will hypothesize on what their lives will be like on Mars in the future if no one comes to rescue them.

Selection of the Population

The population was selected by opportunity as much as any other reason. It was desirable to have the project evaluated by educators who were familiar with the curricula. It was beneficial to this researcher for the educators to share their opinions of various aspects of "Mars 2076, " especially how well they saw it as a possible tool to encourage it as an interactive, small-group activity. It was very necessary for them to experience the project for themselves in order for them to share their views with this investigator.

The Urban and Rural Community Enrichment Program (URCEP) is part of NASA's Aerospace Education Services Program that serves students and educators in inner city and other culturally diverse areas of this country and its territories. Each summer sixty of these educators come to Oklahoma State University to participate in a two-week workshop to learn how NASA's curriculum enhancement products may be able to increase the interest of their students in science, mathematics, and technology. The schools in the culturally-diverse areas of the United States are often also economically deprived. Most activities used in these schools need to include consumables that are easily accessible or inexpensive. NASA Curriculum Enhancement Products are designed to be low cost, as is "Mars 2076."

Research Instrument

Although it may not have been entirely obvious to the educators while they were involved in the "Mars 2076" project, the goal of the exercise was to have them answer a series of questions that require them to evaluate the merits of the project as an interactive, small-group activity.

The questions in the instrument were brief, but required at least one sentence, if not more, to answer. The educators naturally utilized many "higher-order thinking skills" to complete the questionnaire.

The final goal was to discover how well "Mars 2076" works as an educational tool. How well does it work to engage students and meet present-day science standards, while utilizing the best educational methods and practices? The answers the educators gave to the questions in the instrument and follow-up questions should provide the necessary data to revise "Mars 2076" so it can be used in a future middle-school classroom environment (See appendix A).

Follow-up Questions

A series of follow-up questions were asked to randomly selected participants the morning following the completion of the project. These questions were more specific than those the educators were asked to write about immediately following the project. These questions were asked in an interview style with the researcher taking notes. Later, the researcher typed the notes. The questions in each interview dealt with how four specially selected activities, "You Are Not Alone," "Picture This," Rocky Discovery," and "Time Capsule," showed desired learning. There were six questions being asked. These concerned the major themes of the activities, insights into the Mars' planetary environment, promotion of inter-activity between participants, collaboration in decision making, use of higher-order thinking skills, and possible benefit to the middle school student through participation (See appendix A).

Case Studies

Two case studies were made to provide a base for understanding the personal and professional backgrounds of the educators involved in the evaluation of this project. Most of the questions would be considered basic for a personal interview and are followed up with questions concerning educational background and professional education experience. The final area of data concerns the participants' views on the overall appeal and merit of the "Mars 2076" project. The interviews were taped and then transcribed later (See appendix A).

Research Design and Procedure

The following are the steps that were followed in order to complete the study:

1. Design the educational activity "Mars 2076" based upon earlier work and specific objectives.
2. Create the evaluation instrument desired to get responses from educators on specific objectives.
3. Write extended evaluation interview questions.
4. Select a list of questions appropriate for the case studies.
5. Field test "Mars 2076" with Urban and Rural Community Enrichment Program (URCEP) Educators in summer of 1999.
6. Have educators complete initial questionnaires.
7. Conduct follow-up evaluation interviews.
8. Develop case studies of educators' backgrounds through an interview process.
9. Summarize evaluations.

10. Draw conclusions based upon findings.

11. Make recommendations.

Analysis of Data

The evaluations were given to the educators who had participated in the "Mars 2076" project. The questionnaire was explained to them and they had one-half hour to complete the survey. Individual interview sessions took place the following day. The educators were asked more specific questions about key activities in the project. Case study interview answers were used to supply a better understanding of the professionals involved in this evaluation process.

The data from these different evaluations were compiled and analyzed. Recommendations could be incorporated into a revised "Mars 2076" project that may later be field-tested with middle school students.

Summary

The process of evaluation should result in an improved aerospace science curriculum project that will be of benefit to a larger number of students while meeting science standards through utilization of best teaching practices.

CHAPTER IV

FINDINGS

Introduction

One advantage of qualitative research may be that the results may supply significant assistance in the revision of a piece of curriculum. The suggestions made by the participants in this study offer a wide variety of improvements. In the project used in this research, "Mars 2076," the educators experienced totally new activities joined together by a narrative exploration detailing life in an early colony on the Red Planet.

The sixty educators' opinions used here were collected by use of a questionnaire that requested responses that showed understanding of the researcher's goals and ways to improve the project. The original questionnaires asked for opinions on general concepts concerning the educational makeup of the curriculum project.

Nineteen of the same sixty educators were briefly interviewed the day following the completion of the questionnaires. The additional responses provided more detailed criticism of finer aspects of the project they had first experienced the previous day. The researcher recorded and later typed their responses.

In order to gain greater benefit from the responses of the participants the investigator grouped these responses in the following categories:

1. Activities which promoted a better understanding of the Mars' planetary environment
2. Activities which promoted inter-activity among the project participants
3. Activities which promoted collaboration in decision making
4. Activities which promoted the use of higher-order thinking skills
5. Activities which promoted benefits to the overall education of the middle school student
6. Strengths and best practices of the entire project
7. Weaknesses of the entire project

The results of the interviews were grouped in a similar fashion:

1. The specific activity's main theme
2. How the activity may have promoted knowledge of Mars' planetary environment in correlation with the science standards
3. How the activity may have promoted inter-activity among the participants
4. How the activity may have promoted collaborative decision making
5. How the activity may have promoted the use of higher-order thinking skills
6. How the activity may have promoted benefits to the overall education of the middle school student

Results of the Questions Asked in the Evaluation of the "Mars 2076" Project

1. Activities which promoted a better understanding of the Mars' planetary environment:

a. “Introduction”

- Schiaparelli’s view of Mars
- Martian canals

b. “Grandest Canyon”

- Geography
- Valles Marineris
- Caverns
- Marsquakes

c. “Got Water”

- Polar ice caps
- Recycling fluids
- Water in cavern

d. “You Are Not Alone”

- Constellations and their configurations
- Naming constellations

e. “Forming an Opinion”

- Caverns
- Hydroponic farming
- Terra-forming

f. “Bouncing the Sun”

- Atmospheric composition
- Solar radiation

g. “Rocky Discovery”

- Possibility of past life on planet

h. "Silver Reflections"

- Future life on Mars

i. "Picture This"

- "Selling" Mars
- Travel poster

j. "A Good Hike"

- Survival on a foreign planet

k. "Thor's Hammer"

- Olympus Mons

l. "Shifting Sands"

- Winds
- Blowing sands
- Sand dunes

2. Activities which promoted inter-activity among the project participants:

a. "Picture This"

- Creating travel poster of Mars
- Cooperative presentation promoting Mars
- Discussion of how Earth and Mars compare and contrast

b. "You Are Not Alone"

- Developing appreciation of other cultures
- Making up original constellations
- Writing legends to accompany constellations

c. "Skills Needed"

- Listing top five professions
- Deciding upon most necessary skills

d. "Forming an Opinion"

- Discussion of ethics/morals of terra-forming Mars

e. "Bouncing the Sun"

- Solving crop lighting system problems

f. "Got Water"

- Deciding how to purify human waste water

g. "Rocky Discovery"

- Discussion of why any fossil would be an important discovery

h. "A Good Hike"

- Deciding best materials to use for survival

i. "Silver Reflections"

- Projecting success on Mars
- Projecting failures
- Hypothesizing solutions to everyday human problems on an alien world

j. "Protecting the Future"

- Deciding moral need to rescue colonists from damaged outpost

3. Activities which promote collaboration in decision making:

a. "A Good Hike"

- Deciding best way to use materials for survival

- Discussion of best procedures for rescue
- Adverse conditions promote collaboration

b. "You Are Not Alone"
- Agreeing on a constellation made from seven random stars
- Collaborating on an original legend to accompany constellation presentation to group

c. "Silver Reflections"
- Deciding on best methods to educate children
- Compromising on who makes and who enforces laws in the new colony
- Projecting a group consensus of where the colony would succeed and fail in the next twenty-five years.

d. "Protecting the Future"
- Moral decisions on helping others at great risk to yourself

e. "Rocky Discovery"
- Projecting the importance of the discovery of a fossil on the future of Mars colonization
- Deciding how to announce discovery to Earth

f. "Skills Needed"
- Ranking of top five necessary professions for an early Mars colony
- Justification of skills

g. "Picture This"

- Decision of how physical differences between Mars and Earth might affect art, literature, poetry and song.
- Agreement on best manner in which to commercialize Mars as a tourist attraction
- Compromise on best way to portray Mars environment on travel poster

h. "Got Water"

- Deciding if introduction of microorganisms on Mars is ethical

i. "Forming an Opinion"

- Terra-forming justification debated

4. Activities which promoted the use of higher-order thinking skills:

a. "Skills Needed"

- Analysis of professions
- Evaluation of skills needed in colony setting

b. "Protecting the Future"

- Synthesizing the needs of both colonies

c. "Time Capsule"

- Analyzation and evaluation of elements to be included in capsule

d. "Silver Reflections"

- Analysis of reasons for successes and failures in twenty-five year period
- Evaluation of colony

e. "Forming an Opinion"

- Analysis of moral and ethical questions dealing with terra-forming

f. "Got Water?"

