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SPACE EDUCATION, CREATIVITY AND COLONIZATION

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It's no use saying, "We are doing our best".
You have got to succeed in doing what is necessary.
Winston Churchill

INTRODUCTION

Space education is based upon the belief that everyone should understand and appreciate the enormous impact that space is having and will have upon our lives. It is imperative to be aware of the potential benefits that will arise from space exploration and colonization. These elements will contribute to the improvement of our daily lives and our evolving society. Further, it will be absolutely necessary, especially for the young, to realize the continually changing nature of career opportunities related to space. Space education tends to futuristic education that involves the knowledge of the exploration, terraformation and colonization of Mars. Space education is relevant general education excluding any specialized education or training efforts, save the building of model hardware such as Martian planet bases to enrich and solidify scientific principles and human psychology. Students should be exposed to most aspects of the current space programs with support from videos, compact and digital video disks and field trips to space related institutions (1-10).

In most of their general courses, they should study the impact that space activities have on the social, economic and political aspects of our society. Confluent education (11,12), considering the flow of the emotional aspects of learning with the intellectual functions, greatly augments comprehension and assimilation. Learning reaches its highest level when a class is presented with the problems encountered in the design and launch of a rocket or the building of a realistic Martian space colony. This group activity releases the students and teacher out of the time and subject constraints of regular education. Furthermore, this type of activity acts as a platform for the augmentation of student creativity (13-17). Therefore, because space education is interlocked with so many areas of study, lesson plans which emphasize space technology and space activities in the curriculum at all age levels are valid. Students relate to it because it is a practical application of the things they have learned or are learning abstractly in their general subjects. Mathematics and science (18-19) become meaningful because there is an immediate reason to understand. Spontaneous interest in aircraft, rockets, space vehicles and life on other planets propel students into exploratory enterprises which will help them understand this

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complex age and help them to assume responsibility for the improvement of their everyday living. Space knowledge becomes comprehensible, not fearful. Moreover, space education serves to support the general courses of the curriculum by reinforcing the basic tenets of science and social studies (20).

SPACE EDUCATION

Education can be perceived as a deliberate organized attempt to help students become intelligent. It is a process of training and developing knowledge, skills, mind, attitudes, and character through an approach generally referred to as education. Its aim is the development of minds not for human power but rather for adulthood. The right to education arises out of the democratic idea that everyone should have the right to become intellectualized for self-actualization with an accompanying right to work. Education is generally regarded as a necessity to a country because it seems that it is the path to prosperity and power. Industrial advancement and technology is intimately bound to the expansion of education. The larger the pool of literate workers, the greater is the possibility for industrial, technological and scientific progress. However, to clearly understand the basics of technology it is imperative to have an understanding of mathematics and science; to think about technology is to think as a mathematician (18,19). Students must be made aware about technological change; to know that they must cope with the pervasive and profound changes that affects everyone. Students must not only exhibit a youthful fascination with the novelty of technological invention, such as the space shuttle; they must also be taught to have a genuine pragmatic concern about personal and societal survival and advancement in the exploration and colonization of Mars. In essence, they must understand the relationships between technology and society (20-24).

TECHNOLOGICAL INNOVATION

Increasing and changing technology has resulted in new sciences and branches of technology due to space exploration and future colonization (25). However, the lack of basic innovation is clearly with us today. Under the pressure of the present monetary crises, governments are endeavoring to improve the economy by encouraging basic innovations for a quick fix from which a number of new industries are being created (25). Unfortunately, these technological achievements share the stage with, according to the general public, too expensive and too risky innovations such as the international space station (26-28) and the exploration and eventual colonization of Mars that appear as major contributions to minor needs (25). There are reasons to believe that in the haste of events, more important innovations are being pushed aside by projects that offer little more than instant marketability. Consequently, it appears that such technological innovations for space exploration must come later because humans appear to have no more tolerance for any type of innovation because they can only support and cope with a certain number of changes at a given time. However, space education provides knowledge that augments coping skills in the positive resolution of this dilemma. As the new innovations which

satisfy human needs; and the adjustment to them; and the new technological state approach equilibrium, the committed who function beyond these archaic societal structures will propel humans to Mars. Students must be made aware of this shortsightedness and be encouraged to become more visionary (25,29-35).

