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ABSTRACT

Various responses to the current crisis in science and technology education have been initiated, including federal aid, responses from industry and professional organizations, and introduction of more than 30 bills into Congress. Reasons suggested for the crisis include the three ideas that defined the curriculum and instruction foci of the 1960s: (1) science when taught in a way that is known to scientists will inherently be interesting to all students; (2) any subject can be taught in some intellectually honest form to any learner regardless of his/her stage of development; and (3) science must be taught as a narrative of inquiry, not a rhetoric of conclusions. These assertions have not only provided a philosophical base but have also caused several problems, including the separation of science and technology into two distinct identities. However, a new direction for science education, based on findings from Project Synthesis, is proposed. This direction focuses on personal needs, societal issues, career awareness, and academic preparation. Descriptions of 18 science programs are provided as examples of programs which approach the ideal state in secondary schools as suggested by Project Synthesis. (JN)

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Science/Technology Education:

Necessary For All

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Science/Technology Education:
Necessary For All

But What Went Wrong?

To be sure science and mathematics education received much attention and financial support after the launching of the Soviet Sputnik in 1957. In all two billion dollars were spent in efforts to improve science education in the more than a quarter of a century which has intervened.

The public support for science education increased dramatically during the decade of the Sixties. However, as the Seventies emerged some of the unquestioned support of the earlier decade began to disappear. The Seventies were years when most professions and most social institutions were called into question.

It is not surprising that 1976 became a pivotal year with all material curriculum developments for K-12 science curtailed and all support for teacher education activities was terminated.

The total funds for science education nationally were on a decline as their mammoth status studies were funded by the National Science Foundation. As results from these efforts became available, other funds were made available to analyze the results and to synthesize indicators for future directions.

The five years which have followed the national status and synthesis studies have been widely proclaimed as "crisis" years. As 1983 emerges there is clear evidence that the crisis is recognized and that solutions are being proposed that may surpass those that were proposed in 1957 following the launching of Sputnik. In addition, the recognition of the crisis has a broader base and has received more public attention than occurred in the late Fifties.

What are some responses to the crisis conditions in science/ technology education?

Several actions during the past several months indicate responses to the crisis conditions:

1) After recommending the abolishment of the NSF science education directorate and zero-level funding, Congress has appropriated 30 million dollars (apparently with Reagan Administration approval) to support science education during the current fiscal year.

2) The National Academy of Science convened a national convocation to consider the crisis and what might be done to ameliorate it. The president sent a message, two cabinet members and several Senators and Representatives were among the 60 prestigious speakers.

3) Consortia of industrial leaders have been created in a dozen states and as national groups - all designed to offer correctives and specific input into the problem of science/technology education.

4) Information concerning the crisis (especially pertaining to teacher shortages and manpower problems in comparison to other industrial nations) has appeared as front page news in newspapers across the nation, has been discussed in hundreds of editorials, has been analyzed in most leading magazines, has been discussed as a part of regular television news, and has been a focus for such popular television productions as Good Morning America, Nova, and others.

5) The science/technology education issues received top billing at a recent conference of the nation's Governors; since the meeting special committees and task forces have been appointed in half the

states to identify corrective actions possible and feasible at the state level.

6) More than thirty bills have been introduced in Congress - some good, some bad - but all designed to offer correctives to the widely proclaimed and verified crisis.

7) Many scientific societies have proclaimed science education to be the most serious problem of our time; the American Association for the Advancement of Science and organized a coalition of scientific societies with the sole aim of offering corrections to the current crisis. The American Chemical Society has convened an invitational conference of national leaders to address the crisis in K-9.

8) The National Science Board has appointed a National Commission to develop an agenda for action and to chart new directions for science education.

What Went Wrong With the Efforts of the 60's?

As new directions emerge for the 80's, reasons for them are clearer if one looks at the goals, the actions, and the results of the national efforts of the immediate past. Three assumptions arose from three assertions of the leadership of an earlier time, three ideas that defined the curriculum and instruction foci of the 60's, three ideas that are no longer central to current thinking in science/technology education. These assertions were:

1) Science when taught in a way that is known to scientists will be inherently interesting to all students.

2) Any subject can be taught in some intellectually honest form to any learner regardless of his/her stage of development.

3) Science must be taught as a narrative of inquiry, not a rhetoric of conclusions.