- Analyzation of how best to recycle human wastes
- Evaluation of introduction of microorganisims onto planet

g. "Bouncing the Sun"

- Analysis of means of reflecting sunlight

h. "You Are Not Alone"

- Analyzing Earth-based cultural legends
- Evaluation of correlation between Mars' sky constellations and their possible legends

i. "Good for You!"

- Evaluation of living conditions in cavern colony

j. "Picture This"

- Analysis of Mars factors that could influence Earthlings to visit
- Evaluation of factors that might influence artistic pursuit on Mars
- Human needs coupled with environmental conditions on Mars

5. Activities which promoted benefits to the overall education of the middle school student:

a. "You Are Not Alone"

- Appreciation of other cultures
- Creativity in visual and language arts
- Cooperative learning elements

b. "Picture This"

- Opportunity to use artistic abilities

- Decision-making
- Combination of individual work with group work
- Communication skills
- Interdisciplinary study

c. "Time Capsule"

- Critical thinking skills

d. "Silver Reflections"

- Higher order thinking skills
- Communication skills

e. "Skills Needed"

- Career decisions/choices
- Group discussions

f. "Introduction"

- Observational skills
- Scientific and technical appreciation
- Curiosity

g. "Forming an Opinion"

- Decision making
- Ethical debate

h. "Got Water?"

- Problem solving
- Debate
- Leadership opportunities

6. Strengths of the entire project:

   a. Educational methods

      - Hands-on approach to learning
      - Positive interaction of facilitators and participants
      - Good variety of methods used
      - Thoughtful inquiry
      - Good use of scientific theory
      - Interactivity
      - Interesting variety of activities
      - Integration of non-scientific curricular disciplines
      - Interdisciplinary/multidisciplinary

   b. Writing quality

      - Concise, clear, concrete, fun
      - Incorporates creativity into teaching
      - Rich, descriptive text
      - Story-like approach

   c. Resources

      - Materials useful beyond this project
      - Description/demonstration of resources
      - Helpful resources

      Good visual aids

   d. Scientific/technical content

      - Mars' planet details

- Facts easily understood
- Informative content
- Ability to project student into Mars' environment
- Brings space exploration into perspective

e. Student skills

- Collaboration
- Compromise
- Teamwork
- Group Process
- Imagination
- Curiosity
- Higher order/critical thinking skills
- Application of knowledge

f. Human characteristics

- Morality
- Ethics
- Cultures
- Survival

7. Weaknesses of the entire project:

a. General

- Project too lengthy
- Too expensive
- Too messy

- Uncomfortable with science fiction
- Needs more user-friendly package
- Rename project
- Provide more time
- Too much reading
- Project would not work with block scheduling in our school
- Need cooperation of other teachers
- Mess not worth time

b. Resources

- Lack of visuals
- Add visuals to package

c. Content

- Lack of relevance and meaning
- Based on speculation
- Could be controversial
- Future too far away
- Difficult to incorporate with content disciplines
- Lacks weather info
- Necessary to constantly update Mars data
- Lack of content material on Mars
- Creates misconceptions in science
- Students have trouble separating science from fiction

d. Activities

- Need more activities

e. Student skills

- Easy for student to do nothing
- Difficult for students to stay on task
- Give each student a responsibility to make sure each voice is heard
- Give assigned responsibilities to students to prove they are actually involved

f. Educational Methods

- Not inquiry-based
- Developed by a person unfamiliar with public education
- Record sections on audio or video for variety
- Use an elementary or middle school educator to re-write sections
- Educational objectives need to be defined

Results of the Interview Questions Asked in a Further Evaluation for the "Mars 2076" Project

1. What do you feel was the major theme of the "You are Not Alone" section of the "Mars 2076 project?
   a. To give an idea of the future
   b. Population of Martian colonies
   c. Establish that humans are social and need to be in communities
   d. The co-existence or more than one colony in a given area of Mars.
   e. A geologic history of the planet

f. The uses of a new storage battery

g. Hazardous environment on Mars

h. The importance of an energy source

i. Establishment of communications between colonies

2. Were there activities in the "You are Not Alone" section of the "Mars 2076" project that gave you greater insight into the Mars planetary environment? If so, please describe them.

    a. Brief history of colonization on Mars thus far

    b. Energy requirements

    c. Creating new cultures

    d. Night sky much like Earth's

3. Were there activities in the "You are Not Alone" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

    a. Yes, the creation of new constellations

    b. Writing legends about constellations

4. Were there activities within the "You are Not Alone" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

    a. Deciding what constellations to create from seven random stars

    b. Agreeing on how to write a tale about the Mars' constellations.

5. Were there activities in the "You Are Not Alone" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.
    a. Analysis of past legends
    b. Analysis of what creature or object would should be represented by group of stars
6. Would a middle school student receive any benefits from participating in an activity such as those found in the "You are Not Alone" section of the Mars 2076" project? If so, please describe them.
    a. Cooperation
    b. Artistic disciplines mixed with sciences
    c. Creativity
    d. Group presentations
7. What do you feel was the major theme of the "Picture This" section of the "Mars 2076 project?
    a. Cultural differences brought about by Earth vs. Mars
    b. A hands-on activity that provides a visual of the planet
    c. Human culture
    d. The differences that would be apparent to humans born on Mars
    e. Public relations: Are there enough positive features about living on Mars that it will attract others to colonize there?
    f. Culture limitations on Mars
    g. Comparing and contrasting

h. Life on Mars might be like a person growing up in a different culture on Earth.

i. Comparisons of Earth and Mars

8. Were there activities in the "Picture This" section of the "Mars 2076" project that gave you greater insight into the Mars' planetary environment? If so, please describe them.

    a. Comparing and contrasting Earth and Mars environments

    b. Limitations of Mars

    c. How different life could be in colony away from Earth

9. Were there activities in the "Picture This" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

    a. Creating travel poster of Mars

    b. Deciding how to promote Martian environment

    c. Debating differences between planets

10. Were there activities within the "Picture This" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

    a. Creating travel poster of Mars

    b. Deciding how to promote the Martian environment

    c. Debating differences between planets

11. Were there activities in the "Picture This" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.
    a. Analyzing Mars geography and environment
    b. Evaluating best way to advertise the planet
12. Would a middle school student receive any benefits from participating in an activity such as those found in the "Picture This" section of the "Mars 2076" project? If so, please describe them.
    a. Decision making
    b. Cooperation & compromise
    c. Creativity
    d. Public speaking
13. What do you feel was the major theme of the "Rocky Discovery" section of the "Mars 2076 project?
    a. Fossils
    b. To relate "Mars 2076" to real life folks
    c. Hypothesizing on what the fossilized plant could indicate
    d. The possibility of life existing there once. Which brings up other questions like: "Why" it disappeared.
    e. Discovering past life on Mars
    f. Archaeological finds and determining the history of the planet
    g. Geography and history should be researched---there was life before us.
    h. Understanding the past of something by observing "unwritten" evidence.

i. Discovery

j. Imaginary beginnings of the Solar System

14. Were there activities in the "Rocky Discovery" section of the "Mars 2076" project that gave you greater insight into the Mars planetary environment? If so, please describe them.

    a. Possibility of past life on Mars

    b. How different Mars' environment might have been in the past

    c. Origins of life

15. Were there activities in the "Rocky Discovery" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

    a. Debate on importance of a discovery like the fossil

    b. Discussion on how this discovery might change the future of Mars exploration

16. Were there activities within the "Rocky Discovery" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

    a. Agreeing on how to write information concerning fossil

    b. Deciding just how to announce discovery

17. Were there activities in the "Rocky Discovery" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.

    a. Evaluation of impact of such a discovery

18. Would a middle school student receive any benefits from participating in an activity such as those found in the "Rocky Discovery" section of the "Mars 2076" project? If so, please describe them.

