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Virginia's First Project 2061 Model Secondary Magnet School:An Example of Educational Reform[1]

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ABSTRACT

To meet the educational needs of academically talented students and to supply the pool of scientists and engineers, secondary magnet schools for science and technology have proliferated throughout the country. The Southwestern Virginia Governor's School, one of the newest of these schools, has been influenced by *Science for All Americans* (1989), the Project 2061 study of the American Association for the Advancement of Science. This regional secondary magnet school was created in 1990 as a Project 2061 model to serve able students from eight rural Virginia school districts. The school's program and features were designed to be different from the four other regional magnet schools in the state. The Southwest Virginia Governor's School represents an example of a current reform effort in science education.

INTRODUCTION

To meet the educational needs of academically talented students and to increase the pool of scientists and engineers, secondary magnet schools for science and technology have proliferated throughout the country. In 1990, a regional secondary magnet school was created in southwestern Virginia to serve able students in eight school districts. The School's curriculum was influenced by *Science for All Americans* (1989), the first phase of the American Association for the Advancement of Science's Project 2061[2]. Project 2061 (named for the next year Comet Halley will pass through the solar system) is AAAS's long-term, multiphase educational reform effort.

In this paper, the argument for creating specialized schools will be discussed, followed by a description of the planning and design of the program that was implemented in 1990. This program represents one interpretation of the Project 2061 model for reform in science education.

RATIONALE FOR THE SPECIALIZED SCHOOL

Science, math and technology education have been the focus of some 300 reports about educational reform since 1983. The need for improving curriculum

1 This paper is based upon a presentation made at the Annual Meeting of the Virginia Academy of Science, Blacksburg, VA, May 23, 1991. Dr. Bentley was the founding director of the Southwest Virginia Governor's School for Science, Mathematics and Technology. The address of the School is P. O. Box 1739, Dublin, VA 24084.

2 There are four other science-math regional secondary magnet schools in Virginia. All were begun in the mid-eighties prior to the publication of Science for All Americans.

and instruction in these vital school subjects has been agreed upon by the communities of scientists and science educators, indeed, by almost all interested parties (National Science Board, 1983, I.A.E.E.A., 1988, A.A.A.S., 1989, Miller, 1988, Mullis and Jenkins, 1988, Stake and Easely, 1978, Weiss, 1987, 1978). The consensus appears to be that there is need for fundamental restructuring, both in content and teaching methods (Powledge, 1989).

The nation's leaders apparently connect our students' competence in science and mathematics to the country's global technological and economic leadership. There is concern that the pool of scientists and engineers needed to maintain U.S. competitiveness will not be adequate to the task. The National Science Foundation has projected a major shortage of scientific workers by 2006, with nearly 700,000 additional scientists and engineers needed. Currently, only about 5% of 22-year-old Americans earn B.S. degrees (Holden, 1989). Consequently, improving science and mathematics education is prominent among the six goals for public education announced by President Bush and the governors last year: "By the year 2000, U.S. students will be first in the world in mathematics and science achievement." (Rotberg, 1990)

It has become widely accepted in the U.S. that students who are academically able and motivated should be served by specialized programs which match their learning potential. The most able students represent the primary pool from which will come the country's next generation of scientists, engineers, and science and mathematics teachers. Specialized programs, often called "TAG" programs (for "talented and gifted"), have proliferated in school systems across the country in the past twenty years. TAG programs focus on one or more subject areas, and sometimes include advanced science and mathematics instruction for interested students.

More recently, regional specialized schools have been created to educate students of high ability who may not be appropriately served by local TAG programs. In some cases, local school systems may not have the resources to provide suitable science or mathematics experiences for capable students who are interested in more science and/or math.