MATHEMATICS AND SCIENCE

Since Canada and the United States are leaders in the fields of communication, robotics and space technology, it is urgent and important to encourage students to explore spatial sciences using the tools of scientific inquiry and mathematics supported by modeling (36-42). The new generation exposed to space exploration will become more interested in mathematics as the result of seeing some of its significant applications in recent and current space projects. Working out such problems will enhance both the mathematical knowledge and skills of students and their appreciation and understanding of space technology and human achievements. The space program has depended heavily on mathematics. While the perception exists that space related problems are beyond the scope of students, there are many aspects of space science that can be understood using high school mathematics. Understanding of the space shuttle offers problems with respect to describing its motion, position and attitude, all of which can be set up with suitable coordinate systems familiar to high school students. Space science is based on the mathematical description of space in terms of dimensional analyses, which involve length, mass and time. These problems are solved with knowledge of algebra, geometry and trigonometry. Trigonometric analyses are used extensively in space transformations between terrestrial and spacecraft coordinate systems and the tracking of spacecraft from stations on earth (23,24,26,27,38,39).

The recent developments in space have special interest for teachers and students interested in mathematics. Students who are gifted in mathematics find motivation in the logic, structure and beauty of the subject. However, most students only have an appreciation of mathematics when they are presented with its practical application. It is difficult to obtain meaningful and interesting applications for students. Application of the use of algebra and trigonometry are especially difficult to find. However, the mathematics of space activity offers meaningful and exciting applications. The study of space phenomena with the use of simple linear and quadratic equations studied at the high school level provides the student with the basic tools with which to understand and appreciate the power of mathematics in the interpretation of the physical universe. The space age has produced the need for the acquisition of mathematical skills imperative to the continuing advancement in space exploration and colonization. The exciting realm of space provides the challenge and the vehicle for the creation of a more mathematical literate society that is a requirement for humans continuing to search and settle beyond the safe enclosure of Mother Earth (18,19,23).

CREATIVITY, BRAINSTORMING AND MOTIVATION

The awareness that dominates most of the student's thinking about space comes from the analytical left hemisphere of the brain. However, the creativity and intuitive aspects that the student has about space are conceived within its right hemisphere (43,44). Building a Martian planet base requires analytical ability, but to exclude the often irrational concepts developed and revealed fleetingly cuts off the ability to create. In essence, the sight of the whole is lost. All students have creative ability and that there are many learning activities in space education that can develop this ability. Although it is argued that creativity cannot be taught, space education provides a multitude of situations that provide the opportunity for students to become a better creative thinker and help to refine their creativity. All learning is affected by the environment in which it occurs, just as all learning is affected by the personality and effectiveness of the teacher (11,12,14,17,23). Because creative thinking is divergent thinking, it requires intellectual as well as emotional risk on behalf of both the student and teacher. The exploration of space and colonization consists of a new challenge that requires the student to use conventional convergent thinking as well as the components of divergent thinking. Further, providing a stimulating atmosphere and laboratory in which students can think and experiment is of tremendous importance. The laboratory in which space education occurs must be a stimulus to investigation as well as a comfortable place in which to inquire and learn.

Convergent thinking is characterized by its dependence on the reproduction of the things already learned and the fitting of old solutions to new situations in a mechanical way. Divergent thinking, on the other hand, involves fluency, flexibility, originality and elaboration and is essentially concerned with production of a large number of ideas. Both convergent and divergent thinking are essential to the problem solving experience. When convergent thinking is applied during a divergent thinking phase of the problem-solving process, the latter may be seriously impeded. When students are seeking possible solutions to a space related problem, an evaluation of each idea as it is presented tends to minimize the flow of original ideas. The most basic element of a creative thought is the openness to experience. The tendency to close in on a problem shuts off the flow of ideas which might produce better solutions. The teacher must not pass any judgment that would stifle this creative process (8,12,16,20,44).