    a. Collaboration

    b. Creative writing

19. What do you feel was the major theme of the "Time Capsule" section of the "Mars 2076 project?

    a. "Future" thought

    b. Discussions about facts on Mars, OSU has two time capsules near Student Union

    c. Leaving information for future colonists

    d. Immortality---the wish of humankind to go on, even after humans are long gone

    e. Leaving evidence of what occurred

    f. Posterity

    g. The progress

    h. Data gathered should be recorded and stored in a time data bank

    i. The importance of leaving information for others to learn about you, your environment, habits, etc.

    j. Group consensus

    k. Reflection

20. Were there activities in the "Time Capsule" section of the "Mars 2076" project that gave you greater insight into the Mars planetary environment? If so, please describe them.

    a. Survival possibilities

    b. Must depend upon Mars' resources

21. Were there activities in the "Time Capsule" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

    a. Discussion of what items would best represent their culture

22. Were there activities within the "Time Capsule" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

    a. Compromising on what ten items should be included in time capsule

23. Were there activities in the "Time Capsule" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.

    a. Analysis of meaning behind "objects"

    b. Evaluation of chances for future of colony

24. Would a middle school student receive any benefits from participating in an activity such as those found in the "Time Capsule" section of the "Mars 2076" project? If so, please describe them.
    a. Cooperation
    b. Compromise
    c. Group work/effort

Case Studies

Both case studies that are reported here were researched under very similar circumstances. The two educators used in the studies were selected at random from a group of sixty middle school educators who attended a two-week workshop on the campus of Oklahoma State University during the summer of 1999. During the next to last full day of their workshop all the teachers spent three hours participating in an original project developed by this investigator. After the session, each of the educators was asked to evaluate the interactive, small-group, aerospace education project "Mars 2076" by writing answers to a questionnaire. One third of the educators were selected at random and were interviewed the following morning at breakfast. These teachers answered interview questions from the researcher. Since the questionnaires were anonymous, the case studies are based primarily upon the answers given in the interviews and other answers recorded in the course of our conversations. Names of the case study participants have been changed to ensure their privacy.

Case Study 1

Teacher A hails from Puerto Rico, she has taught seven years, most of that time in a city with a population of 15,000 on the western end of the island territory. She is married and has three daughters, all under the age of six. She finds it difficult to get the time to do anything outside the house except for her teaching. Teacher A is a native of Puerto Rico. Her husband is the school principal and emigrated to the island from where he was raised in New York City. She received her teaching degree from a college on the island. Rita was thrilled to be chosen to attend this workshop in the "states." This was only her fourth trip to the mainland; all the others were to Miami or New York to visit relatives. She was a little disappointed not to find cowboys on horseback in Oklahoma. (The investigator was assisted by a colleague who translated some questions from English and Spanish.)

Teacher A enjoyed the project that she participated in yesterday. In the beginning she found the logic of the exercise difficult to follow. She said that it helped her to work on the activities of the project with members of her assigned group. Collectively they understood the tasks and could complete the assignments.

On the specific questions asked of each of the teachers interviewed, Teacher A had the following responses:

She believed that the major theme of "You Are Not Alone" was to assist the participants in realizing that there was actually more than one colony on Mars. As far as the activity giving her a greater insight into Mars' planetary environment, she said that it was successful because before the activity she didn't have much prior knowledge. She particularly remembered the enormous size of the Olympus Mons volcano.

The inter-activity of "You Are Not Alone" dealt mostly with dreaming-up new constellations in the Mars' sky. Her group of four teachers were all from Puerto Rico so they drew a native beetle and wrote a shortened version of its folktale to share with the other participants. Rita gave the same example when asked about the activity lending itself to collaboration in decision making.

Teacher A had some trouble coming up with an example of higher-order thinking skills being applied in the activity, but believed these skills had been present in the constellation activity. She thought that middle school students would benefit from the creative aspects of having to write a legend to accompany their choice of constellation subject.

In the second activity evaluated, "Picture This," Rita said the primary task was to have each group design a travel poster for Mars. She said this was her favorite activity because she was able to provide her artistic talents for the benefit of the group. They became much more aware of the comparisons and contrasts between Earth and Mars when deciding what to place on the poster. The interactivity of the participants allowed exchange of ideas for the poster. The group was "diplomatic" in their choices for what images represented Mars. Rita thought that application of Mars' knowledge in the activity would qualify as a "higher order" thinking skill. Application of creativity would be the benefit to the students.

("Rocky Discovery" contains an activity that combines science and creative writing). Teacher A noted the discovery of the fossilized palm frond would significantly change the scientific evaluation of the history of Mars. She observed that inter-activity took place when the participants shared the "articles" they had written for an Earth newspaper. Collaboration was not as significant in this activity as in others. "Analysis" was most important in writing the news article and was a sign of critical thinking. Rita believed that any opportunity to get her students to write was beneficial.

Teacher A was enthusiastic about the "Time Capsule" activity. She reasoned that this activity was useful in the manner in which it brought closure to the lessons about Mars. It first caused the participants to discuss what they had learned about Mars and then helped them decide how successful the colonists might have been in adapting to the conditions. The primary inter-activity dealt with having members of the group attempt to justify their choices of 10 items to be included in the time capsule. Decision making in her group amounted to the participants voting on which items should be included. Critical thinking involved evaluation. She believed that culminating activities of this sort are very necessary to use with middle school students in order to evaluate their understanding of the material.

Finally, I asked Teacher A to reconsider the "extension" activity for Mars 2076, "Silver Reflections." Would her essay remain the same as what she had written yesterday? She said, "Yes, I do believe the colony would still be successful twenty-five years later despite the hardships the group would have endured.

Case Study 2

Teacher B is a junior high educator from a city in the industrial Great Lakes region. He has taught ten years, three of those at the high school level. His background is primarily mathematics, but he has picked up more science background each year he has taught. He is divorced and father to two boys who visit him every other weekend. They live with their mother. When his sons visit they primarily spend time going to sporting events, watching movies and eating.

Teacher B graduated from Michigan State and received his master's degree from Central Michigan University. He enjoyed teaching high school, but the assistant superintendent thought his methods of teaching were needed in the earlier grades where they would benefit the students who had trouble understanding beginning algebra. Teacher B found the younger students appreciated him more and the relationships have helped him communicate better with his sons.

On the subject of the interview questions, Teacher B had the following insights:

He admitted that he was not a particularly creative person. He had to depend upon the other members of his group to complete this first activity. He identified the activity as one in which multi-culturalism was being addressed. He didn't see that the activity brought him any greater insight into the Mars' environment. The inter-activity of the project was very important because he said he probably wouldn't have completed the task if he had been asked to create the constellation and folk tale by himself. He does not like to write and understands that many of his students, especially the males, don't care for writing assignments. Collaboration was important in the completion of the activity. Teacher B said he never really considered "higher-order" thinking skills when making assignments to his class. He believed that the skills were present in this activity, but could not elaborate. I presented him with a copy of Bloom's Taxonomy and he chose "application." Even though he doesn't ask his math students to write essays, he feels that they should be encouraged to do their writing assignments in their language arts classes.

Again, in "Picture This" Teacher B felt somewhat frustrated because he does not believe he is a "creative" person. He found out a lot about Mars from the discussion of the group deciding what elements of Mars to use in their creation of the travel poster. His contribution was the idea of skiing the polar icecaps of the planet. He did believe that the activity provided some excellent opportunities to collaborate and cooperate in deciding what should appear on the poster. He didn't appreciate his group making him their spokesperson to present their poster idea to the rest of the workshop. Again, he was reluctant to choose a critical skill, but choose analysis—relating to decisions on poster content. He thought the activity was of most benefit to the creative-minded in his group.

To put it bluntly, Teacher B disliked the "Rocky Discovery" activity. He believed that it was not founded in good science, because it is impossible for there to be life on any other place other than Earth. He has many students who would be lost in the assignment because they are "practical" and "realistic." The only way he feels the activity could be successful would be to have the group work together from the beginning and not depend upon each member writing their own individual news article first. He was adamant about no real use to the activity and no true benefit to the middle-school student.

Teacher B did have higher praise for the last activity, "Time Capsule." He liked the interaction of his group. He attributed this to their wise decision to include each of his three suggestions for the contents of the capsule. He admitted that he had learned many facts about the differences between Mars and Earth. He thought the discussions his group held about their chances for survival were good and brought to light factors he would not have considered on his own, He was most sure that his group had been involved in "evaluation." He liked the idea that students might have to debate their personal choices for time capsule items and then pick a means to decide the final ten choices.

Teacher B said he only wrote one short paragraph for the "Silver Reflections." He would not change his view that the colony would probably fail with in a year's time.

Case Study Summary

Even though the two teachers mentioned in these case studies both teach middle school age, economically deprived children, they come to those students from different backgrounds. One is of Hispanic heritage, the other British. They are fluent in different languages. One was much more receptive to the curriculum project than the other. This same person was observed to have a more positive view of education than the other.

