National Science Standards

Grades 9-12
As Addressed by Challenger Learning Center's
e-Mission: Space Station Alpha

Executive Summary

Reference: National Research Council (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

The e-Mission format conceived by the Challenger Center at Wheeling Jesuit University in Wheeling, WV, is a proven, exciting tool for presenting fundamental science concepts. During the e-Mission and their Mission Specialist preparation, students

- actively participate in scientific [explorations] and ….use the cognitive and manipulative skills associated with the formulation of scientific explanations. P.173
- [are introduced to] scientific topics that have been highlighted by current events. P.173
- [are offered] science and technology-related problems [as] meaningful investigations. P.173
- develop meaning through active involvement. P.173.

Science teachers can emphasize 7 ideas that help the students organize and understand the overriding impact of Space Station Alpha…

- It is a significant scientific and technological experiment in a hostile environment.
- It is exemplifies the close relationship between science and technology.
- It is a product of international teamwork.
- It is in itself a laboratory in which humans are totally dependant for their survival upon cutting edge technology.
- It is both a culmination of what mankind's scientific knowledge and a platform for new scientific discoveries.
- It is a "manmade" ecosystem in which humans and technology are integral elements of the system.

Space Station Alpha's scientific and technological complexity requires that the program's developers select scientific and technological topics that are both manageable and meaningful to the eighth and ninth grade science student. To this end we focused on the following aspects of the space station challenge:

- The space station is both a protective fortress and a "living organism."
- The space station and its human cargo constitute a technologically-dependant ecosystem. All new additions to this system influence the balance of the environmental conditions.
- The Sun is both life-source and potential enemy. It has become, only recently and thanks to advances in satellite technology, an astrophysical laboratory.
- Radiation in space, as on Earth, is both beneficial and harmful, both friend and destroyer.
- Electricity is the lifeblood of this technological "organism."
- Life support systems are the technological "umbilical cord" that sustain the health and functions of the space station's human inhabitants.

Perhaps it helps to illustrate the challenge of developing *e-Mission: Space Station Alpha* by listing some of the aspects of the space station we could have, but due to constraints in class time, resources, and student background, chose not to introduce in this project:

- The space station's water cycle and water management systems
- Waste management
- Food sources and management
- Scientific experiments
- Weightlessness
- An unending stream of innovative and exciting technologies

Content Standards

Science standards are fundamental to success of Space Station Alpha

The challenge of developing a curriculum experience based upon the International Space Station begins with the constantly evolving technology and science involved. Scratch the space station's scientific and technological veneer and the complexity of the project grows exponentially. Teacher's *time, resources, and planned science curriculum,* and the students' prior knowledge and skill development are important design constraints. For these reasons, Space Station Alpha is an early "composite" of the International Space Station, a technological set of modules in a growing, complex puzzle. The standards that we address are posed as scientific facts upon which the space station's science and technology depend.

Student involvement is heightened by activities that promote reflection and active discovery.

There is ample opportunity for the teacher to enhance the e-Mission experience with class and small group discussions, [the use of] labeled drawings, writing (student logs), and concept mapping (Web searches) whenever deemed applicable. P. 174

The following National Science Education Standards are fundamental to *e-Mission: Space Station Alpha* and form the basis upon which the scientists, engineers, technicians, astronauts, and your student Mission Specialists succeed with Space Station Alpha.

Note: In the below section, items identified by a 1, 2, or 3 indicates the degree of correlation between that standard and how directly it is addressed in the Space Station Alpha curriculum. 1 indicates a high correlation and 3 a lower correlation. Standards not addressed or only indirectly addressed are not included.

Physical Science

1. Structure of Atoms P. 178

- **1.1.** Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric forces between the nucleus and electrons [and between protons and neutrons] holds the atom together. **(1)**
- **1.2.** an atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. **(1)**
- **1.3.** The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. **(3)**

- **1.4.** Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars. **(1)**
- **1.5.** Radioactive isotopes are unstable and undergo spontaneous nuclear reactions emitting particles and/or wavelike radiation. **(1)**

2. Structure and Properties of Matter

- **2.1.** …A substance composed of a single kind of atom is called an element. **(1)**
- **2.2.** Solids, liquids, [plasma], and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; [plasma, the main ingredient of our Sun, constitutes 98+% of all the matter in our solar system, the wholly independent atoms and atomic particles of which plasma is made collide and fuse in conditions characterized by extreme heat and pressure forming solids and gases and emitting energy levels that embrace the entire electromagnetic spectrum]; and in gases molecules or atoms move almost independently of each other and are mostly far apart. **(1)**

3. Chemical Reactions P. 179

- **3.1.** Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. **(2)**

4. Motions and Forces

- **4.1.** The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. **(1)**
- **4.2.** Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. **(1)**

5. Interactions of energy and matter

- **5.1.** Waves, including…. light waves, [radio waves, microwaves, x-rays, and gamma rays, etc.] have energy and can transfer energy when they interact with matter. **(1)**
- **5.2.** Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat) visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets (called photons] whose magnitude is inversely proportional to the wavelength. **(1)**
- **5.3.** In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. **(1)**

Life Science: P. 181

1. The Cell

- **1.1.** Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires. **(2)**

2. The Molecular Basis of Heredity

- **2.1.** In all organisms the instructions for specifying the characteristics of the organism are carried in DNA…the chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes…and replicated. **(2)**
- **2.2.** Changes in DNA (mutations) occur spontaneously at low rates [some are caused by exposure to various forms of radiation]. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring. **(1)**

3. Matter, Energy, and Organization in Living Systems.

- **3.1.** Living systems [including the Space Station Alpha] require a continuous input of energy to maintain their chemical and physical organizations. **(3)**
- **3.2.** The energy for life primarily derives from the sun. **(3)**

Earth and Space Science: P. 187

1. Energy in the Earth System

- **1.1.** Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. **(2)**

2. The Origin and Evolution of the Universe

- **2.1.** Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements. **(1)**

Science and Technology: P. 190

1. Abilities of Technological Design

- **1.1.** Understanding about Science and Technology **(1)**
  - **1.1.1.** Scientists in different disciplines ask different questions, use different methods of investigation and accept different types of evidence to support their explanations.
  - **1.1.2.** Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
  - **1.1.3.** Creativity, imagination, and a good knowledge base are all required in the work of science and engineering [and technology].
  - **1.1.4.** Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and the technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world.

Science in Personal and Social Perspectives: P. 193.

1. Personal and Community Health

- **1.1.** Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms—sensor, motor, emotional, social, and technological that can reduce and modify hazards. **(1)**

2. [Man-made] ecosystems provide an array of basic processes that affect humans. Those processes include maintenances of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans. **(2)**

3. Many factors influence environmental quality. Factors that students might investigate include ….the capacity of technology to solve problems. **(1)**

4. Natural and Human Induced Hazards

- **4.1.** Normal adjustment of [the Space Station] may be hazardous for humans. **(1)**
- **4.2.** Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students

should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations. **(1)**

History and Nature of Science: P. 200

1. Science as a Human Endeavor
  1.1. Individuals and teams have contributed and will continue to contribute to the scientific enterprise. **(1)**

2. Nature of Scientific Knowledge
  2.1. Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. In areas where data or understanding are incomplete, such as the details of [solar magnetic fields] or questions surrounding [the Earth-Sun relationship], new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest. **(3)**