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ABSTRACT

The Search for Excellence in Science Education was inaugurated in 1982 to carry out the National Science Foundation's 1981 initiative, Project Synthesis. The Search establishes criteria for excellence and applies them to actual programs in one or several fields each year. In each area the Search identifies hallmarks of excellence in terms of goals, curriculum, instruction, evaluation, and teacher qualifications. This document, the "Criteria for Excellence," and the science exemplars in 16 areas include: kindergarten through sixth grade science; middle/junior high school science; earth science; physical science; biology; chemistry; physics; science/technology/society; environmental education; energy education; inquiry science; science teaching and career awareness; science in non-school settings; preservice elementary teacher education; preservice secondary teacher education; and science supervision. (ML)

CRITERIA for EXCELLENCE

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Science Compacts from the National Science Teachers Association

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We are pleased to offer *Criteria for Excellence* as the second in a series of NSTA Science Compacts. We hope this series will provide educators with brief, cogent documents on important areas of concern in science and science education.

Table of Contents

4	Introduction to the Criteria
6	Kindergarten Through Sixth Grade Science
8	Middle/Junior High School Science
10	Earth Science
12	Physical Science
14	Biology
18	Chemistry
20	Physics
22	Science/Technology/Society
24	Environmental Education
26	Energy Education
28	Inquiry Science
30	Science Teaching and Career Awareness
32	Science in Non-school Settings
34	Preservice Elementary Teacher Education
36	Preservice Secondary Teacher Education
38	Science Supervision

An Introduction to the Criteria

The Search for Excellence in Science Education was inaugurated in 1982 to carry out the National Science Foundation's 1981 initiative, Project Synthesis. The Search brings together visions of the ideal in science education from experts in a wide range of scientific disciplines, synthesizes those visions into criteria for excellence, and applies them to actual programs.

The experts are drawn from a wide range of professional and educational scientific organizations, ranging from NSTA, the parent of the Search, through the National Science Foundation and the National Assessment of Educational Progress (partners in Project Synthesis), to the American Association of Physics Teachers, the American Chemical Society, the National Association of Geology Teachers, and the National Association of Biology Teachers, as well as the divisions of NSTA and its division affiliates, the National Science Supervisors Association, the Council of Secondary Science Supervisors, the Society for College Science Teaching, the Association for the Education of Teachers in Science, the National Association for Research in Science Teaching, and the Council for Elementary Science International. The leaders of the program have continued to involve their peers on all levels of education and in all science disciplines.

Project Synthesis identified four kinds of goals for today's science learning: personal, societal, academic, and vocational. Academic success, the most traditional and most narrowly conceived objective of science education, is the one area in which the members of the project saw satisfactory achievement in 1981. But all citizens of the 80's need science competence to make the most of their individual potential, and to cope with an increasingly technical world. And as participants in a democratic society, individuals must be prepared to make informed, responsible decisions about science-related social issues. Moreover, as the pace of change accelerates, new careers are being created almost daily, as diverse as the interests and aptitudes of students themselves. Alerting students to the ever-widening range of opportunities in careers related to science and technology, teaching science for life, and teaching science for citizenship: these are the three challenges the Project poses to the science programs of today and tomorrow.

The Search for Excellence seeks out and honors programs in one or several fields each year. Categories have included general approaches for specific age groups, such as middle/junior or K-6; standard academic disciplines, such as biology and chemistry; and interdisciplinary areas, such as energy

education, science as inquiry, and science/technology/society. In each area the Search identifies hallmarks of excellence in terms of goals, curriculum, instruction, evaluation, and teacher qualifications.

After the criteria have been identified, the search begins. Each year a network of 52 state committees (one for each state plus the District of Columbia and Puerto Rico) seeks out programs that approach the national criteria in each target area. From the states' nominees, a national panel of judges selects six to thirteen programs in each field that most closely approximate the ideal.

No real-life program has ever met all the criteria, or ever will. Some have taken radically original approaches with great success. But after all the hard work of analysis, synthesis, and search, we think these criteria provide a glimpse of the future of science education.

The criteria are just the rudiments of that future. Its real articulation—and the living definition of the excellence the program seeks—is to be found in the classrooms of our exemplars, the people whose commitment to excellence has made our search rewarding.

The Search for Excellence builds for the future by spotlighting shareable models—exemplary programs that really work—and recognizing the talent, dedication, and generosity of the exceptional individuals who make them work. The rest is up to you, the readers of this book.

Look at your program in the light of these criteria. Congratulate yourself and your colleagues on your program's strengths. Then plan together to build towards these ideals in every area where your program can be improved.

Criteria for Excellence in K-6 Science

In an exemplary elementary science program:

Students

1. Exhibit effective consumer behaviors;
2. Acquire effective health habits;
3. Recognize people's relationship with their environment;
4. Bring varied scientific resources to problem solving;
5. Realize that science is hard work, and that the solution to one problem often causes other problems.

Curriculum

1. Provides planned, sequential programs for all students, emphasizing hands-on learning;
2. Employs clear, well-defined objectives that are reflected in the teaching;
3. Includes periodic review and ongoing evaluation of content, instruction, and learning;
4. Presents knowledge and experiences that students can apply to their lives now and in the future;
5. Provides useful teacher guidelines for planning and directing science activities.

Instruction

1. Is supported by an adequate budget and administrative guidance;
2. Offers many problem-solving activities applicable to the daily life of students;
3. Provides enough materials for all students to conduct experiments;
4. Meets or exceeds state and national minimum expectations for science time;
5. Integrates science into other content areas on a regular basis.

Teachers

1. Understand the goals of the science program;
2. Learn new ideas and methods and try them;
3. Provide varied experiences within the content, processes, and other dimensions of science;
4. Provide experiences from many sources including the life, physical, and environmental sciences, technology, and current community and societal problems;
5. Encourage students to solve problems and use their experiences with science.

