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ABSTRACT

Written as a follow-up to the first sourcebook published in 1967, this document seeks to address emerging issues in successful science supervision which have become important since 1967. Among the issues addressed are: (1) an increasing emphasis on the evaluation of students and programs; (2) demands for accountability; (3) changing working relationships with teachers and administrators; (4) emphasis on public relations; (5) concerns of safety and liability; and (6) need for flexibility by the science supervisor in the face of rapid change in science education. (Author/RE)

2nd Sourcebook For Science Supervisors

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TABLE OF CONTENTS

SECTION 4: RESOURCES FOR THE SUPERVISOR

PREFACE

In 1967 the National Science Supervisors Association, realizing there was a real need to give assistance to those who were involved in science supervision, developed *A Sourcebook for Science Supervisors*. That volume, published by the National Science Teachers Association, proved to be much in demand and was of real help to science supervisors everywhere.

While many of the timely and forward-looking ideas in that volume can still be readily applied in successful science supervision, many new challenges for the science supervisor have emerged since 1967. Among these new challenges are an increasing emphasis on the evaluation of pupils and programs; demands for accountability; changing working relationships with teachers and administrators; a new emphasis on public relations; increasing concerns with safety and liability; and the need for a science supervisor to be more flexible than ever before as new trends in science education take place at an accelerating pace.

If this volume is of assistance to science supervisors in carrying out their most important task—improving science learning—it will have been a source of great satisfaction to the many contributing authors who have shared their ideas and experiences. The National Science Supervisors Association appreciates the work these authors have done in the cause of effective science supervision.

WARREN CLASSON
President of NSSA, 1975–76

ACKNOWLEDGMENTS

The work of the NSSA Commission on the Role of the Science Supervisors provided the basis for the first *Sourcebook for Science Supervisors*, published in 1967. There was a great demand for that publication, and many attested to its usefulness.

In 1971, NSSA conducted an informal survey through its newsletter to determine the need for revising the first *Sourcebook*. From this survey, it was evident that some chapters were still useful but that several new topics needed to be covered. Edwin Smith provided the leadership which fostered the decision to produce the *Second Sourcebook for Science Supervisors*. In this book are a few old familiar chapters accompanied by important new topics which have emerged in the last five years.

This book was planned and edited by Mary B. Harbeck and Walter Knighton. Its strength lies in the many authors who were willing to share their experience and know-how with others. We owe our appreciation to John Fowler and Helen Connolly of NSTA, who did final editing and oversaw the production of this book. To these persons and others involved in the production of this publication, we wish to offer this statement of our gratitude for their interest and assistance.

INTRODUCTION

The purpose of a science consultant, supervisor, director, coordinator, department chairperson, or curriculum specialist is to improve the learning situation for students so that they become knowledgeable of the content, process, and application of science and the responsibilities of scientists to themselves and to society.

Titles vary with school systems and do not necessarily differentiate duties and hierarchy of prestige. "Supervisor" will be used as a general term for a science-trained person at any level, who has the responsibilities for the above purposes.

The *Sourcebook* is intended to offer suggestions regarding the possible duties, responsibilities, and activities of a supervisor. It should be clearly understood that no one person can adequately accomplish all that is described. However, it should assist the supervisor in the selection and execution of his or her priorities which may vary from time-to-time and year-to-year. Further, the *Sourcebook* will be useful to science educators who teach supervisors, students of education, school administrators, and others by giving insight into the varied duties and responsibilities of supervisors.

In the last hundred years, society has become increasingly dependent upon science. Early emphasis was on discovery and explanation. By mid-century, technology seemed to dominate most school texts and instruction, which resulted in a loss of basic understanding of scientific principles. The revolt against this condition began with mathematics and science teachers in the mid-fifties and was given sharp impetus by Sputnik and subsequent federal support. The result was the start of the many "alphabet" programs. In the late sixties, a swing away from science was due mainly to changes in social attitudes and the resulting blame put on science for the ills of society. These ills were not so much because of science itself, but because of the desire for materialistic things made possible through technology without due regard to consequences. Recently, many institutional programs have been developed in an attempt to more adequately meet the needs of all pupils.

Science is needed for general education in our highly developed technological and environmentally-minded society and for the many occupations that require varying amounts and kinds of scientific knowledge. Science is not an isolated, intellectual study, but is a subject that deals with content and process and with applications to societal needs. Thus, it has application to and is involved in many vocations and avocations, including research scientist, teacher, doctor, lawyer, nurse, technician, forester, photographer, athlete, homemaker, congressman, building custodian, plumber, carpenter and fireman.

The pendulum is now swinging back, to varying degrees, in schools throughout the country. Science supervisors are in a position to take the leadership among fellow educators and academicians in determining the long range goals for science education and their implementation through suitable science programs and facilities. May you be ready to proceed with vigor to meet this challenge!

EDWIN M. SMITH
Past President, NSSA

A History of Curriculum Changes

Charles Butterfield, *Science Chairman, Ramsey Public Schools, Ramsey, N.J.*

Kathryn Hartman, *Free-lance Science Editor, San Francisco, Calif.*

Nyles Stauss, *Assistant Professor of Science Education, Virginia Commonwealth University, Richmond, Va.*

Factors providing stimuli for reforming the high school science curriculum

In the years following the close of World War II, both science and technology advanced rapidly—so rapidly, in fact, that a shortage of scientists, technologists, and technicians developed. Pressure was exerted on the school system, particularly at the high school level, to relieve the shortage by stimulating larger numbers of capable students to become scientists, technologists, and technicians. The demand for this type of manpower was one of the factors that triggered an examination of and subsequent reform of the high school science curriculum. [27]

At the same time it became apparent that the economic future of the United States was closely aligned with the ability of its research scientists to advance knowledge and the ability of its technologists to be innovative in applying knowledge. In addition, an awareness grew that the economic well-being of a nation was closely related to the quality and extent of the education of its citizenry. This awareness created a demand for better schooling and a growing pressure for increasing numbers of youth to attend college. Thus the economic well-being of the nation was another factor that provided a stimulus for reforming the high school curriculum. [16]

National security was a third factor stimulating curricular reform. Scientific and technological advancements made during World War II, such as a sustained nuclear reaction and the development of radar, very likely contributed to a growing conviction that the development of the untapped scientific and technological resources of a nation did more to ensure its security than expanding its agricultural and manufacturing industries. The importance of the concern for national security is evident when one realizes that the National Defense Act and the National Science Foundation supplied the major financial support for reforming the science curriculum. [27]

The high school science curriculum of the 1940s and 1950s

By 1957 different groups of scientists had become sufficiently concerned about the teaching of science at the high school level to decide that something needed to be done about the high school science curriculum. What was the high school science curriculum like during the 1940s and the 1950s? What were the textbooks like? What was the laboratory activity like?

The content of high school science textbooks was largely descriptive. Little theory had been included to make the descriptions meaningful. Furthermore, some of the theory that was included had already been revised or discarded by the scientific community. In chemistry and physics textbooks, technology (applied science) had been emphasized. When these books were revised, the latest technological developments were added; little of the out-of-date technology was removed; and the textbooks became not only longer but quite dated. [27]

The biology textbooks used in the high schools were equally as outdated as the chemistry and physics textbooks. The content of the typical biology text did not reflect the major advances, such as those in molecular and environmental biology, made during the first half of the 20th century. Nor did they include the topics of organic evolution and human reproduction. These topics had not yet been accepted as suitable ones for a high school biology textbook.

The content of science textbooks was organized around a series of topics. The organization resulted in textbooks filled with facts. Students were usually required to memorize these facts—facts that were the answers to examination questions—for most test items were written on the factual (recall) level.

Often the content of high school science textbooks was presented to students as a body of certain and verified knowledge. The approach of both authors and teachers was authoritarian and dogmatic. Scientific topics were presented without tracing their development, without giving their current status, and without stating what is not known about them. Only a few capable teachers were able to fill in these important missing gaps of learning. [16]

A method for solving problems, "the scientific method," was included in most science textbooks. The scientific method was almost always described as consisting of four or five ordered steps. It was presented dogmatically as the procedure followed by scientists in solving problems and as a way in which students could solve their own problems.

Laboratory exercises were largely confirmatory in nature; they were rarely investigatory. In chemistry, for example, the laboratory work gave the students an opportunity to produce chemicals that they had studied in textbooks and to observe the properties described in textbooks. In some high school biology courses there was little laboratory work. In others, much of the laboratory time was devoted to collecting and classifying specimens and to dissecting preserved specimens. [16]

Reform of the high school science curriculum:
A chronological approach

1. Physical Science Study Committee

Although concern about the science curriculum had been growing in the academic and industrial communities during much of the period following World War II, it was not until the mid 1950s that the first curriculum reform committee, the Physical Science Study Committee (PSSC), was organized. The Committee, made up of representatives of four universities and one research laboratory, began discussions in 1956 at a conference held at the Massachusetts Institute of Technology. This conference was led by Jerrold R. Zacharias, an MIT physics professor. There was general agreement among the committee members that the traditional high school physics textbook was out-of-date, that it obscured the science of physics by stressing technology, and that it was made up of a series of topics overloaded with facts and lacking unity or conceptual structure.

The Committee decided that no amount of effort expended on revising an existing textbook would make its organization acceptable to the scientific community. This meant that it would be necessary to discard the traditional physics text and develop a new one. A broad outline for a new physics course was agreed upon before the 1956 conference adjourned. [14]

During the fall of 1956 and the winter of 1957, research physicists and physics teachers under the direction of the PSSC Steering Committee outlined, drafted, and discussed material for the new course. A staff of sixty people assembled in the summer of 1957 to continue work on the material. The majority of the staff members were high school and university physics teachers with the university people playing the dominant role. The staff produced a preliminary version of the text and the laboratory manual. These materials were taught in eight trial schools in 1957–58. Feedback from the trial schools was used in revising the materials.

In 1958, Educational Services Incorporated (ESI) was formed to administer the continued development of the PSSC physics course. In 1958–59, the revised PSSC materials were tested in a larger number of trial schools. The procedure was repeated in the next school year, and in 1960 final copy was submitted to the selected commercial publisher (D. C. Heath and Company).

To provide a valid picture of their discipline, the authors of the PSSC physics course chose several themes to run through the course and unify it. The content of the course was then developed around the chosen themes. In the preface of the first edition of the PSSC text, Dr. James R. Killian, Jr., Chairman, Board of Trustees of ESI, states that this textbook is the heart of a course in which physics is presented not as a mere body of facts but as a continuing process by which people seek to understand the nature of the physical world.

Laboratory work is an integral part of the PSSC course; it complements the text. It is investigative and student centered in nature. The student makes observations and measurements; he or she collects and interprets data. For example, students compute the size of a molecule from their own measurements of a film of oil that is one molecule thick.

Just as the student's role in the laboratory of a PSSC class differs from the role in the laboratory of a traditional class, so does the teacher's role differ. The teacher is not a director of the laboratory as much as an observer and a guide who usually guides by raising pertinent questions—an investigative process used as a model in the development of other curriculum projects. [16]

When the PSSC physics textbook was published in 1960, it was supported by closely correlated materials: a laboratory guide and a set of new and inexpensive apparatus, films, standardized tests, a growing series of paperback books, and a comprehensive teacher's resource book. A few years later, film loops were added to this list of correlated materials. In 1965, second editions of the text, laboratory guide, and teacher's resource book were published; third editions were published in 1971. In 1966 the *Advanced Topics Supplement* was published. This supplement treats selected topics in greater depth than the text and presents additional topics as well. [21]

2. Chemical Bond Approach Project

In June of 1957, a group of high school and college teachers, who later became known as the Chemical Bond Approach (CBA) Committee, assembled for the first of a series of conferences to study the status of the high school chemistry program. The members of the Committee agreed that the chemistry program at the secondary level—a program that had changed little since 1920—needed far more than the addition of up-to-date terminology and factual information to present an accurate picture of modern chemistry. Rather, it needed to be reorganized and reformed.

For a chemistry program to give high school students a realistic picture of modern chemistry, the program should enable students to see that chemists combine experimental data they have collected in the laboratory with imaginative ideas in order to extend their understanding of chemical systems. The Committee, therefore, chose to present the material in the text in such a way that it portrayed this relationship between experimental data and theory. Furthermore, the Committee chose to construct CBA experiments in such a way that the students are given an opportunity to apply ideas to the data they collect.

The Committee chose chemical bonds as the central theme for organizing the content of the CBA program. Structural changes, random arrangement and random motion, energy and reaction kinetics are other themes running through the program.

In the CBA program, it is recommended that the teacher introduce each laboratory experiment with a prelab discussion and conclude it with a postlab discussion. In many of the experiments, all the students in a class pool the data they have collected and use the pooled data in answering the problem posed in the experiment. All experiments are investigatory; none are confirmatory. They are used to introduce or extend a topic presented in the text.

The first trial edition, which was written in 1959, was used experimentally in nine high schools during that year. On the basis of feedback from teachers and students, the second trial edition was prepared and tested in 1960 by seventy-six teachers in one or more of their classes. Further revision and testing of the material took place in 1961 and 1962 school years. The program, which was published in 1963 by the Webster Division, McGraw-Hill Book Company, includes a student text entitled *Chemical Systems*, a laboratory manual entitled *Investigating Chemical Systems*, and teacher's guides for text and laboratory manual. [14, 16]

3. Chemical Education Material Study

A committee composed of high school and college chemistry teachers was established in 1959 by the American Chemical Society to study the traditional high school chemistry program and to propose a more suitable one. This committee recommended a reorganization of the secondary-level chemistry program and outlined the basic ideas for the Chemical Education Material (CHEM) Study program.

In the CHEM Study program, concepts are developed inductively. The development is based on experimental data which students can collect in the laboratory or which they can obtain from the demonstrations of the teacher, films, or experiments described in the text. Furthermore, the data must be understandable to a high school chemistry student. Instead of the laboratory program running parallel with the text, as in the CBA program, it is an integral part of the text, requiring students to make certain specific observations at fixed points in the program so their observations can be used in developing the textual material. In addition to the experimental nature of chemistry, the CHEM Study program emphasizes structural chemistry and reaction kinetics.

The first trial edition of the CHEM Study materials was tested in twenty-four high schools during the year 1960–61. The writing of this edition had begun in June, 1960. The revised materials, the second trial edition, were tested in a larger number of high schools in the following school year. The second trial edition was revised, rewritten, and expanded into the third trial edition which was tested in a still larger number of high schools.

The final version of the CHEM Study materials was published by W. H. Freeman and Company in 1963. The program consisted of a text entitled *Chemistry: An Experimental Science*, a laboratory manual entitled *Chemistry: An Experimental Science Laboratory Manual*, teacher's guides for text and laboratory manuals, open-book achievement tests, films, and programmed sequences. Also produced were two inservice training films for teachers and twenty-six films for use in the classroom.

When it came time to revise the CHEM Study text and laboratory manual, the CHEM Study Steering Committee invited commercial publishers to submit proposals for revising the materials and seven publishers did so. The Steering Committee selected three publishers to develop revisions based on their proposals. The companies granted revision rights were D. C. Heath and Company, Houghton-Mifflin Company, and Prentice-Hall, Inc. [16, 27]

4. Biological Sciences Curriculum Study

Having secured financial support in late 1958 from the National Science Foundation (NSF) for a curriculum study in biology, the American Institute of Biological Sciences organized the Biological Sciences Curriculum Study (BSCS). Headquarters for BSCS were set up at the University of Colorado, and a Steering Committee was created to provide guidance on matters of policy.

Early in the discussions held by the Steering Committee, the members of the Committee became convinced that many biology students did not have an opportunity to understand the true nature of science because they were in biology programs written by authors and taught by teachers who presented the subject in an authoritarian and dogmatic manner. Because the Steering Committee opposed authoritarian teaching of science and because it felt that there was no one right way to present the science of biology, the Committee decided that BSCS should develop three different versions of a tenth-grade biology text. Much of the material in each of them would be the same. However, a different approach and a different organization would be used for each version.

Accordingly, the seventy participants in the 1960 writing conference were divided into three writing teams. One team was to build its version (blue) upon the area of molecular biology; one was to use the area of cellular biology (yellow version); and one was to use the area of ecology (green version). Each team was charged with the responsibility of producing a text, laboratory manual, and teacher's guide for typical students in a tenth-grade biology course in an American high school.