Similarly they both felt they gained more from the project by working in groups. They both have children of their own. Each appreciated the need to attempt to provide an interactive student-centered curriculum.

Descriptive Analysis of Data

Ultimately the data used in the evaluation of this project was sought for two reasons. One, to discover whether the five primary elements of the project were realized. Again, these are inclusion of background material and activities that provided insight into the Mars' planetary environment, promotion of interactivity among participants, collaborative decision-making, use of higher-order thinking skills, and benefit to the education of the middle school student. Two, what aspects of the project need to be improved to form a curriculum product that would be better suited to a student-centered curriculum.

Of the sixty questionnaires distributed, fifty-nine were later returned to the researcher. One of the URCEP Specialists assisted the Puerto Rican participants by translating the questions and helping the educators write their responses in English. There were two sections of the research that explored the five elements mentioned above. In the initial questionnaire there were questions provided that asked for the participants to recognize the sections and activities in "Mars 2076" that provided the elements desired by the researcher. In the follow-up interviews the participants were asked questions about how four specific sections of the curriculum project may have provided the five elements. The participants gave many answers; those that were very similar were only mentioned in the data once. Some of the educators could not recall specifics; none gave a definitive "no" response. Only one participant declined to answer the interview questions because she had a headache at the time.

The investigator found the answers given by the educator participants showed that they well understood the primary elements he had chosen for the project. The great majority of participants were able to supply the name of at least one section or activity in the project that promoted these elements. A few of the educators named the sections of the project specifically that promoted a certain element, others mentioned an activity within the section, and a few provided both types of responses. Since numbers have little value in a qualitative report, quantities will not be elaborated.

The last two questions provided the participants the opportunity to evaluate the overall "strengths" and "weaknesses" of the entire project. These final two questions on the questionnaire gave the investigator the most assistance in what might be included in a revision of "Mars 2076" and insight into how to create future original curriculum products. These responses have been organized into themes.

In the interviews with the randomly selected participants the following morning, they similarly provided responses that showed to the researcher that they comprehended the five primary elements selected for emphasis. Here, the educators provided the major theme and examples of how insight into the Mars' planetary environment, inter-activity of the participants, collaboration in decision making, use of higher-order thinking skills, and benefit to the middle school student were provided. The four sections, "You Are Not Alone," "Picture This," "Rocky Discovery," and "Time Capsule," were selected for further evaluation by the researcher because he believed these were sections of the project that best included the five primary elements he desired. The investigator believed that interviewing the participants about these four sections would result in the most valuable data in exchange for the educators' time and effort.

The "strengths" the participants provided included a variety of comments concerned educational practices. Some believed that the project modeled good uses of inquiry, hands-on learning, and scientific theory. Other strong elements were inclusion of other non-science disciplines and collaboration. Positive comments within the theme of writing quality emphasized the story-like approach and the incorporation of creativity. In some of the educators' opinions the resources were useful beyond "Mars 2076." Others believed that the multi-media aspects of the project were beneficial. In the scientific content area comments included one that the Mars' details were helpful and necessary to the project. Positive student skills mentioned were collaboration, creativity, and use of higher-order reasoning skills. In concert with that theme, discussion of morality, ethics, and multiculturalism were perceived by some of the educators as important strengths.

In contrast, "weaknesses" were a bit more generalized. These weaknesses centered on the apparent need for too much time, effort, and expense to accomplish the project. There were opinions expressed that the resources provided were inadequate. Some participants voiced the view that the content lacked relevance and meaning to the middle school student. The need for more activities was mentioned as a weakness. The most personal criticisms toward the researcher involved the belief that the project was developed by a person inexperienced with public education and suggestions were made that a middle school educator should be used as a collaborator in any revision of the project. Some of the educators mentioned that they felt that the project as created might allow students the opportunity not to participate. A few respondents were concerned about the controversial nature of the project. They specifically mentioned the science fiction base of the project made them uneasy about attempting the project in their school district.

Summary

The final result of an evaluation of a curriculum product is whether or not the answers or, more correctly, the opinions, expressed by the participants are useful in the improvement of the product. Although there have been many good models utilizing many best practices created in the past, there is no agreed "perfect" model . This is one of the main reasons why a project like "Mars 2076" must be tested with educators to see if their expertise in using curriculum products in their daily teaching can assist the creator in developing a better product. This researcher has found many of their opinions helpful in creating a possible future revision of "Mars 2076."

The goals of this research were simple as compared with other studies—the investigator presented to a group of educators a curriculum project designed to be used with students in a certain grade level familiar to the teachers. In turn, the educators provided insight to the researcher in two areas: One, how well they understood the use of certain educational elements in the presentation of the product, and two, how in their opinion, the project should be revised. The research done in this study shows that the participants observed the desired educational elements:

Within the element of content relating to the Mars' environment, the educators recognized the geography, geology, hydrology, meteorology, and astronomy associated with the planet.

Concerning the element of inter-activity promoted among the participants the teachers mentioned cooperation, discussion, creativity, problem solving, and hypotheses.

Dealing with the collaborative decision making element, the participants emphasized discussion, agreement, collaboration, decision-making, justification, and compromise.

Higher-order thinking skills were noticed as analysis, evaluation, and synthesis.

Benefits to the average middle school students were detailed as appreciation, creativity, cooperation, decision-making, communication, observational skills, debate, and career choices.

Since the elements were observed as being present by a portion of the participants, the researcher would not significantly change the body of the project. The fact that they were observed is significant enough for this study. Had the researcher desired to find out to what degree the elements worked he would have instituted a quantitative analysis. Qualitative data exists well on its own merits as long as it is organized. It does not require the level of interpretation as that which accompanies quantitative research.

One of the more difficult tasks in this qualitative research involved the creation of the questions used in the original questionnaire provided to all the participating educators. The questions referred to elements that were both science content-rich and student-centered. Qualities the researcher hoped would be noticeable in the "Mars 2076" presentation. The form in which the questions were asked needed to remain as neutral as possible so that the teachers could decide for themselves whether or not the desired elements existed, or not. The questions, as open-ended as they were written, may not have provided as detailed information as were desired by the researcher. In spite of this, the investigator was, however, pleased by the depth of information returned by the participants. The two final questions in the evaluation were the most revealing. Not only did these comments provide many helpful suggestions on what needed to be improved in the curriculum project, but emphasized those best practices that should be contained in any good student-centered project.

Based upon the opinions detailed in this chapter, the investigator would suggest the need to make a number of improvements in a future version of the "Mars 2076" curriculum project. He would first present the project in smaller portions over a five-day period. He would give a shortened evaluation at the finish of each day's portion. He would also do a better job of introducing the material on the first day and improve the summation process the final day. The researcher would reserve the overall "strengths" and "weaknesses" area of evaluation for the individual interviews. These interviews would ideally be given two or three days after the project's completion, allowing for greater reflection from the teachers' participation.

The investigator might also change the evaluation to concentrate more upon the methods used in presentation rather than inclusion of the five pre-determined elements he chose. If the evaluation were administered properly the five elements would appear in the answers given by the educators.

Rather than involve educators a second time it might be better to use this improved approach of presentation of "Mars 2076" with actual middle school students. The daily approach to the evaluation and additional time to reflect on their participation before requesting interviews might work well. The questions would have to be altered to allow for the difference in vocabulary levels and understanding of educational methods between middle school students and teachers

The purpose of the random interviews was directed at recognizing which of the five desired elements were present in four primary activity sections of the project. It might have been more beneficial to have the educators take a more in-depth look at the entire project, but this would not have been conducive with the participants' time and patience. Additional follow-up interviews with other participants, guided toward improvement of still more sections of the project could have been conducted.

The timing of the project was a factor that may have caused the evaluations not to be as objective as possible. The project was scheduled on one of the final days of the teachers' two-week workshop. The educators were understandably exhausted before the project began and the length of time to complete all the project's sections left the participants weary. Considering these facts, the researcher was especially pleased with the expanse of the teachers' comments and the amount of time they dedicated to completing the questionnaire.

The interviews were completed on the very last day of the workshop. The level of interest and compliability to the investigator's request for an interview was heartening. The researcher received many compliments from the participants on the manner in which the project was presented. He enjoyed the opportunity to speak more personally with these educators.

The case studies were helpful in realizing the educational environment that is a background for the opinions of the teachers. The views of any educator are influenced by their past and present lives. Had case studies been conducted prior to the beginning of the project, a different participant population might have been recruited. The population used was appropriate for evaluation of the project in ethnically rich locales throughout the United States and its territories.