K- 6 Science Exemplars

Gary Appel
Green Acres Elementary School
Santa Cruz, California

Emma Walton
Anchorage School District
Anchorage, AK

Catherine Seay, JoAnna Harrison,
Margaret Kilgo, Rhelda Ball,
Elizabeth Smith, Carolyn Summers,
Sandra Schnurr
J. P. Cornelius Math/Science
Academy
Houston, Texas

Wende Allen
Greenville City Schools
Greenville, North Carolina

Kathleen M. Melander
Warwick School Department
Warwick, Rhode Island

Susan Sprague, Joanne Wolf
Science Resource Center
Mesa, Arizona

Roger Spratt, Suzanne Kelly,
Luther Kiser
Ames Community Schools
Ames, Iowa

Margaret Harrison
Porter-Gaud Lower School
Charleston, South Carolina

Betty Holderread
Unified School District #373
Newton, Kansas

Larry Small
District 54 Elementary Schools
Shaumburg, Illinois

Sally Stewart, Gary Winter
Delake Elementary School
Lincoln City, Oregon

Cindy Hrebar, Harold Platt
Jefferson County Public Schools
Jefferson County, Colorado

Criteria for Excellence in Middle/Junior High School Science

Middle/junior high school students go through changes and adjustments which set them apart from other students. Exemplary programs must take their special needs and abilities into account, as well as personal concerns, societal issues, career awareness, and academic preparation.

Goals

1. To promote independent use of skills of inquiry and practical problem identification and solution;
2. To emphasize learning how to learn, including the cognitive, affective, and psychomotor aspects of learning;
3. To provide an academic background which encourages career decisions, and which also serves students who will not pursue further formal science education;
4. To promote attitudes that result in appropriate decison making;
5. To emphasize science in interdisciplinary and working settings.

Curriculum

1. Emphasizes science processes and inquiry while exploring science topics at a general and interdisciplinary level;
2. Uses practical applications and everyday experiences, including issues in science and society, career awareness, and historical aspects of scientific thought;
3. Seeks students' input;
4. Recognizes that students at various levels of cognitive development need a range of topics, activities, and strategies;
5. Presents positive role models, both male and female and from different racial and ethnic groups, who are engaged in scientific inquiry.

Instruction

1. Emphasizes a variety of strategies, logical sequencing of activities, concrete experience, and a hands-on approach;
2. Focuses on student success in learning;
3. Makes optimal use of community resources, including field trips, independent study, and interaction with role models.

Teachers

1. Exhibit competence in the broad field of science: they are generalists rather than specialists;
2. Have a strong grasp of science applications and career opportunities;
3. Have specific preparation in the teaching of science to early adolescents;

4. Improvise, adapt, and invent appropriate instructional strategies and resources, matching them to student abilities, backgrounds, and interests;
5. Relate to students as responsible individuals, being sensitive to their moods and needs, and possessing a sense of humor;
6. Enjoy being middle/junior high school science teachers and see the importance of their profession.

Evaluation
1. Is directly related to the goals for both process and product;
2. Considers differences in cognitive abilities, maturity, and background;
3. Leads to improvements in the quality and effectiveness of the program;
4. Reflects awareness of local conditions, restrictions, and possibilities;
5. Continuously evaluates the teacher as well as the students, on the basis of self, peer, student, and administrator observation.

Middle/Junior High Science Exemplars

Sam S. Chattin
Scottsburg Junior High School
Scottsburg, Indiana

Marvin Mikesh, David Arlander, Sam Bailey, George Lueder, Howard Monnet, Roger Nelson
John Adams Junior High
Rochester, Minnesota

Kathaleen Burke, Ann Michael, John Gallivan
Buffalo Science Magnet School
Buffalo, New York

Benjamin Richardson, Douglas Seager, Joseph Accongio, Elena Brandes, Robert Stevenson
City School District of Rochester
Rochester, New York

Robert Ewart
Lower Moreland Middle School
Huntingdon Valley, Pennsylvania

Thomas P. Knorr Sr.
Pen Argyl Area Junior High School
Pen Argyl, Pennsylvania

John A. Bartley
E. T. Richardson Middle School
Springfield, Pennsylvania

Jean McCaskill, Kyle Wilson, Denise Ralph, Patti Martin, Charles Mize
Owen Goodnight Jr. High School
San Marcos, Texas

Lynn L. Archibald, Randy Christensen, Michael D. Salvesen
South Cache Junior High School
Hyrum, Utah

Terry Logue
C.Y. Junior High, and
Dana Van Burgh, Jr.
Dean Morgan Junior High
Casper, Wyoming

Criteria for Excellence in Earth Science

An excellent Earth science program is directed toward the students' understanding and application of knowledge, values, processes, and skills associated with the Earth sciences. The overall aim of the program is to improve the quality of life for the students and society. Exemplary Earth science programs would share these goals:

1. To develop a knowledge of the facts, concepts, and principles related to the major unifying themes of Earth science;
2. To develop understanding and mastery of the processes of investigation used in the Earth sciences;
3. To provide background and analysis of Earth science-related social issues at the local, national, and global levels;
4. To prepare students to acquire relevant information and make responsible decisions regarding science-related social issues;
5. To develop an appreciation for and critical attitudes toward science and technology as an integral part of society;
6. To provide information about careers in the Earth sciences.

A program designed to achieve these goals is different from most existing Earth science programs. An exemplary Earth science program will manifest exceptional qualities in its orientation, as well as in the teachers' perceptions, instructional strategies, use of facilities, and evaluation procedures:

1. Knowledge, values, processes, and skills are presented in the context of socially relevant issues;
2. Real problems are investigated in the out-of-doors;
3. Fulfilling personal needs, understanding social issues, and preparing for life and careers are central to the program;
4. Teachers perceive their task primarily as educating citizens, and secondarily as preparing students for careers in the sciences;
5. Instructional strategies include the use of computers, field work, simulation games, and other non-traditional approaches;
6. Techniques and instruments of assessment reflect the balance among the goals of the Earth science program.

