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REDEFINITION AND VALIDATION OF SCIENCE EDUCATION CURRICULAR GOALS

The University of Arizona PH.D. 1981

REDEFINITION AND VALIDATION OF SCIENCE EDUCATION CURRICULAR GOALS

by

Judith Elaine Enz

A Dissertation Submitted to the Faculty of the

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For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Judith Elaine Enz

entitled REDEFINITION AND VALIDATION OF SCIENCE EDUCATION CURRICULAR GOALS

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

Edward D Bowen	5/14/81 Date
Milo Klemke	5/14/81 Date
Joseph B. Rubin	5/14/81 Date
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	Date

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Edward D Bowen	7/8/81
Dissertation Director	Date

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SIGNED: Judith E. Ens

DEDICATION

I would like to dedicate this work to my husband, David A. Enz, and daughter, Kathleen, for the faith and support they have provided me.

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I would like to express my sincere appreciation to my major advisor and dissertation chairman, Dr. Edward D. Brown, for his guidance and assistance in the completion of this dissertation and for his unfailing faith. Special gratitude is extended to Dr. Milo K. Blecha for his support and nourishment of my science interests as long as 25 years ago when he would accept spiders and beetles mailed to him from a skinny kid, as well as for serving on my committee. Special appreciation is also extended to Drs. Joseph P. Rubin, Robert T. Grant, and Henry E. Butler for serving on my committee and to Dr. Keith Meredith for his statistical advice.

Sincere thanks are extended to George and Sis Bradt for instilling in me a belief in the value of learning and a love of science; to my family for always giving me room to grow and learn; and to numerous friends and colleagues along the way.

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ABSTRACT

The purpose of this study was to redefine and validate science education curricular goals for grades K-12 in the 1980s. Goals were obtained through a survey of recent educational literature. The goals were then compiled into an instrument, Science Education Curricular Goals for Validation, which was mailed to 100 science educators for validation by ranking each of the goals on a 1-7 scale (with 1 being the least important and 7 being the most important). The science educators were randomly selected from the membership of the National Association for Research in Science Teaching, an organization dedicated to research in science education with a United States membership of 582 as of October 1980. The sample of 100 science educators represented 17% of the total United States membership.

Medians and ranks for each of the 17 goals were calculated and the additional goals suggested by respondents, organized with minimal editing, were reported. The results of the study indicated that, although there was some agreement on the initial 17 goals in the instrument, there was also considerable disagreement as evidenced by the suggestions from respondents of 41 additional goals. The highest goal was one dealing with the processes, concepts, principles, and generalizations of sciences. The lowest ranked goal was one dealing with the integration of the humanities and the sciences. In the additional 41 goals suggested by respondents, there were several that were in direct opposition to those in the original 17 or to those additionally suggested

by respondents. It was concluded that considerable further research is needed before a cohesive set of science education curricular goals can be established.

CHAPTER 1

INTRODUCTION

As we enter the decade of the 1980s public education is under critical scrutiny from both professionals and lay persons. At the center of the current scrutiny is the latest "back to basics" movement. Unfortunately, the educational field and its publics have been unable to agree on exactly what basics or whose basics. In response, educators have been put on the defensive and the scope of school curricula has become narrower and narrower.

Not only has public education been undergoing turmoil, but the industrial society in the United States is also undergoing a crisis and is in the throes of change. As the decade of the 1980s opens, the United States faces severe economic problems, energy shortages, overpopulation, world hunger, unemployment, and preservation of peace. Each member of society must become part of the solutions to these and other, as yet unforeseen problems in order to ensure our society's survival. Educaton needs to play an important role in providing society's members with the knowledge and skills they need to deal with its problems.

Numerous studies indicate an emergent curriculum emphasizing reading, writing, and arithmetic to the exclusion of science, social studies, and mathematics concepts (Andrew, 1980; Brandt, 1979; DeRose et al., 1980). Bybee (1979b, p. 157) stated that as indicated by results from the National Assessment of Education Progress "Today's changes

differ from other historical changes in two ways: (1) their magnitude--today's changes will literally affect all of the earth; and (2) their rapidity —today's changes are proceeding at an unprecedented rate." Bybee et al., (1980) discussed the changes in public attitude toward science and found that surveys done between 1966 and 1973 recorded a significant decline in the public's confidence in the scientific community.

All of education seems to lack cohesive direction and nowhere is it more apparent than in science education. At a time when there is greater and greater need for a scientifically literate society, the time spent in teaching science in elementary schools is greatly diminished and in many instances, no time is being spent on this activity.

Since 1971, when the National Science Teachers Association (NSTA) published its position paper on the goals for science education (NSTA Committee on Curriculum Studies, 1971), societal needs as well as needs in education have changed, particularly science education. A number of studies in recent years pointed to new problems in science education and emphasized its criticalness for society. As early as 1974, Goodlad called for education to develop a mankind perspective or there may be no twenty-first century man. The interdependence of all peoples on earth had already become apparent.

No new goals have been developed for science education after the 1971 NSTA set. In the past few years, the education literature has indicated educators' awareness of societal changes necessitating a redefinition and validation of goals for science education curricula for the decade of the eighties. Hopkins (1980, p. 32) stated in a review of Science and

Technology, A Five Year Report, 1979: "Underlying all of it is the profound message that science and technology are the major forces shaping our world, and they are working with great rapidity. Most educators agree that an education system . . . must fit each member of society with the knowledge and skill required for a useful and satisfying life."

Not only has there been a decline in the time spent teaching science, but there has also been a reported decline in the scientific literacy of our students (Maben, 1980; Commission on Human Resources, Panel of School Science, 1980; Piel, 1980). It has become apparent that before science education will be able to change these reported declines it must have a coherent direction. Science educators need an updated set of goals to provide the new direction. Many science educators have indicated a high-priority need for a research project to redefine and validate a set of relevant overall goals for science education to provide a new cohesive direction (Gerlovich & Yager, in press; Helgeson, 1978; May et al., 1980; Renner & Yager, 1979; Yager, 1980, in press). The current study was specifically designed to redefine and validate science goals for science education curricula in the 1980s.

The results of this study could aid science education in general by providing the much needed cohesive direction for science educators in the 1980s to focus on. The results of this study could also contribute to providing a resurgent emphasis on science education in our schools, thus helping to create a more scientifically literate public better able to deal with the problems facing our scientifically and technologically based society.

Problem Statement

This study was an attempt to identify the major goals of science education for the 1980s by reviewing recent educational literature and the opinions of major science educators.

Purposes of the Study

The purposes of the study were:

1. To define major goals for science education curricula as stated in recent educational literature.
2. To validate those goals by having science educators prioritize those they considered most important for the 1980s.
3. To describe those goals receiving the highest priorities.
4. To describe additional goals suggested by the responding science educators.