These propositions provided a philosophical base and caused the following problems:

1) Science was defined by the traditional disciplines with scientists in each area offering descriptions of the unifying themes, the conceptual frameworks, and/or the basic structures of each discipline; these unifying ideas became the organizers for the science courses that had traditionally characterized the school science program.

2) Attention was given to learning theory of the sixties; however, incomplete information was used as fact; misinterpretations and misunderstanding were common; the maturation of the learner was often considered after-the-fact.

3) Science was approached in an abstract manner, including the processes identified and practiced by scientists. Scientific inquiry was often "presented"; little attention was given to the level of abstraction and/or the ability of students to act as "scientists".

Other problems which are recognized only in retrospect include:

1) The problem with separating science and technology into two distinct identities; the failure to use applications of science as a way for students to experience real (pure) science.

2) The lack of any attention to a curriculum in science (all attention was directed to improving existing courses).

3) Teachers were assumed to be a major part of the problem; this resulted in attempts to develop teacher proof curricula, to attract "disciples" to the "gospels" produced by national developers, to develop national courses where any attention to local conditions or issues was rare.

4) All science was conceived to occur in a "science" classroom, within the confines of the school day, and with "correct" results; no attention was paid to science in the broader community; no use of community resources was encouraged.

5) No one noticed that students are not "inherently" interested in science even though a fine cadre of teachers and thousands of communities "bought into" the so-called new science.

How have new directions emerged during the past five years?

Project Synthesis was a major research effort funded by the National Science Foundation. One major undertaking was a definition for ideal conditions for school science based upon an analysis of a wide variety of current indicators. These consisted of reports from various scientific societies, a review of reports criticizing schools, a study of reports from various futuristics groups, an analysis of current social indicators, a review of recommendations from advocacy groups in science education, and a review of problems being addressed by major public and private foundations.

The Project Synthesis effort was organized in a way that recognized school science in five ways; these five "focal" groups included elementary science, biology, physical science, inquiry, and science/technology/society. As the project was conceived several national leaders were involved in debates and discussions concerning the major justifications for teaching science in school programs. Four goal clusters were finally derived and used as important organizers for the Synthesis effort. The four goal areas are:

1) Personal Needs. Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.

2) Societal Issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.

3) Career Awareness. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.

4) Academic Preparation. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

Unfortunately current science programs and most science teachers are concerned only with the last goal cluster. Well over 90% of the teacher effort, course structure, and measured outcomes are related to academic preparation goals. In a traditional program there is little or no attention paid to the other goal areas--those more likely to help in the production of a scientifically literate citizenry.

The Project Synthesis group summarized the new challenge:

> One overarching responsibility faces every person associated with science education, from the local to the national level. The responsibility is to rethink the goals of science education in light of basic education philosophy and the unique role science plays in all of our lives, and to redirect the science education system toward those redefined goals. We are confident that other persons who make an in-depth study of the status of science education will find pre-college science education almost completely dedicated to the academic preparation goal, and that they will agree that major changes are critically needed. We are also convinced that other thoughtful persons will come to conclusions similar to ours; that the goals of preparing the majority of students to use science in their everyday lives, to participate intelligently in group decisions regarding critical science-related societal issues, and to make informed decisions about potential careers in science and technology are equally as important as the goal of preparing a minority of students for more advanced coursework in science.

They further elaborate on the new directions as follows:

> Not only is there an increased need to understand large national issues, there is also an increasing need to understand the way science and technology affect us as individuals. Thus, a new challenge for science education emerges. The question is this: "Can we shift our goals, programs and practices from the current overwhelming emphasis on academic preparation for science careers for a few students to an emphasis on preparing all students to grapple successfully with science and technology in their own, everyday lives, as well as to participate knowledgeably in the important science-related decisions our country will have to make in the future?"

A New Focus

Many have proclaimed a science and society focus for school science to be the major focus for programs for the 80's. The interdependence of society and science teaching must be a point of departure for any discussion of goals, priorities, curriculum, or achievement in science. Some look upon this goal, this emphasis, this focus to be the most important single ingredient for defining trends for the immediate future.

As a part of a special conference on science education at Phillips Exeter Academy, a group of national leaders concluded that:

> Societal issues must be raised as an integral part of the present courses in chemistry, physics, biology, general science, and earth science, not as separate courses. An infusion of perhaps 10% seems appropriate and feasible as an immediate action. Some of this could be achieved by using societal topics in place of present examples to illustrate principles being taught.