Earth Science Exemplars

James Sproull
McLean High School
McLean, Virginia

Rion D. Turley
O'Fallon Township High School
O'Fallon, Illinois

Rand Hogarth
Thomson Valley High School
Loveland, Colorado

Kathryn Gregory
Lake-Lehman Junior High
Lehman, Pennsylvania

Robert Groover, Robert Lewis
Hanby Junior High School
Wilmington, Delaware

Bob Frank
Jefferson Junior High School
Caldwell, Idaho

Carolyn Farnsworth
Wellington School
Columbus, Ohio

LeRoy Lee
James Madison Memorial High School
Madison, Wisconsin

Criteria for Excellence in Physical Science

The characteristics of every excellent physical science program reflect specific goals, so programs will necessarily vary. However, excellent programs will generally have the following characteristics:

Provide opportunities to pursue individual needs, goals, and interests, for example, through modular curriculum design, a project approach, or time periods for investigating individual topics;

Provide opportunities to apply physical science content and processes to real-world problems that have no pat solutions, but require tradeoffs;

Deal with basic concepts of physical science in a discipline-organized pattern;

Deal with basic concepts of physical science in the context of socially relevant problems;

Consider personal needs, societal issues, and career preparation as intrinsic to all facets of the science program;

Provide opportunities to interact with people working in science, including scientists, technicians, and others in related fields;

Emphasize the means by which science knowledge is generated;

Include a wide range of learning experiences, such as:

- Laboratory work, inviting students to acquire information inductively,
- Out-of-school experiences,
- Illustrations of different problem-solving styles,
- Exploratory activities that involve risk-taking, guessing, and hypothesizing,
- Opportunities to participate in actual or simulated research activities,
- Opportunities to develop advanced mathematical techniques as they apply to science,
- Opportunities to develop research and writing skills,
- Opportunities to develop the ability to read science materials.

Physical Science Exemplars

John W. Christensen
Cherry Creek High School
Englewood, Colorado

Karen T. McDermott
Scotch Plains-Fanwood
High School
Scotch Plains, New Jersey

Dorothy S. Helms
South Rowan Senior High
China Grove, North Carolina

LeRoy Lee
James Madison Memorial
High School
Madison, Wisconsin

Harold Pratt, B. J. Meadows
Jefferson County R-1 School District
Lakewood, Colorado

Dustin Gardner
Ensley High School
Birmingham, Alabama

Wyatt Y. McDaniel III, Nancy
B. Bane
Spartanburg High School
Spartanburg, South Carolina

Arthur V. Farmer
Henry Gunn High School
Palo Alto, California

Criteria for Excellence in Biology

An exemplary biology program focuses on developing student understanding at three levels: the use of biological knowledge and methods as a way of thinking; the use of this knowledge and these methods to view the interactions of the biosphere, society, and the individual; and the responsibility to address biological issues that involve ethics, values, and esthetics.

The application of these criteria will vary with the learning level of students from middle school through high school. Teachers must consider, for example, the frequency of various types of appropriate learning experiences, the students' intellectual and social skills, and the complexity of the subject matter.

Student Goals

To understand the present and future needs and interactions of the biosphere, society, and the individual

To experience, understand, and appreciate the dynamics of natural systems as a first step to understanding how human activity affects them

To acquire a social and technological focus for the application of fundamental biosphere principles

To develop widely applicable critical thinking skills, especially in decision making

Instruction

Treat living organisms humanely, especially vertebrates

Make short- and long-term laboratory/field work both experiential and experimental

Create individual and collective opportunities to acquire, utilize, interpret, analyze, and evaluate data

Teach based on current research in educational and developmental theory to optimize learning for all students

Use mathematics, statistics, and computers in learning and problem solving

Ask questions that lead to divergent and convergent, inductive and deductive, and metaphorical thinking

Use in-depth studies of major issues to stimulate small group discussion of open-ended questions

Find creative and safe resources to equip the instructional program

Shift from reliance on textbooks and workbooks to include:

- Community resources (natural and modified environments, museums, zoos, aquaria, libraries, guest speakers, business and industry)
- Current literature for the informed citizen

- Print and non-print media (videodiscs, computers, learning centers, educational television)
- Participation in solving local, regional, and global biological issues

Curriculum

Demonstrates the usefulness of biological science as process rather than product, and as a means to solve real problems

Emphasizes that although our explanations are tentative, continued scientific progress depends upon the assumptions of order, harmony, and balance in the universe

Distinguishes betweeen inference and the empirical reasoning from evidence that is the basis of scientific knowledge

Provides familiarity with the following major themes, within the organizational levels of earth, society, and individual:

- Diversity
- Structure and function
- Energetics
- Integration
- Continuity and change
- Cycles
- Nutrition
- Behavior

Demonstrates an application of this conceptual knowledge in examining options for resolving identified problems of the:

- Atmosphere (climate changes)
- Hydrosphere (fisheries, water supply and quality)
- Lithosphere (soil erosion and fertility, mineral and energy sources)
- Biosphere (population dynamics, extinction, and technological impacts)

Interfaces concepts in biology with appropriate principles from the physical sciences, mathematics and statistics, the social sciences, and the humanities

Applies that interfaced knowledge to explore strategies for political and social change to protect and manage the biosphere

Offers a historical perspective on the evolution of biological ideas

Fosters effective communication of biological ideas through oral and written expression

Develops awareness of options for biological careers and avocations

Evaluation

Collects feedback and assesses impact of program both in and outside of school

Evaluates instructional staff using staff criteria below

Evaluates student progress on the basis of:

- Goals and curriculum and instructional objectives above
- Oral and written reports, laboratory assignments, other objective and subjective measures
- Changes in student attitudes
- Changes in cognitive levels
- Psychomotor (lab) skills
- Informal feedback and self-evaluation

Teachers

Instructors are qualified both personally and professionally to:

- Deal with biological social issues through an integration of ideas from the sciences, technology, and the humanities
- Participate in community activities, and contribute to professional associations and publications

The school system supports participation in personal and professional growth activities.

