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The Influence of Space Exploration on Science Education

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THE INFLUENCE OF SPACE EXPLORATION ON SCIENCE EDUCATION

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Abstract

Scientific research and technological developments associated with space exploration have already had, and will continue to have, significant effects on course content and the learning process. Teachers and students in large numbers continually seek from NASA assistance to help them understand space science and exploration.

Therefore NASA strives to relate developments in space science and technology to classroom education. It prepares space-related instructional materials for teachers. These materials contain suggested classroom and laboratory activities and lists of selected references.

They include space-related curriculum supplements for secondary schools in biology, chemistry, physics, mathematics, industrial arts, physical sciences, astronomy, and general science. Concepts, principles, and topics are chosen from standard course outlines, and material developed from NASA's scientific and technical achievements for use as the teacher desires.

The materials directed to the elementary schools provide suggestions for teachers to bring current knowledge about space into their programs. They are designed to stimulate and capitalize on children's interest, not only in science and mathematics, but also in other subjects.

Supporting materials for the elementary and secondary school teacher guides include:

I. Audio Visuals

A. Single concept 8mm film "loops," such as on fuel cells.

B. Film strips and slides, such as on astronaut food.

C. General interest 16mm films and TV presentations.

II. Publications

A. NASA FACTS, designed specifically to provide information about various aspects of the space programs.

B. Publications providing information in greater depth.

C. Reference aids such as bibliographies and film lists.

Many of these materials are available free to qualified requesters from outside the U.S. Others are available on loan or may be purchased at modest cost.

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The educational community of this nation is well aware of the speed of change induced by fast moving science and a burgeoning technology. This rapid rate of change is a major concern to our curriculum makers, textbook writers, school administrators and teachers who are hard put to keep up with new knowledge, new techniques, new audio-visuals and an avalanche of new software and amazing hardware. They are all trying to come up with answers - to solve the educational problems. This, as always, will take time. Innovations, always desirable, now very popular, are difficult to implement.

Of one thing we can be sure. There has been a sustained and significant stimulus to education in the United States which is attributable to the space program. This stimulus to education, at all levels, may well be the most important by-product of space exploration.

Science education is becoming, at long last, a true continuum, K-12, through national, State and local developments.

At this time, no one pattern exists. However, we in the NASA Educational Programs Division discovered in a recent study that most of the new science curriculums for K-6 are organized around six broad subject areas, as indicated on the chart (show slide 1).

These are not sharply circumscribed or discreet subject areas. They all tend to overlap and are interrelated, as I think they should be.

One outstanding fact surfaced, and is of most interest to me and my colleagues. These six subject areas run like threads through the entire fabric. They are the elements of commonality. Likewise, in the 7-9 grades, we find that the patterns are generally combinations of three substantive areas - Biological Sciences, Physical Sciences, and Earth Sciences.

And, of course, gratifying to us is the fact that the NASA mission and the results thereof have produced, and will continue to produce, knowledge and practical applications which pertain to each, although more in some than in others.

This awareness has provided us with a base upon which to build our programs for greater effectiveness in the K-9 level. We are in an excellent position - perhaps unique position - to provide the teacher with answers to questions such as:

1. What is gravity? Inertia? Friction?
2. How do planets differ from one another?
3. What is solar radiation? How useful is it to living things?
4. What are tools of astronomers?
5. What is a light year? Why is such a unit used?
6. What is the basis for our units of time on earth?
7. What causes weather and climate?

These are only a few of the many questions, and the answers are more and more available and interesting as a result of the space enterprise.

We are presently involved in the development of some multi-media packages - simple fact sheets, film strips, slides, charts, and especially, 8mm film loops on single concepts or topics. These will be most helpful, I'm sure, to elementary and junior high school teachers, in developing adequate understandings of Space Age concepts.

At the secondary level, we are developing curriculum resource projects in Biology, Chemistry, Physics, Mathematics, and the Physical Sciences. We have already completed and distributed one on Industrial Arts. It has been tremendously successful, already being used by several States and School systems to re-structure the Industrial Arts program.

These projects have already, in their experimental stages of development, been termed by many educators involved in their field testing, as innovative. They are a departure from the usual textbook or curriculum syllabus in that they are essentially space-related compilations of resource units, or briefs.

Each curriculum supplement is the product of a university team comprising experts in the discipline and master classroom teachers. Each element relates a space science or a space technology development to a concept, a principle or topic in the on-going course. Each consists of a succinct statement about the subject; suggestions for laboratory experiments; pupil research topics; class discussion topics; audio-visual references; and a bibliography.

I'd like at this time to use some slides to further describe this curriculum supplement program.

Discipline	Contractor	Estimated Completion
BIOLOGY	UNIVERSITY OF CALIFORNIA at Berkeley	FALL 1968
MATHEMATICS	DUKE UNIVERSITY	SPRING 1969
CHEMISTRY	BALL STATE UNIVERSITY	SUMMER 1969
PHYSICS	TEXAS A&M UNIVERSITY	SPRING 1969
INDUSTRIAL ARTS	WESTERN MICHIGAN UNIV. UNIV. OF SOUTH FLORIDA	COMPLETED
PHYSICAL SCIENCE	COLUMBIA UNIVERSITY	FALL 1968

FIGURE II - Curriculum Supplement Program

This figure shows the scope of the program, the disciplines involved, the organization responsible for each development, and the approximate time table.