Southwestern Virginia is an area where student achievement is below state and national norms on S.A.T. and other standardized tests, and where the average per pupil expenditure of $3,362 is below the state median. Only 20% of the high school graduates go on to four year colleges (Department of Education, 1989). Moreover, of the top five percent of high school graduates who do enter college, 40% do not graduate. This has been attributed in part to the lack of academic challenge in most local secondary school programs (Virginia Association for the Education of the Gifted, 1990). In only a few of the rural school districts which comprise the consortium that created the new Governor's School have the ablest students had opportunities for even a limited amount of advanced coursework in science and mathematics.

PLANNING THE SCHOOL

A plan for a new regional magnet school for science, mathematics, and technology was developed in 1989-90 by a committee of school system personnel in the participating districts, comprising the cities of Galax and Radford, and Pulaski, Montgomery, Giles, Floyd, Wythe, Bland, and Carroll counties[3]. The committee worked with the Department of Education and consulted with individuals associated with other magnet schools, particularly Lynchburg's Herb Vitale, who led the planning of the Central Virginia Governor's School in 1985.

The southwest magnet school project was funded by the Virginia Department of Education for the biennium, 1990-1992. The magnet school was designed to serve 110 high school juniors and seniors, beginning with a junior class. The school is governed by a Board comprised of one member from each of the school boards of the supporting districts. The superintendents of the districts take one year turns as "superintendent-in-charge."

Pulaski County Schools provided a facility for the school, a six classroom frame structure on the campus of Pulaski County High School in Dublin. The facility was built as a project by vocational students and previously was used primarily for computer instruction.

The new magnet school opened in August, 1990[4]. It offers a two year program in science, mathematics and technology for juniors and seniors. Students attend three hours each morning and return to local schools for other subjects and for extracurricular activities.

Each district provides funding for a number of "seats" at the magnet school. The selection of students is made by the local district, based upon their own criteria. Nominees are to be interested students capable of achievement in a rigorous science and mathematics program. For each year of successful participation, students receive three credits toward graduation: one each in science, mathematics, and research.

The first year, the staff consisted of two full-time teachers, who also administered the program, three part-time teachers, and one secretary. Additional full-time teachers were added the second year as the student body expanded.

In the summer of 1990 the building's physical environment was renovated to provide a variety of work and study spaces: laboratories, classrooms, seminar rooms, reading and AV rooms, and a computer center. The rooms were made stimulating and dramatic by wall-sized photomurals of science-related scenes.

THE CURRICULUM PLATFORM: PROJECT 2061

Science for All Americans, which was released by the American Association for the Advancement of Science in 1989, became the primary guide for the curriculum developed for the new school. In *Science for all Americans*, the AAAS calls for a restructured curriculum focused upon, "a common core of learning ... ideas and skills having the greatest scientific and educational significance for scientific literacy." (AAAS, 1989, p. 4) Several dimensions of scientific literacy are addressed, including key concepts and principles of science that all citizens need to understand. The scientifically literate person is defined as one who comprehends the

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3 In the spring and summer of 19980, Grayson County joined the consortium project while Montgomery and Radford dropped out.

4 The School began with 43 juniors. Thirty-six completed the first year.

diversity and unity of the natural world. Such a person recognizes the interdependence of science, mathematics and technology, and the reality that these disciplines are human endeavors, which are subject to both strengths and limitations.

In *Science for all Americans*, scientific literacy is discussed in four general categories. The first category, the scientific endeavor, includes the development of science, technology, and mathematics from a historical point of view. Students can understand the development of science by studying the historical development of important concepts. The scientific endeavor also includes themes that pervade science, such as systems, models, constancy, patterns of change, evolution, and scale.

The second category, scientific views of the world, focuses on the beliefs and attitudes that have made the scientific endeavor so successful. Scientists hold that the world is understandable, that ideas are subject to change, and that while knowledge is durable, complete answers to all questions may not be possible through science. Scientists respect and demand evidence. They use logic and imagination to explain and predict. They try to identify and avoid bias, and reject authoritarianism. Scientists are guided by accepted ethical principles as they participate in the complex social activity of doing science.