In their relationships with students, instructors:

- Model the role of the scientifically literate, actively involved citizen
- Provide opportunities for students to present competing ideas and resolve problems cooperatively
- Create an environment that fosters positive attitudes towards the role of science in the world
- Recognize the inherent worth and uniqueness of individuals
- Seek means to encourage full intellectual and emotional development

Biology Exemplars

Joseph Maurer
Lindenhurst Senior High School
Lindenhurst, New York

Raylene Owen, Sally Swartz,
Pat Huwa, Russ Doren
Cherry Creek High School
Englewood, Colorado

Edwin A. Vetter
Kathleen Senior High
Lakeland, Florida

Phoebe Miller
Rockledge High School
Rockledge, Florida

Sid Sitkoff, Matt Matsumoto
Los Angeles Unified School District
Los Angeles, California

Bud Ellis
Addison High School
Addison, Michigan

Bruce Westling
John Burroughs School
Ladue, Missouri

James Sammons
Jamestown School
Jamestown, Rhode Island

Perry Weston
High School for the Health
Professions
Houston, Texas

Frank Castelli, Jack Carney
Brandywine and Concord High
Schools
Claymont, Delaware

Criteria for Excellence in Chemistry

An excellent chemistry program focuses on the four goal clusters which were identified in Project Synthesis, the model for The Desired State of Chemistry Teaching in Secondary Schools. The criteria below identify the conditions which must be present, along with others, to achieve the goals of chemistry instruction. They are neither exhaustive nor exclusive.

Personal Needs

An excellent chemistry program provides opportunities for students to develop the ability to rationally think through:

1. Interpreting passages of factual information;
2. Organizing information into a coherent whole;
3. Using logical analysis to distinguish statements which are supported by data from those which are not;
4. Distinguishing events that are correlated from those that are related by cause and effect;
5. Acquiring information inductively and deductively through laboratory inquiry and experiences;
6. Generating many possible courses of action and outcomes to fit a particular set of circumstances.

Societal Issues

An excellent chemistry program provides opportunities for students to become aware of chemistry-related societal issues and to seek solutions through:

1. Considering real-world situations which are amenable to solutions based on chemistry;
2. Focusing on current chemistry-related issues;
3. Emphasizing the complexity of chemistry-related issues and the variety of possible outcomes;
4. Illustrating the use of scientific/technological information in the decision making process;
5. Exemplifying the pragmatism of a multidisciplinary attack on chemistry-related societal issues;
6. Utilizing resource persons from many disciplines to illustrate the multidisciplinary nature of many societal issues.

Career Education

An excellent chemistry program provides opportunities for students to learn about careers in chemistry and chemistry-related fields through:

1. Career information from professional and trade associations;
2. Resource persons working in chemistry and chemistry-related fields.

Academic Preparation

An excellent chemistry program provides suitable instruction to meet the needs of all students, those who will use chemistry as part of their general education and those preparing to pursue chemistry academically and professionally, through:

1. Emphasizing structure, reactivity, and other conceptual schemes;
2. Integrating and explaining the concepts and principles of chemistry;
3. Integrating chemistry with other elements of students' knowledge and experience;
4. Emphasizing application of concepts and principles in new contexts, as opposed to recall of definitions and routine application of rules;
5. Fostering development of the intellectual skills for applying knowledge in new contexts and deriving new knowledge independently;
6. Inculcating a spirit of inquiry and those values which permeate and underlie the scientific process.

Chemistry Exemplars

Angie L. Matamoras
Coral Springs High School
Coral Springs, Florida

David C. Tucker
Mount Baker Junior/Senior High School
Deming, Washington

Diana Doepken, Pat Smith
Air Academy High School
Colorado Springs, Colorado

Jerry R. Kent
Hazen High School
Renton, Washington

Sheryl Jan James
Scottsburg High School
Scottsburg, Indiana

William Bleam
Radnor High School
Radnor, Pennsylvania

David Byrum
Globe High School
Globe, Arizona

Ronald R. Crampton
Omaha Westside High School
Omaha, Nebraska

Criteria for Excellence in Physics

An exemplary physics program is characterized by the following five criteria:

Goals

1. To provide opportunities to gather, record, organize, and interpret data, and to explain the implications of interpretatations;
2. To provide opportunities to use mathematical skills and develop quantitative reasoning;
3. To promote the understanding that physics is a process, as well as an accumulation of knowledge;
4. To stress qualitative and quantitative analysis based on estimates, enabling students to deal with most real world situations;
5. To insist on distinctions between observation and inference, opinion and fact;
6. To relate scientific knowledge and skills to other areas of human creativity;
7. To provide appropriate physics courses for all students.

Curriculum

1. Learning activities, which include laboratory experiences, discussions, small group activities, and out-of-school experiences, illustrate different problem-solving styles;
2. Program includes well-developed content based on a knowledge of how ideas evolve.

Instruction

1. The teacher encourages creative thinking and experimentation;
2. The excitement of discovery ranks high in an introductory physics course;
3. The facilities enhance flexibility, so teachers may easily respond to changing needs;
4. Varied teaching styles include small and large group instruction, peer teaching, mastery-oriented approaches such as PSI, demonstrations, group experiments, questioning and discussion, field studies, individual investigation, and multimedia approaches;
5. The classroom environment provides a variety of interesting experiences and opportunities to explore, gather data, examine alternatives, and stimulate curiosity;
6. The program provides opportunities to develop knowledge in basic physics, scientific processes, facts, principles, and generalizations, as well as applications of physics.

Evaluation

1. Provides information about student efforts and progress in the process of learning, as well as at the end of the course;
2. Equitably considers individual differences, such as cognitive ability, maturity, and background;
3. Links the evaluation process clearly and directly with the goals of the program;
4. Uses varied methods, such as research projects, written and oral reports, and essay questions.