CHAPTER V

SUMMARY, RECOMMENDATIONS, AND CONCLUSIONS

Summary

The purpose of this study was to discover how aerospace science curriculum projects could contribute to the higher-order learning of students in a period of vast education reform.

Inclusion of background material and activities that provided insight into Mars' planetary environment was successful in the project, according to the evaluations. As were the promotion of interactivity among participants, collaborative decision-making, and use of higher-order thinking skills. The evaluators did believe that the project would benefit the education of the middle school student.

To further evaluate the success of this study the researcher would like to revisit a list of recommendations of best practices established by key players in the reform movement and compiled by Zemelman, et al., first mentioned in the review of literature. In relation to thirteen "best practices" that could create a progressive curriculum, was "Mars 2076":

1. Student-Centered? The curriculum project used in this study presented activities which allowed for student choice in the ways the participants interacted and allowed choices to perform one segment of an activity or another.
2. Experimental? The project asked for participation in a number of activities involving original experiments, many not found in the average classroom curriculum.
3. Holistic? The storyline nature of the project provides the students with a model of a Mars colony with many realistic complexities.
4. Authentic? The realism of the activities follows what NASA believes are logical daily situations found on missions into space.
5. Expressive? There are many elements in this project that involve disciplines outside science, math, or technology. The arts allow the students a wider-range of expression.
6. Reflective? The "Silver Reflections" culminating activity asks students to evaluate their future, based upon their past actions.
7. Social? Many of the activities gained greater value to the groups participating by encouraging them to pool their resources in completing the activity.
8. Collaborative? The strength of the outcomes is far better in these activities than if the students were left to figure responses individually.
9. Democratic? Although each working group could decide upon their responses used for presentation to the group by many different means, the students are led by the design of the project to make those choices democratically.

10. Cognitive? Many of the "Mars 2076" activities have to be analyzed by the group through discussion before the group is able to formulate their answers.
11. Developmental? The curriculum project is progressive by the way it follows a storyline toward the period when the colony's success is evaluated.
12. Constructivist? The students were asked to take initial content material on Mars and use it to formulate their outcomes for the colony.
13. Challenging? There are many choices involved in the project's activities which present safe versus harmful conclusions.

It is the opinion of this researcher that projects similar to "Mars 2076" may provide successful examples, not only to aerospace science educators, but to educators in other academic disciplines of how well student-centered activity-rich projects can lead to a more ideal reform-based curriculum.

Recommendations

A curriculum designed to be student-centered should ultimately be field tested with students. This researcher would recommend that this project be revised as outlined:

1. The project should be performed with a middle school class.
2. Present the project in smaller portions, 1-2 hours of activity, over a five-day period.
3. Give shortened evaluations at the end of each day's participation.
4. Adjust the vocabulary in the questionnaires to be appropriate for middle school level participants.
5. Introduce the material more completely on the first day.

6. Improve the summation process on the final day.
7. Reserve the evaluation of overall "strengths" and "weaknesses" for individual interviews.
8. The interviews would ideally be given two or three days after the project's end, allowing for greater reflection from the students' participation. This concept is based on John Dewey's belief in the importance of "reflection"
9. More participants should be utilized in the creation of case studies. This would present a better base of understanding for the participant population.

Conclusions

This researcher believes that there are places in any curriculum for projects similar to the one examined in this study. This project incorporates many of the elements prized by today's reform movement in America. Serious consideration should be given to how well the elements of the project fit the thirteen best practice elements of a student-centered curriculum listed above.

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APPENDIXES

APPENDIX A

PARTICIPANTS QUESTIONAIRE, INTERVIEW

QUESTIONS, AND SAMPLE QUESTIONS

FOR CASE STUDY DEVELOPMENT

An Evaluation of the "Mars 2076" Project To the best of your ability as an educator please write your reactions to the following questions that deal with the "Mars 2076" project you participated in today.

Responses to this survey will be confidential; no individual will be identified with his or her responses.

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(1) Were there activities in the "Mars 2076" project that gave you greater insight into the Mars' planetary environment? If so, please name or describe them.

(2) Were there activities in the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please name or describe them.

(3) Were there activities within the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please name or describe them.

(4) Were there activities in the "Mars 2076" project that promoted the use of higher-order thinking skills? If so, please name or describe them.

(5) Would a middle school student receive any benefit from participating in an activity such as "Mars 2076?" If so, please describe that benefit.

(6) What do you feel are the major strengths of the "Mars 2076" project?

(7) What do you feel are the major weaknesses of the "Mars 2076" project?

Further Evaluation Questions for the "Mars 2076" Project

These questions were used during interviews with selected educators that had filled out the initial qualitative questionnaire.

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1. What do you feel was the major theme of the "You are Not Alone" section of the "Mars 2076" project?

2. Were there activities in the "You are Not Alone" section of the "Mars 2076" project that gave you greater insight into the Mars' planetary environment? If so, please describe them.

3. Were there activities in the "You are Not Alone" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

4. Were there activities within the "You are Not Alone" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

5. Were there activities in the "You Are Not Alone" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.

6. Would a middle school student receive any benefits from participating in an activity such as those found in the "You are Not Alone" section of the "Mars 2076" project? If so, please describe them.

7. What do you feel was the major theme of the "Picture This" section of the "Mars 2076 project?

8. Were there activities in the "Picture This" section of the "Mars 2076" project that gave you greater insight into the Mars' planetary environment? If so, please describe them.

9. Were there activities in the "Picture This" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

10. Were there activities within the "Picture This" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

11. Were there activities in the "Picture This" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.

12. Would a middle school student receive any benefits from participating in an activity such as those found in the "Picture This" section of the "Mars 2076" project? If so, please describe them.

13. What do you feel was the major theme of the "Rocky Discovery" section of the "Mars 2076" project?

14. Were there activities in the "Rocky Discovery" section of the "Mars 2076" project that gave you greater insight into the Mars' planetary environment? If so, please describe them.

15. Were there activities in the "Rocky Discovery" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

16. Were there activities within the "Rocky Discovery" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

17. Were there activities in the "Rocky Discovery" section of the "Mars 2076" project that encouraged the use of higher-order thinking skills? If so, please describe them.

18. Would a middle school student receive any benefits from participating in an activity such as those found in the "Rocky Discovery" section of the "Mars 2076" project? If so, please describe them.

19. What do you feel was the major theme of the "Time Capsule" section of the "Mars 2076" project?

20. Were there activities in the "Time Capsule" section of the "Mars 2076" project that gave you greater insight into the Mars' planetary environment? If so, please describe them.

21. Were there activities in the "Time Capsule" section of the "Mars 2076" project that promoted inter-activity between you and other participants? If so, please describe them.

22. Were there activities within the "Time Capsule" section of the "Mars 2076" project that lent themselves to collaboration in decision making? If so, please describe them.

23. Were there activities in the "Time Capsule" section of the "Mars 2076" project that encouraged higher-order thinking skills? If so, please describe them.

24. Would a middle school student receive any benefits from participating in an activity such as those found in the "Time Capsule" section of the "Mars 2076" project? If so, please describe them.

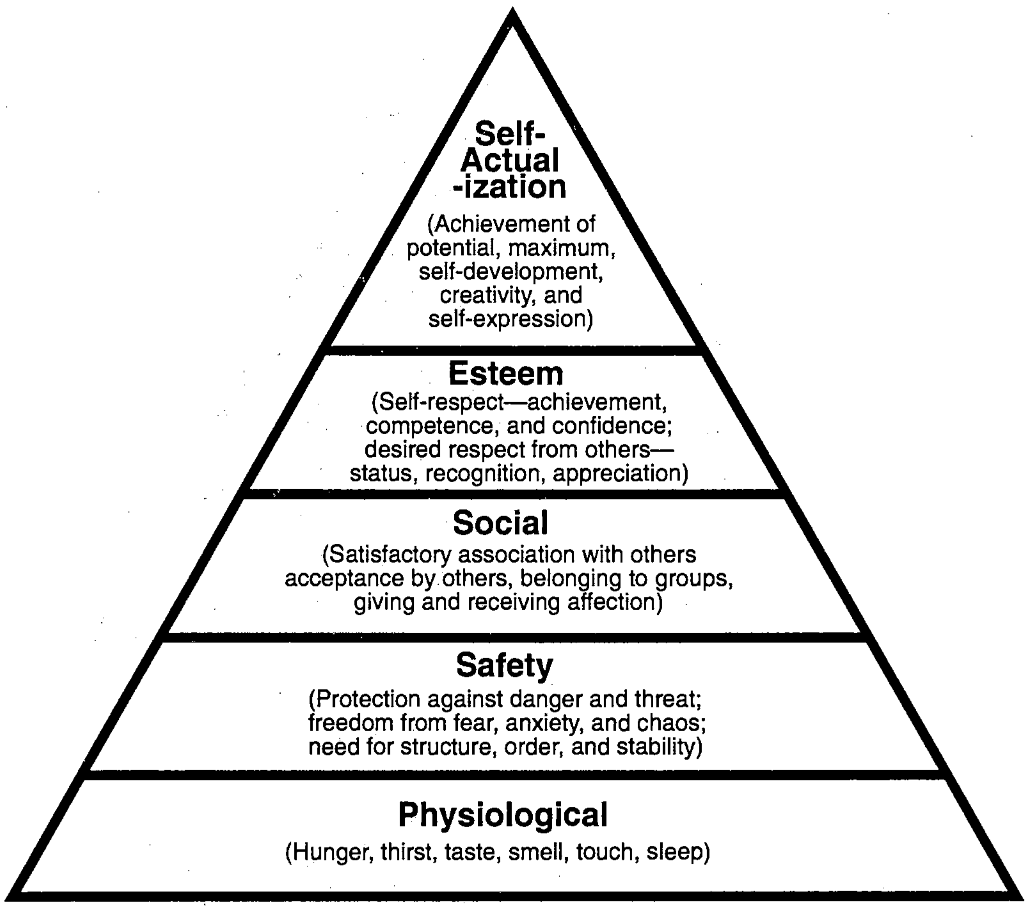
Sample Questions for Case Study Development