Methodology

The study used the methodology of descriptive-survey research. Major science curricular goals were selected for science education as defined in recent education literature. These major goals were then validated by having science educators prioritize those that seemed most relevant for the 1980s. A survey approach was used to reach major science educators all across the United States. The science educators were also asked to supply additional goals they believed relevant.

Assumptions and Limitations

In this study it was assumed that the members of the National Association for Research in Science Teaching (NARST) were representative of all major science educators in the United States. A limitation to the study was that the data from which the conclusions were drawn were limited by the number of surveys returned.

Definition of Terms

The terms used in this study are defined as follows:

Recent educational literature: Literature in professional educational journals from 1974.

Science education: education related only to the science curricula of the elementary and secondary grades (K-12) in public schools in the United States of America.

Science educators: Predominantly university-level personnel engaged in training teachers in science curricula (both preservice and inservice training).

CHAPTER 2

LITERATURE REVIEW

The following discussion of the pertinent literature is divided into four sections: (1) historical perspective of science education goals, (2) current status of science education, (3) current goals for science education curricula as stated in recent educational literature, and (4) need for definition and validation of goals for science education curricula.

Historical Perspective

As early as 1917, a decline in the enrollment of science in Massachusetts during the previous 50 to 60 years was reported by Downing (1917). He saw a need for the sciences to come to some agreement on the objectives to be reached and recommended (Downing, 1917, p. 254):

> To test out results only in terms of the information acquired, is to ignore the accomplishment of the more important ends. Habits and attitudes of mind, as tools of inquiry in settling the problems of individual living and of a democratic society, appreciation and ideals, are the real things to be achieved in public school science, and the organized knowledge of the sciences and the method of science are means to an end.

This was the beginning of a somewhat sporadic and desultory concern for goals in science education curricula in the public schools.

A committee of the American Association for the Advancement of Science (AAAS) reported in 1928 on "The Place of Science in Education" (AAAS, 1928) and made recommendations similar to those made by Downing in 1917. Then Whipple (1932) edited a yearbook on science education in

for the National Society for the Study of Education which recommended that science curricula should be organized around the principles and generalizations of science because they had the greatest potential for influencing thought and action of the learner.

Conklin (1937, pp. 3-4) stated that "the essence of all real education is habit formation. . . . science teaching is peculiarly well fitted to cultivate sound mental and social habits. This . . . should be the chief aim of science teaching. Powers(1944, p. 137) stated that "science is an integral part of the world today and pervades all living. The goal of science teaching is to help young people realize that science is as much a part of their personal lives as it is a part of their physical world."

Subarsky (1945, p. 147) stated:

> To make its proper contribtuion to the lives of people in our society and to the evolution of our society itself, science education must provide not only an abundance of direct experiences with natural phenomena leading to psychological assimilation of general principles; it must provide as well experiences which will establish the scientific method of thinking in all aspects of living to which it is applicable.

Noll chaired the committee that wrote Science Education in American Schools: Forty-Sixth Yearbook of the National Society for the Study of Education, Part I (Noll, 1947a). In an article in Science Education he (1947b, pp. 297-299) restated the goals recommended by the committee:

> 1. The method of science should become the procedure employed generally, indeed, universally in solving the problems facing our civilization.
>
> . . . . . .
>
> 2. Science as a subject of instruction should be accorded a pre-eminent place in the curriculum of element and secondary schools. This is an age of science and successful living in it and solution to problems facing humanity required a knowledge and

> solution to problems facing humanity require a knowledge and an understanding of science.
>
> . . . . . .
>
> 3. It follows that meeting this challenge successfully will require far better instruction in science than on the average now obtains. At the elementary level, many teachers are seriously lacking in science background.
>
> . . . . . .
>
> 4. There is need for a comprenhensive and continuing attack on many problems of science instruction.
>
> 5. . . . It is of utmost importance to our future welfare as a people that the two-fold function of science for the layman and for the future specialist be kept constantly in view.

Blanc (1952, pp. 51-52) reviewed goals in science teaching from 1920 to 1952 and made the following recommendations:

> A. To develop understanding and insight into the forces and nature of the environment. . . .
>
> B. To develop knowledge and understanding of the facts, principles and concepts of science. . . .
>
> C. To develop personal growth in the habits and methods of science.
>
> . . . . . .
>
> E. To develop democratic social attitudes towards the resources of science.

Henry (1960) edited the fifty-ninth NSSE yearbook relating to science education, which emphasized the attainment of science concepts and principles as well as attitudes and modes of reasoning that would lead to the organization and application of the concepts and principles. The National Science Teachers Association (1978, p. 3), after reviewing past goals for science education, stated: "Thus, in 1932, 1947, and 1960, NSSE Yearbook Committees all agreed that the 'big ideas' and central concepts of science are important to the science curriculum."

Finally, the NSTA Committee on Curriculum Studies (1971) published a major document delineating goals for science education in the 1970s. That document expressed goals similar to previously stated ones.

Current Status of Science Education

Numerous reports, studies, and articles by major science educators report a crisis in science education. Science is not being taught in our elementary schools and is being taught less and less in our junior and senior high schools. There have been major public changes in attitude towards science. The "back to basics" movement has eroded the place of science education in our public schools.

Bybee et al. (1980, p. 379-380) discussed the changes in public attitude toward science:

> Between 1957 and 1964 the proportion of people who thought science made "life change too fast" increased from 43 to 57%. In the same period the proportion of people who thought "science breaks down people's ideas of right and wrong" increased from 23 to 42%. These can be interpreted as early trends toward a change in the public's perception of the scientific enterprise.
>
> Between 1966 and 1973, surveys recorded a decline of 19 percentage points in the public's confidence in those running the scientific community. . . . The decline was not monumental, but certainly a significant trend.
>
> . . . by 1974 the public's positive attitudes toward science were declining at a time when science-related social problems were increasing.

Handler (1980) was concerned that public erosion of faith in science would lead to less and less support. He (1980, p. 20) noted that we had already "gone backwards" and that support for science was at the level it had been in 1967.

Yager and Stodghill (1979, p. 443) stated that "providing strong science programs in schools is not considered as high a priority as it was ten years ago. Surprisingly, many people do not consider it a 'basic' at a time of cultural, environmental, and resource crisis." DeRose et al. (1980, p. 45) reported:

> On the basis of survey data . . . science in elementary schools, not regarded as basic, is given a low priority in comparison to reading, mathematics, social studies, and health.
> . . . . . .
> Elementary school science, like that in junior and senior high schools, is taught primarily by lecture and recitation based on one textbook.