Furthermore, nine unifying themes were chosen to be woven through each of the versions. The individual themes could be used in various ways and in varying degrees in the three versions. The nine themes are science as investigation and inquiry, the history of biological concepts, complementarity of structure and function, diversity of type and unity of pattern, change of organisms through time, genetic continuity, complementarity of the organism and its environment, regulation and homeostasis, and the biological basis of behavior.

Through extensive use of inquiry, students would be given numerous opportunities to collect and to interpret data, the conviction being that a student would gain an understanding of the nature of science by participating in science.

The beginning sections of the first trial edition of each of the three versions were ready for distribution at the briefing session held in August for the 105 teachers chosen to test the materials in the 1960 school year. Each of the teachers had agreed to participate in the activities of one of the fifteen different centers scattered throughout the United States. All of the teachers affiliated with any one center were to teach the same version.

During the school year, the teachers in a center met weekly to compare their experiences, to compile a report for the BSCS office, and to discuss (usually with a nearby university professor present as a consultant) the materials and ways to present them effectively. The centers were the means for providing BSCS with valuable feedback and the teachers with an inservice training program.

At a second writing conference, held in the summer of 1961, the second trial editions of the three versions were prepared. These were tested in the school year of 1961. The testing program continued through the 1962 school year.

Manuscript for the commercial edition of the three versions was written during the summer of 1962 and during the 1962 school year. All three versions were available for use in the school year 1963. Each carried a 1963 copyright date. The blue version was entitled *Biological Science: Molecules to Man* (Houghton-Mifflin Company); the yellow, *Biological Science: An Inquiry into Life* (Harcourt Brace Jovanovich, Inc.); and the green, *High School Biology: BSCS Green Version* (Rand

McNally and Company). Student materials for each version included both text and laboratory experiments, bound together or separately, but sold only in sets. Material to aid the teacher in presenting the program is available for each version as are a series of tests for each version. In addition, BSCS produced the *Biology Teacher's Handbook* for use with all three versions. The Handbook contains a statement of the philosophy of BSCS and an account of its history, as well as other general information. The second edition of the handbook was published in 1970.

The second commercial edition of each version was published in 1968. In both the blue and the green revisions, the experiments were written into the text. In the back of the blue revision there were, also, twenty additional investigations. BSCS again revised all editions by 1973. All editions now have the laboratory activities integrated into the text.

Ancillary materials developed under the auspices of BSCS include a series of laboratory blocks, each of which is a six-weeks in-depth study of one topic; a series of single topic inquiry films, each of which is four minutes in length and presents several biological problems; four volumes entitled *Research Problems in Biology*, each volume containing forty unsolved problems in biological science that would be suitable for a highly motivated student to investigate; and a series of twenty-four pamphlets, each devoted to a single biological topic and published individually over a period of three years from 1962 to 1965. In January 1970, an inquiry-oriented slide program was published.

By the summer of 1970, five of eight pamphlets had been published in a series entitled *BSCS Patterns of Life Series*, and three of a projected series of forty books had been published. The three books are part of a series entitled *BSCS Science and Society Series*. The books in this series are on topics of interest to a large segment of society and are written for the layperson.

Following procedures similar to those used for developing the three basic versions, BSCS has developed a second level course for high school students entitled *Biological Science: Interaction of Experiments and Ideas* (Prentice-Hall, Inc.) and a course for academically disadvantaged high school students, *Biological Science: Patterns and Processes* (Holt, Rinehart, and Winston, Inc.). BSCS has also developed two sets of materials for mentally handicapped students.

BSCS has given free permission for use of its materials to teams of biologists and educators abroad if they will adapt the materials to their own biological environment, their own culture, and their own educational organization. Adaptations of BSCS materials have been produced in more than fifty countries and in twenty languages.

BSCS decided that a curriculum study group should remain in continuous existence instead of phasing out, as had several of the study groups. The National Science Foundation, the major source of funds for producing BSCS materials, felt its responsibility to science education did not include indefinite support of an organization such as BSCS. BSCS and NSF agreed upon a plan by which NSF funding was reduced and NSF gradually terminated its interests in BSCS materials. The royalties BSCS received from the distribution of its materials has enabled it to convert from a foundation-sponsored project to a non-profit educational corporation. [3, 16, 22]

5. Earth Science Curriculum Project

Following some preliminary study, the Earth Science Curriculum Project (ESCP), sponsored by the American Geological Institute (AGI) and financed by NSF, held a conference in the summer of 1963. The conferees were scientists from the various fields of earth science and science educators. Their task was to prepare an outline for a ninth-grade earth science program.

The first writing conference was held in the summer of 1964 and the materials produced at the conference were tested the following school year. The materials were revised during the summer of 1965 and were tested during the 1965–66 school year. Manuscript for the third and final version, the commercial version, was prepared during the spring and summer of 1966. The text entitled *Investigating the Earth*, and the teacher's guide, were published under a 1967 copyright by Houghton-Mifflin and revised in 1972.

Additional resource material for the teacher includes the *Geology and Earth Sciences Sourcebook for Elementary and Secondary Schools* produced by AGI prior to the establishment of ESCP; a *Reference Series* of pamphlets presenting the various kinds of resource assistance available to earth science teachers; and three of a series of field study guides.

Investigating the Earth is an interdisciplinary science text. Material from the fields of astronomy, geology, geography, oceanography, and meteorology is included, as is material from the fields of geochemistry, geophysics, and space physics. In addition, material from the areas of biology, chemistry, mathematics, and physics is used as needed.

Behavioral themes, concept themes, and an historical theme have been woven through *Investigating the Earth*.

The behavioral themes define attitudes and abilities that the student should develop as a result of the course. The conceptual themes relate primarily to the major principles underlying earth science; they are content themes the student should come to understand. The historical theme emphasizes the development of earth science. [11]

The behavioral themes (can also be called processes or intellectual skills) are science as inquiry, comprehension of scale, and prediction. The conceptual schemes are universality of change, flow of energy in the universe, adjustment to environmental change, conservation of mass and energy in the universe, earth systems in space and time, and uniformity of process: a key to interpreting the past. The historical theme is stated as historical development and presentation.

The laboratory investigations are integrated into the text. They are designed to give the student opportunities to be a thinker, an innovator, an inquirer, and a discoverer. In some of the investigations, students use the natural world directly; in others, they use laboratory equipment and instruments (kits are available for purchase that correlate with the laboratory activities); and in still others, they use models and/or data that are provided.

On April 1, 1970, major federal funding of ESCP was terminated. However, sufficient funds have been provided to finance the completion of a pamphlet series, a reference series, and a film series, and to finance for a limited time the continuation of certain services such as filling requests for information and free materials.

Feeling that the task assigned to ESCP—improvement of education in the earth sciences—had just begun, AGI in conjunction with the ESCP staff started two more programs, the Earth Science Teacher Preparation Project (ESTPP) and the Environmental Studies Project (ES). Both were charged with the task of improving education in earth sciences. ESTPP concentrated its efforts on the preservice education of earth science teachers. ES, recognizing that every student is in an environment, believed every student can learn from that environment. Therefore, in ES materials, three environments were considered: the inner environment of the student, the student's immediate environment, and the global environment. ES has concentrated on publishing task cards in these areas for individual use by the student.

In 1973, the project, under the name of Earth Science Educational

Program, moved its headquarters from the University of Colorado at Boulder to Evergreen College, Olympia, Washington. [14, 16, 27].

6. Harvard Project Physics

In 1962 James Rutherford, a high school physics teacher (now Chairman of the Science Education Department of New York University and past president of the National Science Teachers Association), invited Gerald Holton, a physicist at Harvard University, and Fletcher Watson, a science educator at Harvard University, to join him in developing a new high school physics course. Guided by the story line and the objectives of Holton's college text, *Introduction to Concepts and Theories in Physical Science*, the collaborators prepared a course outline and some instructional materials. They secured funding from the Carnegie Corporation to field test the materials. The successful field test of the materials and the interest of the NSF in the financing of the development of another high school physics course were among the stimuli that triggered the formation of Harvard Project Physics (HPP) in 1964. The three collaborators became the directors of the project.

In certain aspects, *Project Physics* differs markedly from the high school science courses developed by other study groups; however, the procedures used for developing the course were similar to those used by other study groups.

The directors chose to develop a course in which physics is depicted in its historical and cultural setting. They, also, chose to develop a physics course that would be attractive to a large number of high school students. The directors assumed that students will differ in learning skills and capabilities. They, also, assumed high school physics teachers will differ in training, in philosophy of science education, and in style of teaching. To accommodate for these differences, the directors chose a multi-media program.

Student materials for *Project Physics* include a text, handbooks, laboratory equipment, programmed instruction booklets, tests, film loops, films, overhead transparencies, and books of selected readings. The text, consisting of six units, is a systematic guide for the student. It is needed to teach the course, but the course cannot be properly taught using only the text. At the end of each unit is a study guide containing many different kinds of items from which students can choose those that will be most helpful to them in learning physics. There is a handbook for each unit which contains the experiments, additional activities or investigations students may do on their own, and notes on the film loops.

HPP developed forty-eight film loops. In the majority of these, students have to take data from the projected images as they view them and then analyze the data. In addition, HPP has produced three sound films. Each of these films accurately portrays some of the social, cultural, psychological, and historical aspects of scientific work.

Teacher materials for *Project Physics* include a teacher resource book and teacher briefing films. The teacher briefing films, of which there are twenty-one, portray methods and styles of teaching *Project Physics* in addition to the management of equipment. HPP does not intend for these films to substitute for teacher training institutes. [16, 24] A second edition of *Project Physics* was published in 1975.

7. Engineering Concepts Curriculum Project

The Man-Made World was developed by the Engineering Concepts Curriculum Project (ECCP) based at the Polytechnic Institute of Brooklyn. The program consists of a textbook, laboratory manual, and teacher's manual. Basic contributions to the textbook and laboratory manual were made by scientists and engineers from Bell Telephone Laboratories, International Business Machines Corporation, the Johns Hopkins University, Massachusetts Institute of Technology, Purdue University, and the Polytechnic Institute of Brooklyn. The teacher's manual was prepared by a group of high school teachers in consultation with the authors of the text and laboratory manual.

The material was tested in twenty-eight high schools in the school year of 1966. In the following school year, it was tested in sixty-three schools. Further testing was conducted in the school year of 1968. Commercial publications (McGraw-Hill Book Company) of part of the program carry a 1968 copyright date; others carry a 1969 date. A second edition was published in 1971. From the evaluation program conducted by the staff of ECCP, the staff has concluded that students in grades 10, 11, and 12 should be able to understand the concepts in the course, that two years of mathematics is an adequate prerequisite for the course, and that boys and girls can do equally as well in the course if they have the same academic capabilities.

The developers of *The Man-Made World* have chosen to present relevant problems—problems relevant to the technological world in which humans live today, such as routing a police car through city streets. The problem is studied first; then the system for solving the problem is presented; and finally the principle on which the system is based is introduced. Hopefully the course will help a student to understand how man-made devices can be used to serve humans and how technology can be used to solve some of today's most pressing social problems.

When commercial publishers of science textbooks widely used in the 1950s revised these textbooks in the 1960s and 70s, they incorporated into their books, usually in modified form, some of the features introduced into or stressed in science programs developed by the curriculum reform groups. [16, 24]

Reform of the elementary and junior high school science curricula

The typical elementary science series on the market in the 1950s had been constructed by selecting a set of science topics thought to be suitable for children and developing the topics on the basis of either the "spiral" or "block" approach. Experiments included in the textbooks were frequently activities, such as constructing a compass or making an electric motor. Although most children enjoyed doing the activities, scientists felt that the activities had little relation to what scientists actually do.

As the high school science courses being developed began to meet with success in the trial schools, concern grew over the elementary school and junior high school science curricula. In 1960 the American Association for the Advancement of Science (AAAS), with financial support from the National Science Foundation, sponsored three regional conferences to determine whether the nation should undertake a major effort to improve the elementary school science curriculum. The membership of each conference included teachers, school administrators, science educators, and scientists.

The conferences reached the following conclusions: Instruction in science should be a regular part of the curriculum from kindergarten to grade nine (and beyond, but the conference considered only these grades), a major effort should be undertaken, and this effort should involve improving both course materials and classroom teaching. [17]

The participants agreed that science, including its concepts and methods of inquiry, could be taught to children in ways that are consistent with the meaning and spirit of modern science. [20]

Among the groups set up to develop elementary science materials were the Commission on Science Education, established in May 1962 by AAAS and the School Curriculum Improvement Study (SCIS), established in the winter of 1962 by Robert Karplus, a professor of theoretical physics at the University of California in Berkeley. The Elementary Science Study (ESS) had been launched in 1960 by ESI, which had expanded since its establishment in 1958 into areas of subject matter other than high school physics. The work of each of these study groups, as well as the work of another elementary science project, and the work of six junior high school curriculum projects are briefly described in the remainder of this section. [20, 27]

1. ELEMENTARY SCIENCE PROJECTS:

A. Commission on Science Education. Under the direction of the Commission on Science Education, scientists, science educators, and teachers developed *Science—A Process Approach* (S—APA), a science program for kindergarten through grade 6. The primary goal of the program is for children to become skilled in using the processes considered to be fundamental to all sciences.

In kindergarten through grade 3, the children work with eight basic processes: observing, classifying, measuring, communicating, inferring, predicting, using space/time relations, and using numbers. In grades 4–6 emphasis is placed upon five integrated processes that are rooted in the basic processes: formulating hypotheses, controlling variables, interpreting data, defining operationally, and experimenting.

Because the ability to use the processes of science is the primary goal of the program, rarely are children asked to learn particular facts or principles. Rather, they are expected to learn such things as how to observe solid objects and their movements and how to classify liquids. The content serves as the vehicle for teaching the processes. The distribution of content chosen from the various fields of science is as follows: physical sciences, 40 percent; life sciences, 25 percent; mathematics, 18 percent; earth sciences, 10 percent; and social and behavioral sciences, 7 percent.

The processes may be considered intellectual skills. The development of an intellectual skill is from the concrete and specific to the abstract and general. This progression is thought to depend upon the accumulated effects of learning a considerable variety of relatively concrete principles.

According to Robert Gagné, the American psychologist who identified the processes taught in *Science—A Process Approach*, each process consists of a hierarchy of subskills and no subskill can be learned effectively until those below it in the hierarchy have been mastered. Accordingly, a hierarchy of subskills was built for each of the processes. The hierarchies form the framework of *Science—A Process Approach* and the rationale for selecting and ordering the sequence of exercises making up the program.

No student text was written for this program. Instead, the exercises, which make up the teacher's guide, were written as instructions for the teacher. A special effort was made during the trial period to control the difficulty of the exercises. The aim of the project was that 90 percent of the students should achieve 90 percent of the stated objectives. Appraisals, which are built into each of the exercises, are based on the behavioral objectives stated in the exercise and may be used by the teacher to measure the achievement of students.

Much effort has been expended by the project in teacher preparation. Most elementary teachers need training in the processes of science, science content, and techniques for teaching the program. The commercial publisher of S—APA is Ginn and Company, Xerox Educational Division. [20, 23]

A revision of *Science—A Process Approach* has been completed (Ginn and Company, 1974). S—APA II, as it is designated, continues the emphasis on the processes of science. The program format has been altered to a modular format. These modules carry no grade level designation. If the program is begun in the kindergarten, then 12–15 modules are normally recommended per year. The total program is constituted of 105 modules. The contents of each module are stored in a labeled drawer. Clusters of modules are packaged in a "Modpod."

S—APA II, according to the publisher, offers greater choice of content and greater sequence planning flexibility. While over-all topics and activities have undergone change, behavioral objectives have not. The revised program also offers more opportunity for self-teaching and individualization. The program is available as a total system, by grade-level sets, by learning clusters, or by individual modules, thus offering greater flexibility.