Teachers

1. Show interest in self-improvement through enrollment in physics-related courses, participation in professional science organizations, use of community resources, etc.;
2. Manifest personal joy and excitement in physics;
3. Demand excellence in student work: will not accept careless or incomplete assignments;
4. Participate actively in the total science curriculum, K to 12.

Physics Exemplars

J. Bruce Bauer
Stillwater High School
Stillwater, Minnesota

LeRoy Lee
James Madison Memorial
High School
Madison, Wisconsin

LeRoy W. Kallemeyn
Omaha Northwest High School
Omaha, Nebraska

Frank Hand
East Greenwich High School
East Greenwich, Rhode Island

Howard N. Fowler
Centerville High School
Centerville, Ohio

Charles Lang
Omaha Westside High School
Omaha, Nebraska

Francis X. Finigan
Winchester High School
Winchester, Massachusetts

Donald L. Williams, Frank J. Volpe
Scotch Plains-Fanwood
High School
Scotch Plains, New Jersey

Chandra Bapu, Peter Insley
Whitney M. Young Magnet
High School
Chicago, Illinois

Roderick S. Dickens, Jr.
N. B. Forrest Senior High School
Jacksonville, Florida

Criteria for Excellence in Science/Technology/Society

S/T/S programs recognize the need to give all citizens a fundamental understanding of science and technology to enable them to make informed policy decisions. This understanding is essential to maintain our commitment to the democratic ideal of full participation. It is the new literacy for functioning in society.

Goals

1. To provide opportunities to compare and contrast science and technology and to appreciate how science and technology contribute to new knowledge and power;
2. To give examples from the past and present of the profound changes science and technology have wrought on society, economic growth, and the political process;
3. To offer global perspectives on the relationship of science and technology to society, indicating their impact on developing nations and on the ecology of Spaceship Earth.

Curriculum

1. Includes issues that affect the lives of students, their families, and their communities, and relates them to themes of broader significance;
2. Focuses on the actual processes and procedures by which S/T/S knowledge is gained, asking "How do we know?" and "How can we learn more?";
3. Introduces decision-making strategies and uses the strategies to reach decisions on real problems;
4. Provides opportunities to gather information by reading and interviewing and to share it by writing reports.

Instruction

1. Employs a variety of instructional strategies to examine the assumptions on which various arguments are based and explore the reasoning processes of peers, adults, and experts;
2. Fosters skills in testing the validity of arguments, and considers examples of seemingly sound scientific reasoning that led to erroneous conclusions;
3. Motivates students to examine emotions and values in relation to the data of specific events;
4. Makes good use of field trips, guest speakers, information from the media, films, student projects, role playing, and simulations.

Evaluation

1. Favors non-traditional techniques to assess analytic and reasoning skills, for example, students analyze unfamiliar S/T/S problems, or propose alternative solutions for familiar ones;
2. Develops techniques that will promote further awareness and understanding of S/T/S problems and solutions;
3. Identifies weaknesses in student reasoning and gaps in understanding, in order to continually improve instruction and curriculum.

Teachers

1. Represent both the natural sciences and the social sciences, in order to give interdisciplinary perspectives;
2. Bring in resource persons from the community—from local industry, government, the press, and public interest groups.

Science/Technology/Society Exemplars

Jon L. Harkness
Wausau West High School
Wausau, Wisconsin

Larry G. Clark
Toledo High School
Toledo, Oregon

Virginia Carol Demchik,
Michael Demchik
Scott High School
Madison, West Virginia

Elizabeth Horsch, Roxie Dever
Kelly Walsh High School
Casper, Wyoming

Albert Orlando, Arthur Lebofsky,
Wayne Browning
Clarkstown South High School
West Nyack, New York

Carol A. Wilson
Dr. Mark T. Sheehan High School
Wallingford, Connecticut

Willa Ramsay & Tom Yount
Gompers Secondary School
San Diego, California

Vincent Cusimano, Stephen
Halpern
Susan E. Wagner High School
Staten Island, New York

Jim Black, Dave Brotherton
Monte Sano Elementary
Huntsville, Alabama

M. Doug Vliet
Quilcene Junior-Senior High School
Quilcene, Washington

Criteria for Excellence in Environmental Education

Effective environmental education depends on multidisciplinary instruction but has a strong science component. It involves minds-on direct contact with environments as well as vicarious experiences. The learner grows from awareness and understanding to concern and action.

Goal

To develop and practice creativity and critical thinking along with values analyses. Teachers and learners will search for alternative solutions to environmental issues and evaluate the ethical, social, ecological, and economic costs and benefits of alternatives.

Curriculum

1. Provides activities and information to interest learners in the interactions between people and environments;
2. Develops in the learners the intellectual tools to effectively explore the world around them;
3. Directly involves learners in investigating the world around them and their relationship to it.

Instruction

1. Fosters open minds and the generation and examination of alternatives;
2. Stimulates and fosters creativity and critical thinking;
3. Respects the social, intellectual, and developmental maturity of learners;
4. Links science with other areas of intellectual and emotional activity;
5. Provides opportunities for learners to be involved in environmental activity at an appropriate level of challenge; hence, fosters a growing sense of confidence that groups and individuals can positively affect the environment;
6. Relates the components of the ecosystem to our health, well-being, and potential for development.

Evaluation

Effective programs and materials provide:

1. Evaluation design based on stated goals, objectives, and outcomes;
2. Field testing of programs and materials in terms of stated goals and objectives;
3. Continuous modification and feedback.

Teachers

Who is an environmental educator? Formal educators, including teachers and administrators, and nonformal educators at nature centers, residential

centers, museums, and other facilities that provide sequential programs which:

1. Distribute EE guidelines to colleagues;
2. Encourage colleagues to increase their environmental literacy;
3. Hold clearly stated goals and objectives for learner behavior;
4. Treat controversial issues fairly and honestly;
5. Teach people how to think, not what to think.