Smith (1980, p. 60) stated:

> The "back-to-basics" movement is a fundamental determinant of elementary schools curriculum today. By some, science and social studies are not included among these basics, although why they are not is a pertinent question. Scientific concepts such as time, distance, gravity and life maintaining requirements of the living organisms are among the most basic ideas one can imagine. The fact that natural science is not considered a "basic" is probably a reflection of some of the misconceptions held about the sciences at large.

Piel (1980, p. 34) said: "The 'back to basics' movement has preempted time previously given to the sciences and the more interesting branches of mathematics that come along in the curriculum after the third R." Weiss (1978, p. 51) reported that teachers in grades K-3 reported they generally spent about 20 minutes each day on science and that teachers in grades 4-6 spent about 30 minutes each day. A concern similar to the previous ones was reported by the Commission of Human Resources, Panel on School Science (1980).

Helgeson et al. (1978, p. 19:1) reported that:

> What science education will be for any one child for any one year is most dependent on what that child's teacher believes, knows, and does—and doesn't believe, doesn't know, and doesn't do. For essentially all of the science learned in school, the teacher is the enabler, the inspiration, and the constraint.

In a similar area, Stake and Easley (1978, pp. 13:5-13.6) wrote:

> Most schools we studied had some written policy about what an how elementary school science should be taught, but what actually was taught was left largely to individual teachers. By and large, the elementary teachers did not feel confident about their

> understanding of science concepts. Even those few who did like science and felt confident in their understanding of at least certain aspects of it often felt that they did not have the time nor material resources to develop what they thought would be a meaningful program. As a consequence, science has been deemphasized at the elementary school level, with some teachers ignoring it completely.
>
> When and where science was formally taught, the material was usually taken directly from a textbook series. The method of presentation was: assign - recite - test - discuss. The extent to which the emphasis on reading and textbooks pervaded the elementary science program is illustrated by an episode observed in an elementary life science class where the teacher opened a recitation period with the question: How do we learn? A chorus of students replied: "We learn by reading." . . .
>
> Other than the fairly common practice of learning science by reading from a textbook series, the selection of what was to be read and the actual time spent on reading science varied greatly from teacher to teacher. In most of our school systems, no district-wide elementary science program was identified.

Yager and Stodghill (1979, p. 440) stated: "Examples of effective science teaching approaching modern goals in the elementary school are rare. Teaching science in the junior high school is primarily by recitation."

It is apparent from the above reports that science education has received a low priority in our public schools over the past decade and that teachers are not really prepared to teach it. This presents a serious problem in an era faced with problems requiring scientific solutions and input.

Hopkins (1980, p. 32) said in his review of Science and Technology, A Five Year Report

> Underlying all of it is the profound message that science and technology are the major forces shaping our world, and they are working with great rapidity. Most educators agree that an education system . . . must fit each member of society with the knowledge and skill required for a useful and satisfying life.

Maben (1980, p. 37) wrote:

> All major problem areas--economics, population, energy, food supply, natural resources, government, land use, health—require scientific input if solutions are to be reached.
>
> Scientific literacy is a universal need. . . .
>
> One source or pressure for a 1980 elementary science curriculum is the realization that the cultural context of science has changed immensely in recent years. That change is likely to continue. As science becomes less an isolated activity and more integrated into society, science and science teaching will be asked to assume greater social responsibility.
>
> Civilization has unraveled increasingly complex problems that require scientific problem solving on a global scale.

Finally, Taylor (1978, p. 218-282) reported:

> Never before have humans been so dependent upon science and technology for their comfort and livelihood. . . .
>
> A place for science in education is warranted by its contribution to preparing the citizenry for life in our society. The primary objective of contemporary education is to improve scientific literacy on a global scale. To communicate the meaning of science and to develop everyone's capacity to use its values should be among the major purposes of education in our own and every other country.
>
> Because science provides a means for constructing an orderly system of explanations for natural phenomena and a basis for intelligent control and use of the natural world, it is an important resource for the education of youth.

Current Goals for Science Education Curricula As Stated in Recent Educational Literature

Forty-four goals for science education curricula were found in a survey of recent educational literature. Only 17 of these goals were found to be discrete as reviewed by educators.

Several goals were derived from NSTA (1978, p. 4):

1. Science education must provide a broad, general education for all citizens.

> A broad general education in science should provide every person --child or adult--basic knowledge about the natural world, an understanding of the methods of scientific investigation, especially the relationship between theory and evidence, an appreciation of the limits of scientific theory, and some knowledge of the ways in which scientific research can be used to improve daily life.

It should also provide an awareness of social and moral problems which may arise in the practice of scientific research and technological applications in the world.

2. Science must provide a more specialized education for the science-prone students that would be more sophisticated in knowledge and expertise in traditional and emerging scientific fields.

3. Science education must emphasize processes, concepts, principles, and generalizations of science.

4. Science must be studied in the context of the times and society.

Sabar (1979, p. 264) stated that science and humanities should be related in integrated science education.

Taylor (1978) stated that science education should help prepare our citizenry for life in our society and that science instruction should help children learn to apply problem-solving skills to situations that deal with not only with scientific phenomena but also with social factors.

Williams (1978) believed that science must be taught as a human activity, inseparable from the humans who engage in it, changing with time in response to the needs and interests of its practitioners and to the needs and pressures of the society in which it exists.

Yager (1980) stated a number of goals:

1. "The teaching of science should be oriented toward the resolution of scientific, technological, and social problems" (p. 41).

2. "A rationale for science education should reflect the nature of science, the nature of society/culture, the expectations of education, the needs of human beings, and the way people learn" (p. 42).

3. The teaching of science in schools should have a focus of personal and societal problems and issues" (p. 45).

4. "The science curriculum should provide real-life situations for students to deal with value, ethical and moral issues that are science based and conspicuous in our society/culture" (p. 45).

5. "The basic skill of communication essential for all students is a responsibility shared by science teachers" (p. 45).

6. "Teachers of science have a responsibility to provide students with opportunities to learn about careers in science and technology" (p. 45).

Seven goals were selected from DeVito (1979).

1. The science curriculum should be concerned with "the intellectual parameters wherein the acquisition of scientific knowledge, the communication of scientific knowledge, and the use of scientific knowledge in the solution of problems are reviewed and stressed" (p. 49).

2. "Science education should assist individuals in acquiring the skills, knowledge, and the emotional adjustment needed by them to relate successfully to themselves and to the world around them" (p. 50).

3. "Science education should extend the individual's ability to learn, to relate, to choose, to vote, to communicate, to challenge, to respond to challenges to that the individual may live with purpose in the world of today and tomorrow and achieve pleasure and satisfaction in the process" (p. 51).