Such a focus for school science make it more appropriate for all students. If students in school today will be living most of their lives in a post industrial society, it is apparent that their experiences in school need to be aimed toward better preparation for dealing with problems and issues. The school science program needs to help students to think logically, to offer experience with using information (evidence) in resolving problems, to take best actions after using all available information. The school science program must come closer to considering the essence of real science. Science is an exploration of the universe in which each person exists; it is forming or creating explanations of the objects and events encountered; it is testing such explanations for accuracy. Basically science includes these three ingredients, i.e. 1) exploring, 2) explaining, and 3) testing the explanations. These three features must be central to every science course.

What are some features of exemplary science programs for the 80's?

There is general agreement concerning features of exemplary science in secondary schools. These features include:

1) A science/technology curriculum built around major societal issues that are unique at a given point in time and/or to a given community.

2) Applications of science central to curriculum planning; the basic science knowledge will derived from experiences with direct applications.

3) The laboratory and the source of information must be the universe itself where students can explore, offer explanations, and test such explanations.

4) Science must be experienced and presented in a social setting; it must emphasize what people do and what the consequences of action and lack of action are.

5) Science must be presented within an ethical and value dimension.

6) Just as science/technology is central to modern society, it must be central in a school program; science must be related to the larger society-to what is happening in the world today.

7) Current science will de-emphasize the disciplines of science as such, special terminology, organized knowledge, experiences designed to verify the known, mastery of textbook information.

8) Growth in and with dimensions of science other than the information one must be used in assessing success of new science programs.

Some Examples of Newer Approaches

The National Association of Science Teachers initiated a Search for Excellence in Science Education program late in 1981. By June of 1982 more than 165 exemplary programs were identified by selective committees in each state. The criteria for the NSTA searches were the five ideal-state conditions defined by the Project Synthesis researchers. These criteria meet the general criteria of new directions outlined above.

In October of 1982, exactly 25 years after the launching of Sputnik and the beginning of a Golden Age of science education in the U.S., NSTA identified 50 national exemplary programs in science. Some of these are identified as examples of the new directions for school science for the 80's.

Programs which approach the ideal state for science in secondary schools include:

Title/Description of Program	Contact(s) - School(s)
Mankind: A Biological/Social View	Arthur Lebofsky Clarkstown South High School Demarest Mill Road West Nyack, NY 10994

This mankind course revolves around the problem, "How did we arrive where we are today, and what are some projections for the future?" The course simultaneously examines the positions taken by both scientific and social science communities on such topics as evolution, eugenics, human agression, overpopulation, cloning and energy shortages. It is the intent of this program, through interdisciplinary study, to prepare students to use science for improving their lives and cope with an ever-increasing technological world.

Wallingford Auditing Technical Team (WATT) (Energy Waste)	Carol Wilson Dr. Mark T. Sheehan High School Hope Hill Road Wallingford, CT 06492

The Wallingford Auditing Technical Team (WATT) grew out of a classroom study of energy sources and our non-renewable reliance. The academic content is interdisciplinary. Students use and improve their skills in solving word problems, calculation, geometry, measurement, physics, information, organization and dissemination, public speaking and leadership. Students assume responsibility for making appointments for audits, performing the audits, checking the information, completing the audits, and writing the final audit reports.

Science/Mathematics/Computer Technology	Tom Yount Gompers Secondary Center for Math/Science/Computers 1005 47th Street San Diego, CA 92102

The Science/Mathematics/Computer Technology program was designed to provide enriched experiences in math, science, and computers for students with high interest and/or abilities and to encourage minority participation in those areas of study where they are surely underrepresented. The program is in operation for grades 7 through 12.

Contemporary Issues in Science

Victor Cusimano

Susan E. Wagner High School
1200 Manor Road
Staten Island, NY 10314

The Science Forum program has created an information service that provides resource personnel, institutional support, data, scientific background, and pedagogical experience necessary for designing an effective model for bringing students in grades 10-12 to a working understanding of the relevance of Technological Advances and the impact of those advances on society.