B. *Science Curriculum Improvement Study.* The Science Curriculum Improvement Study (SCIS) project, located at The University of California, Lawrence Hall of Science, has developed sequential, but ungraded, physical science and life science units for use in an elementary science program for kindergarten through grade 6. Each unit consists of a teacher's guide, a kit of materials, and usually, a student booklet. SCIS believes that "the early years of school should provide a highly diversified program based heavily on concrete experiences" and that "the concrete experiences must be presented in a context that helps to build a conceptual framework for operations with abstractions." SCIS also believes that "to be able to use information obtained by others, to benefit from the reading of textbooks and other references that present information in abstract form, the individual must have a conceptual structure and a means of communication that enable him to interpret the information as though he had obtained it himself." SCIS calls "this functional understanding of scientific concepts 'scientific literacy.'" [20] SCIS sees scientific literacy as its basic goal. To attain this goal SCIS blends content, process, and attitude in its units. Attitude is considered to be the development of a free and positive approach toward science.

The content is built around major scientific concepts with interaction serving as the pivotal concept. Four major scientific concepts—matter, energy, organism, and ecosystem—are used to give depth to the concept of interaction.

SCIS has singled out four analytical tools (process-oriented concepts) as being basic to the ability to pose and interpret problems in scientific investigations. They are: property—to be used by a child to describe an object or a concept; reference frame—to show a child the relativity of all properties to each other and to demonstrate that more than one description or viewpoint may be correct; system—to help a child isolate related objects of interest and thereby to pinpoint where interaction occurs; and scientific model (a mental image of a real system)—to lead a child from evidence of an interaction to a hypothesized explanation of the parts of the system. The scientific and the process-oriented concepts and the physical and intellectual involvement of a child in his or her environment constitute the framework upon which the SCIS program is built.

In addition, SCIS structured the program on the levels related to three of the four developmental stages of a child's thinking, as described in the work of Jean Piaget, a Swiss epistemologist. The first level involves a child's transition from the preoperational to the concrete operational stage. The second level is the concrete operational stage. The third level involves a child's transition from the concrete operational stage to the stage of formal reasoning.

A teacher of a SCIS unit plays two roles. When he or she is introducing a concept, he or she directs the class. When the students are working individually or in small groups on their own experiments, the teacher serves as an observer who listens to each child and notices how well they are progressing in an investigation and as a guide who leads them to see the relationship of their findings to the scientific concepts. The commercial publisher of SCIS is the Rand McNally Company. [20]

SCIS has successfully adapted many of its units for use by blind students. In addition, the Lawrence Hall of Science has developed a program entitled *Outdoor Biology Instructional Strategies* (OBIS). OBIS consists of a series of individualized modules in outdoor education for middle-grade students.

C. *Elementary Science Study.* The Elementary Science Study (ESS) project developed investigative, open-ended units for kindergarten through grade 8. A school may use ESS units to supplement its science program, or it may build its basic science program from ESS units. ESS has not planned its units sequentially. Rather it takes the position that a school should work out its own sequence based on its own objectives.

The units tend to be very flexible. They can be used for varying lengths of time and in a range of grades. Several units lend themselves to application in social studies and mathematics as well as science.

There is a teacher's guide for each unit, but there are no student texts. For most units there is a package of materials and/or a class kit for 30 students, or a teacher kit and a student kit for 6 students. Some units contain only a teacher's guide. These guides suggest student activities utilizing common materials that can be obtained locally. For certain units there are also student sheets, sets of illustrations, or worksheets. Film loops and some 16-mm films have been produced to accompany certain units. ESS units are not based on a specific theory of how children learn, or on the logical structure of a discipline, or on any societal need. Instead, ESS has used student involvement as the basis for its units. Whether or not a student will become involved in an ESS unit is determined to a large extent by how children respond to the material during the developmental stage of the unit. In ESS units, a child works with things, for ESS feels that things encourage children to ask questions and to find their own answers to their questions. ESS also tries to create situations in which children need to talk to each other.

A teacher of an ESS unit must believe that children learn best from their own activity. The teacher serves as a consultant and as a guide, doing those things for children that they cannot do for themselves.

ESS materials are being published by the Webster Division of McGraw-Hill Book Company. [23] Currently the publisher is re-editing portions of certain teacher's guides adding insights on classroom management and methodology. In addition, some new units are being produced by the publisher along the ESS format.

D. Conceptually Oriented Program in Elementary Science. The Conceptually Oriented Program in Elementary Science (COPES) project, based at New York University, began in the middle 1960s as a pilot study for investigating the feasibility of constructing elementary science materials around a conceptual scheme. The principle of the conservation of energy was the scheme used in the pilot study. With the success of this study, COPES began the development of an elementary science program for kindergarten through grade 6, based on conceptual schemes.

In the material for kindergarten through grade 2, COPES developed seven introductory concepts. Each concept is related to one of three fundamental ideas: *Descriptions of Matter and Energy*, *Matter and Energy Interactions*, and *Variability*. For example, the introductory concept, "all objects can be characterized either as living or nonliving," is related to the fundamental idea listed first.

The introductory concepts are basic to the development of the conceptual schemes. In addition, nine skills selected for development throughout the seven-year curriculum are all introduced at the K–2 level. The skills are: analyzing, classifying, communicating, experimenting, interpreting, mathematical reasoning, measuring, observing, and predicting.

Five interrelated conceptual schemes form the core of the program for grades 3–6. They are: the structural units of the universe, interaction and change, the conservation of energy, the degradation of energy, and the statistical view of nature. COPES believes that long after students have forgotten the facts they have learned, they will remember the conceptual schemes and will retain some feeling for the nature of science. Equipment for the program is inexpensive, and teacher's guides for K–6 are available from COPES, New York University. [10, 23]

2. Middle School/Junior High School Science Projects:

A. Introductory Physical Science. By 1963 it had become apparent that many of the high school students enrolled in PSSC physics and in trial classes of CBA or CHEM Study chemistry lacked the intellectual and/or the mathematical skills required for satisfactory performance in these courses. Primarily to eliminate the deficiencies, a junior high school physical science course, *Introductory Physical Science* (IPS), was developed in much the same way as the PSSC program had been developed. A group of scientists and science teachers wrote, tested, and then revised the material. Four years later it was published by a commercial publisher. Uri Haber-Schaim, a physicist on the staff of Educational Services Incorporated (ESI), guided its development.

The IPS course is laboratory-oriented with the investigations written into the textbook. The investigations were designed so that they can be performed in a classroom equipped with flat-top desks and a sink. The student's laboratory notebook is a wire-bound book of blank sheets of quadrille paper. Because numbers of teachers found that their students needed guidance, a notebook containing instructions has been published independently of the program.

As in CBA chemistry, a story line runs through the IPS course. In IPS students first investigate mass, one of the properties of matter. This investigation paves the way for them to investigate a second property of matter. This process is continued until students have worked their way through a series of investigations on the properties of matter and have acquired sufficient background to be introduced to the atomic model.

The course was designed both for those students who plan to take biology, chemistry, and/or physics, and those who plan to take only biology. It is usually taught in either the eighth or ninth grade; however, some schools use IPS as a terminal science course in the senior high school. The program is published by Prentice-Hall, Inc. [16, 27]

B. Physical Science II. In 1967, ESI merged with the Institute for Educational Innovation (IEI) to form Educational Development Center, Incorporated (EDC). EDC is one of the twenty regional laboratories authorized in the Elementary and Secondary Education Act of 1965.

Under the direction of Uri Haber-Schaim of EDC, a second course in physical science entitled *Physical Science II* (PS II) was developed. It is designed as a sequel to IPS and is intended for high school students who have taken the IPS course.

Two major topics were chosen for the PS II course. One topic deals with some of the fundamentals of the chemistry and physics of electric charge, the other with forms of energy and conservation of energy. The story line of the PS II course is built on these topics and is a continuation of the story line of the IPS course.

The developers of the PS II course realize that a two-year sequence of physical science is not now part of the standard science curriculum in American schools. They believe, however, that the basis for our present sequence of high school science courses is no longer valid. They see the IPS-PS II combination as a possible foundation for several sequences, ranging from IPS, PS II, and biology, to IPS, PS II, physics and/or chemistry, biology, and a second year of biology or earth science. [23]

C. *Time, Space, and Matter*. The junior high school science program entitled *Time, Space, and Matter* had its origin in the summer of 1962 during the Elementary Science Summer Study session conducted by Educational Services Incorporated. The project was transferred to Princeton University in April 1963 and was named the Secondary School Science Project. In 1968, the project became affiliated with Rutgers, The State University of New Jersey.

Time, Space, and Matter is made up of nine interrelated investigations that have been designed to enable the student to learn something about the nature and history of the physical world through direct observation and inference. A story line built around the themes of time, space, and matter provides continuity from one investigation to the next and incorporates material into the course from the disciplines of astronomy, chemistry, geology, mathematics and physics.

Each teacher folio, one for each investigation, contains an overview of the investigation, a list of the basic ideas that the investigation is designed to present, a list of equipment and supplies, suggestions for the allocation of time, and instructions for presenting the investigation. Students record their observations and their interpretation of their observations in a record book, originally a book of blank pages. As they make subsequent observations and interpretations, they refine what they have written. They continue to use the knowledge and skills they have acquired in successive investigations. The course is designed in this way so that students experience the investigative nature of science and learn to think of science as an ongoing activity.

For each laboratory investigation there is a student investigation book and special equipment and supplies. The investigation book provides a source of observations that students would not ordinarily be able to make themselves. Furthermore, the student may refer to the Science Reading Series. Some of the books in the series provide accounts of important observations, interpretations, and experiments in the words of the people who made them; other books provide background material. Each of the books is correlated with an investigation.

The teacher acts as a guide and as an active collaborator with the students. To play this role, he or she must understand the underlying philosophy of the course and be familiar with the sequence of the investigations and the laboratory procedures. Even though the teacher folios were developed to assist the teacher in presenting *Time, Space, and Matter*, it is strongly recommended that teachers attend a training program specially designed for those who plan to teach the course for the first time.

It is unlikely that any class can cover in one year all the material outlined in the teacher folios. Each teacher will have to make a number of choices, and in so doing it is hoped that he or she will develop the curriculum best suited for fulfilling his or her objectives. A teacher may choose to stress certain investigations or to teach one of several series of investigations that form a logical, self-contained sequence. [17]

D. The University of Illinois Elementary School Science Project. The program, written by professional astronomers and educators, is based on more than six years of classroom experimentation. It is interdisciplinary, drawing upon mathematics, physics, geophysics, and physical chemistry to develop understandings basic to astronomy. The program introduces physical principles that are applicable to the study of astronomy and emphasizes how astronomers have used these physical principles and their observations of celestial bodies to build conceptual schemes.

The Elementary School Science Project consists of six sequential and progressively more difficult books in astronomy. The books may be correlated with any basic science series in grades 5–9, or the six books may be used as a year course in astronomy at the junior high school level. [23]

E. Interaction Science Curriculum Project. After extensive classroom testing over a three-year period, *Interaction of Matter & Energy* (IME), a physical science program for grade 8 or 9, was published in 1968 by Rand McNally and Company. It was the first of a series of three junior high school courses to be developed by a commercial publisher using the procedure followed by the federally financed projects. The authors, working together as a writing team, prepared experimental editions which were used in classrooms throughout the country. Based on feedback gathered during the trial period, the experimental materials were revised for publication.

IME was designed to articulate between the elementary and secondary school science programs developed by federally financed study groups. It provides the student with opportunities to develop scientific skills and attitudes. In the laboratory, students conduct investigations, learning to collect and interpret their own experimental data and to construct generalizations from their interpretations. A teacher's edition and achievement tests accompany the student edition.

The Interaction Science Curriculum Project has completed a second and a third course for its junior high school series; *Interaction of Man & the Biosphere* (IMB) was published in 1970 and *Interaction of Earth and Time* (IET) was published in 1972. [17]

F. Intermediate Science Curriculum Study. Probing the Natural World is the title of the laboratory-centered junior high science program developed by the Intermediate Science Curriculum Study (ISCS) of The Florida State University. ISCS materials have been written to give the student a sequence of content and experiences that will enable him or her to understand the nature of modern science and the way scientific knowledge is gathered.

The content of level I is organized around the theme of energy, its forms and characteristics. Measurement and operational definition are the processes stressed. As defined by ISCS, an operational definition describes quantities in terms of how they can be detected and measured. The organizing theme for level II is matter, its composition and behavior. In this level the process of model building is emphasized. Content for level III is made up of a series of independent and relatively unstructured problem situations selected primarily from the biological and earth sciences. As the student investigates each problem, he or she utilizes the science concepts and investigative skills acquired at levels I and II. The processes of experimentation and investigation are emphasized in level III.

The activities for each of the three years are carefully sequenced to provide a story line for the student to follow. Early in the three-year sequence, students are guided in setting up the needed equipment and in interpreting their observations and data. As they proceed through the program, they are left more and more on their own.

Not only was the ISCS designed so each successive level builds on the previous level or levels, but it is also designed for individualized science instruction. Much of the student's work is done independently, with the teacher giving individual guidance as he or she moves among the students. Each students sets his or her own learning pace and the difficulty of the material is automatically adjusted to individual ability.

Departures from the story line, called excursions, have also been developed by the ISCS project. Excursions are designed to provide additional work on a given topic or a greater challenge for the more capable student. By careful selection of excursions, ISCS teachers can design a multitrack program suited to their own students. ISCS materials are published by the Silver Burdett Company. [23]

An upward extension of ISCS has been developed at Florida State University entitled *Individualized Science Instructional System* (ISIS). Various minicourses are being or have been developed so that a high school can plan its science program by selecting certain ones. ISIS is published by Ginn and Company (Xerox Educational Division).

Several additional programs have been developed in recent years; some still undergoing refinements at the present time. At the elementary level these include *Individualized Science* (IS), developed at the Research and Development Center of the University of Pittsburgh (commercial producer, Imperial International Learning Corporation, Kankakee, Illinois) [23] and the *Elementary School Sciences Program* (ESSP) being developed by Biological Sciences Curriculum Study (commercial publisher, J. B. Lippincott Company). [4]

At the middle school level, BSCS is in the process of developing a *Human Sciences Program* (HSP). This program is being designed as a three year middle school sequence. No commercial publisher has as yet been designated. [4]

In addition to the elementary and middle school programs, BSCS is also developing materials for Special Education. *Me Now*, for 11–13 year olds, has been completed, and *Me and My Environment*, for 13–16 year olds, is nearing completion. In the planning stages is *Me in the Future* which will feature career selection emphasis. Hubbard Scientific Company is publishing the first two Special Education programs. [4]

Summation of the work of the study groups in the late 1950s and the 1960s

1. Contributions to Science Education by the Study Groups

What contributions—contributions that should be considered when planning a science curriculum for the 1970s and 1980s—did the study groups (or projects) make to science education? First, the study groups perceived science as a way of studying the phenomena of nature in order to develop a better understanding of nature. To study nature, scientists make observations. From their observations they gather facts—the word *fact* denoting information gathered from repeated agreement of observations, and 'therefore,' having a high degree of credibility. With the facts, scientists formulate a hypothesis or a theory, a tentative explanation of these facts. Then they make predictions based on the hypothesis or theory. If they can verify the predictions, they will have additional facts to support their premise. If they cannot verify the predictions, they must revise, remodel, or on occasion, discard their original hypothesis or theory.

The information that the scientist gathers usually is organized logically with previously known information. Newly acquired information frequently is fitted into an existing organization, which may be called a conceptual framework. Sometimes new information forces a slight modification in the existing framework. The conceptual framework of a scientific discipline is often referred to as the structure of the discipline.

How did the study groups of the 1960s construct science programs that enabled a student to gather information, formulate hypotheses or theories, and make predictions for testing hypotheses or theories just as a working scientist does? In most of the science curricula developed by study groups, a number of conceptual schemes were chosen to serve as the framework of the program. The "genetic continuity of life" and "the conservation of matter" are two examples of a conceptual scheme. Inquiry-type activities in which the student solves a problem by conducting an investigation are used in developing each conceptual scheme.

As a scientist makes observations and interprets data, he or she uses certain scientific processes, such as measurement and inference, and uses the process of communication to report findings to other scientists. In varying degrees, the study groups have stressed the processes of science. In some programs the student is encouraged to communicate findings to his or her classmates, to compare results with them, and to defend a position he or she has taken by carrying out further investigations.