4. The individual should acquire from the study of science:

> The acquisition of the skill of experimentation; . . . the questioning of all things; . . . a consideration of premises, impinging variables, and the consequence of proposed action; . . . a spirit of demonstrative verification; . . . a search for data and their meaning; and . . . a respect for logic, and the development of a strategy for inquiry (p. 52).

5. "The individual should gain insight into the relationships between science, society, technology, and philosophy" (p. 52).

6. "Elementary school science should be exploratory in nature. The nature of the learner, rather than the structure of the sciences, dictates the curriculum" (p. 53).

7. "The capstone to any science instruction should be the capacity of an individual to relate sensitively, to think divergently, and to perform imaginatively in personal confrontations with people and ideas" (p. 53).

Blumenfield (1978, p. 393) stated that science education should "produce an informed citizenry, one capable of making decisions in a world beset by technological and social problems."

Two goals were selected from Kahle and Yager (in press).

1. The teaching of science will focus on current scientific/technoligical/societal problems.

2. Values and ethics will be considered integral parts of science education as they are related to scientific/technological/societal problems.

Bybee et al. (1980, p. 393 stated that science education should provide knowledge about "the basic nature of science related problems, such as energy, pollution, population, food supply, disease, resource conservation, and human behavior. . . . [Science education should] improve understanding of the role of science, especially basic science, as it leads to new knowledge that may improve human life."

Bybee (1979b) suggested five goals.

1. Science education should develop the appropriate cognitive, affective, psychomotor, and social objectives to "fulfill basic human needs and facilitate personal development; . . . maintain and improve the physical

and human environment; . . . conserve and efficiently use natural resources; . . . develop greater community at the local regional, national and global levels' (p. 159).

2. "The goal of science education should be to develop a scientific literacy that includes the fundamental relationship of individual human beings to the environment and to each other in communities" (p. 159).

3. "Science education should be directed to the fulfillment of basic human needs and to the development of respect for human rights and fundamental freedoms" (p. 159).

4. "Science education should be directed toward understanding the various aspects of the environment and the ethical decisions involved in the wise use of natural resources and the environment" (p. 159).

5. "Science education should be directed toward greater understanding of the interdependence of individuals on each other and on their environment at the local, regional, national and global levels" (p. 160).

Agin (1974, p. 403) stated that "science education should provide each individual with an understanding of science that will help him make intelligent social and political decisions" (p. 405).

Bybee (1977a, p. 85) stated that science education had three major aims that underlie the organization of curriculum and instruction:

1. Empirical knowledge of physical and biological systems.
2. Scientific methods of investigation.
3. Personal development of the student.

Four goals were selected from Bybee (1979a):

1. Science education should consider the "development of the individual which places emphasis on the fulfillment of basic human needs

and discovering means of nurturing continued healthy personal growth" (p. 107).

2. Science education should consider the "development of environmental quality which includes the protection, conservation, and improvement of all the factors, e.g., air, water, noise, and stress, that affect individual and community development" (p. 107).

3. Science education should consider the "development of resources which means deciding what natural resources are to be used and the degree to which they are used, recycled, and conserved" (p. 107).

4. Science education should consider the "development of the community which entails greater recognition that there are groups of humans at local, regional, national, and international levels that are dependent on one another for the basic requirements of individual development and that we must cooperate in the elimination of racism, sexism, and war" (p. 108).

An additional four goals were selected from Bybee (1979c):

1. "The aim of science education would certainly be to contribute to an understanding of the interrelationships and interdependence of those living in an Ecological Society" (p. 249).

2. "Science education should be directed toward fulfillment of the student's basic needs and to the strengthening of respect for the basic needs and fundamental rights of all humankind" (p. 250).

3. "Science education should be directed toward the student's understanding various aspects of the physical and human environment and the ethical decisions required in the use of natural resources" (p. 251).

4. "Science education should be directed toward the student's understanding of the interdependence of individuals with each other and with their environment" (p. 252).

Gega (1976) recommended that science be concerned with human problems (social and personal) and the world's limit of material resources and be interdisciplinary.

O'Hearn (1976, p. 103) recommended that science education be concerned with scientific literacy defined as "(1) basic scientific knowledge, (2) nature of science, (3) the processes of science, and (4) social and cultural implications of science."

Evans (1977, p. 29) stated that science education should "help our children become self-reliant, intellectually curious and critical; sensitive to the needs of others; and environmentally aware."

Need for Defintion and Validation of Goals for Science Education Curricula

In some recent surveys, there has been a call for the definition and validation of goals for science education curricula by science educators across the country. May et al. (1980, p. 156) reported that the eighth ranking concern in their priorities study was the "definition and validation of goals of science instruction."

Gerlovich and Yager (in press) reported on the 1979 surveys of Iowa science supervisors, graduate faculty from university centers, and a cross-level sampling of the profession, including teachers, supervisors, curriculum directors, graduate students, and college faculty. They stated: "One of the striking results of the studies is the unanimity of the

of the most important problem--that of defining better the goals and objectives for the discipline"(n.p.).

Gallagher and Yager (in press-a, in press-b) reported in two different articles the results of a mail survey directed to 28 science educators at the 28 universities in the United States responsible for nearly all graduates that the most frequently mentioned item was uncertainty about the goals and objectives of science education. The same study was reported by Yager (1980) and Renner and Yager (in press).

Yager (in press) summarized the results of two studies conducted in 1980 and stated that 150 faculty members at 30 large graduate centers ranked "uncertainty about goals and objectives of science education" first (75%) among the problems perceived for science education in the United States. The 150 teachers, in-service supervisors, workshop supervisors/department chairs, graduate students, and college science educators (30 each) surveyed in the other study ranked "confusion and uncertainty concerning goals and objectives" first (71%).

From these studies done in 1979 and 1980, it is apparent that a primary need in science education curricula is the redefinition and validation of science goals for the 1980s. This study attempted to fill that need.

CHAPTER 3

RESEARCH PROCEDURES

The research procedures for this study were devised to describe and validate major goals for science education curricula in the 1980s as determined by science educators. The descriptive survey method of research was used.

Subjects

The population for this study was the membership of the National Association for Research in Science Teaching (NARST), an organization dedicated to research in science education with a United States membership of 582 as of October 1980. A random sample of 100 United States members were selected by using a table of random numbers. This sample represented 17% of the total United States membership.

Description of Instrument

A survey instrument comprised of goals for science education curricula, as stated in recent educational literature, was developed and mailed to the 100 science educators in the sample for prioritizing. Initially, 44 goals were found, but a removal of a large overlap narrowed the total number of goals to 17. A major science educator reviewed the goals to ascertain their discreteness. Many of the goals were worded as orginally stated in the literature. Other goals were

were restated to obtain verbal uniformity. A discussion of the 17 goals included in the survey instrument follows.