Environmental Education Exemplars

James A. Kolb
Marine Science Center
Poulsbo, WA

Sharon Hackley
Palo Christi Elementary School
Kingman, AZ

Michael Specht
Nathan Bishop Middle School
Providence, RI

Janet Thomson
Great Falls Public Schools
Great Falls, MT

William Hammond
Lee County Schools
Fort Myers, FL

Zoneth Overby
Kimbark School
San Bernadino, CA

Edward J. Zero
BOCES III of Suffolk County
Smithtown, NY

Jane L. Person
East Stroudsburg Area
School District
Stroudsburg, PA

Rosemary Pearson
Berwick Alternative School
Columbus, OH

Sidney Stephens
University of Alaska
Fairbanks, AK

Criteria for Excellence in Energy Education

An excellent energy education program is interdisciplinary, and helps students to use knowledge from the humanities, natural science, and the social sciences to enhance their understanding of themselves and to benefit the quality of life for all human beings. The study of past, present, and future sources and uses of energy focuses on human interaction within natural and social systems. Students make decisions with concern for questions of ethics, values, and aesthetics. They learn to act responsibly on contemporary energy/environment/economic issues. The program presents a balanced, objective view of world energy practices, issues, and futures.

Goals

1. To understand the use of energy in our lives, our economy, and our society;
2. To develop skills in energy use and management at home, at school, and on the job;
3. To acquire knowledge of energy resources and energy conversions;
4. To develop rational decision-making strategies to examine and to respond systematically to public and personal energy issues and policies.

The knowledge for achieving these goals is found in most comprehensive recent curricula. Programs of excellence, however, differ significantly in the organization of the curriculum, selection and emphasis of objectives and learning activities, and teacher practices and behaviors.

Curriculum

1. Well-chosen curriculum materials convince students of the need for energy literacy.
2. The curriculum draws on the community both for problems and issues to study and as a resource for solutions.
3. Inter- and intra-grade level articulation and coordination develop energy concepts, practices, and attitudes sequentially.
4. Evaluation techniques reflect affective and cognitive objectives.

Objectives and Learning Activities

1. Content and instructional activities are broadly based in the humanities, natural sciences, and social sciences.
2. Conceptual areas such as Energy: A Basic Need, The Limits of Energy Usefulness, The Environmental Impact of Energy Choices, The Social Impact of Energy Choices, Energy Policy, and Energy Futures constitute the major unifying threads.
3. Goals and student outcomes are selected to reflect a hierarchy of affective and cognitive outcomes.

Teachers

1. Teachers possess the knowledge and instructional skills to deal with issues and problems in an open, inquiring, and objective manner.
2. Teachers model behaviors that they expect students to develop.

Energy Education Exemplars

Mike Jackson
Camp Lejeune Dependent Schools
Camp LeJeune, North Carolina,

Carla Ross
Onslow County Schools
Jacksonville, North Carolina

John Brennan
Denver Public Schools
Denver, Colorado

Terry Switzer, Carol Snell,
Thomas M. Baird
The Energy Management Center
Port Richey, Florida

Florence M. Kane
Houston Outdoor Education Center
Trinity, Texas

Richard A. Donin
Portland Public Schools Energy
Study Center
Portland, Oregon

Marilyn Symaszek
Pond Hill School
Wallingford, Connecticut

Laurie Ervin-Geiszler
Renton School District 403
Renton, Washington

Bonnie Brunkhorst, Royal E.
Doughty
Jonas Clark Junior High School
Lexington, Massachusetts

Criteria for Excellence, Inquiry

Excellence for inquiry is defined by considering the characteristics of the curriculum, the classroom, the instruction, the evaluation, and the teacher.

1. The curriculum for all students includes explicit statements of desired outcomes which consider science process skills, the nature of scientific inquiry, attitudes and values, and individual needs and goals.

2. Things happen in the inquiry classroom. Its science objects are obviously in use. Equipment and supplies are organized and available in a way that stimulates student investigations. The physical arrangement of the room is flexible enough to allow activities of various kinds without undue problems or loss of time.

3. Instruction in inquiry classrooms may reflect a variety of methods, such as discussions, investigative laboratories, student-initiated inquiries, lectures, or debates. Teachers serve as role models in debating issues, examining values, admitting errors, and confronting areas of their own ignorance. The classroom atmosphere is conducive for students to ask questions and to take action; it stimulates a thorough, thoughtful exploration of objects, ideas, and events, rather than a mindless drive to finish the text.

4. Techniques and instruments for evaluation are selected and used in a way that allows meaningful assessment of student outcomes which reflect inquiry learning.

5. The teacher plays the crucial role in inquiry teaching. Effective teachers value inquiry, encourage an inquiry orientation in others, and are skilled in enabling others to use inquiry as a way of knowing.

Inquiry Exemplars

Patricia Denninghoff, Kenneth Marx
Merritt High School
Brevard County, Florida

Donald L. Birdd
Eastern Kentucky University
Richmond, Kentucky

Judy Holtz
Westchester Elementary School
Coral Springs, Florida

Ann M. Justus
Camelback High School
Phoenix, Arizona

Lois S. Durso
Willison Northampton School
Easthampton, Massachusetts

Eva Kirkpatrick
Seckman Junior High
Imperial, Missouri

Lawrence Fauque
North Toole County High School
Sunburst, Montana

Shelley E. Partin
Pamilico County Junior
High School
Baysboro, North Carolina

Marvin Selnes, Victor Rames,
Arlyn Thomas, T.R. Maursetter,
Robert Simonson, LaVonne Zeeb
Patrick Henry Junior High School
Sioux Falls, South Dakota

Troy D. Bridges
Spartanburg High School
Spartanburg, South Carolina

Criteria for Excellence in Science Teaching and Career Awareness

An exemplary science teaching/career awareness programs is characterized by the following criteria:

Goals

1. Understand that science is applied on the job not just by scientists, technologists, and related workers, but by all paid and unpaid workers in every field. Today's citizens must master at least basic life science and physical science principles in order to function competently in an increasingly technical world;
2. Understand that the interests and abilities necessary for success in all careers exist within all groups, regardless of sex, race, creed, nationality, or handicapping conditions;
3. Can make appropriate personal, societal, and on-the-job decisions which apply scientific principles and processes;
4. Exhibit essential personal attributes and interpersonal skills such as the ability to reach consensus;
5. Can find information about science-related careers, evaluate that information in terms of their own interests and aptitudes, and act on the conclusions they reach.