The study groups made several contributions to science education. Perhaps their most important contribution was the construction of science programs that enable students through active participation to develop an understanding of the nature of science. To construct these kinds of programs the study groups used conceptual schemes and inquiry-type activities; they emphasized scientific processes.

Second, to construct a program for presenting science as a scientist sees it, the study groups envisioned the teacher and the student functioning in different ways than they did in a traditional program. During most if not all of the time, the teacher of a program developed by a project is a guide, a consultant, and a pacesetter; the student is involved actively in the program. The attention of both the teacher and the student is directed toward the understanding of concepts instead of the memorization of facts. A second contribution of the study groups to science education was, therefore, the development of a new role for the teacher and the student.

Some of the projects have drawn attention to the desirability of writing behavioral objectives for each lesson or unit. Behavioral objectives establish clear-cut goals; they enable both a teacher and a student to identify just what it is that the student is to learn or be able to do at the completion of a given lesson or unit. For the teacher, behavioral objectives also serve as a guide in constructing evaluation items with high content validity. The use of behavioral objectives was a third contribution to science education.

Most of the study groups have developed complete programs, allowing the teacher to concentrate on strategy. Not all have written student textbooks, but all have prepared detailed teacher's editions or guides. Most study groups have constructed a testing program; many have developed visual materials; and numbers of groups have assembled kits of equipment and materials. Thus, the development of the complete program was a fourth contribution.

The humanistic approach used in *Project Physics* and the *Man-Made World* can be considered a fifth contribution to science education by the study groups. This approach may point the way for the next phase of curriculum reform in the 1970s and 1980s. [14, 17, 27]

2. Deficiencies of the Science Programs Developed by the Study Groups

What are the deficiencies of the science programs developed by the study groups in the late 1950s and the 1960s? First, many of the science programs were constructed as a program might be constructed for pre-science majors. Many science educators have criticized this approach and feel that science should be presented as general education.

A second deficiency, found particularly in the high school and junior high school programs, is their failure to interest a large number of students in science. One reason for this may be that many students find the courses to be too difficult. A second reason may be that students do not find a program built on the structure of the discipline to be inherently interesting as it was assumed the program would be. A third reason may be that study groups in planning a program did not take into account a student's previous experiences. Nor did they relate the subject matter to the problems of contemporary life. This does not mean that conceptual schemes, inquiry-type activities, and processes of science should be cast aside or emphasized less. Rather, it might mean that contemporary problems, especially those directly related to the student's life, should be considered in developing a science program.

An unsolved problem that may be considered here is the problem of training teachers to present the new programs. The study groups recognized that the programs they were developing would require a different style of teaching than conventional courses. In order to evaluate a program during the developmental stages, they usually required teachers to attend a briefing session or a special institute (often supported by NSF funds) before presenting the program for the first time. At the briefing session the teacher was instructed in the philosophy of the program and in teaching techniques and content that might be new. Even though most of the programs are now available commercially, most study groups continue to recommend special training for teachers before they present the program for the first time.

Rationale for a K–12 science program

The curriculum projects of the past decade and a half created a ferment in the planning of science curricula that rescued science teaching from the stagnation that had set in prior to this period; however, federal funding of projects has practically come to a halt. If we are to prevent another period of stagnation in science teaching, then the time has come to address ourselves to the future.

Planners of a K–12 science program for the coming decade need to concern themselves with certain major objectives:

A science program should reflect the character of science. It should present science as a never-ending search for information about nature; as a continuing intellectual quest to understand nature; as a product of man's intellect based on the assumptions that nature is not capricious and that natural effects have natural causes. It should reflect the nature of science as viewed by scientists. The understanding of the nature of science that students attain quite conceivably is related directly to the design of the science program in which they are enrolled and the manner in which the program is implemented. A new program should portray science as a dynamic on-going enterprise, continuing a pattern established by the curriculum projects.

A science program should foster the development of scientifically and technologically knowledgeable citizens—citizens who see the difference between science (man's search for and accumulation of knowledge about natural phenomena) and technology (the activities that result in the production of goods and services); citizens who understand the interrelationships between science and technology; citizens who appreciate the impact of science and technology on the quality of life.

In the past, two extremes have been embraced in regard to the inclusion of technological matter in a science program. Traditional courses often stressed technology almost to the exclusion of science. Many of the programs developed by study groups all but eliminated any mention of technology. Obviously, neither extreme prepares the student to function optimally in a society built upon the interaction of science and technology. Citizens should not only be scientifically literate but also technologically knowledgeable. A science program should reflect the interaction of science, technology, and society.

A science program should further the students' general education. Education from kindergarten through grade 12 is almost universally accepted in the United States, with many locales extending this range to include a two-year junior college or vocational-technical school education. The concept of the comprehensive high school is fundamentally adhered to at the secondary level. The Educational Policies Commission (1961) has stated that the fundamental purpose of education must be to develop the student's rational powers. All of this underscores our belief as a nation in a program of general education for all citizens—a program that provides the student with a broad foundation rather than specialization in a specific subject.

Furthermore, if a science program is to be an effective vehicle for educating students capable of functioning ably in a science-oriented society, the program should concern itself with contemporary problems, especially those problems directly related to the lives of students.

Youth of the coming decade are apt to reject a program of science instruction that does not concern itself with the vital problems facing society, for they seek involvement in the problems of our scientific-technological society. For a science program to have relevance for them it should have a humanistic component.

The content of a science program should be commensurate with the level of cognitive readiness of the students. Considering the various degrees of cognitive readiness (genetic and environmental affectation) encountered in the elementary school per se, as well as within a specified grade level, not only may cognitive readiness determine whether a child can learn certain concepts and intellectual skills, but even more importantly, the lack of cognitive readiness may adversely affect the child's attitudes. If the child experiences fear and frustration in the science program, he or she may develop a long lasting, if not permanent, dislike of science. Conversely, if the child is given experiences long after he or she is cognitively ready for them, he or she has lost in terms of time and personal satisfaction.

Study groups that developed elementary science programs have been well aware of the implications of Piaget's work. In the development of their materials they have taken into account Piaget's work and the research studies of others concerned with the nature of the learner and learning theory. However, some of the study groups that developed science materials for the secondary level failed to give adequate consideration to the levels of cognitive readiness of the students destined to use their materials. But, consideration of the nature of the learner cannot be ignored at the secondary level. While the general premise of Piaget's work is that children have reached the stage where they are capable of abstract reasoning by the time they have reached the secondary-school level, it should not be assumed that all children have arrived at this point. Furthermore, there are obviously degrees of abstraction and cognitive sophistication. There is, also, variation in the experiential background of the students. Thus, no less attention can be given to the nature of the learner at the secondary-school level than at the elementary.

The arguments advanced above should not be construed as a plea for easy science courses. Such a science curriculum would fail to provide the challenge needed to stimulate learning. There is little objection to rigor in a discipline, provided the degree of rigor is commensurate with the cognitive readiness of the learner.

The objectives of a science program should be stated clearly in *behavioral terms and should be drawn from the cognitive, psychomotor, and affective domains.* While the debate concerning the merits of behavioral objectives continues, and by all indications will not abate in the near future, it is certainly obvious to the discerning educator that the lack of well-defined objectives can reduce the effectiveness of a science program.

Most, if not all, of the study groups and, in recent years, commercial publishers as well have made a conscious effort to state clearly the philosophy of their programs so teachers might present the programs in the manner envisioned by the planners. These groups have conducted workshops and inservice training institutes to acquaint teachers who will be using their materials with the philosophy behind their program.

The necessity for such training sessions is almost universally accepted. Unless teachers are thoroughly grounded in the rationale and the philosophy of the program that they are teaching, they do not recognize many of its unique characteristics, characteristics that are vital to the effectiveness of the program. But, while this is a concern, another equal, if not even greater concern, is that of lesson-by-lesson or day-to-day objectives. Far too often, the content of the program is merely covered without any knowledge of, or any concern about the reasons why the material is important, what it forms a basis for, or what the student is to be able to do as a result of having studied the material. In fact, unless students have been given the objectives in behavioral terms at the outset, or soon after, they may never be certain what it is that they should have learned from the instruction.

The cognitive domain is not our only concern. Certain manipulative skills and techniques can and should be acquired by studying science. Behavioral objectives in the psychomotor domain will state for the teacher and the student which of these skills or techniques should be stressed in a given lesson.

In addition, science educators are becoming increasingly aware of the importance of the affective domain in a science program constructed to further a student's general education. Unless students become cognizant of the interrelationships of science and society and the ramifications of these interrelationships, unless students are enrolled in a science program that encourages them to develop wholesome and realistic attitudes toward their environment and toward human culture, society, and the individual, the science program may have failed to meet its most important challenge—the challenge of furthering a student's general education.

A science program should be composed of a variety of components. Even within a specific grade level, there are children with a wide range of interests and abilities. To enable the teacher to plan a science curriculum suitable for this diverse group, the science program should provide a variety of ancillary materials. Then the teacher can exercise individual judgment in the choice of materials and can structure the science curriculum in accordance with the needs of the class. Furthermore, the program should include sufficient aid for the teacher, especially at the elementary-school level, to enable him or her to feel comfortable teaching it.

By choosing a variety of ancillary materials and by using the suggestions given for varying teaching techniques, the teacher can prevent the boredom and resulting disinterest that often besets a class regardless of the original interest and enthusiasm. In addition, the greater the number of different approaches used by the teacher in presenting the material, the more likely is the student to achieve an understanding of the content.

The six major objectives discussed in this part constitute a rationale upon which a science program for the coming decade might be built. Such a program would capitalize upon the strengths of the science curricula developed by the study groups and projects in the late 1950s and the 1960s and would at least minimize their weaknesses. [5, 7, 14, 17, 19, 30]

APPENDIX: *Science Programs*

Developed by Study Groups with Publishers

(* denotes NSF or other federal funding support)

Grade Level	*Program*	*Publisher*
* Elementary Level	Child-Structured Learning in Science (being developed at Florida State University)	
	*Conceptually Oriented Program in Elementary Science (COPES) Developed by the staff of New York University, involves both process and concept teaching.	
	**Elementary School Sciences Program* (ESSP)—A multi-disciplinary program developed by BSCS for grades K-6.	J. B. Lippincott Company
	*Elementary Science Study (ESS) Developed by ESI, has both content and process base—made-up of many short units, school or teacher utilizes units as desired.	Webster Division McGraw-Hill Book Company
	*Individualized Science (IS) Developed at the Research and Development Center of the University of Pittsburgh.	Imperial International Learning Corporation
	**Science—A Process Approach* Developed by the AAAS with process development being the major theme—widely used in many parts of the nation.	Ginn and Company (Xerox Educational Company)
	**Science Curriculum Improvement Study* (SCIS) Developed at the University of California, a sequential program emphasizing both content and process. Noted for its well-developed life science program.	Rand McNally and Company
	Space, Time, Energy, and Matter (STEM) A program commercially developed utilizing the work of the funded projects as a basis, a blend of process and content.	Addison-Wesley Publishing Co.

Middle School/ Junior High School		
Astronomy	**The University of Illinois Elementary School Science Program* (grades 5–9)	Harper and Row Publishers, Inc.
Earth Science	**Time, Space, and Matter* Princeton and Rutgers Universities	Webster Division, McGraw-Hill Book Company
Life, Earth, and Physical	Interaction Series *Interaction of Man and the Biosphere* (IMB)	Rand McNally and Company
	Interaction of Earth and Time (IET)	
	Interaction of Man and Energy (IME)	
	Ideas and Investigations in Science—Physical and Biological Levels (IIS)	Prentice-Hall, Inc.
	**Probing the Natural World* (ISCS) Developed by the staff of Florida State University—a three year program. Involves individualized work and based on behavioral objectives.	Silver Burdette Company
Life Science	**Human Sciences Program* (BSCS), in preparation, program being designed for middle school/junior high school level.	
Physical	**Introductory Physical Science* (IPS) Developed by ESI and EDC.	Prentice-Hall, Inc.
	**Physical Science II* A second level course of IPS usually used at high school level.	Prentice-Hall, Inc.
High School		
Biology	**Biological Science: Molecules to Man* (BSCS Blue Version)	Houghton Mifflin Company
	**Biological Science: An Inquiry into Life* (BSCS Yellow Version)	Harcourt Brace Jovanovich, Inc.
	**High School Biology BSCS Green Version*	Rand McNally and Company

APPENDIX: *Science Programs*

Developed by Study Groups with Publishers
(* denotes NSF or other federal funding support)

Grade Level	*Program*	*Publisher*
High School Biology	**Biological Science: Patterns and Processes* (BSCS Special Materials)	Holt, Rinehart and Winston, Inc.
	**Biological Science: Interaction of Experiments and Ideas* (BSCS Second Course)	Prentice-Hall, Inc.
	*BSCS Laboratory Blocks	D. C. Heath and Company
Chemistry	**Chemical Systems* (CBA Project)	Webster Division, McGraw-Hill Book Company
	*CHEM Study	W. H. Freeman and Company
	Revisions of CHEM Study	D. C. Heath and Company; Houghton Mifflin Company; Prentice-Hall, Inc.
Earth Science	**Investigating the Earth* (ESCP)	Houghton Mifflin Company
Engineering	**The Man-Made World* (ECCP)	Webster Division, McGraw-Hill Book Company
Physics	**Physics* (PSSC)	D. C. Heath and Company
	**Advanced-Topics Supplement* (PSSC)	D. C. Heath and Company
	**Project Physics*	Holt, Rinehart and Winston, Inc.
Multidisciplinary	**Individualized Science Instructional System* (ISIS)	Ginn and Company (Xerox Educational Division)

REFERENCES

1. American Association for the Advancement of Science. *Science—A Process Approach*. AAAS, Washington, D.C. 1967.
2. American Association for the Advancement of Science. *Science—A Process Approach II*. Orientation Package, Introduction. Ginn and Company, Lexington, Mass. 1974.
3. Biological Sciences Curriculum Study. *About BSCS Biology*. BSCS, Boulder, Colorado. 1969.
4. Biological Sciences Curriculum Study. *BSCS Newsletter*, Nos. 55 (April 1974), 56 (September 1974), 60 (September 1975), 61 (November 1975).
5. Brandwein, Paul F. *Building Curricular Structures for Science*. NSTA, Washington, D.C. 1967.
6. Bruner, Jerome S. *The Process of Education*. Vintage Press, New York, N.Y. 1960.
7. Butts, David, editor. *Designs for Progress in Science Education*. NSTA, Washington, D.C. 1969.
8. Chemical Bond Approach Project. *CBA Newsletter*. McGraw-Hill Book Co., Manchester, Missouri. Feb. 1961, April 1963.
9. Chemical Education Material Study Newsletter. University of California, Berkeley. May 1967.
10. *COPES Newsletter*. Center for Educational Research and Field Services, School of Education, New York University, N.Y. 1975.
11. Earth Science Curriculum Project. *Investigating the Earth*, Teachers Guide, Houghton Mifflin Co., Boston, Mass. 1967.
12. Elementary Science Study. *Introduction to the ESS*. McGraw-Hill Book Co., Manchester, Missouri. 1966.
13. Gagne, Robert M. "Elementary Science: A New Scheme of Instruction," *Science*. Vol. 151; Jan. 1966.
14. Haney, Richard E. *The Changing Curriculum: Science*, ASCD and NEA, Washington, D.C. 1966.
15. Harbeck, Mary, editor. *A Sourcebook for Science Supervisors*. National Science Teachers Association, Washington, D.C. 1967.
16. Hurd, Paul D. *New Directions in Teaching Secondary School Science*. Rand McNally and Company, Chicago. 1971.
17. Hurd, Paul D. and James J. Gallagher. *New Directions in Elementary Science Teaching*. The Wadsworth Publishing Co., Belmont, California. 1968.
18. Ipsen, D. C. *Issues in Elementary School Science*. NSTA, Washington, D.C. 1970.
19. Jacobson, Willard. "Elementary Science in the Seventies" in *Developments in Elementary School Science*. AAAS, Washington, D.C. 1970.
20. Karplus, Robert and Herbert D. Thier. *A New Look at Elementary School Science*. Rand McNally and Company, Chicago, Ill. 1969.
21. Lockard, J. David, *Report of the International Clearinghouse of Science and Mathematics Curricular Developments—1967*, University of Maryland and the AAAS, 1967, 1968.
22. Lockard, J. David. *Eighth Report of the International Clearinghouse of Science and Mathematics Curricular Development—1972*, University of Maryland and the AAAS, 1972.
23. Lockard, J. David. *Sixth Report of the International Clearinghouse of Science and Mathematics Curricular Developments—1968*, University of Maryland and the AAAS, 1968.