Goal 1: *Science education curricula should integrate science and humanities.* Sabar (1979, p. 264) stated that there has been a "growing recognition among science educators that science and the humanities should be related in integrated science education."

Goal 2: *Science education curricula should reflect the nature of science, the nature of society/culture, the expectations of education, the needs of human beings and the way people learn, and should be directed to the fulfillment of basic human needs and to the development of respect for human rights and fundamental freedoms.* Yager (1980, p. 42) in listing selected policies for science education stated "a rationale for science science education should reflect the nature of science, the nature of society/culutre, the expectations of education, the needs of human beings, and the way people learn." Bybee (1979a, 1979b, 1979c) and Williams (1978) dealt with these same concerns.

Goal 3: *Science education curricula should provide real-life situations for students to deal with values, ethical and moral issues that are science based and conspicuous in our society/culture.* Yager (1980, p. 45) stated "the science curriculum should provide real-life situations for students to deal with value, ethical and moral issues that are science based and conspicuous in our society/culture." Taylor (1978) and Kahle and Yager (in press) also referred to the same area.

Goal 4: *Science education curricula should be directed toward understanding the various aspects of the environment and the ethical*

decisions involved in the wise use of natural resources and the environment. Bybee (1979b, p. 159) stated "science education should be directed toward understanding the various aspects of the environment and the ethical decisions involved in the wise use of natural resources and the environment." Bybee (1979a) and Kahle and Yager (in press) addressed the same need.

Goal 5: *Science education curricula should improve the understanding of the role of science, especially basic science, as it leads to new knowledge that may improve human life.* Bybee et al. (1980, p. 393) stated that science education curricula should "improve understanding of the role of science, especially basic science, as it leads to new knowledge that may improve human life." This same issue was also addressed by Bybee (1979a) and the National Science Teachers Association (1978).

Goal 6: *Science education curricula should be oriented to allow the individual to gain insight into the relationships between science, society, technology, and philosophy.* DeVito (1979, p. 52) state "the individual should gain insight into the relationships between science, society, technology, and philosophy." This was addressed by O'Hearn (1976), NSTA (1978), Pella (1976), and Yager (1980).

Goal 7: *Science education curricula should be directed to provide greater understanding of the interdependence of individuals on each other and on their environment at the local, regional, national, and global levels.* Bybee (1979b, p. 160) wrote "science education should be directed toward greater understanding of the interdependence of individuals on each other and on their environment at the local, regional, national and global levels." Bybee (1979c) again addressed this concern.

Goal 8: *Science education curricula must emphasize processes, concepts, principals and generalizations of science.* The National Science Teachers Association (1978, p. 16) stated in its Accomplishments and Needs: A Working Paper that "there must be continued emphasis on the processes, concepts, principles and generalizations of science as they are enduring, valuable and necessary in an era of rapidly expanding knowledge." Similar concerns were addressed by Bybee (1977a), DeVito (1979), O'Hearn (1976), and Pella (1976).

Goal 9: *Science education curricula should be oriented toward the resolution of scientific, technological, and social problems.* Yager (1980, p. 41) stated "the teaching of science should be oriented toward the resolution of scientific, technological, and social problems. A similar concern was addressed by Blumenfield (1978),DeVito (1979), Kahle and Yager (in press), NSTA (1978), and Taylor (1978).

Goal 10: *Science education curricula should help our children become self-reliant, intellectually curious, and critical; sensitive to the needs of others; and environmentally aware.* Evans (1977, p. 29) stated that science education should "help our children become self-reliant, intellectually curious, and critical; sensitive to the needs of others; and environmentally aware." Bybee (1979b) and DeVito (1979) also refer to this concern.

Goal 11: *Science education curricula should provide each individual with an understanding that will help that individual make intelligent social and political decisions.* Agin (1974, p. 405) stated that science education should provide each individual with an understanding of science that will help him make intelligent social and political decisions."

Blumenfield (1978), DeVito (1979), NSTA (1978), and Yager (1980) also referred to this same need.

Goal 12: *Science education curricula should provide knowledge about the basic nature of science related problems, such as energy, pollution, population, food supply, disease, resource conservation, and human behavior.* Bybee et al. (1980, p. 393) stated that science curricula should provide knowledge about the "basic nature of science related problems, such as energy, pollution, population, food supply, disease, resource conservation, and human behavior." Similar concerns were addressed by DeVito (1979), O'Hearn (1976), and Pella (1976).

Goal 13: *Science education curricula should be concerned with human problems (social and personal), world's limit of material resources, and interdisciplinary in nature.* Gega (1976) and Taylor (1978) addressed the above concern.

Goal 14: *Science education curricula at the elementary school level should be exploratory in nature with the nature of the learner, rather than the structure of the discipline, dictating the curriculum.* DeVito (1979, p. 52) stated that "elementary school science should be exploratory in nature. The nature of the learner, rather than the structure of the sciences, dictates the curriculum."

Goal 15: *Science education curricula should provide at the secondary level a more specialized education for the science-prone students that would be more sophisticated in knowledge and experiences in traditional and emerging scientific fields.* The National Science Teachers Association (1978, p. 4) , referring to science education, stated that "more specialized education additionally would provide science-prone

students with more sophisticated knowledge and experiences in traditional and emerging scientific fields."

Goal 16: *Science education curricula should provide students with opportunities to learn about careers in science and technology.* Yager (1980, p. 45) stated that "teachers of science have a responsibility to provide students with opportunities to learn about careers in science and technology."

Goal 17: *Science education curricula should share in the responsibility for teaching and developing the basic skills of communication essential for all students.* Yager (1980, p. 45) stated that "the basic skills of communication essential for all students is a responsibility shared by science teachers."

Data Collection and Analysis

The survey instrument (Appendix A) was mailed to the 100 educators in the sample. The science educators were requested to prioritize each goal as to its importance for science education curricula in the 1980s on a 1 to 7 scale. Additionally, the educators were asked to add any goals they believed were missing from the list and/or to comment on any of the goals in the list. This provided two types of data. The first was numerical data that would allow a ranking of each goal in the instrument. The second was descriptive nominal data that would add to the body of knowledge concerning goals for science education curricula for the 1980s. Follow-up procedures were designed to attempt to get a maximum number of surveys returned in the form of reminder letters and second mailings (Appendix B).

The numerical ranking of each goal was tabulated and a median was calculated. The median was used because it is less influenced by extreme scores. The goals were then examined in ordinal fashion. The set of descriptive data was collected, examined for similarities, overlap, and reported, indicating any major areas of significance.

