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ABSTRACT

A number of documents were written in 1983 by groups seeking to improve American education. This digest was developed to review and examine some of the common themes (as they pertain to science education) from these documents. They are: (1) "A Nation at Risk"; (2) "Educating Our Citizens: The Search for Excellence"; (3) "Action for Excellence"; (4) "Educating Americans for the 21st Century"; and (5) "Images of Science." The digest includes: (1) a discussion of implications related to standards, time for instruction, and curriculum (noting that all documents urge increased rigor in education); (2) lists of desired science instruction outcomes for grades K-6, for grades 7 and 8, for biology, for chemistry, and for physics; and (3) a discussion of implications for teacher education. (JN)

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Some Implications for Science Education from National Reports

In 1983 a number of documents were written by groups seeking to improve American education. ERIC users were provided with some insights into a few of these reports in the science education and mathematics education 1983 ERIC/SMEAC information bulletins. This digest was developed to continue the review process and to examine some common themes from *A Nation at Risk, Educating Our Citizens: The Search for Excellence, Action for Excellence, Educating Americans for the 21st Century,* and *Images of Science.*

Implications Related to Standards, Time for Instruction, Curriculum

All documents urge increased rigor in education: better (higher) achievement, higher standards, tougher grading, increased graduation requirements for high school students, higher standards for admission to college, and increased time for instruction.

The writers of three of the four documents suggests that higher expectations for student academic achievement and conduct are needed. (*Images of Science* is a report of what is, not what should be.) To bring this about, teachers need to set high standards in their classes, both in terms of work done in class and in the use of homework. More homework is advocated. Also, periodic standardized testing should take place, especially as students move from one level of schooling to another (elementary to secondary school) and for high school graduation. Promotion should take place on the basis of achievement rather than on social factors.

It does not appear possible to increase the quality of American education within the presently-existing time framework of the schools. Increased instructional time is needed. While some time may be found if interruptions are kept to a minimum or if better classroom management techniques are employed, the message appears to be that the school day and/or the school year may have to be lengthened.

Time and curriculum are linked in the *21st Century* document recommendations that "Local school districts should revise their elementary school schedules to provide more time-on-task for the study of mathematics, science and technology . . ." (p. 39) It is urged that 30 minutes should be the minimal daily allocation for sciences in grades K-6 and that a full year of science and technology should be required in both grades 7 and 8.

It seems logical to question the assumption that "more (time) is better" — which appears to be implied in the advocacy of a lengthened school day or school year. While we are no longer an agrarian society in which young people are needed for spring planting or autumn harvesting chores, research in educational psychology or learning must provide some data about the effects of information overload on learning and retention. How long can pupils remain in class before physical and mental fatigue sets in? What is the minimum number of hours a teacher can teach or the optimum number of individual and group contacts a teacher can make before he/she is unable to generate enthusiasm for teaching and interest in subject matter? When does stress overtake patience, flexibility? What will longer school days/longer school years cost in salaries, utilities, and building maintenance? Increasing instructional time without improving quality of instruction seems unwise.

The reports urge colleges and universities to increase requirements for admission. By so doing, it is assumed that high schools will be forced to upgrade course offerings and increase graduation requirements. The authors of the *21st Century* document advocate that college admission requirements should ". . . include four years high school science, including physics, chemistry, and one semester of computer science. . ." (p. 41). Even if a high school student does not plan to go to college, he/she should ". . . be required to take at least three years of . . . science and technology . . ." (p. 40) to graduate.

Both the *Action for Excellence* and *21st Century* documents contain statements that may be interpreted to mean that non-college bound, non-science-oriented students are not to be neglected. Among the action recommendations in *Action for Excellence* is a statement that the school should ". . . serve better those students who are now unserved or underserved" (p. 40). Groups that deserve consideration include the academically gifted and talented and also women and minority students, the absentees and dropouts, and the handicapped. Among the recommendations to the National Science Board in the *21st Century* document is one stating that "All schools should provide opportunities for their students to develop their mathematical and scientific skills to the limits of their abilities and should offer appropriate sequences of courses for students at various levels of ability." (p. 40)

Science educators need to carefully consider what the future science curriculum should be. Certainly "more of the same" is not the solution for increasing academic achievement in science or for promoting more favorable attitudes toward science, if we attend to the data reported in *Images of Science*. What the science courses should emphasize and what course options are available to students appear to be open to debate, or at least discussion.

Data reported in *Images of Science* provide evidence that children are gaining science information from television and other informal science education experiences. The *21st Century* report advocates informal science education through the use of science museums so that parents and children can pursue science hobbies and become involved in weekend and evening programs. Libraries, voluntary youth organizations, Boy and Girl Scouts, the Audubon Society and other science and technology related groups are urged to work with museums and schools to provide an enriched environment for informal learning (p. 61).

Desired outcomes of science instruction are specified in Exhibit B of the *21st Century* document. Entitled "Suggestions for Course Topics and Criteria for Selection," desired outcomes are identified for grades K-6, grades 7 and 8, and for biology, chemistry, and physics (pp. 96-100).