Curriculum

1. Includes in its regular science courses examples of the way scientific principles are applied on the job, in the home, and in the community;
2. Provides interactions between students and role models, including people from a range of jobs and educational backgrounds, representing both genders and all races, to demonstrate how science is used by all;
3. Informs students about the education and experience needed for careers which build on science skills, and teaches them how to acquire further career information;
4. Integrates science instruction with other subjects so students can see how science skills are used.

Instruction

1. Engages students individually and cooperatively in hands-on science activities related to careers;
2. Uses individual and community resources for technological updates and career information;
3. Includes a range of learning strategies, levels of difficulty, and types of incentive appropriate for the diversity of students.

Evaluation

1. Reflects the significance of career awareness in science instruction, and is an ongoing, integral part of the learning program;
2. Includes a variety of evaluation procedures so that (a) affective and cognitive gains may be assessed, (b) students are helped to make career decisions, and (c) data may be used to make program changes;
3. Is reported to and used by students, parents, administrators, and the community.

Teachers

1. Achieve success in meeting the above criteria, and know that their performance will be taken into account in their job evaluation;
2. Know about science career applications, draw from their own hobbies or work experience to teach about them, and share their enthusiasm with students;
3. Participate in ongoing inservice training which updates and broadens their science career awareness and ability to impart the information to students.

Career Education Exemplars

Susan Leach
Jones Middle School
Upper Arlington, Ohio

James H. Kolb
Marine Science Center
Poulsbo, Washington

(Gloria) Marge Melle
Jefferson County Schools
Lakewood, Colorado

Tish McKinstry
McLean High School
McLean, Virginia

Gil Turpin
Science Mentor Program
Indianapolis, Indiana

Criteria for Excellence in Non-School Settings

Science education needs to be a lifelong, year-round process. Despite the significant role that formal in-school education plays in influencing science literacy, schools alone can't do the job. By the time children finish high school, they have spent 11,000 hours in the classroom and roughly 65,000 waking hours outside. During that time, they watch about 15,000 hours of television—the dominant out-of-school activity. Many potential learning hours are open to be filled.

The fact that the average American hears the words "education" and "school" as synonyms is not in the best interests of either the American public or the American school system. Science educators should accept the importance of the out-of-school, or informal educational milieu for meeting the science education goals that most professionals share.

Potential settings for informal learning range from institutions like museums, zoos, aquariums, and nature centers to working in the garden, reading the news, watching television, or participating in scouting. While the latter sorts of experiences are too diverse for formal evaluation, an excellent science learning opportunity in the institutional non-school setting:

1. Clearly defines some problem or issue in science;
2. Provides visitors with
   - a sense of wonder and excitement;
   - a sense of scientific progress underpinning exhibits or programs;
   - opportunities to view scientists as human beings;
   - information presented as the current state of the art, not as if static throughout time;
   - cognitive information clearly presented;
   - concrete experiences—involvement, discovery, adventure;
   - awareness of the implications a given aspect of science has for past, present, and future technology;
   - awareness of the social implications of the science content presented;
   - awareness of opportunities to participate in science, as a consumer, as a decision maker, and through career choices;
3. Includes ancillary materials that extend experience beyond the informal setting and promote lifelong learning;
4. Includes mechanisms for assessment;
5. Evidences responsiveness of exhibit and program to feedback received. How have visitors influenced the exhibit or program?

Science in Non-School Settings Exemplars

Sally Luttrell-Montes
Pacific Science Center
Seattle, Washington

Martha Monroe
Dahlem Environmental
Education Center
Jackson, Michigan

John Santos
Nature's Classroom
Southbridge, Massachusetts

Kenneth H. Finch, Ronald L.
Bilodeau
Science Museum of Greater
Hartford, Inc.
West Hartford, Connecticut

Ivan Dyreng
East High School
Salt Lake City, Utah

Richard C. Clark
Minnesota State Department
of Education
St. Paul, Minnesota

G. Thomas Walls, Jr.
Susan Steele Planetarium
Richmond, Virginia

Judith A. Brueggeman, Susan
Matthews
Busch Gardens Zoological
Education Project
Tampa, Florida

Karen Holm
Kampsville Archaelogical Center
Kampsville, Illinois

David A. Wilson
Missouri Botanical Gardens
St. Louis, Missouri

Criteria for Excellence in Preservice Elementary

Program goals enable teachers who will:
1. Develop positive attitudes toward science and science instruction;
2. Make children aware of the importance of science in their lives;
3. Implement courses which meet national criteria for excellence;
4. Commit to continue learning science by reading and participating in professional organizations and inservice training.

Curriculum of science content and process courses:
1. Include 12 semester hours of study balanced among biology, physical science, and Earth science;
2. Are specifically applicable to elementary school classrooms;
3. Illustrate societal implications of science and technology;
4. Provide competence in the problem-solving processes of science, such as observing, classifying, measuring, interpreting, predicting, and experimenting.

Curriculum of science teaching methods courses:
1. Provide at least three semester hours of study after a science base has been acquired;
2. Provide options for a wide range of student abilities and socio-economic and ethnic backgrounds over the developmental span of grades K to 6;
3. Provide hands-on activities for problem solving and process skill development;
4. Develop classroom environments that promote positive attitudes;
5. Use media, computers, and all appropriate technology in the classroom;
6. Use a variety of instructional strategies and materials including local/community resources and personnel;
7. Model procedures for ensuring safety in science activities.

Instruction
1. Field and laboratory activities are integrated in science content study, with a minimum of 30 percent of program time spent investigating phenomena in direct experiences with scientific equipment;
2. Field experiences include a progression of opportunities to plan and teach science lessons to elementary students each year;
3. Facilities, equipment, instructional materials, and library holdings promote science learning and exemplify outstanding school science programs.

