New York State Mathematics, Science and Technology Standards

Grades 9-12

As Addressed by Challenger Learning Center's *e-Mission: Space Station Alpha*

Executive Summary

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.
- are introduced to scientific topics that have been highlighted by current events.
- are offered science and technology-related problems as meaningful investigations.
- develop meaning through active involvement.

Science teachers can emphasize seven 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 ninth and tenth grade science student. To this end we focused on the following aspects of the curriculum:

- 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:

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.

The following New York State 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 will succeed:

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
Standard 2: Students will access, generate, process, and transfer information using appropriate technologies.
Standard 3: Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.
Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.
Standard 5: Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.
Standard 6: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.
Standard 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Standard 1—Analysis, Inquiry, and Design (Commencement)

Mathematical Analysis

1. Abstraction and symbolic representation are used to communicate mathematically.

Students:
- use algebraic and geometric representations to describe and compare data.

2. Deductive and inductive reasoning are used to reach mathematical conclusions.

Students:
- use deductive reasoning to construct and evaluate conjectures and arguments, recognizing that patterns and relationships in mathematics assist them in arriving at these conjectures and arguments.

3. Critical thinking skills are used in the solution of mathematical problems.

Students:
- apply algebraic and geometric concepts and skills to the solution of problems.

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Students:
- elaborate on basic scientific and personal explanations of natural phenomena, and develop extended visual models and mathematical formulations to represent their thinking.

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Students:
- use various means of representing and organizing observations (e.g., diagrams, tables, charts, graphs, equations, matrices) and insightfully interpret the organized data.

Standard 2—Information Systems (Commencement)

Information Systems

1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Students:
- understand and use the more advanced features of word processing, spreadsheets, and data-base software.
- utilize electronic networks to share information.

2. Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

Standard 3—Mathematics (Commencement)

Number and Numeration

2. Students use number sense and numeration to develop an understanding of the multiple uses of numbers in the real world, the use of numbers to communicate mathematically, and the use of numbers in the development of mathematical ideas.

Students:
- understand and use rational and irrational numbers.

Operations

3. Students use mathematical operations and relationships among them to understand mathematics.

Students:
- use addition, subtraction, multiplication, division, and exponentiation with real numbers and algebraic expressions.
- develop an understanding of and use the composition of functions and transformations.
- explore and use negative exponents on integers and algebraic expressions.

Modeling/Multiple Representation

4. Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships.

Students:
- represent problem situations symbolically by using algebraic expressions, sequences, tree diagrams, geometric figures, and graphs.
- use learning technologies to make and verify geometric conjectures .
- model real-world problems with systems of equations and inequalities.

Measurement

5. Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data.

Students:
- derive and apply formulas to find measures such as length, area, volume, weight, time, and angle in realworld contexts.
- relate absolute value, distance between two points, and the slope of a line to the coordinate plane.

Uncertainty

6. Students use ideas of uncertainty to illustrate that mathematics involves more than exactness when dealing with everyday situations.

Students:
- judge the reasonableness of results obtained from applications in algebra, geometry, trigonometry, probability, and statistics.
- use experimental or theoretical probability to represent and solve problems involving uncertainty.

Patterns/Functions

7. Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently.

Students:

- represent and analyze functions using verbal descriptions, tables, equations, and graphs.
- translate among the verbal descriptions, tables, equations and graphic forms of functions.
- apply linear, exponential, and quadratic functions in the solution of problems.
- use computers and graphing calculators to analyze mathematical phenomena.

Standard 4—Science (Commencement)

Physical Setting

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:
- explain the properties of materials in terms of the arrangement and properties of the atoms that compose them.
- use atomic and molecular models to explain common chemical reactions.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:
- observe and describe transmission of various forms of energy.
- explain variations in wavelength and frequency in terms of the source of the vibrations that produce them, e.g., molecules, electrons, and nuclear particles.
- explain the uses and hazards of radioactivity.

5. Energy and matter interact through forces that result in changes in motion.

Students:
- explain chemical bonding in terms of the motion of electrons.
- compare energy relationships within an atom's nucleus to those outside the nucleus.

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Living Environment

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:
- explain how the structure and replication of genetic material result in offspring that resemble their parents.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:
- relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms.

Standard 5—Technology (Commencement)

Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

Students:
- explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.
- explain how complex technological systems involve the confluence of numerous other systems.

History and Evolution of Technology

5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

Students:
- explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.

Impacts of Technology

6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

Students:

- explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology.
- explain how computers and automation have changed the nature of work.

Standard 6—Interconnectedness: Common Themes

(Commencement)

Systems Thinking

1. Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Equilibrium and Stability

4. . Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Students:

- describe specific instances of how disturbances might affect a system's equilibrium, from small disturbances that do not upset the equilibrium to larger disturbances (threshold level) that cause the system to become unstable.

Standard 7—Interdisciplinary Problem Solving (Commencement)

Connections

1. The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

Students:

- design solutions to real-world problems on a community, national, or global scale using a technological design process that integrates scientific investigation and rigorous mathematical analysis of the problem and of the solution.

Strategies

2. Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

Students participate in an extended, culminating mathematics, science, and technology project. The project would require students to:

- work effectively
- gather and process information
- generate and analyze ideas
- observe common themes

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Skills and Strategies for Interdisciplinary Problem Solving

Working Effectively: Contributing to the work of a brainstorming group, laboratory partnership, cooperative learning group, or project team; planning procedures; identify and managing responsibilities of team members; and staying on task, whether working alone or as part of a group.

Gathering and Processing Information: Accessing information from printed media, electronic data bases, and community resources and using the information to develop a definition of the problem and to research possible solutions.

Generating and Analyzing Ideas: Developing ideas for proposed solutions, investigating ideas, collecting data, and showing relationships and patterns in the data.

Common Themes: Observing examples of common unifying themes, applying them to the problem, and using them to better understand the dimensions of the problem.

Realizing Ideas: Constructing components or models, arriving at a solution, and evaluating the result.