The third category, perspectives on science, covers the basic knowledge about the overall structure of the universe and the physical principles upon which everything functions. Physical principles are organized into concepts on matter, energy, motion, and forces. Basic knowledge also includes how living things function and interact, which encompasses the diversity of life, the transfer of heritable characteristics, the structure and function of cells, the interdependence of all organisms and their environment, the flow of matter and energy in the biosphere, and evolution as the explanation for the similarity and diversity of life. The "big ideas" are stressed.

The final category, scientific habits of mind, is about scientific ways of thinking. The patterns of thought found in science are reflected in such specific skills as manipulation, observation, computation, and communication.

A fundamental premise of Project 2061 is that "less is more." The advice is not to teach more and more content, but to teach key concepts and principles, using improved teaching strategies. Other major premises relate to developing higher order thinking skills and teaching so that students see connections between disciplines.

THE PROGRAM DESIGN

Following *Science for All Americans*, the content for the courses at the new magnet school center around "big ideas," hands-on experience, and problem solving, while optional offerings provide opportunities for students to investigate a variety of topics. Coursework emphasizes interpretive frameworks, major concepts, direct experience, communications skills, and cooperative group work.

In the two year sequence, the juniors undertake a group research project and a project involving the communication of science or math. The seniors, in turn, undertake in-depth studies in subdisciplines and individual and team projects.

Juniors take core science and mathematics courses and elect among laboratory courses in physics, chemistry and environmental science. The core course in science, based upon Project 2061 recommendations, involves cross-disciplinary study with themes clustered into two major strands. One strand deals with structures and functions, scales, origins, and change in nature, while the second strand deals with science as an interpretive system and the relationship of science to technology and society. As recommended by Project 2061, the history and philosophy of science are woven into the course content.

The core math course focuses upon applied mathematics, emphasizing functional analysis and contextual pre-calculus, and leading to intuitive calculus. Students explore properties of mathematical relationships from an analytical as well as a geometric viewpoint. Topics recommended in Project 2061 are included, such as data collection and descriptive statistics, inferential statistics, mathematical modeling, and simulations.

Application work involves linear algebra, linear programming, operations research, probability, number theory, data analysis, discrete mathematics, and numerical methods. Additional facilatory units are offered on computer usage, including word processing, data storage and retrieval, and science/math-related software.

Juniors elect one of three laboratory courses. The chemistry and physics courses include basic content at the introductory level, which involve extensive hands-on investigations. Students learn lab and safety skills and become familiar with tools used in these disciplines. Environmental science is broadly interdisciplinary and focuses upon field studies. A wooded area behind the school is used as the primary study site.

Student research is an important aspect of the program design. Research methods are taught through student participation in one of two interrelated group projects. Students work in task forces aided by an advisor. Students elect either to study the New River Valley watershed or to develop a model for efficient housing for the region. Both projects are vehicles for developing skill in research and communications, and both require integrating and applying knowledge across disciplines.

The program also provides students opportunities to pursue individual interests. Students are able to tap the resources and expertise of the community--its various industries, two community colleges and two state universities and the many retired professionals who live in the area. A variety of special interest offerings are structured in the following ways: as short-term seminars modelled on the Great Books program, as workshops (e.g. on computer languages and software), as skill-oriented tutorial sessions (e.g. on test-taking skills), as colloquia featuring guest speakers, and as Saturday and summer field trips. Offerings also are arranged in response to student requests and interests. Figure 1 illustrates the unique college-type "fortnight" schedule which provides the structure for the courses and the many elective opportunities.