Evaluation
1. Addresses science teaching techniques, science content and processes;
2. Is congruent with instruction;

3. Uses continuous feedback to keep the program current in both science education and science.

Faculty Characteristics

1. Faculty teaching science content and methods courses are qualified, experienced, and interested in providing high quality instruction;
2. Faculty model sound instructional design, translating science education trends into classroom practice;
3. Methods faculty have specific training and experience in the teaching of science; keep current in science education research; model participation in professional science education associations; and maintain contact with elementary schools.

Preservice Elementary Exemplars

James R. Gress
University of Toledo
Susan M. Johnson
Ball State University
Muncie, Indiana

Joseph P. Riley II, Michael Padilla
University of Georgia
Athens, Georgia

Suzanne Stevens, Horace McMahan
Eastern Michigan University
Ypsilanti, Michigan

Donald R. Daugs
Utah State University
Logan, Utah

Rebecca Slayden-McMahon
Austin Peay State University
Clarkesville, Tennessee

Iva D. Brown
University of Southern Mississippi
Hattiesburg, Mississippi

Criteria for Excellence in Preservice Secondary Teacher Education in Science

With regard to the preservice education of secondary teachers in science, the exemplary program will prepare teachers who:
1. Display positive attitudes toward science and science education;
2. Recognize the inherent value of science in the lives of all people;
3. Implement courses which meet the SESE criteria for excellence in high school teaching;
4. Seek continuing professional self improvement.

With regard to background in science concepts and processes, the program that prepares the preservice secondary teacher will:
1. Require specialization (that is, preparation equivalent to the bachelor's level) in one of the following: biology, chemistry, Earth and space sciences, general science, physical science, or physics; as well as significant coursework in at least two additional areas of science. In each specialization offered, NSTA-recommended standards for that area shall be met or exceeded.
2. Require supportive preparation in mathematics to at least introductory calculus, in the scientific and educational use and interpretation of statistics, and in a variety of computer applications to science teaching;
3. Require that supplementary authorization to teach additional sciences, if offered, involve coursework at least equivalent to a minor in that area (20 semester hours of carefully selected coursework);
4. Cover the science content of the secondary science curriculum through courses specially designed for secondary school teaching;
5. Provide an understanding of the societal implications of science and technology;
6. Provide competence in observing, classifying, measuring, interpreting data, predicting, and experimenting.

With regard to training in science teaching curriculum, approaches, and strategies, the program preparing preservice secondary teachers will provide the candidate with:
1. At least three semester hours in pedagogy, ideally undertaken just prior to student teaching;
2. Knowledge and skills to work effectively with students of differing abilities and socioeconomic and ethnic backgrounds;
3. Personal problem solving and process skills, acquired through significant hands-on experience;
4. The knowledge and skills to develop a classroom environment that

promotes positive attitudes toward science;
5. The ability to use media, computers, and other technologies appropriately in classroom science instruction;
6. The ability to use a variety of teaching strategies and materials, including community resources and resource persons;
7. An understanding of how to insure safety in science activities;
8. An understanding of techniques for evaluating pupil progress which are congruent with instruction and which address the processes as well as the content of science learning.

The candidate's instructional program will be carefully organized to provide:
1. Field and laboratory experience: at least 30 percent of the candidate's science coursework should be based on direct experience in investigating phenomena with scientific equipment.
2. Opportunities to observe exemplary science teaching, teach science to children in schools, and receive appropriate feedback and reinforcement from skilled observers. These experiences should begin early in the program with observation and tutoring, and gradually proceed through various forms of small and large group instruction.
3. Full-time involvement as a practice teacher in at least one secondary school for at least one full semester or term, which includes experience in both planning for and teaching science. Student teaching at more than one level, or in more than one area of science, is strongly recommended.
4. Experience with a wide range of student abilities and socio-economic and ethnic backgrounds;
5. Significant contact with the kind of facilities, equipment, instructional, and library materials which are typical of outstanding science teaching/learning programs;
6. A continuous feedback process to keep the program current in both science and science education.

Faculty who serve in the preservice education of secondary teachers in science should:
1. Have the qualifications, experience, and interest to provide high-quality instruction;
2. Model exemplary instructional design and practice in science teaching;
3. Keep current in science and science education research;
4. Participate in professional associations in science education;
5. Maintain a close continuing association with cooperating secondary schools.

Criteria for Excellence in Science Supervision

Excellent science supervision is evidenced by a science supervisor who
1. Has the scientific knowledge necessary to communicate successfully with science teachers;
2. Is active in professional activities in and out of the local district;
3. Works with teachers to plan and implement after-school and summer enrichment opportunities for students;
4. Provides leadership and assistance in identifying creative and talented science students.

Excellent science supervision is evidenced by planning and curriculum development which
1. Takes the long-range view;
2. Has the support of teachers and the administration;
3. Bases curriculum revision on current research and on goals and objectives that meet the needs of the local community and of society at large;
4. Includes all dimensions of science education—content, process, attitudes, and science/technology/society;
5. Includes a grading/reporting system that is consistent with the nature of science.

Excellent science supervision is evidenced by a program of inservice opportunities which
1. Provides experiences which are tied to the long-range plans, goals, and objectives of the curriculum;
2. Includes a science center where teachers can share, solve, and create;
3. Enables teachers to study, evaluate, and recommend solutions to local problems of concern to them;
4. Addresses the professional development of individual teachers.

Excellent science supervision is evidenced by an administration which supports science education by
1. Providing an adequate budget for supplies, equipment, and staff development;
2. Cooperating with teachers to identify strengths and remediate weaknesses;
3. Facilitating linkages among classroom teachers, administration, and the local governing board;
4. Fostering ongoing staff planning.

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Shirley L. Watt, managing editor
Alice E. Green, assistant editor
Mary L. Liepold, editorial assistant