24. National Science Foundation (2). *Course and Curriculum Improvement Projects.* Superintendent of Documents, Washington, D.C. 1966 and 1970.
25. Phillips, John L. *The Origins of Intellect: Piaget's Theory.* W. H. Freeman Co., San Francisco, Calif. 1969.
26. Schmuckler, Joseph, *et al. Chemical Education for the 1970's—Chaos Revisited.* Department of Science Education, Temple University, Philadelphia, Pa. 1972.
27. Thurber, Walter A. and Alfred T. Collette. *Teaching Science in Today's Secondary Schools.* Allyn and Bacon, Inc., Boston, Mass. 1968.
28. Triezenberg, Henry, editor. *Individualized Science: Like It Is.* NSTA, Washington, D.C. 1972.
29. Trump, Lloyd, and Delmas Miller. *Secondary School Curriculum Improvement: Proposals and Procedures.* Allyn and Bacon, Inc., Boston, Mass. 1968.
30. Wisconsin Department of Public Instruction. *A Guide to Science Curriculum Development.* Madison, Wisc. 1971.

Section 1

The Role of the Science Supervisor

A Performance Model

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Accountability is the watchword in education today. But the question is, "Accountable to *whom* and *for what?*" A science supervisor is not immune to accountability; his or her responsibility is that of upgrading science instruction through involvement of the teacher, administration, community, and all professional channels. The effectiveness of the supervisor's work can be assessed through desirable changes in behavioral patterns of children, as demonstrated in the development of scientific attitudes, skills, usable knowledge, and methods of solving problems. In seeking these behaviors in children, what does a science supervisor do?

The model proposed here is one which should help the science supervisor and coordinator (or in small schools, the department head) to determine what his or her job description is in terms of competencies expected by administrators. Each competency is stated in performance terms. The basic outline of competencies, taken from *Assessment of Professional Performance: The Highland Plan* [2], was modified to fit various role descriptions of science supervisors.

This author's eleven years experience as a science supervisor in public schools has confirmed the fact that a science supervisor's role is constantly changing. Thus, this model is not meant to be a static role description. Unique needs of a school system should demand modification, addition, or deletion of specific tasks in the model.

The science supervisor, with his or her administrator, can utilize the model to identify a role description suitable for the school system's needs and the individual's skills. The agreed-upon role description can then be used as an evaluation device for the supervisor's performance. Clarified role descriptions in performance terms give direction and meaning to the task of science supervision. When one's role is clarified and one's performance is evaluated in terms of role expectations, then the questions of accountable to whom and for what can be intelligently answered.

The model

The responsibilities of the science supervisor fall into the following basic divisions:

Curriculum and instruction

The effective Science Supervisor who coordinates his or her efforts with others for cooperative development of the instructional program will:

1. assume leadership in developing school-wide science education philosophy consistent with system philosophy.
2. contribute to the development of a system-wide science education-curricular structure.
3. develop comprehensive goals and related sequences of performance objectives in science and test these sequences.
4. analyze the results of tests and revise goals and sequences accordingly.
5. cooperatively develop instructional guidelines and resources, and make provision for their use and refinement.
6. develop and administer assessment programs and inservice programs for science staff members.
7. develop programs of science activities for students consistent with school system philosophy.

In cooperation with other staff members, the effective science supervisor, consistently seeking improvement of instruction and of the total instructional program in science, will:

1. keep informed about significant new developments in science curriculum and instruction.

2. stimulate and assist staff members in investigating and evaluating promising new developments in science education.
3. implement science instructional changes under way and secure staff support for them.
4. work with the science staff to support and strengthen the instructional staff assessment program by: communicating the philosophy effectively; securing staff cooperation and support; assisting science staff members in selecting appropriate and significant objectives for professional growth; assisting in the development and execution of professional growth plans, including means of measurement; and completing required general evaluations.
5. conduct research projects related to science curriculum and instruction.
6. initiate proposals relative to supplemental funding of science curriculum and instructional projects.
7. make and evaluate recommendations concerning science programs, materials, and tests in cooperation with science staff.
8. work for science curriculum development and improvement through a program of regular meetings with science staff.
9. prepare an annual report of status, accomplishments, needs, and unresolved issues in the area of science education.
10. resolve conflicts within the area of science education.
11. contribute to overall efforts by accepting responsibility for special assignments.

Staff personnel

In recruitment and selection of science staff, the effective science supervisor will:

1. work for and in the employment cycle of the school system.
2. participate in the implementation of developed recruitment programs for certificated personnel.
3. exhibit professional behavior which will attract capable and desirable personnel to the school system.
4. collect data from which judgments can be made about prospective candidates for vacancies.
5. make a positive contribution to the visitation phase of the recruitment and selection process for certificated personnel.
6. recommend to the appropriate person in the school system the candidate who is best qualified for each science vacancy.

7. develop science recruitment materials.
8. encourage capable student teachers in science to seek a teaching career.

Assignment, transfer, and work load

The effective science supervisor assumes responsibility for assignment, transfer, and work load of science staff; he or she will:

1. consult with other administrators regarding assignment of science staff, and enlist their cooperation in making the process as effective as possible.
2. help make work assignments based on the strengths of the individual in relationship to the description of the job.
3. help make science instructional loads equitable and fair for each employee.

Orientation of the school employees in science

The effective science supervisor participates in the orientation of the school employee in science; he or she will:

1. develop orientation programs for new science employees to introduce them to the school system's philosophy, materials, curriculum, and community resources.
2. develop programs and procedures which provide the opportunity for experienced staff personnel in science to assist the new science education employees.

Staff management

As part of his or her staff management role, the effective science supervisor will:

1. develop a cooperative and positive relationship with other school personnel to achieve the goals of the school system.
2. stimulate staff morale, promote organizational purpose and readiness to change, and pursue traditional goals of efficiency and economy.
3. exhibit rational administrative behavior in job-relevant situations which will encourage other school personnel to trust and respect his or her leadership.
4. place organizational needs and goals above one's own professional aspirations.

In terms of personnel development, the effective science supervisor will:

1. develop comprehensive inservice educational programs which are well organized and well planned.
2. communicate to all members of the school system the nature of the professional development program and how its objectives relate to their area of concern.
3. provide opportunities for selected professional development of science employees under his or her supervision.
4. secure the cooperation and involvement of all affected personnel in preparing science budgets based upon the needs of the science education program in the school system.
5. prepare a realistic budget for the science education program.
6. develop cost estimates of proposals that would allocate budget funds in accordance with expressed needs and budget limitations.
7. inform science personnel who are responsible for budget funds of the amounts of funds available.
8. provide for efficient purchasing procedures and expenditures of funds under his or her control.
9. check the receipt of equipment and supplies, and report to the proper school officials.
10. arrange for efficient purchasing through proper bidding procedures.
11. secure established procedural approval before obligating the expenditure of budget funds.
12. establish an accurate and efficient system of controlling the expenditure of science funds.
13. keep informed of the availability of Federal, State, and local sources of revenue.
14. secure all possible funds from available sources that are necessary for the efficient implementation of the total science program.

School buildings and equipment

The effective science supervisor, having responsibility for school buildings and equipment, will:

1. establish an effective means of inventory of all science equipment in the system.
2. keep informed of advances in science education programming, building design, equipment, and materials.

3. survey the adequacy of existing facilities and equipment; analyze results of these surveys to develop an overall plan for meeting the needs of the system.
4. arrange opportunities for staff to become involved in the planning of new construction in science instructional areas.
5. submit requests for repairs, alterations, and improvements to proper staff members.
6. provide for care of and respect for science physical facilities and their usage.
7. plan for and supervise the effective use of materials and supplies.
8. follow stated procedural practices in the requisition, storage, and distribution of science materials and supplies.

School-community relations

To foster good relations between the school and the community, the effective science supervisor will:

1. contribute to the development and implementation of a system-wide, school-community relations program.
2. interpret the policies, objectives, and conditions of the science program to others in the school system and the community.
3. create a climate which is conducive to strengthening the lines of communication between school and home.
4. utilize media available to communicate to others in the school system information regarding science education.
5. use media such as science fairs, exhibits, projects, etc. to inform the community about the school science program.
6. develop assessment instruments to determine whether the community understands the science education program.
7. use special weeks and special educational programs to show the community what schools are accomplishing in science education.
8. develop and maintain an up-to-date listing of organizations and clubs which can be valuable sources of support for school science programs.
9. prepare a community file of parents and others willing to share their specialized knowledge.
10. consult with school personnel in the planning, production, and presentation of specific communications.
11. provide assistance to staff members in preparing and submitting articles for publication.

12. provide staff members with assistance and materials for exhibits at educational conventions, workshops, and seminars.
13. evaluate the relative effectiveness of various communication media and channels.

Professional growth

The effective supervisor will:

1. help to identify and select desirable professional growth projects to be undertaken by management and staff personnel.
2. participate actively in group undertakings for professional growth such as workshops, conferences, study groups, planning and research projects, pilot programs, and appraisal and evaluation seminars.
3. identify and assign priorities to significant professional growth activities related to science.
4. follow a plan of personal professional growth activities.
5. belong to and participate in science professional organizations, such as NSTA, NSSA, and state science organizations.
6. encourage staff membership in professional science education associations.

Summary

Precise role descriptions written in performance terms enable one to clarify administrative expectations and to develop a self-competency evaluation form. In developing a role description, be realistic. Consider time alloted for the tasks, finances available, the needs of the school system, and the specific strengths and weaknesses of the supervisor. Capitalize on individual strengths, and seek ways to acquire new professional behaviors when performance weakness is found. As changes occur, renegotiate the role description with the administrator. Removing the ambiguity of role expectations can facilitate harmonious, productive science supervision.

REFERENCES

1. Anderson, Hans O. "The Supervisor as a Facilitator of Self Evaluation." *School Science and Mathematics* Vol. 62; October 1972.

2. *Assessment of Professional Performance: The Highland Plan.* Highland Public Schools, Highland, Indiana. 1970.
3. Harbeck, Mary Blatt, editor. *A Sourcebook for Science Supervisors.* National Science Teachers Association, Washington, D.C. 1967.
4. "NSTA Position Statement on School Science Education for the 70's." *The Science Teacher* 38:46–51; November 1971.
5. Ogletree, James R. "Changing Supervision in a Changing Era." *Educational Leadership* Vol. 29; March 1972.
6. Ploutz, Paul F. "Survey of the Science Supervisor." *The Science Teacher* 28:41–45; October 1961.

The Role of the State Science Supervisor

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State, regional, and local science supervisors all have a common goal: the improvement of science instruction for all students. The problems of science curriculum, theory, methods of development, strategies for coördination and articulation, and techniques and procedures for implementation are all within the domain of the science supervisor. Local science supervisors are involved in day-to-day operations of a given school system, while the state and regional (area) supervisors are involved in providing assistance and services to local supervisors and teachers. Regional or area science supervisors are not a part of each state's educational system. However, a great benefit of the regional or area organization is that the area science supervisor provides more direct services to local classroom teachers. The role of the state science supervisor varies somewhat from state to state. However, there are many common functions and activities that each state science supervisor performs. In this chapter, three broad categories will be used to represent the role of the state science supervisor: development of the state science supervisor's position; functions and activities of the state science supervisors; and history and functions of the Council of State Science Supervisors (CS^3).

Development of the state science supervisors' positions

For most states, the science supervisor positions came into being following the enactment of the National Defense Education Act of 1958. Much of the energy and time of these first supervisors was used in the implementation of the National Defense Education Act, through the laborious mechanics of the science materials acquisition program. As this acquisition program became more routine and additional personnel were employed, considerably more time and effort has been given by state science supervisors to the more basic educational aspects of science education.

Functions and activities of the state science supervisors

The state department of education (called the department of public instruction in some states) often becomes involved in curriculum development by providing leadership to local school systems through the efforts of the state science supervisor. For the state science supervisor to provide effective leadership, he or she must be able to identify local needs, understand local attitudes, and identify local leadership potential. The state science supervisor also provides curriculum leadership at the state level. To be effective at the state level, the state science supervisor must be fully aware of the diverse science education practices in the state, the rate of adoption and/or adaptation of curriculum projects, and the role of administrators in curriculum decisions. He or she must also be cognizant of the appropriate procedures for initiating new science curriculum projects. The state science supervisor performs a variety of services for the regional or local levels; he or she should:

1. establish an effective communication system with local science supervisors.
2. help to organize and establish committees which work in the development and implementation of curriculum change.
3. assist local systems in analyzing their present program(s) to help establish needs and priorities.
4. assist in defining and implementing a program to meet the needs for inservice education of teachers.
5. bring national viewpoints and trends in science education to teachers and administrators at the local levels.
6. assist in the development of articulated sequences from kindergarten through secondary education.
7. establish state science committees to work on developing guidelines for the development of "new" science thrusts (e.g., the metric system).
8. foster and maintain cooperative and harmonious relationships with

science and science education departments in colleges and universities in the state to better coordinate inservice education.

Leadership activities of the state science supervisor require a knowledge of established local and state policies, accepted protocols, and legal aspects of the state code. The laws mandated by the state code may affect the local district, the state department, or both.

The daily functions of the state science supervisor consist of a variety of activities. These activities may be classified into seven major areas and the supervisor's time commitment to each category calculated. The seven major areas and the percentage of time allocated to each are listed in the accompanying table.

SEVEN MAJOR CATEGORIES AND PERCENTAGE OF TIME ALLOCATED TO EACH FOR THE STATE SCIENCE SUPERVISOR*

Percentage of Time	*Category Description*
25%	Office activities, such as serving on statewide committees, telephone and letter correspondence, staff meetings, and preparation of publications.
20%	Planning, organizing, and implementing inservice programs.
20%	Resource services, such as serving as a state representative for curriculum committees for state-supported community junior colleges (area colleges), serving as a science resource person for curriculum planning for teacher certification in the colleges and universities.
17%	Planning, organizing, and speaking at conferences and workshops (usually 1–2 days in length).
9%	Professional activities, such as attending professional meetings, and presenting papers.
7%	Serving as a team member for professional accrediting associations.
2%	Other activities.

* These categories and percentages represent the state of Iowa science supervisor's schedule for the period from July 1, 1974 to June 30, 1975. The state science supervisor's role in different states varies. However, this data does help to illustrate the areas of concentration that do represent the most common activities that most state science supervisors perform.

History and functions of the Council of State Science Supervisors

To work effectively with educators, state science supervisors must be active in many professional organizations, including the National Science Supervisors Association (NSSA) and the Council of State

Science Supervisors (CS³). The CS³ is the only one designed specifically for the state science supervisor.

In 1963 the Council of State Supervisors was organized to provide leadership expertise to those individuals who have the major responsibility for science education for state departments of education in the United States and its territories. Since its inception, the CS³ has held several conferences, in cooperation with other agencies, that focused on unique problems for the state science supervisors. *Science Curriculum and the States*, edited by Kenneth W. Dowling (1971) and *Data Utilization: A Key to Improved Science Education* by James W. Latham (1974) are CS³ publications which were the outcomes of two such conferences.

The Council of State Science Supervisors is a very dynamic organization. It provides and maintains communication channels with agencies and organizations interested in science education. It keeps its membership informed about federal programs; maintains close contact with the United States Office of Education; and initiates and develops programs at the state, regional and local levels.

Section 2

The Supervisor at Work

Working with Teachers

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In an increasing number of cases the science supervisor is becoming a member of a team composed of teachers, paraprofessionals, curriculum coordinators, and administrators. This team is striving to provide learning situations for each child. Advancing technology makes the attainment of this objective more feasible than ever before. Also, as the trend toward individualized instruction gains in momentum, the traditional classroom-centered school with group scheduling patterns will evolve into facilities engineered to provide a high degree of flexibility in grouping and scheduling. New types of teaching and learning equipment will necessitate setting up learning situations for larger numbers of students in an increasing scope and variety.