1. Name?
2. Where do you reside?
3. For how long?
4. Where were you born?
5. Do you mind if I ask your age?
6. Could I please know your and your families' cultural background?
7. Where did you attend college?
8. And your major was?
9. Do you have any advanced degrees?
10. (If so...) From what universities?
11. Are you now or have you been married?
12. If you have children, what are their ages and gender?
13. What activities does your family like to do together?
14. Do you have any personal projects and hobbies?
15. What other grade levels or subjects have you taught in the past?
16. Are there favorite grades or subjects that you teach or have taught?
17. Concerning the "Mars 2076" project, What details did you like?
18. What aspects of the project were disappointing?
19. What improvements might you suggest in the project?
20. Additional follow-up questions as needed to promote further responses.

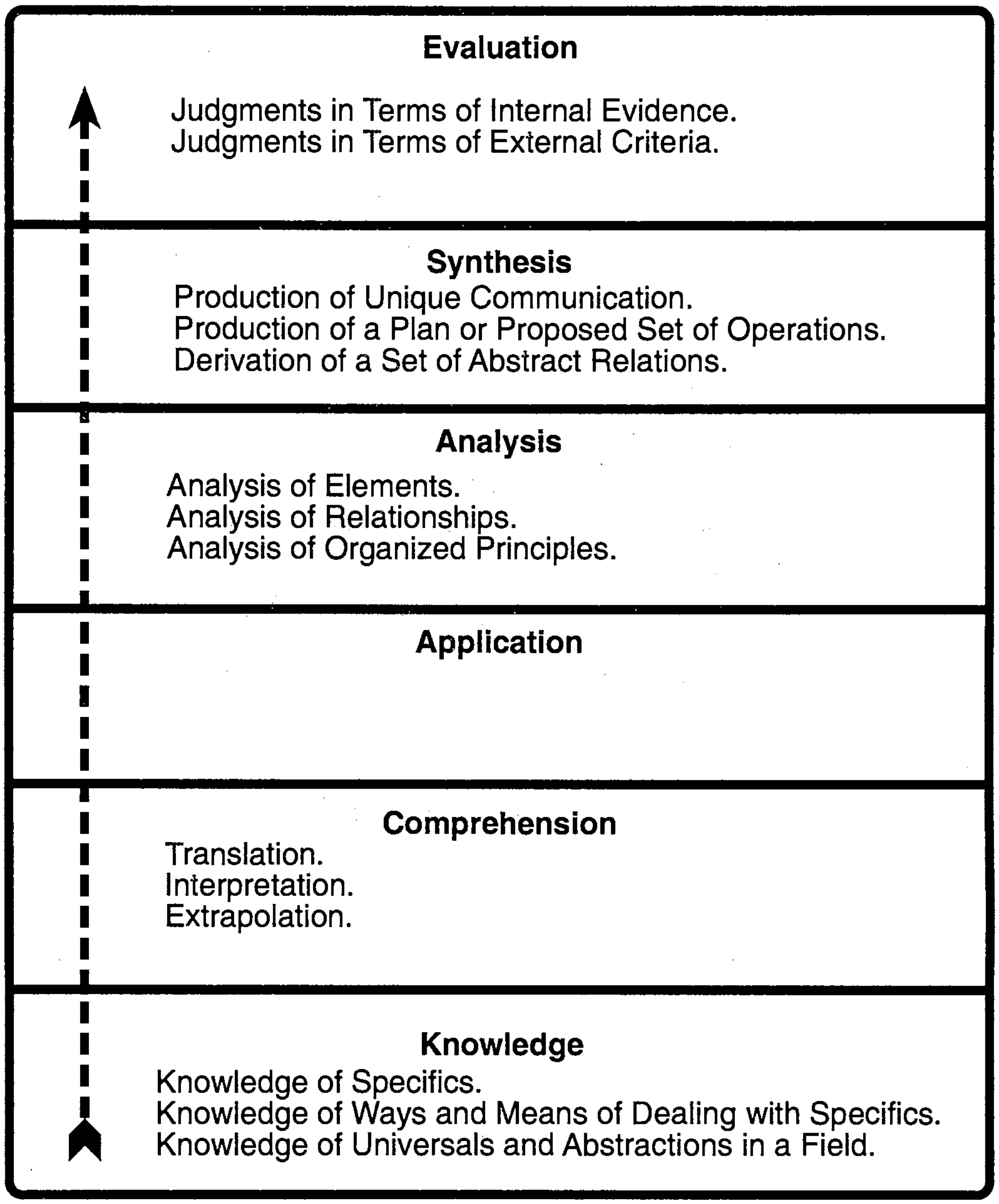
APPENDIX B

"MASLOW'S HIERARCHY OF NEEDS" AND

"BLOOM'S TAXONOMY"



Maslow's Hierarchy of Needs



Bloom's Taxonomy of the Cognitive Domain

APPENDIX C

"MARS 2076" PROJECT"

Mars 2076

"Introduction"

The year is 2076, the tercentennial of the United States. Our country is continuing to head up an expeditionary mission to a remote area of the planet Mars. Ever since the country first sent astronauts to Mars in 2019 there has been interest exhibited in finding the most suitable areas in which to establish colonies on the planet. Early colonies consisted of inflatable structures hardened over with cement that kept harmful solar radiation and daily freezing climate outside and necessary oxygen, air pressure, heat and humidity inside.

In later years more countries joined larger numbers of expeditions to different areas of Mars there became greater need to find better facilities to house humans. A controversial plan to terra-form Mars had been debated in the United Nations for years. The Security Council agreed to allow it in a remote cavern area discovered near Valles Marineris. The cavern was discovered by a U. S. expedition in 2045. It was believed to be an underground tributary of the river that had formed that expansive gorge. A branch of the river found its way underground and had carved out a large cavern.

The whole idea of Mars' exploration was controversial. Many political leaders were willing to put money into the venture as long as the risks were not too hazardous or too expensive. Politicians threatened time after time to cut off funding for the slightest failures. Their arguments always included waiting until a time when budgets were less tight and technology had further advanced.

(Early observations of Mars from Earth were made by numerous astronomers; chief among these were Giovanni Schiaparelli and Percival Lowell. Both promoted the idea of canals on the planet.)

Postcards from Mars poster (EW-1997-02-127-HQ)
Space-based Astronomy Educator's Guide **(EG-102, 8-94)**
Martian Canals activity

"Forming an Opinion"

The cavern became an ideal place to set up a colony because it didn't require large amounts of money to establish a structure. Initially, the cavern was used to house extra supplies necessary for the extremely harsh winter months on the planet where temperatures can reach to minus 40 degrees Celsius.

The great advantage of the cavern, eventually named, Agassiz, after Louis Agassiz, the famous geologist, was that it had the ability to hold water in a liquid state under greater air pressure than the Mars' surface. The water came from the northern icecap of Mars. A series of stations robotically gathered the ice from the edges of the Polar Regions and warmed it. The melt-water could then flow through a series of pipelines into the cavern.

The terra-forming that was used in the cavern transformed part of it into a rather lush semi-tropical climate that could support many species of plants. Animals, besides humans, had not been introduced into this new eco-system. The environment made growing vegetable crops much easier than had been the case in the earlier colonial structures. Even at a greatly accelerated pace it had taken close to twenty years for the "seeds" of the terra-forming to create a natural environment inside the cavern.