CHAPTER 4

RESULTS

One hundred science educators were sent a copy of the 17 science education curricular goals and were asked to rank each goal on a 1-7 scale, with 1 being least important and 7 being most important. Of the 100 sets of goals, 60 (60%) were returned. Two of the 60 were returned without any priority rankings and were unusable.

For this study the median of the priority rankings for each of the 17 goals was computed. The frequencies and median for each of the 17 goals are shown in Table 1. Not all respondents ranked all 17 goals; therefore n shows the actual number of respondents who ranked the goal.

Table 2 shows the 17 goals in descending rank order based on medians of priority rankings. Goal 8 received the highest rank with a median of 6.8. Goal 1 received the lowest rank with a median of 4.7.

Priority ranks for goal 8, which ranked first by median, had the most restricted range, 4-7. There was no consistent ranking pattern to the ranges for the remaining 16 goals. Eight goals, with ranges from 1 to 7, ranked 1-17; 5 goals, with ranges from 2 to 7, ranked 2-13; and 3 goals, with ranges from 3-7, ranked 4-15.

Twenty respondents suggested 41 additional goals that they perceived as not being listed in the original 17 goals. The 41 suggested goals were grouped by similar topics such as environmental concerns and

Table 1

Frequency Distribution for Priority Ranks Assigned to Science Education Curricular Goals by 60 Science Educators

Goal	n	Priority Rank[a] None[b]	1	2	3	4	5	6	7	Median	Range
1	58	2	4	9	6	8	17	8	6	4.6	1-7
2	55	5	1	1	11	9	8	8	17	5.2	1-7
3	58	2	0	4	5	6	11	19	13	5.7	2-7
4	57	3	0	1	0	4	8	23	21	6.2	2-7
5	57	3	0	0	3	4	13	20	17	5.9	3-7
6	57	3	2	1	2	6	19	16	11	5.4	1-7
7	57	3	0	3	9	7	14	10	14	5.2	2-7
8	58	2	0	0	0	4	6	5	43	6.8	4-7
9	57	3	1	2	6	13	16	15	5	5.0	1-7
10	56	4	0	1	3	2	12	10	28	6.5	2-7
11	56	4	1	0	4	8	8	17	18	5.9	1-7
12	56	4	0	0	2	2	7	19	26	6.4	3-7
13	56	4	0	0	6	8	22	8	11	5.1	3-7
14	57	3	2	3	1	5	8	11	27	6.5	1-7
15	57	3	2	0	7	11	8	13	17	5.5	1-7
16	57	3	0	2	4	12	11	18	10	5.5	2-7
17	58	2	1	0	4	7	15	10	21	5.7	1-7

a. Priority scale: 1 = least important; 7 = most important.

b. Two respondents returned survey questionnaire without ranking goals. Other respondents did not rank all goals.

Table 2

Ranking of Science Education Curricular Goals by Median Priority Rank Assigned by 60 Science Educators

Goal	Statement	Median Priority Rank	Rank
8	Science education curricula must emphasize processes, concepts, principles and generalizations of science	6.8	1
10	Science education curricula should help our children become self-reliant, intellectually curious, and critical; sensitive to the needs of others; and environmentally aware	6.5	2
14	Science education curricula at the elementary school level should be exploratory in nature with the nature of the learner, rather than the structure of the discipline dictating the curriculum	6.5	2
12	Science education curricula should provide knowledge about the basic nature of science related problems, such as energy, pollution, population, food supply, disease, resource conservation, and human behavior	6.4	4
4	Science education curricula should be directed toward understanding the various aspects of the environment and the ethical decisions involved in the wise use of natural resources and the environment	6.2	5
5	Science education curricula should improve the understanding of the role of science, especially basic science, as it leads to new knowledge that may improve human life	5.9	6
11	Science education curricula should provide each individual with an understanding that will help that individual make intelligent social and political decisions	5.9	6
3	Science education curricula should provide real-life situations for students to deal with values, ethical and moral issues that are science based and conspicuous in our society/culture	5.7	8

Table 2--Continued

Goal	Statement	Median Priority Rank	Rank
17	Science education curricula should share in the responsibility for teaching and developing the basic skills of communication essential for all students	5.7	8
15	Science education curricula should provide at the secondary level a more specialized education for the science-prone students that would be more sophisticated in knowledge and experiences in traditional and emerging scientific fields	5.5	10
16	Science education curricula should provide students with opportunities to learn about careers in science and technology	5.5	10
6	Science education curricula should be oriented to allow the individual to gain insight into the relationships between science, society, technology, and philosophy	5.4	12
2	Science education curricula should reflect the nature of science, the nature of society/culture, the expectations of education, the needs of human beings and the way people learn, and should be directed to the fulfillment of basic human needs and to the development of respect for human rights and freedoms	5.2	13
7	Science education curricula should be directed to improve greater understanding of the interdependence of individuals on each other and on their environment at the local, regional, national and global levels	5.2	13
13	Science education curricula should be concerned with human problems (social and personal), world's limit of material resources, and interdisciplinary in nature	5.1	15
9	Science education curricula should be oriented toward the resolution of scientific, technological, and social problems	5.0	16
1	Science education curricula should integrate science and humanities	4.6	17

are listed in Appendix C. These 41 goals are quite varied and contain some overlaps with each other and with the original 17 goals.

Another nine respondents offered general comments and reactions to the study. This was not unexpected because participants were not informed that goal statements had been taken from the literature and were not the creation of the investigator. The participants were deliberately not so informed because it was thought that such information would have entered an external bias into the participants' responses.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to redefine and validate science education curricular goals for grades K-12 in the eighties. Goals were obtained through a survey of recent educational literature. The goals were then compiled into an instrument, Science Education Curricular Goals for Validation, which was mailed to 100 science educators for validation by ranking each goal on a 1-7 scale (with 1 being the least important and 7 being the most important). Sixty instruments were returned (60% return rate). A median for each of the 17 goals was calculated and additional goals suggested by the respondents were organized with minimal editing and reported.

Results obtained in this study may be summarized as follows:

1. Sixteen of the 17 goals were validated as somewhat important (medium ≥ 5.0) by respondents as indicated by the median rankings. With the exception of goal 1, no goal received a median less than 5.0.

2. Goal 8 received the highest rank with a median of 6.8 as well as the most restricted range (4-7). Goal 8 was a very traditional type goal that had long been used in science education. It stated: Science education curricula must emphasize processes, concepts, principles, and generalizations of science.

3. Goals 10 and 13 were both ranked second with a median of 6.5. Goal 10 had a range of 2-7 and goal 14 had a range of 1-7. Both were broad, child-centered type goals. Goal 10 stated: Science education curricula should help our children become self-reliant, intellectually curious, and critical; sensitive to the needs of others; and environmentally aware. Goal 14 states: Science education curricula at the elementary school level should be exploratory in nature with the nature of the learner, rather than the structure of the discipline, dictating the curriculum.