The culmination of the junior year is a week long field trip to the Illinois Research and Development Corridor outside Chicago. Students visit modern research facilities at Fermilab, Argonne National Labs, Amoco Research Center, Chemical Waste Management Environmental Testing Laboratories, the University of Chicago, and Northwestern University. They meet and talk with scientists, mathematicians, and related professionals. They visit the Illinois Mathematics and

Week I

8:30 - 10:00 am	
M - W - F	LAB BLOCK (Physics, Chemistry, Env. Science)
T - Th	CORE BLOCK (Science, Math)
10:00 - 11:30	
M - W	OPTIONS (Seminars, Projects, Other studies)
T - Th - F	CORE BLOCK

SATURDAYS: Elective Field Trips (approx. alternate Saturdays)

Week II

8:30 - 10:00 am	
M - W	LAB BLOCK
T - Th - F	CORE BLOCK
10:00 - 11:30	
M	OPTIONS (Seminars, etc.)
T - Th	CORE BLOCK
F	COLLOQUIA (Guest presentations, interviews)
10:00 - 10:50	
W	OPTIONS (Seminars, etc.)
10:50 - 11:30	
W	COMMUNITY MEETING (or Options)

FIGURE 1. The "Fort-night" Schedule

Science Academy and some of Chicago's outstanding science and natural history museums.

One other significant feature of the program design is the student assessment system. While the school's students are selected because of demonstrated academic ability in math and science, nevertheless students are different in their starting points, interests and learning styles. Further, different paths ought to be available for students to reach particular academic goals and objectives.

In response to these realities, portfolios primarily are used to assess student progress. Students choose and place in a file the work that most represents their accomplishments. Students also have a voice in determining evaluation criteria. In addition to self-evaluations, students may include graded assignments, recommendations from instructors, records of work in teams and on independent studies, and excerpts from their "process logs" (journals).

Students work with an advisor through periodic meetings for goal setting and progress monitoring. Advisors coach their advisees in preparing the portfolios, which are reviewed by a staff committee each quarter.

PROGRAM EVALUATION

An independent third party evaluation is desirable for a program where selected students benefit from public school funding significantly above the state per pupil average, such as in the case of the regional magnet school. An independent evaluation is desirable also for innovations which might be models for wider dissemination. Consequently, formative and summative evaluations were contracted to be done by a team headed by Dr. Robert Covert, Director, Evaluation Research Center, Curry School of Education, University of Virginia. This team designed an evaluation plan which addressed significant questions and accessed multiple sources of data (Shulha, 1991).

The Southwestern Virginia Governor's School has now completed its second year and the curriculum has, of course, evolved. An issue which divided the school community during its initial year was student assessment. The portfolio assessment model, which gives more responsibility to the student, is a radical change from traditional grading. Success in this model requires student planning and self-monitoring. The dispute over assessment resulted in changes in the school's program and in the staff.

The implementation of the model illustrates that, in education, results are sensitively dependent upon initial conditions[5]. The program for this school, as for others, is a product of negotiations between the staff, local district administrators, parents and students, and the school's governing board. Among these parties are a variety of educational values, expectations for the students, and perceptions of what are problems and what constitutes progress. Patience, persistence, open-mindedness, and realistic expectations are needed by all parties concerned with educational reform and with creating alternative schools.

This paper has been about a particular program modelled on AAAS's Project 2061. *Science for All Americans* is the current standard for designing such specialized programs, as it is for programs for all students. Meeting the specific needs of the ablest students is important, but should not be a substitute for reforming science and math programs for the majority of students. Specialized programs designed to improve science and mathematics education, such as this one, are warranted *if* fair, third party evaluations are conducted and if successful exportable features are disseminated throughout the educational community via teacher workshops, conference presentations, and publications.

Reform initiatives in the regular schools also should be supported by funding agencies, especially at the middle school level. The middle grades have been found to be most critical for the development of values, self-concept, and intellectual interests in young people (National Science Teachers Association, 1988).

Almost everybody agrees that improving science and mathematics education ultimately depends on helping teachers be more effective. Consequently, attention should be given to in-service teacher education programs and to on-going instruc-

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5 The "butterfly effect," a principle of chaos theory, is certainly as applicable to classroms and schools as it is to phenomena in the physical realm.

tional support systems. Fortunately for Virginia, the Department of Education's V-QUEST initiative, currently funded by the National Science Foundation, should address needs such as these (Exline, 1990).

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