For grades K-6, the desired science instruction outcomes are:

— knowledge of phenomena in the natural environment and opportunities to use applicable arithmetic in the learning of science. In addition, the integration of science with the teaching of reading and writing should be actively pursued.
— growth in the natural curiosity of children about their physical and biological surroundings.
— ability to recognize problems, develop procedures for addressing the problem, recognizing, evaluating and applying solutions to the problems.
— personal experiences with appropriate level hands-on science activities with both biological and physical phenomena.
— ability to use appropriate level mathematics in describing some science and in solving science problems.
— ability to communicate, orally and in writing, observations of and experiences with scientific phenomena.
— some knowledge of scientific and technical careers and of the necessary background for continued study in these areas.

For grades 7 and 8, the desired outcomes include:

— an understanding of how their own bodies function.
— recognition of societal issues related to science and technology.

— development of greater skill in observing, classifying, communicating, measuring, hypothesizing, inferring, designing investigations and experiments, collecting and analyzing data, drawing conclusions and making generalizations.
— growth in problem-solving and decision making abilities.
— ability to ask questions, manipulate variables, make generalizations and refine concepts.
— a beginning understanding of the integration of the natural sciences, social sciences and mathematics.
— familiarity with the usefulness of integrating technologies (calculator, computer, cable television) with experiences in science.
—appreciation of local resources such as museums, scientists and specialists to extend learning experiences beyond the school walls and hours.
— continued development of a potential science role in career or life choices.

For biology, desired outcomes are:

— understanding of biologically based personal or social problems and issues such as health, nutrition, environmental management, and human adaptation.
—ability to resolve problems and issues in a biosocial context involving value or ethical considerations.
—continued development of students' skills in making careful observations, collecting and analyzing data, thinking logically and critically, and in making quantitative and qualitative interpretations.
— ability to identify sources of reliable information in biology that they may tap long after formal education has ended.
— understanding of basic biological concepts and principles such as genetics, nutrition, evolution, reproduction of various life forms, structure/function, disease, diversity, integration of life systems, life cycles, and energetics.

For chemistry, desired outcomes of instruction are:

— illustration of how answers to chemical questions are obtained.
— familiarity with the molecular description of matter and implications of such a particulate view.
— understanding of elementary atomic structure and the regularities contained in the Periodic Table
— understanding of molecules and chem bonds.
— understanding of reactions (stoichiometry, equilibrium, energetics rates).
— familiarity with the chemistry of common substances (descriptive chemistry).
— understanding of the states of matter, and the nature of solutions.
— familiarity with applied chemistry (radioactive materials, common poisonous and conbustible chemicals, water purification, prevention of food spoilage).
— familiarity with the variety of chemistry-related careers.

For physics, desired instructional outcomes are:

— laboratory experiences including opportunities to acquire information inductively.
— opportunities for continued development of more advanced mathematical techniques as applied to science matters.
— comprehension of fundamental units, derived units and systems of measurement.
— understanding of the concepts of motion from the smallest particle to celestial bodies.
— understanding of the conservation of mass and momentum, of energy, the kinetic theory of gases and wave phenomena.
— understanding of light and electromagnetism.
— appreciation of atomic and nuclear physics, and of relativity.
— familiarity with the variety of physics-related careers.

Can these desired outcomes of instruction be translated into science curricula that will interest the "now unserved and underserved" as well as the other groups within the school population?

Implications for Teacher Preparation

The outcomes identified in the *21st Century* document, and the other reports cannot be achieved without the intervention of competent, qualified teachers. All four reports contain material related to teacher education. All four contain recommendations for the upgrading of college admission standards and/or for graduation from teacher preparation programs. The writers of the *21st Century* document distinguish between "certified" and 'qualified" teachers. A "qualified" individual is one who has an adequate preparation in subject matter knowledge (p. 28). It is possible that a "certified" teachers may not necessarily be qualified if his/her content knowledge in subject is minimal. The writers also advocate a comprehensive liberal arts education for both elementary and secondary teachers, with secondary teachers having ". . . a full major in the subject matter to be taught . . ." (p. 31). How many constitute a limited number of courses and the criteria for determining effectiveness are not a part of this report.

Who can quarrel with having highly competent, subject-matter-qualified science teachers? If such individuals are to be attracted to and remain in teaching, they must be adequately compensated. All four reports contain statements relative to salaries, indicating that salaries should be increased so they are competitive with those of other professions. Also advocated is the practice of recognizing and rewarding outstanding teachers for superior performance. This may involve salary differentials, the designation of "master teacher" and a special career ladder to provide such recognition. It may also include scholarships and other tributes, according to *Action for Excellence* (p. 37).

What of those science teachers whose performance is not worthy of recognition? Such individuals should receive help on the job or have access to special programs through regional training centers. If they fail to take advantage of this help or if it is not sufficient to bring about change for the better, they will be asked to find another occupation.

What changes will need to be made in order to produce science teachers who are qualified as well as certified? Can a future teacher complete a comprehensive liberal arts education (to use the report phraseology) and education courses as well as student teaching within a four year period of time? What needs to be done to make teaching salaries sufficiently competitive that an individual will be willing to spend more than four years in preparation for a teaching career? *Action for Excellence* contains some information about "hopeful signs" — how quickly will such actions spread to other states and communities?

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