4. Goal 12, with a median of 6.4 and a range of 3-7, was ranked fourth. It dealt with gaining knowledge about the basic nature of science-related problems. Goal 12: Science education curricula should provide knowledge about the basic nature of science-related problems, such as energy, pollution, food supply, disease, resource conservation, and human behavior.

5. Goal 4 was ranked fifth with a median of 6.2 and a range of 2-7. It stated: Science education curricula should be directed toward understanding the various aspects of the environment and the ethical decisions involved in the wise use of natural resources and the environment.

6. Goal 1 was ranked as the least important of the 17 goals with a median of only 4.6 and a range of 1-7. It stated: Science education curricula should integrate science and humanities.

7. The additional 41 recommended goals suggested that there are numerous goals not in the literature that are considered important by science educators. The additional 41 goals also suggested that consensus

on a cohesive set of goals for science education curricula by a majority of the science education community will be difficult to obtain.

Based on the results of this study, the following conclusions may be drawn:

1. Although there was some agreement among the responding science educators, there was also considerable disagreement as to major goals for science education curricula.

2. Goal 8 was obviously considered important to the respondents. Goal 8 not only had a median rank of 6.8, but 43 (74%) of the respondents ranked it as 7, and the lowest rank it received was 4.

3. The percentages for each rank for each of the 17 goals is shown in Table 3. Goal 14 had 47% of the respondents rank it as 7, and Goal 10 had 50% of the respondents rank it as 7. Goal 12 had 46% of the respondents rank it as 7, and goal 4 had 37% of the respondents rank it as 7. Goals 14, 10, and 12 must therefore be considered important by the respondents. Conversely, Goal 1 must be considered as not important by the respondents. Only 10% ranked goal 1 as 7, and 33% ranked it as 3, 2, or 1.

4. An examination of the additional 41 goals indicated several interesting things:

   a. Four goals dealt with thinking, reasoning skills in some manner.

   b. Two goals (12 and 13, Appendix C) were but one example of the lack of consensus among the respondents. The first states that science courses should emphasize concepts and principles of science. The fads such as values, energy, etc.

Table 3

Percentage of Responses for Each Rank

		Rank						
Goal	n	1	2	3	4	5	6	7
1	58	7	16	10	13	29	14	10
2	55	2	2	20	16	15	15	31
3	58	0	7	9	10	19	33	22
4	57	0	2	0	7	14	40	37
5	57	0	0	5	7	23	35	30
6	57	4	2	4	11	33	28	19
7	57	0	5	16	12	25	18	25
8	58	0	0	0	7	10	8	74
9	57	2	4	11	23	28	26	9
10	56	0	2	5	4	21	18	50
11	56	2	0	7	14	14	30	32
12	56	0	0	4	4	13	34	46
13	56	0	0	11	14	39	14	20
14	57	4	5	2	9	14	19	47
15	57	4	0	12	19	14	23	30
16	57	0	4	7	21	19	32	18
17	58	2	0	7	12	26	17	36

should be given little emphasis. The second goal states that science education curricula should deal with energy education: conservation and utilization of alternative energy resources.

c. Four goals recommended the use of microcomputers and a basic understanding of their operation and use.

d. Seven goals referred to environmental and energy concerns.

Based on the information obtained in this study, the following recommendations are made:

1. A modified Delphi technique should be used, including both the initial set of 17 goals and the additional 41 goals suggested by science educators to further clarify, redefine, and validate goals for science education curricula.

2. A broader range of members of the science education community should be included in future attempts to establish a cohesive set of goals for science education curricula. These might include elementary and secondary teachers and administrators, university professors, graduate students, and perhaps even some secondary students.

3. Consideration should be given to dividing science education curricular goals into primary, intermediate, and junior and senior high levels.

4. The science education community should examine its field in depth to decide which goals are critical to the survival of science in our public schools.

5. The science education community should decide whether to set its own goals or whether to accept the myriad goals of textbook publishers.

6. Consideration must be given to the dissemination and implementation of science education curricular goals, once established, so they do not join other stacks of unused papers filling file drawers.

7. Realistic consideration must be given to the development of curricula once science education curricular goals are established.

Perhaps the most important recommendation of all is that the science education community unites to develop a cohesive set of science education curricular goals that are then disseminated to all public and private schools as well as colleges of education.

APPENDIX A

SCIENCE EDUCATION CURRICULAR GOALS

FOR VALIDATION

DIRECTIONS: Please read and evaluate each goal as to its importance in the decade of the 1980s. Select a rating for each goal on the 1-7 scale provided with #1 indicating the lowest priority and #7 indicating the highest priority. In the second part, please add any goals you consider important for the decade of the 1980s that are not listed and/or comment on any of the goals listed.

SCIENCE EDUCATION CURRICULAR GOALS FOR VALIDATION

		Low ---------- High
1.	Science education curricula should integrate science and humanities.	1 2 3 4 5 6 7
2.	Science education curricula should reflect the nature of science, the nature of society/culture, the expectations of education, the needs of human beings and the way people learn, and should be directed to the fulfillment of basic human needs and to the development of respect for human rights and freedoms.	1 2 3 4 5 6 7
3.	Science education curricula should provide real-life situations for students to deal with values, ethical and moral issues that are science based and conspicuous in our society/ culture.	1 2 3 4 5 6 7
4.	Science education curricula should be directed toward understanding the various aspects of the environment and the ethical decisions involved in the wise use of natural resources and the environment.	1 2 3 4 5 6 7
5.	Science education curricula should improve the understanding of the role of science, especially basic science, as it leads to new knowledge that may improve human life.	1 2 3 4 5 6 7
6.	Science education curricula should be oriented to allow the individual to gain insight into the relationships between science, society, technology, and philosophy.	1 2 3 4 5 6 7
7.	Science education curricula should be directed to improve greater understanding of the interdependence of individuals on each other and on their environment at the local, regional, national and global levels.	1 2 3 4 5 6 7

8. Science education curricula must emphasize processes, concepts, principals and generalizations of science. 1 2 3 4 5 6 7

9. Science education curricula should be oriented toward the resolution of scientific, technological, and social problems. 1 2 3 4 5 6 7

10. Science education curricula should help our children become self-reliant, intellectually curious, and critical; sensitive to the needs of others; and environmentally aware. 1 2 3 4 5 6 7

11. Science education curricula should provide each individual with an understanding that will help that individual make intelligent social and political decisions. 1 2 3 4 5 6 7