The responsibilities of the supervisor working with and for his or her administrator are discussed in the following chapter. Careful budgeting of time and thoughtful establishment of priorities also make it possible for a supervisor to fulfill the other half of his or her professional commitment—service to teachers. There are several ways in which his or her work with teachers may be organized. One useful classification is working with (a) individual teachers, (b) groups of teachers, (c) students and their teachers, and (d) personnel activities.

Individual teachers

The individual science teachers with whom supervisors work present many of the same problems that a group of students presents to the classroom teacher. Individualized help to each teacher according to his or her needs is the ideal for which the supervisor strives. A single system for the observation, evaluation, and help for teachers will not suffice for improving the science program in a school, no matter how well it is planned and structured.

One approach to the problem of providing for the individual differences among teachers is to think of them in several different categories. Just as students are placed in different reading and arithmetic groups in an elementary classroom, teachers may be considered as being in one set of groups when the supervisor is planning inservice programs and in another when individual classroom visits are being scheduled.

Most supervisors schedule at least one visit to each teacher sometime during the semester, plus, of course, visits made by invitation. Each teacher needs to have personal contact with the supervisor. This provides an opportunity for the supervisor to bolster the confidence of a competent teacher who is hesitant, or—diplomatically—to define areas in need of improvement to the complacent or overconfident teacher. Individual visits help him or her to spot innovative ideas being developed by a teacher so that these ideas can be properly applauded and disseminated to other teachers. Potential troubles can be identified and perhaps corrected before any real damage is done.

As individualized instruction for children becomes more commonly practiced, supervisors will need to increase the attention given to each teacher. The use of new technology will be difficult for many teachers as they find themselves being scheduled for large- and small-group instruction, for individual help sessions, and for especially prepared lectures. Elementary teachers responsible for 30 children in a self-contained classroom, and secondary teachers accustomed to a six- or seven-period day in which a similar lesson is taught to two or more groups of children, must adjust both thinking and planning. Many secondary teachers have had no previous experience with grouping children within a class, much less the planning of individual learning situations for a variety of students.

A science supervisor will need to be alert to an individual teacher who flounders while attempting a new teaching technique. Perhaps a demonstration lesson for several teachers with similar problems would be helpful. In some cases the supervisor can work with the troubled or doubtful teacher in a two-person teaching team for a day or two. Most successful supervisors exercise much creative ingenuity in devising ways to help a teacher in trouble. The fact that they are not at first able to find a way does not deter them from trying again. The hardest aspect of this problem is probably finding a way to effect a change in the teaching behavior without hurting the pride or self-image of the teacher.

A more formal way of observing and helping new teachers is usually necessary. Some type of check list or evaluation sheet, to be used by the teacher and the supervisor, is a practical way to provide data to be used for post-observation discussion. When working with student teachers, the supervisor must give guidance in how learning situations for children, as opposed to instructional situations by teachers, can be best structured and maintained. It is so easy to get sidetracked into discussing housekeeping chores and bulletin board construction.

Part of the supervisor's job is to inform teachers about the resources of the school and community. Because most supervisors do not have the time to help individual teachers with direct information at every time of need, it is necessary to develop procedures by which teachers can help themselves. An information card file listing the names and addresses of persons to be contacted for special equipment, field trip guidance, or similar services is a valuable adjunct to the supervisor's desk. The simpler the information retrieval devices of this sort are, the more efficient and speedy will be the task of informing teachers so that they can proceed without the supervisor's individual attention. A file of information about new national curriculum projects or one describing the summer school offerings at local colleges is an example of indirect help to teachers. A monthly one-page bulletin for staff distribution is a practical way to report news about science education in the school.

Many supervisors will be expected to work directly with the library, testing, guidance, and research staff members or, from time to time, to confer with department chairmen in mathematics and science. Staff members who work with each other above the teaching level should plan and practice shortcuts to facilitate communication and the exchange of information among themselves.

In working with individual teachers, the challenge is found in maintaining a balanced schedule so that all teachers are served, not just those who clamor for attention. The quiet teacher may be the one in most need of help and may also be the one who will, in the long run, contribute the most strength to the program.

Science supervisors can also facilitate recognition of outstanding work or special talents by publicizing fellowships and awards and by nominating teachers for awards, for fellowships, and for assignments in professional organizations. Beginning in 1967, NSTA has given awards each year for distinguished service to science education. Industries and other professional organizations are interested in recognizing outstanding science teachers.

Groups of teachers

The science supervisor may be asked by his or her administrator to plan and implement teachers' workshops, curriculum writing groups, textbook selection committees, and discussion groups. It is very often advantageous for a supervisor to take the time to assess the real need for these activities so that he or she can initiate group work for which teachers can see some necessity or value.

The science supervisor has the responsibility for quality control when helping teachers to plan activities for themselves or their students. Teachers, as a group, must be led by the supervisor to establish priorities for using time and energy to implement special activities. Teachers should not be asked to undertake a new instructional program, inservice courses, a formal evaluation program, and the planning of a science seminar simultaneously. The supervisor is in a position to look at the whole picture from a long-range point of view. Teachers who find themselves trying to do too many projects, some of which are of questionable value, are not likely to remain enthusiastic about program innovations.

After the priorities have been established, the supervisor has the additional task of establishing guidelines for the activities which have been selected. Any project must be shown to be educationally worthwhile, pedagogically sound, economically feasible, and of possible accomplishment with the available resources and staff members. The supervisor may have to convince any or all of the administrators, teachers, and students of the value of the project, and its precedence over other desirable activities.

Much of the work with groups of teachers will be in the area of curriculum development. There are organizational chores in setting up committees, collecting materials, and arranging the meetings. When the work of the committee is finished, much time is involved in editing materials, printing and distributing them, and then encouraging appropriate experimental use and evaluation. With practice, these chores become easier, so that the supervisor can turn his or her attention to the more important roles of leadership for and evaluation of the work as it is being done.

As group work of any kind proceeds, it is important that the objectives originally formulated do not become lost in the mass of details. At the end of the project, someone must equate the results with the original purposes and make an evaluation. It is assumed that the objectives were first designed to fulfill some clearly recognized requirement and that the composition of the committee and its work was engineered into a manageable task.

For example, most districts have now abandoned the practice of trying to evolve a science education program which originates completely in the minds of the committee. Neither are groups of teachers being asked to sit down alone to develop a curriculum. A new course of study for a local district is much more likely to be an adaptation synthesized from one or more of the national curriculum projects or from commercially prepared materials. Teacher committees should work with a consultant knowledgeable in devising curriculum building techniques—a task for which most teachers have had little training or experience. The supervisor or a qualified person from outside the school system may fill this role on a short-term or intermittent basis. Some school districts are employing selected teachers and supervisors during the summer months. Such committees usually include persons from all levels of instruction in order to bring a diversity of talents and viewpoints to bear upon the work to be done.

As the year-to-year curriculum revisions are made, a supervisor is faced with the continual educational needs of the teaching staff. Opportunities for additional education must be provided by the local district in a variety of ways. How many different opportunities are offered and what the scope of these programs should be will depend upon the competences and characteristics of the teachers. Inservice programs are now more likely to be of a developmental nature, rather than remedial.

The methods of instruction used in inservice programs should be worthy of imitation in the classroom. Teachers do not learn how to conduct lab-centered lessons by listening to a lecture. Inservice sessions may be conducted by the supervisor, a professor from a neighboring college, a talented teacher from the local or a nearby school system, or a publisher's representative. The supervisor, in any case, should assume a great deal of responsibility for the planning of the content and format of the sessions. He or she can then be assured that a balanced offering of different teaching techniques is used.

Group work with teachers may be necessary for a variety of reasons. In addition to the curriculum development and inservice programs, teachers may need meetings to share teaching ideas among themselves, to plan equipment purchases, to plan visitation or exchange programs with other districts, to hear visiting lecturers, to tour nearby educational facilities (nature park, museum, industry, learning-resource center), and to plan special science events for students, parents, and the community.

With other staff members

The supervisor will also work periodically with a representative of the library staff. The newer science education programs require reference materials in larger quantities and greater scope than ever before. Many school libraries are receiving increased support from several sources so that present holdings can be more easily updated and enlarged.

However, many librarians do not feel qualified to make selections of reference materials for science. This is particularly true in the matter of journal and periodical acquisitions and in the field of science for the elementary grades. Help is needed in collecting books for the professional library used by staff members.

Librarians want to spend their money on materials of high quality that will be used. The supervisor can collect teacher requests and add his or her own selections to the list. The librarian can be of help to the supervisor in choosing references which are in the best format, printing, and binding. Together they can plan for the most satisfactory use of the money available and a sound long-range acquisition program.

Participation of schools in educational research projects is increasing. Supervisors and teachers are working together on research projects and grant-seeking proposals. School district budgets often include an item for research and development. The impetus for educational research may come from a higher education institution, the school board, the supervisor, or the teachers themselves. Working in ongoing research projects is a valuable experience for the professional growth of teachers and supervisors. This activity gives opportunities for teachers to learn about research design, searching the literature, reading and writing abstracts, and using the technological tools available to researchers. Doing scientific research (as many high school students are) is an excellent way to learn the nature of science and how scientists work. A supervisor who is doing some research will find that his or her teachers will be more willing to try it also.

Research activities will increase the work that science supervisors are already doing with guidance directors, general curriculum coordinators, testing officers, science department chairmen, and mathematics personnel. These people, including the science supervisor, make up a school services team which influences the philosophy and aspirations of a whole school. This team, in its work with the administrative staff, can literally make or break the reputation of the school.

When working with different groups of staff members, the supervisor is in a role of double management. The objectives must be identified and fulfilled, and the people involved must be employed with efficiency and in harmony with each other.

With students

The science supervisor will be called upon to work with individual students or to plan programs for groups of students. Teachers should be encouraged to solicit the help of the supervisor in solving problems of certain students. If the invitation comes by some other route, the teacher should be notified promptly so that communication is open and smooth.

If a student or group of students is planning to work on a special project involving cooperation with an outside agency, such as an industrial firm, health association, or a local scientist, the supervisor will be expected to act as a liaison person among the interested parties. This may involve the preplanning of schedule adjustments, contract negotiations, as well as the preparation of any publicity needed to give the community an understanding of the project and its value.

Science fairs or exhibits are a concern for many supervisors. Educators, in increasing numbers, are coming to the realization that the traditional competitive science fair has some serious shortcomings and pitfalls. Supervisors who work in a district where a science fair each spring has become a school tradition may wish to work with teachers and students to re-examine the objectives of the fair to ascertain how much real value still exists in the program.

Some districts have abandoned the fair in favor of an event which affords the opportunity for individual students to report the scientific research which has been done as an integral part of course work or as a result of an individual interest. Good science fairs are a natural outgrowth of the school science program rather than being the reason for which the work was planned in the first place.

There are other types of special science activities which may reflect the spirit of science better than the traditional fair alone. Some schools have students meet in seminars, with or without an audience, to hear each other's reports and then ask questions. Others have established a junior academy of science which emphasizes the presentation of a paper rather than an exhibit. Subsequent publication of the proceedings provides a record of work done from year to year.

Supervisors should insist that when competitive types of science youth activities are planned their educational values should take precedence over their public relations value to sponsoring organizations. The quality of science fair projects can be expected to be in direct proportion as to the quality of the judging done from year to year. Judges should be chosen from the scientific community to assure that the evaluations will be based on and reflect the scientific merits of the projects. Good rules and regulations for conducting science fairs are available from the national science fair organizations. Supervisors should see that teachers transmit up-to-date information to their students about award programs and other activities such as the Ford-Future Scientists of America Awards (NSTA) and the International Youth Science Fortnight.

Students sometimes need advice in connection with individual work they are doing, which neither the teacher nor the supervisor is prepared to give. Again, outside help should be sought. Sometimes a disinterested, bored student can be stimulated by contact with a local scientist who will help him work on something of special interest to him. This becomes the student's science program. Supervisors are usually aware of valuable resource people in a variety of occupations who can provide for individual differences in this way.

Another area of interest for the supervisor is that of career guidance. He or she is in an advantageous position to identify and nurture the science-prone student who needs help in learning about the new occupations and professions arising in the field of science. With the help of the guidance counselor, he or she can portray to the student the science-oriented vocations which fit particular capabilities and probable educational opportunities. Too often students are lost to the scientific fields because they think only the most intelligent and highly educated people can qualify for the work.

Special lectures or seminars can also be planned for both students and teachers. Traveling exhibits sponsored by industrial firms, non-profit educational institutes, and governmental agencies are also available to those who wish to enrich the science program for the entire student body or some segment of it. Preplanning and follow-up activities are necessary to make this kind of program a justified part of the total school instructional plan. The present trend is away from packaged traveling programs and toward flexible program segments which can be mixed and matched to fit the wishes of each individual school.

To implement an effective program for students, the supervisor must be well informed about and have rapport with local scientists and the institutions these scientists and other resource people represent.

Personnel activities

A science education program will be no more effective than the combined efforts of the total teaching staff. This idea should be in the supervisor's mind in the recruitment of new teachers, the supervision of student teachers, the preparation of recommendations for teachers, and the assignment of the staff members to existing or new positions in the school.

In traveling, attending conferences, and visiting other programs, the supervisor should be alert to identify individuals who are looking for new positions which offer a chance to grow professionally. Sometimes young teachers do not sense this growth need in themselves, except as a vague frustration about their present situation. Such teachers may need some gentle prodding toward positive thinking about the chances they have for advancement in the profession. With the advance of educational technology, many new directions for this growth will emerge.

The supervisor will also travel to observe teachers whose applications for positions have been received by the district. The written credentials of a prospective teacher are no substitute for knowing firsthand how the teacher relates to students and other teachers.

The science education staff can also be strengthened internally.

The early identification of the most promising student teachers can result in an opportunity to give preservice attention to those who may apply for positions. By involving student teachers in performing real tasks, instead of planned hypothetical exercises, it is possible to make a better evaluation of their potential, while at the same time giving them a vested interest.

The supervisor who is able to delegate responsibilities to others in an ethical, mutually satisfying way can groom members of the present staff for reassignment to different positions where their particular talents can be most effectively used. When teachers are sparked by an enthusiastic supervisor, they will do many things which lighten his or her workload and at the same time help them to grow professionally. In a situation like this everybody wins.

A less-satisfying aspect of personnel work is the occasional necessity to help those teachers who are not making a satisfactory contribution to the science program to find a more appropriate niche somewhere else on the staff or to arrange for the termination of employment. This is a cooperative venture which involves the teacher, the supervisor, and the administrator of the school. No supervisor should attempt it alone.

Some teachers need and want experiences outside the framework of the school program. By judicious recommendations of teachers for fellowships, special courses, retraining in a particular skill, or participation in research studies, it is possible to upgrade the science teaching staff. Useful and rewarding ways for using these teachers should be preplanned so that they can see a genuine value in completing this special preparation. If this is not done they are likely to go elsewhere so that the new training can be used profitably.

The contemplation of so many tasks to be done with and for teachers can be a dazing experience. These ideas have been presented in the hope that each reader will gain insight into the many possible avenues of endeavor. No single school system can expect one supervisor to perform them all continually. Some may not be appropriate in a given school. Those most applicable and workable can be instituted immediately. Others may become more valuable later. As supervisors gain skill in doing two or three things at a time, they will feel more confident about enlarging their scope of services.

An enthusiastic supervisor is not likely to want to operate in the same way each year. Abandoning ineffective work plans and shoulder-ing new ones from time to time will help to keep the job of supervision exciting and satisfying. This practice also sets a good example to teachers. The work that supervisors do with teachers will keep them close to the object of all their creative thinking—the students to whom they are responsible.

Working with Administrators

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The science supervisor, coordinator, or director of science education provides a liaison between the science teachers and the administrative leaders in the school, district, county, or other organization. This liaison is essential to teachers, for they depend on the supervisor to inform the members of the administrative staff on the nature and implications of the scientific enterprise. This liaison is essential to the superintendent, for he or she needs one person who can be depended upon to be the knowledgeable spokesperson for the science phase of the total educational program. The science supervisor also represents science education in the school program to the school board, the parents, the community, and to other agencies. The special relationship between the science supervisor and the administrators of a school or district is the chief concern of this chapter.