In order to insure creativity through space education, the teacher must constantly encourage students to challenge assumptions, because nothing is ridiculous if they think that it might work. The teacher must avoid being predictable. Hypothesis-making must become part of the learning process. The teacher should insure that students share in the results of their work. Originality stems from the student's ability to produce unusual ideas, to solve problems in unusual ways; in other words, the ability to make remote or indirect connections. Generally, the student is predisposed to the intellectual risks associated with creative thought. The creative student is persistent which is marked by the determination to succeed in the face of failure. Frustration seems to propel this student further into the resolution of the problem. While allowing the problem to maintain its freshness, the creative student resists the tendency to judge too soon. Anything is possible in space. Every idea should be put in incubation, in order that the

unconscious takes over allowing all associations and connections to be tried. This activity is impeded by the conscious mind because it has no time for such ridiculous ideas and conclusions. From this activity a sudden flash of insight can burst forth. However, this creative type of problem solving must be checked by being subjected to the logical procedures of mathematical and scientific logic. Sound judgment must complete the work that imagination has inspired (12-17-19,23,24).

While it appears that the creative thinking process is individualistic; deferred judgment of ideas through brainstorming is truly effective. Brainstorming means to use the brain to storm a problem, and this functions extremely well in groups due to its competitive dynamics. Furthermore, piggybacking on the ideas of other students furthers the students' creative line of thought. Through intuitive thinking, students express ideas that they would probably not have considered individually. While brainstorming should welcome wild ideas in quantity, the combination and improvement of already submitted ideas should be void of criticism. Creativity is the process by which the challenged student of space activity goes beyond.

Motivation is an integral element of the creative process. While extrinsic motivation can curtail the creative process because it is often the result of incentives from the teacher for better grades, intrinsic motivation increases creativity because its etiology comes from intense interest in space exploration (8,11,13).

CONFLUENT EDUCATION

Confluent education encompasses a process of teaching in which the affect or emotional aspects of learning work synergistically with the cognitive or intellectual functions. Further, confluent education is the holistic learning process involving the body, mind and spirit. Since the education of space learning involves student group activities, cognitive and affective growth occur simultaneously (8,11-20). The problems posed by designing and launching space vehicles or the building a model of a realistic Martian space colony releases the student and teacher out of the time and subject constraints which characterizes regular education. Mathematics takes on meaning when calculating the center of gravity for the group's spacecraft. Space education fosters true inquiry rather than the inquiry game through guided discovery where the teacher knows the answer. Students are more easily motivated by allowing them to determine the problem and seek out a reasonable solution. This is how students become problem solvers, not simply solution finders as in a television game show. Since it is impossible for any teacher to have all the answers posed in the laboratory where space activities are occurring, the teacher should be the facilitator of learning where everyone considers solutions to problems. The appropriateness of these possible solutions can only be validated by them being subjected to the absolute processes of mathematics and science. Real learning comes when the teacher emphasizes the affective values of participation, enjoyment and success. Hands-on participatory activities involving the tools of mathematics, science and communication will result in the development of positive attitudes about space exploration and colonization (9,10,18-20,22-24,36-41).

INTERNET

In North America there are about 300,000 schools providing education to thousands of elementary and high school students who must be provided the best possible instruction in order to function successfully in this information technological environment. Therefore, it is imperative that schools aim to give these young people the knowledge, skills, ability to reflect and instill an overall set of coping capabilities which they need to successfully function in today's international society, more commonly called the global village (43-48). The Internet provides the students with such a vehicle with which to exercise true responsibility for their own learning and an active role in seeking and using information. These objectives are truly attainable by the student because the role of the teacher has shifted from being a distributor of book learning into being a tutor guiding the students.