Environmental Science

Virginia Demchik

Scott High School
404 Riverside Drive
Madison, WV 25130

The Environmental Science program at Scott High School serves four major purposes, including the affective, content and practical domains. Students examine, analyze, evaluate and react to problems in today's world and the future world based on known environmental conditions in our community, state, nation and the world. They concentrate on water, air, light and noise pollution; coal, petro, nuclear and associated future energies; fuels and potential fuel sources; and wildlife and wildlife resources. Primary emphasis is placed on these areas and their interactive effects, as well as, interdisciplinary connections not often brought out in traditional science courses about our community, the state, the nation and the world. Students develop alternative solutions to problems posed within the framework of the course content and examine attitudes and life styles affected by the environment. They examine career opportunities interlaced in the study of Environmental Science.

Unified Science Curriculum for High School

Jon Harkness

Wausau West High School
1200 West Wausau Avenue
Wausau, WI 54401

This program provides integration of the science disciplines within an overall emphasis on the process of inquiry and subsequent emphasis on three other components: the knowledge of science, the nature of science, and the cultural implications of science. A major goal of unified science is to provide scientific literacy to all students while at the same time providing for post-secondary student plans. In this sense, unified science makes a major contribution to general education at the high school level through a highly flexible curriculum that involves scientific processes and values as well as science content.

Energy and Us

Elizabeth Horsch & Roxie Dever

Kelly Walsh High School
3500 East 12th Street
Casper, WY 82609

Each year the emphasis of Energy and Us is on a different aspect of energy production in Wyoming and the impact of that production. In each instance, a case study approach is used. Students go where the action is, and much of the study is conducted in the field. Personnel from industry, government, agriculture, and the community at large serve the students as "walking textbooks".

Human Ecology

Frank A. Castelli

Brandywine High School
1400 Foulk Road
Wilmington, DE 19803

The program uses as a model, Cornell University's definition of Human Ecology which is, "a study which relates to the development of individuals and the well being of both individuals and families in their immediate social and physical environments. The study seeks, through research, education, and the application of knowledge in the humanities and the physical, biological, and social sciences possible solutions to problems of human welfare and family well being which is of compelling significance in contemporary society."

Biology I and II

Ferne (Bud) Ellis

Addison High School
Comstock Street
Addison, MI 49220

This high school program increases student interest in biology, by improving course content, by dealing with student's future needs after high school, by increasing student activity in their own education and by bringing to "life" the topics covered in biology. Study centers on topics of interest and resources other than textbooks. Considerable in-class research is stimulated by grants available to students. Students make choices and decisions related to this study and environment.

Modified Team Approach to Teaching Biology

Daniel Van Gorp

Cherry Creek High School
9300 East Union Avenue
Englewood, CO 80111

This team taught program focuses on environmental and ecological studies. Particular attention is paid to current issues related to biology and these issues are incorporated as much as possible. Separate lab activities have been developed on drugs and cardiopulmonary resuscitation to add to the human anatomy and physiology units. This student-centered program is designed to be socially relevant and lead to personal initiative on the part of students.

Research Science Program

Robert E. Bruton

Merritt Island High School
100 E. Mustang Way
Merritt Island High School

The philosophy of the program is that through participation, some students may be able to proceed far beyond the best that the usual science curriculum may be able to offer them, especially in the area of inquiry. The express purpose of the program is to develop sophisticated techniques for encouraging independent student investigation, and teaching the skills and concepts needed for such independent research. It is intended that the students learn the careful, patient, exacting and creative methods of study and laboratory investigation used in inquiry by professional scientists.

Application of Physics

Arthur Farmer

Henry Gunn High School
780 Arastradero Raod
Palo Alto, CA 94306

This program for all students uses common examples of the applications of physics to the real world--how stoplights work, supermarket computer sensing devices that check prices and metering of gasoline. The Advanced students are taught a much more academic program as well. In addition to regular experiments, students create and evaluate their own experiments.

Physical Science Program

Leroy Lee

James Madison High School
201 S. Gammon Road
Madison, WI 53704

The total physical science program was developed to be an articulated program to provide the greatest opportunity to meet the diversified needs of individual students. Content and skills, taught in conjunction with science processes, concepts and themes, reflect the increasing emphasis on the development of an informed individual preparing to assume an adult role. This development involves courses, units within courses, and extracurricular activities that will emphasize: personal interest - the exploration of science concepts, knowledge and skills that will provide personal satisfaction and development of science interest; informed citizenry - comprehension of the impact of science and technology on the individual, culture and society; career - exploration and development of knowledge, skills and experiences necessary to successfully continue formal education or training, or to assist in immediate science related job entry.