A science supervisor sells one commodity only—confidence. To the superintendent, he or she must sell confidence in his or her knowledge of the total scientific enterprise, both within the school or district and within the nation. The confidence or respect that a science supervisor can earn from the superintendent comes from proven professional judgment based on:

1. Current knowledge about content in the sciences (chemistry, physics, biology, and earth and space science)
2. Current knowledge about curricular materials in science and methods in science teaching
3. Current knowledge about children and how they learn
4. Leadership ability based on improved management techniques

The science supervisor plays a unique role in administration, for this professional role requires a full-time commitment involving continuous study and extensive reading. Only by being current in the knowledge required can the supervisor serve two of the major functions of the position, the design and implementation of science programs and the provision of services and materials to facilitate the work of the science teachers.

The relationship between a competent science supervisor and the superintendent must be based on frequent, scheduled contacts, because the demands of science education are changing radically from the position science occupied a few years ago. As new, activity-oriented programs are added to or replace the outmoded, textbook-oriented science classes, increased financial support is needed to provide:

1. Larger and better equipped rooms for science from first through twelfth grade
2. More equipment and supplies per pupil per year
3. More science scheduled for more students
4. Increased services in a laboratory program (e.g., laboratory technician, research projects, reduced class loads to allow better laboratory supervision)

These demands for financial support must compete with other programs in the total system. Careful judgment on the part of the supervisor is needed to see where and when the demands of a modern science program should be emphasized. At certain critical times in the administration of a dynamic district the supervisor must be prepared to present a carefully constructed program with aggressive salesmanship. Some of these critical phases include:

1. Long-range capital improvement programs
2. Annual budgeting for current operation of all programs
3. Planning facilities in a new building or renovations of older buildings

The science supervisor may be looked upon by the superintendent as the agent for "quality control" in the district. This description of the supervisor's role would be deceptively easy to fill if the accepted quality were quite low—the "control" would present no problem. But when the quality demanded is high, then the pressures for bringing all schools up to the desired level work positively for the supervisor and his or her total enterprise. If the supervisor can move one school ahead in one aspect of the program, either in the physical plant or curriculum phase, then other schools will be critical of their own position. If the new position represents the quality all are striving for, then teachers and principals join the demand for a similar science program.

The major obstacle to the kind of professional relationship between the supervisor and the superintendent described above is the lack of opportunity to affect the key people. It, therefore, falls upon the supervisor to establish regular communications with all key people in administration in order that he or she be informed of plans and anticipated changes and, in turn, may confer and advise on those changes affecting science. A supervisor can easily get so involved in the teacher-committee and classroom activities that this important phase, exchange of vital information with key administrators, can be slighted.

A two-way street

No relationship can be adequately described from one direction. What can the science supervisor reasonably expect from the superintendent?

First, he or she needs the opportunity to present the design and implementation of the continuing science program for periodic review. Such a review should include long- and short-range goals, cost analysis, personnel, facilities, and inservice implications. The superintendent should provide the broad base of planning for the school or district with which the science phase must be coherent.

The superintendent should keep the supervisors informed of trends, discussions, and changes in total planning (fiscal, buildings, personnel, etc.) which are essential to the supervisory role. He or she should, in turn, ask for recommendations or advice on matters within the professional realm of a science supervisor in time for the supervisor to give a response based on available information rather than guesses. Examples of such "advice" questions might be:

1. What would be the effect on the science program if we changed to modular scheduling in the senior high school? How would the science facilities of a new school be planned under modular scheduling?
2. What kind of instructional organization at the elementary level

would produce the best science program? How would this organization affect the child, the teacher, the curriculum?

3. Should science be taught as a major subject to all students in grades 7–9? Why?

In contacts with other administrators the superintendent must be supportive of the science supervisor. When the supervisor is in a "service" or "staff" position, where his or her advice may be accepted or rejected by principals, this kind of support from the superintendent is most essential. Administrators who lack the professional training to judge the supervisor's recommendations can defeat the movement of the science program if independent decisions are made.

The superintendent can provide the balanced fiscal policy within which a healthy and dynamic science program can function. For it is the long-term, regular financial support that builds the confidence of staff which, in turn, makes the essential difference in vigorous science education.

A key concept behind the relationship a supervisor establishes with the principals in the district is the fact that each one needs the other to do his or her job well. A principal cannot have the professional background in each discipline which the supervisor is expected to maintain; therefore, the principal must call upon the supervisor of science for advice on the science program based on the supervisor's broad background of information and experiences. The supervisor can produce no improvement or change without the support of the principal, who is traditionally "the educational leader or his or her building." Together they can plan for and implement the needed schedule, facilities, equipment, teacher assignment, inservice, etc. The supervisor brings the broader picture to the building and can often suggest resources not realized within the school. Rivalry has no place in the relationship between a supervisor and a building principal, for they have a common objective, the design and sustenance of a good science education program.

It is one role of a principal to bring the picture of the educational program in his or her building to the public through various publications, meetings, PTA programs, etc. The supervisor should encourage him or her to present the science program to the public; he or she should help the principal to interpret the needs and goals of science to the staff and community. The science supervisor can experience greatest satisfaction when public recognition for the quality of the science program is bestowed upon the principal, staff, and pupils.

Providing the Learning Environment

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School systems and human beings are organisms of great diversity. If one thinks about the vast range of structures and functions that comprise our life processes, it is truly remarkable. Each organ is structurally unique; still, all organs are functionally related. Each system is solitary, yet there is unity among all systems. The structure and function of our systems are designed to achieve both our steady maintenance and our continued development. In a way which appears to be paradoxical, this is accomplished through the dual tendency of specialization and coordination. There is specialization of organs and systems; yet, there are some systems (e.g., hormonal, nervous) which have the function of coordination.

In much the same way, the science program in a single school, a district, or a state is also one of great diversity. A continuum of grade levels, different disciplines, styles of teaching, and needs of students are but a few conditions contributing to the diversity. There must be maintenance if the science programs are to operate smoothly; there must also be change if the programs are to continue developing and improving. It is the function of the supervisory system to integrate and maintain myriad programs while facilitating change and development in science education.

At the individual level, the supervisor's role is to coordinate science programs so an identifiable organization is maintained, and to facilitate development by creating a climate in which there is a continuing change in science programs. There exist numerous long lists of "what the supervisor does." A review of many of these lists will show that most of the jobs are some variation of two themes: maintenance of the present programs and development of new programs. The category of maintenance includes providing equipment, replacing supplies, organizing field experiences, preparing materials, and very importantly, replenishing the science teachers' personal energy through encouragement. Development in new directions occurs through workshops on new teaching techniques, meetings to update scientific knowledge, inservice programming to implement new curricula, and released time and funds for travel to professional meetings.

Responsibilities and ambiguities

Achievement of the stated goal is indeed difficult because the supervisor has many responsibilities. There are ambiguities of the task to be done, arising chiefly because of the supervisor's indirect influence on the educational environment. That is, the supervisor must facilitate a better educational environment through other media.

The difficulty of supervision is often compounded by an inherent ambiguity of goals, tasks, and completion. An ambiguity of goals arises from the simultaneity of maintaining the present program and developing new programs. To further the problem, goals are often partially determined by students, teachers, administrators, parents, financial constraints, and social trends. There is also an ambiguity of the task: How should the goals be achieved? When should the supervisor push for change? Which new curricula are best for the students and teachers? How should changes be facilitated (inservice, summer programs, released time)? The task is not an easy one because there are many variables to be considered and, more often than not, some goals are in opposition. Finally, there is an ambiguity of completion. Just when are the goals achieved? One answer is every day; another is never. Actually, both are correct.

Resources and sources

Resources are the various means that can be used to the educational advantage of students; they are the various people and things used in maintaining the present programs in science. As a resource person, the supervisor is one to whom teachers can turn for ideas and for supplies, equipment, and materials. All of these can be drawn upon as needed for the continuation and revitalization of existing science programs.

Science supervision also includes initiating new curricular programs, and creating new teaching techniques to enhance the effectiveness of student-teacher encounters. Thus the science supervisor is also a source initiating change and new growth in the science education system.

What are the supervisor's resources? Those things that can be used to facilitate a better educational environment. Environment includes those factors, intrinsic and extrinsic, that influence education in the science classroom; not only physical facilities, equipment, materials, and books, but also the attitudes, motivations, and behaviors of students; the enthusiasm, methods, beliefs, and knowledge of the teacher. Environment includes the complex social and cultural conditions affecting interactions between students and teachers during science instruction.

The teacher, as the factor of greatest importance, is the main resource of the supervisor. Over the years, hundreds of research studies have been reviewed on the qualities of good teachers. The results of this review can be put simply: There are no common and identifiable characteristics of good teachers. Yet we all know there are good teachers. Good teaching is a function of the person's uniqueness; it is the teacher's individual characteristics and style that contribute to effective instruction. The teacher's style includes knowledge of subject matter, use of appropriate curriculum materials, ability to plan and carry out class procedures, use of different teaching methods, enthusiasm, and adequate personal relations with students. All of these (and probably many more) characteristics are necessary. Effectiveness in science instruction is determined by the unique ways these attributes are combined as the teacher encounters many different situations in the classroom environment.

The social use of resources has been dominated by a view of unlimited economic consumption, which is evident in an ever increasing GNP and the idea that quantities of material goods contribute to a better life. Though the translation is less than direct, there is the corollary view that many educational problems are solved through the development of curriculum materials and the purchase of new textbooks. This is in part true; but just as there are limits to natural resources, so there are limits to the development of new curriculum materials to solve old problems. A variety of factors have set limits on new curricula; it is time to seek new directions of growth. We have gone through an era of curriculum reform and are now in an interim of transition to a new epoch of instructional effectiveness.

Discussions of the educational environment often center on topics such as designing new facilities, implementing new curricula, ordering supplies, and obtaining equipment. There is no doubt in anyone's mind concerning the importance of the supervisor in these tasks. By and large, supervisors know how to do these things; they have done them for years; they are discussed in every book on supervision.

Curriculum development is important, and it must continue. The curriculum is an important part of teaching and should complement the teacher. Curriculum is a resource the supervisor can use toward the goal of improving the educational environment, but curriculum development is not the whole answer.

The role of the supervisor and the goals of supervision, as well as some responsibilities and resources have been discussed. Let us turn to some practical suggestions for improving the educational environment.

Ideas and innovations

This section provides some ideas and references to help the supervisor facilitate innovations in science education. These ideas are an attempt to provide meaningful and practical suggestions contributing to the stated goal of science supervision—improving the education environment.

1. "My" Project Workshop

Almost every teacher has two or three projects in mind that will improve classes. These ideas are still just ideas because, "We'll get to them sometime," or "I just can't find time to do them." In this workshop, the primary resource is time and anything else that will help bring teachers' ideas to fruition. Work in groups so there will be cooperation, exchange, testing, and sharing. The supervisor should act as a facilitator, doing whatever is needed to make the teacher's ideas actual.

2. Asking, Waiting, and Listening in Science Teaching

Questioning is one of the primary instructional techniques used by teachers to engage the learner's interest. The complete act of questioning includes: asking a question, waiting for an answer, and listening to the answer given. Many science teachers don't think of the best types of questions for their purpose; they can't wait and often listen only for the response confirming the answer they had in mind. Information and experience in asking the right questions, waiting for answers, and listening to all responses can be valuable to science teachers. Aims of the workshop are to ask different types of questions appropriate to the science teacher's situation, to increase waiting time, to not only listen for answers, but also understand any confusion or frustration in the students' responses. This workshop might include the presentation and discussion of types of different questions; teachers' analyses of questions recorded on a cassette tape during one or two earlier classes; practice of asking, waiting, and listening through simulation; and working on questions to be used in future lessons.

References which the supervisor can use for the workshop include *Developing Questioning Techniques* (by A. Curin and R. B. Sund, 1971) and "The Art of Questioning, or How You Ask Makes a Difference" by A. H. Stone in *Becoming a Better Elementary Science Teacher* (by R. B. Sund and R. W. Bybee, 1973), both of which are published by Charles E. Merrill, Columbus, Ohio. *Classroom Questions: What Kinds?* (by N. M. Sanders, Harper & Row, New York, N.Y. 1966) and *How to Ask the Right Questions* (by P. Blosser, NSTA, Washington, D.C. 1976) are useful publications on this topic. Refer also to "Science, Silence, and Sanction" by M. B. Rowe in *Science and Children* (6:11–13; March 1969).

3. Diagnosing, Deciding, and Responding in the Science Classroom

A science teacher makes an average of fifty decisions per class hour of instruction, every one of which is made in terms of the student, the lesson, the curriculum, the teacher, and other factors in the educational environment. Nowhere in our training do we emphasize the importance of decision making, and this is a crucial factor underlying effective science instruction. This is a difficult issue; most time and energy is spent on curriculum materials which the teacher assumes as the long range intentions of teaching. To complement this, there is also the need for spontaneously reacting to classroom situations and student needs. This workshop could focus on new knowledge about students (e.g., the theories of Piaget, Kohlberg, and Maslow) and attempt to answer the initial question, "What do I look for in students' behavior?" Then, a discussion of the difficulty of making a decision could bring the teachers to an awareness of their own perceptions of what is important in the decision making process. Teachers say, "I understand these ideas, but how do I respond to students in the classroom?" Again, the workshop can only heighten a teacher's awareness because each classroom situation will be unique. But, as a start, teachers can become aware that sometimes it is appropriate to respond with an answer, sometimes a question, and sometimes a reference.

For reference sources to use in this workshop, consult *Teacher-Student Relationships, Causes, and Consequences* (by J. Brophy and T. Good. Holt, Rinehart and Winston, Inc., New York, N.Y. 1974); *The Art of Helping* (by R. P. Carkhuff. Human Resources Development Press, Amherst, Mass. 1972); *The Study of Teaching* (by M. Dunkin and B. Biddle. Holt, Rinehart and Winston, New York, N.Y. 1974); and *Models of Teaching* (by B. Joyce and M. Weil. Prentice-Hall, Englewood Cliffs, N.J. 1972). "To See Ourselves as Others See Us, But More Deeply" by N. Kagan in *New York University Education Quarterly* (Winter 1975) and *Human Interaction in Education* (by G. Stanford and A. Roark. Allyn and Bacon, Inc., Boston, Mass. 1974) are also excellent sources.

4. The Special Student in Science

With the recent requirement in many places that special students be mainstreamed, there is an opportunity to provide learning experiences in science for these individuals. However, the potential of this opportunity has been veiled with frustration arising from a lack of understanding of the unique problems of these students and of materials and appropriate methods for teaching them. There is valuable assistance available in the form of fundamental information concerning the physiology and anatomy of various handicaps; methods, materials, and problems of teaching the mentally retarded, visually impaired, and physically handicapped; and ways to develop positive student perceptions and attitudes while integrating the special student into regular science classes.

In preparing materials for the workshop, refer to "Teaching Science to the Blind Student" by R. J. Eichenberger in *The Science Teacher* (4:53–54, December 1974); "Science Classes for Mentally Retarded Adults" by S. D. Schery in *The Science Teacher* (42:44–46, January 1975); and "We Can Do It" by H. D. Thier and D. Hadary in *Science and Children* (2:7–9, December 1973). Two special issues on special education are *The Kappan* (April 1974) and *Science and Children* (March 1976).

5. Group Dynamics in the Classroom

One of the major sources of difficulty in teaching, and the origin of many discipline problems, is a lack of understanding of the dynamics of groups, in particular student groups in classrooms. Science classes often require changes from a large group to small groups for laboratory work or individual work on projects, and the return to a large group at the end of class. Because of the great variety of group changes it is important that science teachers have some basic understanding of social psychology as it applies to the classroom. Applying a few important ideas in group process can bring about smooth and efficient changes within the educational environment. Information and application of dynamics would be the aim of this workshop. After discussion of concepts fundamental to social psychology, the teachers would consider ways of using the principles in their own classrooms.