The remaining figures I will show will give only glimpses of the content and orientation of the curriculum supplements. I hope that these brief glimpses will give you an appreciation for the ways in which these supplements can assist the teacher in creating and fostering interest in the traditional subject matter by providing up-to-date and exciting examples from space science and exploration.

BIOLOGY

LIFE CYCLE	LIFE SUPPORT IN SPACECRAFT
PHOTOSYNTHESIS	STORAGE SYSTEMS
RE-USE OF WASTE MATERIALS	REGENERATIVE SYSTEMS
INTERDEPENDENCE OF PLANTS AND ANIMALS	CLOSED ECOLOGICAL SYSTEMS

FIGURE III - Space Biology

The topics listed in the first column of this figure are normally discussed in courses in biology in most American high schools. Out of this discussion should grow the appreciation that the earth is almost an ideal space station for man. With energy provided by the sun, the earth has been able to supply the needs of living creatures for millions of years. Prospects for the future are promising.

Students will understand readily, after discussion of these topics, the problem of life support in a spacecraft, listed in the second column. The physical and biological needs of man are the same in space as on the earth. The preparation of compact nutritious food and the adaptation of physiological functions to the weightless environment in the spacecraft represent initial solutions to some of the problems. Our manned spacecraft to date have depended on open or "storage" systems. All of the needed supplies have been carried on board. Wastes have been collected. The liquid wastes have been discarded in space, while solid wastes have been returned to earth. But on the longer space flights, the sheer weight of the supplies needed will be so great that storage systems may not be feasible. Men are experimenting with regenerative systems which will use chemical means to reprocess the cabin atmosphere and liquid wastes, so that the oxygen and water can be used over and over.

The space biology supplement describes these problems in detail, reports on the latest research, and suggests many related experiments and laboratory activities that students can carry out.

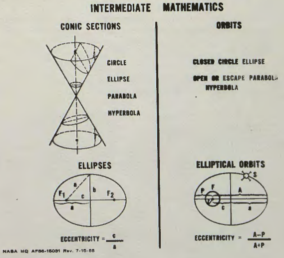


FIGURE IV - Space Mathematics

High school students generally study descriptive material about the conic sections in courses in general mathematics or geometry. After having had some elementary work in analytical geometry, they can study the mathematical properties of the conics in more detail.

The study of the conics takes on more meaning if their relationship to flight paths of satellites is pointed out, as indicated in the second column.

PHYSICS

CENTRIPETAL (CENTRIFUGAL) FORCE

$F = \frac{mv^2}{r}$

PULL OF GRAVITY

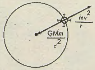
$F = \frac{GMm}{r^2}$

WEIGHT

PULL OF GRAVITY GIVES WEIGHT TO OBJECTS

GRAVITY VARIES INVERSELY AS THE SQUARE OF THE DISTANCE FROM THE CENTER OF ATTRACTION

BODY IN CIRCULAR ORBIT



$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{9.56\ (10)^4}{r}}$$

"WEIGHTLESSNESS" IN ORBIT

PHYSICAL WEIGHT IN SPACE

$$w_h = \left(\frac{r}{r+h}\right)^2 w_s$$

FIGURE V - Space Physics

Gravitation is a standard part of the high school physics course, including Newton's Law of Universal Gravitation.

The Physics supplement contains some interesting space-related materials and examples, as shown on this slide. The role of gravity in keeping a spacecraft in orbit and other simple phenomena related to terrestrial gravity are investigated. Problems involving the gravities of bodies in the solar system, and the use of gravities in achieving trajectories by using techniques called "fly-bys" and "swing-arounds" are discussed.

Special attention is given to the Earth-Moon system and to the location of the barycenter.

These materials will increase the student understanding and interest of physics and of space technology.

SPACE SCIENCES

- THE ENERGY OF STARS--ENERGY SOURCES
- THE COMPOSITION OF COSMIC MATERIAL
- THE FORMATION OF STARS
- COSMOLOGY--THE UNIVERSE AS A WHOLE
- THEORIES OF THE ORIGIN OF THE UNIVERSE

FIGURE VI - Studies In The Space Sciences

In this supplement there are several units, cutting across all disciplines. One is on "Atomic Nucleii and Stars," and some of the topics treated are shown on this slide. Especially interesting are the steps in the life of a star, including collapse from gravitational force, radiation of energy, formation of other elements from the basic hydrogen, and the aging of the star into a red giant, and then into a white dwarf or a super nova.

SPACE SCIENCES

- THE COMPOSITION OF LIVING THINGS--THE FOUR BASIC ELEMENTS
- THE DNA MOLECULE
- THE PRIMORDIAL ORIGIN OF LIFE
  SYNTHESIS OF AMINO ACIDS AND NUCLEOTIDES – NASA RESEARCH
- LIFE ON OTHER PLANETS – NASA PLANS
- THE EVOLUTION OF HIGHER FORMS OF LIFE
- THE POSSIBILITY OF INTELLIGENT LIFE ELSEWHERE IN THE UNIVERSE

FIGURE VII - Space Sciences

This shows the interdisciplinary nature of the supplement, dealing with Biology and Chemistry. The publication, then, could serve to enrich standard science courses, or to stand on its own as a separate course.