Do humans have the right to change a foreign planet to suit their own purposes?

What if plant or animal life, even in microscopic forms, are present on the planet?

Resource:

Snows of Olympus, The: A Garden on Mars **(1994). Arthur C. Clarke. New York: W.W. Norton. ISBN: 0-393-03911-0.**

"Your Mission"

You and the members of your expedition are visiting the Agassiz cavern habitat for one month in order to examine the progress of many newer introductions to this environment, several were made during the last expedition nearly two months before.

One of the newer innovations in colonial life on Mars has been an improved process for purifying the natural water found in the cavern. The new process designed by Hans Muess, a Swiss chemist, saves considerable energy.

Wind turbines, located on the surface produce the majority of power used in the cavern. There is always at least a stiff breeze of 50 kph blowing on the surface. Major problems can occur when the wind picks up the abundant sand particles. Usually the sand moves low to the ground, but during seasonal high winds the sand can get up to the height of the turbines and filter into the machinery. The sand particles cause havoc with the engines' lubrication. At 100 kph the turbines turn their blade edges in the direction of the wind and shut down. This prevents the turbine mechanics from working too hard which could cause major problems in their operations and require more frequent maintenance. Work to repair a turbine would require a technician to don a life support suit and spend hours away from the protection of the habitat.

Resource:
Planetary Geology Educator's Guide **(EG-1998-03-109-HQ)**
Winds of Change activity

"Got Water?"

Inside the habitat some of the energy is allocated to the water purification system. The water is free of large amounts of contaminants when taken directly from the pipeline that empties the polar icecap meltwater into the holding tanks in the cavern. The minor improvement is elimination of some of the high iron content and a few other minerals like sulfur that make the taste less than desirable to many humans. The same water in unpurified form is used to irrigate the farm crops grown in the cavern. A much larger problem is the re-purification of the water after it has been used by humans to drink, take showers, or wash clothes or dishes. An ingenious system for this purification, called the Muess process, uses layers of soil, rocks, sand and microorganisms to clean the water with little energy, except that needed to circulate the water to and from the purification tanks.

Do you feel that you would want to drink water that had been recycled in part from human body fluids?

Why do you think there had been so much debate in the scientific community about introducing microorganisms from Earth as part of the Muess filtration process?

Resource:
Our Mission to Planet Earth Educator's Guide **(EP-1997-12-292-HQ)**

"Bouncing the Sun"

Another crucial consideration for survival of the vegetation is sufficient amounts of sunlight necessary for photosynthesis to take place. Carbon dioxide is abundant on the planet, but natural light is not. Being twice the distance from the Sun as Earth, it is difficult to capture enough intense sunlight to do much good in the cavern. Two years ago another new system was developed for the colonies on Mars. The Fernandez System was named after the Nobel Laureate who first developed it. This system collected light from the Sun by use of parabolic mirrors that concentrate the Sun's rays similar to the way that dish antennas intensify radio signals, only on a much larger scale.

Giant arrays of dishes were erected on the Martian surface and the light is bounced from one set of mirrors to another and then reflected through a major glass-domed skylight in Vanaheim's cavern roof. The sunlight is reflected again inside the habitat until it reaches the crops. Not only are the plants necessary as a source of food for the colonists, but the photosynthesis process produces very valuable oxygen needed by the humans.

What would you anticipate to be some of the problems associated with this type of lighting system for growing plants?

Resource:
The Dynamic Sun CD-ROM (ver. 2.0)

"You Are Not Alone"

Your group has brought with it another innovation. It is a new storage battery that is capable of transferring and holding the surplus energy no longer needed to purify the water. The excess power can be used to ration out to individual colonists for electrical devices to produce music, watch movies, or operate computers for personal reasons, like transmitting messages to family or friends back on Earth. In an emergency the extra power could be used to operate fuel cells that are capable of creating both oxygen for breathing and hydrogen for fuel from the cavern's water supply.

Electric vehicles brought you to this remote outpost from the original colony located near the base of Olympus Mons nearly 500 km away. The Asgard Colony was named after the home of Thor, the Viking god of thunder, because Olympus Mons was said to rumble like thunder from time to time. Others were positive that the volcano had become extinct long ago. The only other colony that had been established successfully on Mars was still further away by 500 km. It was called Midgard. The population of both colonies was currently 200 each.

There is a rich diversity of cultures that make up your expedition. One evening as the group in the cavern was enjoying the last of their evening meal one of the colonists mentioned the fact that the night sky that they could see out the skylight was little different than that on Earth. The stars appeared in almost exactly the same positions as they did in the Northern Hemisphere on Earth. Another colonist suggested that they should imagine their own constellations based on legends from their various cultures or create new legends unique to Mars.

Resources:
"Let's Talk Robotics" video
***Exploring the Moon Educator's Guide* (EG-1997-10-116-HQ)**
Legends in the Sky activity
Mythological Neighbors in the Solar System activity

"Good for You!"

You are to remain at Agassiz for a total of one month. Your are currently halfway through your visit. So far you have been able to evaluate the efficiency of the Muess water filtration system. It successfully kept the plants growing for the past two months since the last expedition left. Only one set of plants died because a valve malfunctioned and closed off the water to that area of the farm. Luckily, there was another planting of wheat on the other end of the fields. Bread made from the wheat was always a welcome addition to the Martian colonial meals.

Just yesterday your personal group finished installation of the new storage battery system. Overnight it had checked out well and appeared to be fully capable of storing excess power and converting it to other uses. With each expedition the Agassiz cavern was becoming more comfortable.

Is the cavern hospitable enough to become a colonial site of its own?

Resources:
***Plants in Space Educator's Guide* (EG-1997-02-113-HQ)**

"Picture This"

Your lives on Mars are different than the "normal" lives you spent on Earth. Think about how human culture might have been different if it had begun on Mars instead of Earth.

- What might be different?
- What would be similar?
- What might family life be like if you had been born on Mars and your family didn't have knowledge of anything concerning Earth?
- How might the length of the Martian year change human time references?
- How would change in physical surroundings such as lack of forests, bodies of water, and fields of crops change human references in art, poetry, or song writing?
- Without plant or animal life what would be the primary influences in children's literature?
- What natural features on Mars would influence the arts?

Design a travel poster for Mars.

Resource:
Galactic Vacation activity

"Grandest Canyon"

For some unknown reason the pipeline carrying fresh water from the northern polar cap into the cavern has ceased to supply water. Your group has been chosen to go on an expedition to find the cause and, hopefully, repair the damage. You pack your supplies into a solar-cell powered electric rover and set out to find the problem.

When you reach that area there appears to have been an avalanche in one of the canyon walls that has caused a break in the pipeline. The water has evaporated as quickly as it reaches the open area of the pipe and is exposed to the minute pressure of the Martian atmosphere.

Resources:
"Geography in Space" video

"Skills Needed"

In order for your group to be successful in its exploration of this outpost particular skills would be necessary. Discuss in your group what would be the most necessary occupations for each of you to hold to be successful in your endeavor to spend one month in the cavern evaluating the outpost as a place for a possible future Martian colony.

(Below list the five professions your group believes would be most important for the success of the mission.)

Resource:
Mars-VE CD-ROM (EC-1998-02-001-ARC)
Crew Member activity

"Rocky Discovery"

You get out of the rover to inspect the damage. In anticipation of making repairs, your group has brought along extra pieces of flexible pipe. There is enough to fix the one meter-wide gap in the pipeline caused by the rockslide.

As some of your group clears away the debris one person sees the outline of an object in one of the flat rocks. On further inspection by the other members of the group the consensus is that the object is a fossilized leaf much like a palm frond. The group members begin to hypothesize upon what this discovery could mean in terms of the history of this planet. No fossil of any sort had ever been found on Mars before.

What could a real fossilized plant tell us about Mars?

Why would this be such a significant discovery?

Resource:
Unusual Phenomena Survey Report 9-0457 (Red Rover 2 activity)

"Falling Hopes"

Repairs on the pipeline are going well. Suddenly, rocks above you begin to fall... your group takes cover under a nearby ledge. Just when you believe the avalanche has ceased, even more rocks fall. You all huddle under the ledge again hoping that the rockfall doesn't break it off. After another stressful ten minutes no additional rocks fall and the dust begins to settle. You check to see if the other members of your party are OK. Thankfully, they are. As you crawl from underneath the ledge that saved you, you are relieved to see that the pipeline has not been further damaged. Someone notices the rover; rocks have crushed its front end badly. After inspecting the vehicle, it is decided that the only way the group is getting back to the cavern is by foot.