The World Wide Web has become the paramount service on the Internet for the purpose of educational instruction. The web is the service that is changing the whole Internet for the distribution of knowledge for education due to its popularity and rapid growth. Its accessibility and ease of use is playing a major role in the immediate access to knowledge. It is primarily based on the student/server model with the web browser at the student's end and web server at the host's end. Search engines are used to retrieve documents and index them. Some of them do very sophisticated work, indexing the whole text of a page while others just locate the title and its location. This valuable tool through the existence of appropriate educational web sites, such as NASA and the Mars Society can be utilized to provide knowledge about space exploration and colonization, to both the student and teacher. Communication with other student/teacher users can be performed by way of electronic mail. This electronic mail, or just email, is the way to handle mail. Modern e-mail programs offer multimedia capabilities such as the transfer of pictures, audio and videos and faster delivery of messages in a cost effective manner; one thousand lines emailed to one thousand recipients costs less than a stamp. Every student and teacher user will have at least one e-mail address, thereby being able to communicate with other learners and educators around the world. This instantaneous communication will tremendously contribute to obtaining the most appropriate solutions in the resolution of problems through universal brainstorming (23,43-48).

Due to apprehensive behavior of the student and even the teacher, the Internet has become very user friendly. It no longer requires the student to be involved in the typing of lots of obscure command codes and remembering indecipherable addresses. The student has now to only point and click in order to access information on the Internet. The World Wide Web uses hyper links for navigation. These are author defined areas of the document which, when clicked upon, opens another relevant page. In this way the student can navigate the World Wide Web with a single mouse button. Further, documents can also be viewed with a variety of user controlled font sizes, colors and other access options. This simplicity and variety completely eliminates any threatening environment perceived by the student, regardless of academic ability.

While the Internet already offers access to a wide range of information sources via interactive interfaces, new sources are being continually added. Web site design is important for attracting the student and retaining the initial interest. Frames, images, rich textures, animated graphics, sound and video clips must have aesthetic appeal and above all be user friendly (46). The appropriate web site should provide information to the student in terms of attendance, homework assignments, class tests and parent/teacher meetings. Further, this information should be secure with access only available to the student, the teacher and parents with respect to the educational activity and experience of the student (48).

COLONIZATION OF MARS

Presently, planet Earth supports the entire human race. Therefore, it is possible that one catastrophe could completely destroy our form of life. However, if some humans were living on Mars, our immortality would greatly increased. As population pressures increase, there will be ever increasing incentives to migrate to Mars and beyond. In addition to possible rotating colonies, the colonization of Mars and the Moon will probably always be dependent on Mother Earth for many years just as the colonization of Australia was dependent on Mother England for a couple of centuries and is now independent of material support (49-57). The habitability of Mars depends on its intrinsic properties, namely mass, rate of rotation and age, as well as the positional properties of distance from the Sun, orbital eccentricity and inclination of the equator. Further, there are many essential material factors such as temperature, light, gravity, atmospheric composition and pressure, and water that are major human requisites for survival and growth. Therefore, in order to colonize Mars, it is necessary to create an Earth-like environment suitable for human beings: a breathable atmosphere, an ozone layer and a comfortable range of temperatures. Long-term survival of such a world would require biochemical recycling of elements for life and the replenishment of the atmosphere. The student must first consider these physical elements before embarking on spacecraft design (58).

