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A Role for Planetariums in Science Education Reform

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In the 1960's and early 1970's the National Defense Education Act (NDEA) provided federal funds to local governments for science education purposes. Largely, due to the aid provided by these funds, planetarium instruments were built by many local governments and school systems. Unfortunately, due to the lack of trained personnel to operate them and the lack of local funding for their maintenance, many of these instruments were (and are today) not used to their fullest potential. Throughout the years of 1970-1995, however, several excellent school system based planetarium programs flourished in various parts of the country and were devoted to science education as it related to the field of astronomy. Most featured the introduction of astronomical content in a chronological approach on a yearly basis which met the needs of the learner best. Many, though not all of these, involved instruction in the smaller, inflatable, and portable planetaria. A factor that each of these school based programs had in common was that they promoted a high degree of student and attending teacher participation. However, in the 1990's a new aspect of science educational reform began to emerge which necessitated the restructuring of much of science curriculum in the K-12 level, including that related to astronomy. A major document to emerge in recent years with some excellent suggestions reforming the science curriculum is Project 2061: Science for All Americans which was published in 1989 by The American Association for the Advancement of Science (AAAS). Project 2061 was designed to occur in three phases. The first phase of Project 2061 culminated with the publication of the Science For All Americans manual, where the conceptual base for reform was established by recommending the knowledge, skills, and attitudes all students should acquire as a consequence of their total school experience. The second phase, still occurring in many local school systems, involves the cooperative effort of scientists and educators to transform the recommendations of the first phase into new and alternative curriculum models. This paper describes the implementation of one of those models in the form of a school based K-12 planetarium program which is interdisciplinary in nature and which supports the total school science curriculum utilizing these recommendations. Four planetarium lessons from the program are highlighted which actively involve the attending teacher in the lesson delivery through well planned pre and post planetarium lessons. Each lesson also promotes active student participation and stresses the mastery of specific scientific habits of mind as a primary focus instead of merely the delivery of more astronomical content. One lesson each has been selected from the elementary (K-5), middle (6-8), high school (9-12), and university (13-14) level. The focus is on utilizing the planetarium as a teaching laboratory rather than a passive recreational device. Suggestions for improving and refining the delivery of science content have been adapted from the American Association for the Advancement of Science's Project 2061 and its related manual, Benchmarks for Science Literacy. These planetarium lessons are available in DOS text and WordPerfect 5 format via anonymous ftp from: ftp://magnus1.com/planetarium.
Worksheets and student activity sheets are available from the planetarium at the address noted above. Lesson descriptions follow:

**ELEM (G 2-5) A First Data File of the Solar System:** Students pretend to "discover" the nine planets as they enter the Solar System from the outside. As they visit each of the planets they classify each on the basis of size (relative to Earth), solid surface (yes or no), rings (yes or no), moons (yes or no), and color. At the end of the trip each student has his/her own planetary database! Skills focus on collection of data and data classification.

**MIDDLE (6-8) A First Analysis of Stellar Data:** Students collect data and classify data on selected stars of the winter sky according to several traits including surface temperature, size, and luminosity. Then they solve comparison problems involving the brightness, distances, and surface temperatures of stars.

**HIGH SCHOOL (9-12) How Can The Distances of the Stars be Inferred?:** Given the starting information, students construct a H-R Diagram prior to the planetarium lesson. In the planetarium, they are presented with a list of 15 stars along with their spectral types and luminosity classifications. Students must work in cooperative groups to 1) find each star on the dome, 2) estimate its apparent magnitude to the nearest 0.5 magnitude unit compared to some known standards, and 3) estimate its distance by using their H-R Diagram to compare the star's apparent and absolute magnitudes.

**COLLEGE (12-14) The Mass of a Binary Star System:** Students observe a "variable star" and graph its apparent magnitude compared to some known standards over about a forty day simulation. Then, after plotting the star's light curve, which turns out to be a classic eclipsing binary of the Algol type, they are presented with simulated spectra which display doppler shifts toward and away from Earth at different phases of the orbits. Students then calculate the star's orbital velocity from the doppler shifts. Using the time for one complete revolution obtained from their light curve, they calculate the orbit's circumference and radius and use Kepler's third law to calculate the mass of the binary system.

The third and final phase of the recommendations of Project 2061 is the current collaborative effort in which many groups active in science education reform such as the Astronomical Society of the Pacific use the resources of the first two phases to move the nation toward scientific literacy. Today's students are preparing to function in the complex, technological society of the 21st Century. It is essential that all teachers assist them in acquiring the skills and knowledge necessary to improve the quality of life by understanding the interrelationships between the Earth and its surroundings in space. It is equally important that students develop attitudes of open-mindedness as well as skills of careful investigation. A goal of this planetarium program is to support science education reform through promoting scientific literacy in its citizenry. A scientifically literate person is aware that science, mathematics, and technology are interdependent human enterprises with both strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. We believe that through the implementation of this planetarium program, we can demonstrate our commitment to achieving this goal.