12. Science education curricula should provide knowledge about the basic nature of science related problems, such as energy, pollution, population, food supply, disease, resource conservation, and human behavior. 1 2 3 4 5 6 7

13. Science education curricula should be concerned with human problems (social and personal), world's limit of material resources, and interdisciplinary in nature. 1 2 3 4 5 6 7

14. Science education curricula at the elementary school level should be exploratory in nature with the nature of the learner, rather than the structure of the discipline, dictating the curriculum. 1 2 3 4 5 6 7

15. Science education curricula should provide at the secondary level a more specialized education for the science-prone students that would be more sophisticated in knowledge and experiences in traditional and emerging scientific fields. 1 2 3 4 5 6 7

16. Science education curricula should provide students with opportunities to learn about careers in science and technology. 1 2 3 4 5 6 7

17. Science education curricula should share in the responsibility for teaching and developing the basic skills of communication essential for all students. 1 2 3 4 5 6 7

ADDITIONAL GOALS FOR SCIENCE EDUCATION CURRICULA:

APPENDIX B

COVER LETTER

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF EDUCATION
DEPARTMENT OF ELEMENTARY EDUCATION
Room 819

Several recent research reports have indicated that science educators all across the country and at all levels feel a need to redefine and validate goals for science education curricula. You were recommended as a leading science educator who might supply expertise with this concern.

The attached questionaire is an attempt to begin this process of redefining and validating goals for science education curricula for grades K-12 in the eighties. It will only take a few minutes of your time -- probably no more than fifteen minutes -- and could be very valuable for providing direction for science educators.

If you would be interested in receiving a copy of the final report please advise and I will send one at the completion of the project.

A stamped envelope is enclosed for returning the questionaire. I would appreciate receiving your return by April 1, 1981.

Thank you for your time and consideration.

Sincerely yours,

Judith Enz
Doctoral Candidate

Milo K. Blecha
Department Head
Dept. of Elementary Education

enc.

APPENDIX C

ADDITIONAL GOALS SUGGESTED BY RESPONDENTS

1. One hundred percent of science education curriculum at the elementary level should be based on activity-oriented materials, discussions, and these used to improve attitudes to stimulate reading.

2. Science education should stress application of classroom content to the local environment so that interest will be stimulated and learning will be facilitated.

3. Science education curricula should provide students with opportunities to explore their immediate environment for first-hand knowledge of problems related to the environment at the local level.

4. Science education curricula should assist with the development of "reasoning" skills in students.

5. Science education curricula should place emphasis on "thinking" while demanding good reading and writing skills throughout one's formal education.

6. Science education curricula should be less concerned with comprehensive coverage of a discipline and more concerned with the developing of reasoning skills within the context of science courses and concepts.

7. Science education curricula should allow for or make provision for training competencies of teachers using them.

8. Science education should be directed to convincing our local, state, and national power structure that the simplistic and enticing three R's goal is not sufficient for the future of a nation such as ours.

9. Science at the secondary level (7-12) should deal with science as a body of knowledge. Opportunities to specialize in an area should be limited. Suggested pattern for most students would include a heavy biological, environmental, ecological emphasis with chemistry and physics, physiology, and anatomy at the 10th, 11th-grade levels.

10. Science education curricula should stress (at the secondary level) the basic nature of science as a means to better understanding the world we live in.

11. Science education, especially at higher levels, should assist students not only in an awareness of environmental and science-society related issues but also the skills necessary to take "action" of some form relative to issues.

12. Science courses should emphasize the concepts and principles of science. The fads such as values, energy, etc. should be given little emphasis.

13. Science education curricula should deal with energy education--conservation and utilization of alternative energy sources.

14. Science education curricula should give students the ability to design and execute a simple experiment with one independent and one dependent variable.

15. Science education curricula should develop process skills.

16. Science education curricula should provide a wide knowledge base to understand the complexity of the subject and its implications to man.

17. Science education curricula and humanities must move toward dealing with topics that concern both but that are in the province of neither.

18. Science education curricula should integrate with other curricula areas--it is dying otherwise and besides it is rather ludicrous to say that science exists by itself!

19. Science education should not be restricted or limited to students who are interested; rather it is vital that all students add logic, research, and other goals of science to their repertoire.

20. Science education curricula should provide for the vast range of student abilities and interests at all levels.

21. Science education curricula should allow for and include different modes of learning for students--verbal, spatial, level of reasoning.

22. Science education curricula should emphasize field work as well as lecture/discussion/demonstration/laboratory work.

23. Science education curricula at levels K-12 should be based upon our very best knowledge of how children learn.

24. Science education should include a vision of futurism--basic forecasting techniques.

25. Science education curricula should emphasize that "science" is tentative and doesn't have "all the answers"; should help students

develop an inquisitive and skeptical attitude and mind set; questioning attitude; challenge the "authority" of science.

26. Science education curricula should develop scientific literacy.

27. Science education curricula should provide students with the direction and resources necessary to explore a variety of topics through readings related to specific scientific topics to ensure a well-rounded and scientifically literate individual.

28. Science education should include a basic understanding of the computer--its operation and use.

29. Science education curricula should use microcomputers as an integral part of curriculum; emphasize problem solving.

30. Science education should teach computer literacy.

31. Science education curriculum should provide students with a knowledge of newer innovations and technological advances in emerging scientific fields such as the use and function of microcomputers.

32. Science education curricula should enable students to be able to distinguish propaganda from fact in today's social climate as related to energy and fuels as well as related areas.

33. Science education curricula should provide a process of approaching problems with open mindedness and to shed bias towards certain areas.

34. Science education should deal with adult education--programs that deal with the 90%+ of the population that has little or no grasp of science and technology today.

35. Observation and record keeping; science education should provide children with ways of communicating their findings through a variety of methods: written, verbal, models, pictures, charts, graphs.

36. Initiative and inventiveness; science education should provide opportunities at the elementary level for children to practice the methods of science and to use tools and apparatus needed to investigate a variety of scientific problems. Children must be allowed to inquire and make discoveries in their own way.

37. Curiosity and interest; science education provides the opportunity to explore the real world, the world of technology, and the world of nature. The child should be encouraged constantly to explore the nature and significance of changes in living and nonliving things.

38. Persistence; children must be encouraged to continue to investigate the materials provided in each science unit even after the novelty of the materials has worn off or after their classmates have finished their investigations.

39. Independent critical thinking; through scientific inquiry children may discover that there are several ways to test an ideal or make an observation. They should be encouraged to develop methods to test their ideas before accepting or rejecting them.

40. Science education curricula must begin, particularly with physical science (and some parts of biological), to address science-math education and thought processes common to both

41. Science education curricula should begin to build linkages with science education research; to include practical applications of research in their design and implementation.

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