An important ingredient in the success of the voyage to Mars will depend upon the psychological and interpersonal relationships of the crew. The reduction of stress will have to be controlled by environmental engineering, astute crew composition and provisions for emotional support (59,60). These situations will provide students with group activities that mirror their educational experiences, especially those in brainstorming. The terraformation of Mars, followed by its colonization, would start with ecopoiesis which is the establishment of a microbial ecosystem tending to a terraformed planet endowed with an oxygen atmosphere, hydrosphere and biosphere similar to that existing on Earth. It would contain terrestrial microorganisms, plants and animals (61-74). This new earthlike planet creates a scenario for student inquiry and participation. It is an entertaining activity for students to apply and integrate a range of scientific knowledge to a complex problem. It promotes lateral thinking and alternate ways of looking at the habitability of a terraformed planet and future habitability of the Earth. Students are encouraged to work as a team and integrate their knowledge of the sciences such as physics and

biology, in order to create an imaginary but realistic planet fully stocked with life forms. Not only will students gain the experience of interdisciplinary scientific work, but the intellectual experience will also be very enjoyable and highly motivating. However, whereas the laws of physics are thought to be universal in space and time (24,35,36), the motivating social forces behind civilization are ever changing and unpredictable and must be continually considered in this research for creation. Creativity is the tool by which the student realizes this goal through the cross-fertilization of ideas stemming from activity in the cognitive and affective domains (13-17).

A timetable for terraformation (75) is extremely important to students because their interest and enthusiasm must not be dampened by the thought that this idea is only science fiction and may never occur within their lifetime. It is reasonable to assume that within fifteen years, the establishment of a moon base with robotics mining and enclosed agriculture will be operating on the Moon. Oxygen extracted from lunar rocks will be used to fuel lunar-to-orbit shuttles (23). Between 2015 and 2025, a spaceship will leave for Mars. Then, a space station will be docked to the Martian moon Phobos. Between 2025 and 2035, expertise learned and acquired from the mining and agriculture on the Moon will be applied to Mars which will increase colonization. Further, the inhabitants of Mars will experiment with the construction of airstrips, habitats and manufacturing facilities. During these periods, methods of raising the temperature 100 degrees will occur, thereby releasing water frozen in the polar caps. Further microorganisms are introduced to cycle atmospheric carbon dioxide in oxygen so that humans will be able to breathe Martian air (61-74). However, this intention to terraform creates some ethical questions. Many environmentalists believe that ecopoiesis should only occur if Mars is indeed sterile. However, if life forms do exist then terraformation should consider their preservation (76,77).

INDUSTRIALIZATION OF SPACE

Scientific and engineering communities have begun to develop concepts which call for the macro-realization of space, that is space industrialization and manufacturing, satellite solar power generation and space habitation Students must have some basic knowledge of all aspects of space through a multidisciplinary curriculum. A key feature of space is the continuous risk of direct and lethal exposure to the vacuum of space. Fear of potential physical danger resulting from a space facility constitutes another feature intrinsic to the space environment. However, like parallel dangers in the colonization of Australia and the conquest of the West, determination and resourcefulness will prevail. Students must be urged to invest time in the study of space exploration and colonization in order to uplift the human spirit to the new concept of what can be achieved; and set a new standard of what is desirable to achieve beyond daily needs (20-24,27,28,42,53-57).

A permanent space station orbiting the earth is a basic requirement for countries wishing to produce various materials under microgravity conditions (78) which have a commercial value. For future employment and investment, the student must be made aware of the industrial

possibilities and benefits of space. Weightlessness is a state that can only be attained for a few seconds on earth during free fall of a body in an aircraft such as the KC135. The process which controls the production of materials is solidification. Since processes such as convection and sedimentation are eliminated in microgravity, solidification becomes solely a diffusion process. Single crystals for use in the semiconductor grow larger in microgravity because many processes which hinder their growth on earth are absent.

It will be possible to exploit the space resource of solar energy; the subsequent price of electricity will finance the whole operation. The manufacture of these space solar power stations will inevitably require the extraction of exterrestrial materials from the moon and asteroids in favorable orbits. The energy required to transport materials from the moon is much less than from the earth's surface. The earth-space-moon system could become an industrial complex. Liquid oxygen could be extracted from lunar minerals and used as fuel. Permanently manned stations on the moon could house miners and factory workers. These habitats could evolve into space colonies with workers living with their families to form a space community. Structures could be put at gravitational equivalent points in the earth-moon system where they would rotate to provide the artificial gravity that is considered essential for human well being in space. These space colonies would be self sufficient, needing to be productive ecosystems based on recycling, intensive farming and animal husbandry. Further, they could play an important role as refueling stations for spacecraft on the way to Mars (20,21,23,24,27,35-37,49-51, 51-57).