What do you do now?

"A Good Hike"

Right now you are 50 miles from the Agassiz Base. Your expedition was to have lasted as long as five days. No one may come to look for you until that time. Without power the rover is not much protection from the cold Martian nights (The night temperature could be as low −100°F. The day is half over.)

Your group decides to start hiking toward the base. Only the most critical items of those on board your rover may be taken for the trip. On the accompanying page is a list of the 15 items aboard the rover. Your task is to decide which are the five (5) most important items that you both will carry with you on your trip that could best assist you in reaching the Agassiz Base. (You are now wearing your space suit.)

Place number 1 beside the most important item, number 2 by the second, and so on through your fifth selection.

First do the ranking yourself, then compare your choices with the other members of your group and create a consensus ranking; finally compare group rankings in order to compile a class consensus.

Suited for Spacewalking Educator's Guide **(EG-1998-03-112-HQ)**
Spacesuit poster (EW-1997-09-124-HQ)
Down on Mars (Red Rover 1) activity

"Home?"

Tired and hungry you have arrived at the Agassiz base, congratulations! As soon as you are through the airlock you each take off your spacesuits. Many of the other colonists come to greet you.

"Thor's Hammer"

As you reach the floor of the cavern one of the scientists tells you that they had communicated with the Asgard Colony while you were gone. The earthquake that probably caused the rockslide that broke the water pipeline also ruptured the airlock to their colonial site.

This colony, at the base of Olympus Mons was originally constructed by forming concrete over a series of inflated tubes. After the concrete had hardened the tubes were deflated and discarded. A series of airlocks divided one tube from another. Those colonists that had been in the tube closest to the outer airlock had been subject to the breach and fifty had died because of the loss of oxygen and air pressure.

The other interior airlocks had automatically closed and saved the lives of the additional150 colonists.

After this disaster had happened the Asgard colony had attempted to contact their sister colony, Midgard. Strangely, there had been no answer from that colony.

(Colonial structures can be made by using the natural materials found on the planet.)

Resource:
Rockets Educator's Guide **(EG-1996-09-108-HQ)**

"Protecting the Future"

Asgard was asking that since they were not sure of the status of the colony at Midgard, could they, instead, send 25 children and their caregivers to Agassiz for safety. A hovercraft would be able to transport these colonists to Vanaheim in two days.

During the next few days your crew checks out the operation of the water supply and the reliability of the purification system.

The children and five caregivers arrived at your settlement. It will be different having children around on a daily basis. There had not been much room on the craft that brought them here for extra supplies. Thirty additional people mean that food, water, and oxygen usage will have to be monitored more closely.

Resource:
Space Food and Nutrition Educator's Guide **(EG-1999-02-115-HQ)**

"Shifting Sands"

Although there had been warnings that seasonal winds might bring sand storms to this area of the planet sooner than usual, the pilot of the hovercraft insisted that he start back to Asgard immediately to be with his wife to celebrate their fifth wedding anniversary.

(How might celebrating special events be done differently in space or on an alien planet like Mars?)

(How would a Martian calendar be different than an Earth calendar?)

The next day the winds did pick up dramatically outside the cavern. Sandstorms on Mars were very strange because the visibility would be obscured by the sand whizzing by the skylights, but the air on Mars was so thin that the wind, some said they were thankful, produced no howl, as it would have on Earth.

The next day there was a radio message from Asgard. They were asking the whereabouts of the hovercraft pilot. He had not made it back to the colony as yet.

There was no chance for either the folks at Asgard or your settlement to send out any sort of search party at this time because of the sandstorm.

Resources:
Aeronautics Educator's Guide **(EG-1998-09-105-HQ)**
Exploring Aeronautics CD-ROM (EC-1998-03-002-ARC)
Earth's History as One Year activity

"Talk to Me"

Three days passed by and the wind finally subsides to normal. Your group at Agassiz radios the colony at Asgard to ask if the pilot had, hopefully, arrived back there safely. There was no answer from Asgard. Your radio officer attempts to reach Midgard. Then, almost frantically, he tries to radio Earth Station Gamma in orbit around your home planet. It would take a total of ninety minutes to receive a message back from that far in the Solar System.

After ninety minutes, no word from Earth. You wait another hour and then send a new message to Earth. The next day came and there was still no word from Earth. Your communications experts tear into the radio control panels hoping to find a cable or wire that is the culprit. If that can be repaired, then maybe you can still get word from someone that they have received your signal.

All the connections are tested and all the software examined. Your radio appears to be working perfectly. But, why isn't anyone answering you? Where are they, what could have happened to them?

"Silent Heroes"

After three more days a group of three volunteers sets out to visit Asgard and find out why no one has contacted you. This group uses one of the three remaining electric rovers that brought your original exploring party from Asgard a month ago.

The commander of the mission is told to make contact with your base every hour on the hour.

After the crew sets off on their journey, the first hourly report received was just enough to say that they were on course. The second report was a bit more dramatic. The crew has made a rest stop at the rim of one of the craters and had seen the wreckage of a hovercraft down at the crater's deep bottom. It probably ran off the cliff in the sandstorm.

Every additional report after that was strictly routine until about 3 AM. There was no report. The communications director became concerned when there was still no report by 6 AM.

No word was heard all that day or the next. Radio calls are repeatedly made to Asgard, Midgard, and Earth Station Gamma. Nothing, absolutely nothing… yet you are sure your radio is working properly.

(Cratering on Mars occurs more frequently than on Earth because the thinner atmosphere offers less protection.)

Resource:
Exploring the Moon Educator's Guide: **Impact Craters (EG-1997-10-116-HQ)**

"Time Capsule"

As days and weeks progress talk among the members of the settlement about your future becomes more and more concerned.

The commander of your Agassiz settlement calls for a meeting of the whole group. He asks each of you to share your concerns about the situation of the settlement. Although you have the essentials to survive in this location for many years, some of the inhabitants question what the quality of life may be like. He suggests that the group, uncertain of its future, bury a time capsule in the wall of the cavern. He asks each of you to consider what would be ten items that would tell a future visitor to this settlement what life was like at Agassiz in 2076.

"Silver Reflections"

It hasn't been easy, but here you are in 2101 still living at Agassiz 25 years later.

On this silver anniversary of your life on Mars tell us how your group of settlers has made it to this day.

How were you successful?

What is the cavern like today?

Describe in one page what your successes and disappointments have been.

How has your group dealt with:

- Conflicts between colonists?
  - Who enacts laws?
  - Who enforces laws?
- Daily life?
  - Marriages?
  - Pregnancies?
  - Educating children?
  - Diseases?

Why do you believe no one from the Martian colonies ever came to your rescue?

Why did no one ever visit from Earth again?

Resource:

Tunnel in the Sky. **(1995). Robert Heinlein. New York: Charles Scribner's Sons. ISBN: 0-684-18916-X.**

APPENDIX D

INSTITUTIONAL REVIEW BOARD

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	May 8, 2000	IRB #: ED-00-240
Proposal Title:	"A QUALITATIVE ANALYSIS OF THE INTERACTIVE, SMALL-GROUP, AEROSPACE EDUCATION PROJECT MARS 2076"	
Principal Investigator(s):	Steve Marks John Ulrich	
Reviewed and Processed as:	Exempt	

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson

Carol Olson, Director of University Research Compliance

May 8, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

N

VITA

John Alan Ulrich

Candidate for the Degree of

Doctor of Education

Dissertation: A DESIGN OF MARS 2076: A STUDENT-CENTERED AEROSPACE CURRICULUM

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born in Kenton, Ohio on April 23, 1950, the son of Alfred and Thelma Ulrich

Education: Graduated from Upper Sandusky High School, Upper Sandusky, Ohio, in May 1968; received Bachelor of Science in Earth Science Education in March 1973, additional certification in Elementary Education awarded June 1976, both from Bowling Green State University, Bowling Green, Ohio; received Master of Science in Aerospace Education in May 1993, from Oklahoma State University, Stillwater, Oklahoma. Completed the requirements for the Doctor of Education degree with a major in Applied Educational Studies at Oklahoma State University in August 2001.

Experience: Raised in the small rural community of Upper Sandusky, Ohio; employed as an elementary teacher in Norwalk, Ohio, a middle school teacher in Grafton, Ohio; aerospace education specialist at the NASA Glenn Research Center, Cleveland, Ohio; aerospace education specialist at the NASA Kennedy Space Center, Florida; NASA Educator Resource Center Coordinator, Oklahoma State University, Stillwater, Oklahoma, 1991 to present.

Professional Memberships: National Science Teachers Association, National Council of Teachers of Mathematics, International Technology Educators Association, and Association for Supervision and Curriculum Development.