SPACE CHEMISTRY

COURSE TOPIC — **SPACE-RELATED MATERIAL**

POWER — **FUEL CELLS**

Electrochemical Cells — **Hydrogen-Oxygen Fuel Cell**

RELATED ACTIVITIES AND PROJECTS

THERMOCHEMISTRY
- Energy From Chemical Reactions

ROCKET THRUST
- Liquid Propellants
- Solid Propellants

EXPERIMENTS & DEMONSTRATIONS

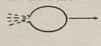
FIGURE VIII - Space Chemistry

Our chemistry supplement is just getting "off the pad." It will offer some new and exciting space-related materials to enrich the normal offerings. This slide highlights chemical power for launching rockets as well as in-space power from fuel cells.

PHYSICAL SCIENCE

- ACTION AND REACTION
- A FORCE PRODUCES MOTION
- A CONTINUING FORCE PRODUCES ACCELERATION
- HERO'S ENGINE

- ROCKET PROPULSION
- THRUST FROM A BALLOON



- THRUST FROM A ROCKET ENGINE

- MEASURING THRUST FROM A MODEL ROCKET (SOLID PROPELLANT) ENGINE

FIGURE IX - Physical Science

This slide shows the concepts, on the left, which are quite naturally and effectively illustrated from the world of reality on the right.

PHYSICAL SCIENCE

ACCELERATION

- VELOCITY: $v = \frac{s}{t}$
- ACCELERATION: $a = \frac{v}{t}$

$g = 32.2$ FT. PER SEC. PER SEC.

$$\frac{f}{a} = \frac{w}{g}$$

- IN AN ASCENDING ELEVATOR:

$$\frac{20}{a} = \frac{160}{32.2}$$

$a = 4$ FT. PER SEC. PER SEC.

$= 1/8\ g$

- IN A SPACECRAFT BEING LAUNCHED:

LET $a = 6g$, find f

$$\frac{f}{6g} = \frac{w}{g}$$

$f = 6w$

- FORCE PUSHING ASTRONAUT IS EQUAL TO SIX TIMES HIS NORMAL WEIGHT

$a = 6g = 6 \times 32.2 = 193$ FT. PER SEC. PER SEC. $= 132$ mph. PER SEC.

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FIGURE X - Physical Science

Likewise, on this slide are shown space applications to the basic principles usually studied in relation to velocity and acceleration.

INDUSTRIAL ARTS

TOPIC	AEROSPACE APPLICATIONS
THE TRADITIONAL WORLD OF WORK	INCREASING COMPLEXITY OF INDUSTRIAL ACTIVITY
QUALITY CONTROL	HIGHER STANDARDS OF QUALITY - ZERO DEFECTS PROGRAM
MASS PRODUCTION REPETITIVE PRODUCTION OF LIKE PARTS	RESEARCH, WITH DEVELOPMENT OF INDIVIDUAL ITEMS
SELECTION AND USE OF MATERIALS METALS PLASTICS	NEW MATERIALS FOR SPACE APPLICATIONS NEW ALLOYS STRONGER AND LIGHTER METALS NEW SYNTHETICS NEW CERAMICS
SKILL-ORIENTED PROGRAMS	NEW DIRECTIONS EXPERIMENTATION EMPHASIS ON CONCEPTS AND UNDERSTANDINGS

FIGURE XI - Industrial Arts

Industrial arts courses have in the past been oriented toward the development of skills. But now this objective is being made part of a larger perspective, with an emphasis being placed upon the development of insights and understandings. If the student has an understanding of the broad scope of American industry, has developed problem-solving skills related to materials and techniques, and has a background of knowledge in the applied sciences related to technical processes, he is able to use his technical skills more creatively and with more satisfaction. The aerospace applications have real meaning and great motivational values.

This, then is a quick look at the high school science curriculum supplement program. They will be, I believe, an unusual ready resource to busy classroom teachers. They can go directly to any part which is of interest and value for the instructional process.

The space program is one of the most photographed research efforts ever undertaken by man, and we seek to use these remarkable pictures to extend the senses and the knowledge of man. We continually develop a variety of educational publications, charts and fact sheets to provide information about elements of the space program. I'm sure you've seen some of the recent pieces done on Apollo 7 and Apollo 8, and of countless other photos of earth from space, the Moon, Mars and Venus.

We have developed an equally varied and useful audio-visual program - motion pictures, filmstrips, television and radio programs, and "single concept" film loops. These AV materials are designed to extend the results of our scientific and technical research into the classrooms, and to illustrate space-related concepts and phenomena.

These are truly only glimpses of some of our NASA educational services. I present them because they are relevant to the topic assigned to me - the influence of space exploration on science education. Obviously, as more and more of the space-related new knowledge is cranked into the system, the greater the influence such new materials of instruction will have upon educational patterns.

Thank you.