As all students are aware, the communications satellite industry is growing fast. These satellites are set in geosynchronous orbits which are becoming increasing popular places to be. Today there are one-shot flights that are very expensive plus satellites do not work for many years. It is therefore necessary to orbit large powerful communication satellites, so strong that millions of people could communicate with them. They would augment the present use of satellites for electronic mail, the Internet, widespread educational television, personal automobile navigation, as well as, emergency and rescue beacons, disaster communications, air traffic, burglar detectors and earthquake warning (23,80).

Because of the unequal gravitational pull of the earth, sun and moon, these satellites need fuel to keep them in place. A space station with platforms could provide this fuel. This type of communication will demand the construction of a permanently manned space station that would be needed to build the required platforms in space. These large satellites would form a skynet that would enhance communication around the earth. Complexity inversion would become common where communication satellites become increasingly larger and more efficient and ground systems simpler with many more of them. The sky would be 'wired' through the recognition that space is a medium through which we can communicate without the debilitating effects of rain and cloud cover interfering with transmission. Laser communication in space will create a quantum leap in the rate with which humans communicate. Putting a large computer in the sky would effect an extremely efficient communication and data processing system. Space-to-space communication will become virtually unlimited and inexpensive (21,23,24,27,36,40,50,55). Need it be said that all students must be educationally prepared for these space phenomena?

EMPLOYMENT IN SPACE

The success of the space shuttle and the continuing construction of the international space station, in addition to the increasing interest in the colonization of Mars is creating and will continue to create needs for not only test pilots but also for scientists, engineers, doctors, technicians and computer specialists who will fly comfortably and routinely to and from earth orbit. As space habitats become more sophisticated, standards of specialization, education and health will become relaxed, as spacecraft passenger service becomes an every day occurrence. All occupations will be needed in space to satisfy the basic needs ranging from aerospace engineers to educators and novelists. Eventually, it will be possible to reconcile virtually any career with living and working in space (81). Space activity will produce profound changes in the student's viewpoints of the existence and manner in which fellow students live. The compelling urge to explore and the thrust of human curiosity leads "to go where no one has gone before". This is why the television program StarTrek is so intriguing to all, especially students. While most of the surface of the earth has been explored, the exploration of outer space is now the next objective. National prestige is an important factor involved in this impetus to surge beyond. To be bold and strong in space technology enhances a country's prestige and creates added confidence in scientific technological and industrial strength (23,27,40,51,52,66,67,72). Space technology affords humans opportunities for scientific observation and experimentation that will add to knowledge, thereby producing a greater understanding of the earth's role in the solar system and the universe.

SUMMARY

Within two or three decades many of today's high school students will have the opportunity to venture into space for exploration and commercialization of neighboring bodies such as the Moon and Mars. Space education at the pre-university level will do much to convince the public of tomorrow that nations can cooperate in space exploration and colonization. While space exploration is expensive and dangerous, it is above all possible and exhilarating. Through encouraged creativity in science and mathematics coupled with surfing the net, students will develop technological knowledge and skills heretofore undreamed. These skills generating confidence within students will carry over into all other segments of their daily lives. The lack of knowledge that they have of technology can create fear, which must be eradicated or prevented from occurring by improving their scientific and mathematical skills as well as their written, oral and written communication abilities. Practical space related activities would assist greatly in diminishing the misconceived notion of difficulty associated with these subjects. In short, their awakened interest in space exploration becomes the donkey's carrot in the acquisition of mathematics and scientific knowledge.

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