Topics in Applied Science

Harold Pratt

Jefferson County R-1 School District
1209 Quail Street
Lakewood, CO 80215

Course content is topics of energy, land use, technology, and natural resources. Students learn scientific concepts and apply them to improve their own lives in a complex technological world. Students act responsibly toward themselves and their environment by using problem solving and decision making skills in working with energy, land use, technology and survival issues. Students use knowledge gained in the course to improve the quality of their life and environment in the present and the future.

Individualized Science Investigations

Lawrence Fauque & Dennis W. Roseleip

North Toole County High School
P.O. Box 467
Sunburst, MT 59482

This program provides the opportunity for selected tenth, eleventh and twelfth graders to actually plan and complete scientific inquiry and research experiments and projects that they are interested in. Students meet each day for an hour and have full use of laboratory facilities before and after school. Personal responsibility, creativity, and resourcefulness are stressed.

Solar Projects Class

Larry Clark

Toledo High School
Olalla Road
Toledo, OR 97391

The solar projects class provides students with a direct experience in learning and applying state of the art technology in the area of solar energy by combining classroom learnings with the field experience of building a solar efficient home. A problem-solving model is developing in the curriculum package which guides students to clarify the problem, identify goals, analyze data, examine possible constraints, list potential solutions, identify several strategies for the choice solutions, and access the results after the fact.

Marine Environmental Program

M. Doug Vliet

Quilcene Jr.-Sr. High School
P.O. Box 40
Quilcene, WA 98376

The Marine Environmental Program has curriculum components (1) at the first and second-grade level; (2) at the seventh grade level on Marine Environmental Science; and (3) at the ninth grade level on Environmental Science. The core of the curriculum is the recognition of man's interdependence with both the natural and the man-made components. The program promotes the effective utilization of the unique marine to alpine environment of the Quilcene-Brinnon area.

Problem Solving in a General Physical Science Curriculum

Eva Kirkpatrick

Seckman Junior High School
Seckman Road
Imperial, MO 63052

Energetics is a program that: develops an awareness of international, national and local energy situations, appropriate to ninth grade understanding, therefore contributing to a future energy-literate community; attracts and encourages talented students to careers in energy-related fields; prepares all students for the approaching changes in life-styles and luxury level; establishes a strong organization of students, educators, government and industrial personnel who will communicate and work towards the advancement of all; and promotes the interest and involvement of students in "make and take it" workshops with construction of paper-clip magnet motors, thermostats, solar hot dog cookers, tetrahedral kites, paper recycling, etc. Instructional and reference material that focus on energy cost factors are supplied for discussion.

MAJOR FEATURES

New Programs in science have specific characteristics. Such new directions for school science seem clear.

In the past science courses have mirrored college courses. Such courses always respect discipline boundaries when concern is for the quantity of content students are likely to encounter in each discipline.

Although teachers talk of other goals--give lip service to others--the major goal in practice is preparing students for the next course and/or the next academic level. Secondary school science is justified too often as college preparatory. With such an emphasis--usually ignoring any other possible goal--typical high school graduates achieve a diploma and enter adulthood scientifically illiterate--unable to use the information mastered, unaware of the basic features of science, unable to think logically, unable to make decisions about their own welfares.

New programs in science must emphasize the use of scientific knowledge and scientific procedures. They must focus on technology and application. They must provide experience with using information in arriving at decisions--decisions that will affect personal well being and the future of society.

Science education of the past has not helped produce citizens for the life they will lead. It has focused entirely upon preparing people for further study for careers they will not follow. Fortunately there are many encouraging signs on the horizon; fortunately there are many examples of "new programs" that have been designed to respond to the current situation.

KUDOS...............This issue of Curriculum Report was prepared by Robert E. Yager, Science Education Center, The University of Iowa, Iowa City, Iowa 52242. Dr. Yager is currently president of the National Science Teachers Association and a member of numerous committees and commissions concerned with the future of science education. He was a part of the Project Synthesis research effort that he cites as well as the NSTA Accomplishments and Needs assessment. Dr. Yager has directed mver 100 NSF projects; he has been involved with several national curriculum developments in science; he has authored over 200 research and curriculum reports.