On the topic of group dynamics, refer to *Joining Together: Group Theory and Group Skills* by D. W. Johnson and F. P. Johnson and *Learning Together and Alone—Cooperation, Competition and Individualization* by D. W. Johnson and R. T. Johnson (both published by Prentice-Hall, Englewood Cliffs, N.J. 1975). Also, *Educational Social Psychology* by M. A. Barry and L. V. Johnson (Macmillan Publishing Co., New York, N.Y. 1975); *Group Processes in the Classroom* by R. A. and P. A. Schmuck (William C. Brown Co., Dubuque, Iowa 1973); and "Using Group Dynamics in the Classroom" by J. K. Smola and A. Mandell in *The Science Teacher* (41:28–31, April 1974) are good sources.

6. Discipline in the Science Classroom

Classroom discipline is one of the major concerns of those entering the profession, of teachers, and of the public in general. Science teachers need to understand the cause and development of behavior problems in general, as well as some of the areas unique to science where problems may originate. For example, setting up laboratories, working on investigations, cleaning up, handling dangerous materials, and preventing breakage of equipment are all areas of potential discipline problems that are specific to the subject matter. The workshop could incorporate discussions of different theories of discipline, prevention of problems before they occur, effective techniques of handling problems that do occur, the rights of students, and the rights of teachers.

A number of books and articles have been written on the subject of discipline; some of these are: "Our Nation's Schools—A Report Card: 'A'" by Birch Bayh in *School Violence and Vandalism* (U.S. Government Printing Office, Washington, D.C. 1975); *Violence in the Schools: Causes and Remedies* by M. Berger (Phi Delta Kappa Educational Foundation, Bloomington, Indiana 1974); "Discipline" in *Today's Education* (64:58–63, March-April 1975); "The Public Looks at the Public Schools" by George Gallup in *Today's Education* (64:16–20, Sept.–Oct. 1975); *Discipline: A Shared Experience* by I. D. Welch and Wanda Schutte (Shields Publishing, 1973); and *Managing Instructional Problems* by J. Warrell and C. M. Nelson (McGraw-Hill, New York, N.Y. 1974).

7. Science, Ethics, and Social Decisions

We live in an age of crises. Energy sources are being depleted; the environment is being polluted; and the global population continues to increase. In many cases science and technology are simultaneously being blamed for the problems and looked to for the solutions. Many science teachers could benefit from discussions of science and technology. The social consequences of science; the distinction between the values of science and the value decisions of applied science; appropriate use of value clarification techniques; analysis of curriculum materials and teaching methods dealing with environmental awareness; modification of present programs to include more environmental education; and the ethical issues posed by global scarcities are only a few of the topics for discussion. Specifically, this program could increase the science teacher's knowledge of global scarcities and the limits to growth, and thus expand the teacher's understanding of scientific, technologic, and individual values.

References on science, ethics, and social decisions include: "Science, Technology, and Society" by P. de Hart Hurd in *The Science Teacher* (42:27–30, February 1975); *An Inquiry into the Human Prospect* by R. L. Heilbroner (W. W. Norton, New York, N.Y.

1974); a special issue on moral education, *The Kappan*, June 1975; "Futures Planning: Biology, Society, and Ethical Education" by G. Kieffer in *The Science Teacher* (42:10–11, October 1975); *The Limits to Growth* by D. H. Meadows (New American Library, Inc., New York, N.Y. 1972); *Mankind at the Turning Point* by M. Mesarovic and E. Pestel (E. P. Dutton and Co., Inc., New York, N.Y. 1974); and *The Survival of the Wisest* by J. Salk (Harper & Row Publishers, New York, N.Y. 1973).

8. An Intradisciplinary View of Science

This workshop is an attempt to broaden the scientific literacy *within* the community of science teachers. There are various approaches that might be used. The aims are to update scientific knowledge in areas other than the teacher's specific discipline and to provide a sense of intradisciplinary focus to teachers. Topics for the workshop might include: recent advances in various disciplines (e.g., quarks, continental drift) or an intradisciplinary analysis of contemporary problems (e.g., energy, pollution).

9. An Interdisciplinary Exchange of Ideas

The division between the sciences and the humanities can be narrowed by having teachers from the sciences and humanities give workshops for one another. They can exchange ideas, do simple lessons, and discuss fundamental concepts in their disciplines. Humanities teachers would enjoy a good discussion of an issue such as the energy problem and they would probably learn a great deal. Likewise, science teachers might enjoy the opportunity to read and discuss a novel, play, or work of art.

This is a brief attempt to describe the supervisor's role in facilitating the goal of improving the educational environment. The topics and ideas stressed are different from those usually included in a discussion of the educational environment. It is the human environment and the human ecology of the classroom that are most important, so this has been stressed, leaving discussions of designing new classrooms, providing equipment, and implementing curricula to others.

In the first half of the essay is the rationale underlying supervision. In response to the penetrating and everpresent question, "What can I do tomorrow?", ideas and references have been provided for a variety of workshops that might be first steps on the long journey toward facilitating a better educational environment.

REFERENCES

1. Harbeck, Mary B., editor. *A Sourcebook for Science Supervisors.* National Science Teachers Association, Washington, D.C. 1967.
2. Leeper, Robert R., editor. *Role of Supervisor and Curriculum Director in A Climate of Change.* Association of Supervision and Curriculum Development, Washington, D.C. 1965.
3. Stotler, Donald, *et al. The Supervision of School Science Programs.* Charles E. Merrill Books, Columbus, Ohio. 1967.
4. "The Supervision of the Science Program." In *Rethinking Science Education.* The Fifty-ninth Yearbook of the National Society for the Study of Education, University of Chicago Press, Chicago, Ill. 1960.

Preparing For and Implementing Change

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Ever since education came into being as a means of preparing the next generation to live in an already existing adult society, it has tended to be conservative in its approach. It has followed changing trends in society rather than acting as an instrument of change. Because of its conservative attitude, education has changed slowly. The first major innovation in education, the textbook, occurred less than 600 years ago. The chalkboard came about 200 years later. The next major innovation, the use of technological teaching aids, occurred during the present century.

Systems design

The development of educational learning is not new. Well-developed learning systems were in operation more than 5,000 years ago. The rectangular classroom, with seats in rows, taught by a teacher with teacher aides could be found in large cities. There was an "assistant principal" to deal with discipline problems. Students were punished for standing up in class, talking, leaving the room without permission, and especially for poor work. Delinquency and truancy were not uncommon.[1]

Today many learning systems are changing rapidly. Often these changes are piecemeal and poorly planned, with expediency rather than rationality motivating the changes. Some of the confusion is the result of a lack of a guiding philosophy for the management of the system.

Two viewpoints of management found in industry were described by Douglas McGregor in 1961. [2] Translated into educational terms, the ideas would be expressed as two theories.

Theory X describes traditional assumptions of management. In educational terms, these might be paraphrased as:

1. Teachers are naturally lazy, and will do as little as possible.
2. Teachers are primarily motivated by pay raises and promotions.
3. Teachers are naive, and depend on direction from above. They need to be told and trained in proper procedures.
4. Teachers need close supervision, with praise and blame properly distributed.
5. Teachers do little, if any, work outside of school, and then only when they have to.
6. The school system is of primary importance; teachers are selected, trained, and fitted into the system.
7. Teachers need to be pushed in order to obtain adequate outcomes.

The antithesis of Theory X is Theory Y:

1. Teachers are active, enjoy their work, and are proud of their accomplishments.
2. Primary motivating forces are internal, rather than external.
3. Teachers are professionals, and are quite capable of doing their own organization and planning.
4. If provided with the necessary supplies and equipment and encouraged to do their best, teachers will work hard to improve their teaching.
5. Teachers welcome independence and responsibility, and when given the opportunity and encouragement, will work long hours to improve their teaching.
6. The interaction of teachers and students is of primary importance in learning, and the school system should be designed to promote this interaction.
7. Teachers crave approval from their superiors and their peers, and will work hard to obtain this approval.

It is probable that administrators in most school systems would not accept either theory X or theory Y in their entirety, but would lean towards one theory or the other. Whichever theory is accepted usually becomes a self-fulfilling prophecy, and the administrator finds that his or her theory is "right" as far as his or her school and teachers are concerned. For this reason, the viewpoints of the administration have a profound effect on the morale and behavior of the teachers in the system.

Developing a viable system

A viable school system is capable of growth and development. An autocratic system based on theory X makes such development very difficult, if not impossible. A "non-system" characterized by crash programs and emergency decisions makes orderly change equally difficult. A well-designed system based on theory Y offers the best environment for orderly change.

What are the components of such a system? They are many and varied, but the following characteristics are essential for a well organized school system:

1. Clearly defined goals and objectives. A system cannot function effectively with its members at cross purposes or with differing aims.
2. Trust and confidence among the groups in the school and the community. When the students fear the teachers, the teachers fear the principal, the principal fears the school board, and the school board fears the opinions of the voters, there can be no effective school program.
3. Open communications. A "chain of command" becomes just that, a chain that binds the system. If a principal is not afraid of what teachers think of him or her, he or she will not object to their talking to the superintendent or the school board. When everyone is working together to build a better school system, organizational structures serve as a framework for progress, not as a block to communication.
4. Cooperation and consensus. Open communication leads naturally to the next essential for curriculum change: the necessity of full cooperation among all aspects of the system, from the student to the community, including administration and professional staff. The rule of the majority may be a democratic procedure, but it leaves a dissatisfied minority that can be fatal to effective school programs. Individuals and groups with differing viewpoints must be brought together to discuss their differences and to resolve them if possible, rather than continuing to encourage unproductive confrontations between extremist viewpoints. If the "middle majority" can succeed in establishing a truce between extremist viewpoints, and in enlisting cooperation for developing more effec-

tive schools, the future can offer great promise for coming generations.

5. Positive leadership. As long as educational leaders spend their time "putting out fires" their is little time for positive leadership. Teachers must be given encouragement, support, and recognition instead of being criticized for every weakness that can be found.
6. Effective outcomes. Every effort to develop a better school program will fail whenever students fail to learn. In the past when students failed to learn it has been customary to blame the students and teachers. The design of a successful system will recognize student failure as an indication that something is wrong with the system, and will lead to the search for needed revisions.
7. Satisfied constituency. This is a primary consideration in a learning system. If parents, students, and teachers are unhappy with a school system, every attempt to develop an effective system is bound to fail. In such a situation, the first step must be to establish contact among the divergent groups and attempt to resolve differences of viewpoints and opinions. Until this is done, no meaningful efforts to improve the system can succeed.

The role of the supervisor

The supervisor has the role of providing a link between the administration and teachers. The supervisor can help provide parents and students with the opportunity to bring their viewpoints of education into focus, and to assist in developing a philosophy and goals of education toward which all members of the community can work.

Effective curriculum development and the articulation of the science program constitute important facets of supervision, well worth skillful, constant, and thoughtful effort. The science supervisor must be deeply involved in inspiring, planning, coordinating, and implementing curriculum change.

A special word needs to be said here for new supervisors. Often they have worked as classroom teachers, or perhaps as department heads. They have given primary consideration and allegiance to their own subject fields and the need to improve their knowledge in their own sphere of specialization. Science department heads have been largely responsible for their own courses, for ordering laboratory equipment, and possibly for holding informal meetings of science teachers in which some degree of consensus concerning the aims and course content for science teaching was achieved.

Often, when such individuals move into positions as science supervisors, they assume a role already accorded them by their colleagues. It has been documented that supervisors newly promoted "from the ranks" are in ideal positions to take the step to leadership. They already have the confidence of associates and the administration, or probably would not have been promoted. It is necessary to build on the confidence and maintain the contact established with both groups. The problem is to learn to act as a liaison between the two, and to learn how to do this without failing to support worthwhile change for fear of offending one group or the other.

This provides new supervisors with their first important decision. Should they follow trends and implement suggestions made by the administration and faculty, or provide leadership into new fields and develop new ideas that will provide the trends of the future? The latter choice has its hazards, but it is the most constructive one for the imaginative individual who really wants to see some worthwhile changes in science education.

Building support for the system

Many communities lack confidence in the educational system and its program. When confidence in the system is lacking, the first step must be to build support for program development and to convince the various groups in the community that something can and will be done. This is a public relations job that will require all the skill that can be found. Fortunately, the science supervisor is not alone in the desire to improve community relations. He or she can count on the support of administrators as soon as they find that the public relations program will produce positive results. Some good suggestions for building bridges between the community and the school are:

1. Publicize interesting school projects. Is one of the classes doing an unusual project? Take some pictures and tell the community about it. Are some of the students working to improve the environment in the community? Let the public know what is going on. The newspapers will welcome well-prepared, interesting items about what is happening in the schools.
2. Recognize good teaching. Try to get the Rotary Club or some other service organization to sponsor awards for outstanding teachers in the system.

3. Plan a slide show of some of the interesting developments in science or science education. The community is interested in learning what science is all about. PTA programs, community library exhibits, or the use of a bank window may provide an excellent opportunity for publicizing the school program, and will provide a challenge to the students in the science class as they plan exhibits which will display what they can do.
4. Take advantage of special events: eclipses, new discoveries in science, and news about scientists. Alert the community to the importance of science in their lives.
5. Once the community has been alerted to the fact that science is interesting and important, the next step is to find out what they think should be included in the school curriculum. Traditionally, science teachers have been interested in their own particular field, and have tended to emphasize the great concepts and theories of science, to the exclusion of everyday events.

The students and the general public are usually interested in how science affects their daily lives. They are willing to learn theory as long as they can see why it is important, but they frequently reject the idea of studying science for its own sake. Failure to bridge the gap between theory and application has been one of the factors causing a decline in the public's interest in science and its distrust of scientists.

One way of bridging the gap is finding out what parents and students think is important to know about science. One way of doing this is to use a device like the Science Decision Game. [3] This game has been used by parents, students, and teachers to determine what they consider important in science and to find out to what extent the school is placing emphasis on desirable components of the science program.

Philosophy and goals

Failure to consider the interests and wishes of the students and the public in designing a science program often has resulted in negative attitudes toward the program. Some science programs have been devised by scientists and science teachers without considering the needs and interests of the students and the public. Such programs have been effective for preparing future scientists, and helping students who take science in college, but such programs often are not effective in developing scientific literacy in the general public.

In developing a philosophy and goals for a science program to meet the needs of the general public, the questions below should be considered:

1. To what extent should scientific literacy be emphasized in contrast to preparation for taking college courses?
2. How important is a knowledge of applied science to the students?
3. How does science fit into the whole curriculum? What relative emphasis should be given to it?
4. What basic science is important for everyone to know?
5. How important are student attitudes and interests?
6. How important is environmental science?
7. How important is interdisciplinary science, in contrast to traditional science subjects?
8. What should be done about developing continuity in a science program (K–12)?
9. What relative emphasis should be given to laboratory work and to verbal learning?
10. What is the role of the teacher in the science program?

When such questions are honestly faced, and a consensus reached, the next step is curriculum development. But who will decide these questions? The science teachers in executive sessions? Unless the community and students are involved in determining the philosophy and goals for the science program, there is apt to be distrust and opposition to whatever program is evolved.

The science committee

One effective way of developing consensus about the science program is to form a science steering committee that represents the different groups in the community. A steering committee, as an advisory committee, provides a "sounding board" that teachers can use to resolve conflicts of viewpoints and interests. Who might be included on such a committee?

1. The science supervisor (as a motivator, not necessarily as the committee chairperson).
2. An administrator with interest in science and a good scientific background.

3. Two or three high school science teachers.
4. A social studies and an English teacher.
5. Two junior high school science teachers.
6. At least two elementary teachers who have a special interest in science.
7. One or two parents who are interested in the science program.
8. An engineer and/or a scientist from the community. (A doctor, biologist, health officer, technician, etc.)
9. A banker, businessman, lawyer, or other individual who is not particularly interested in or knowledgable about science.
10. Others who might provide useful suggestions for planning an effective program.

The Decision Game mentioned previously may provide a good way of getting the committee thinking about the role of science in education. The committee then might discuss the issues listed in the sections on philosophy and goals. By this time the group will be in a position to begin to provide guidance to the working group that will develop the science program.

The working group might be a sub-committee of the steering committee, or another group selected for its ability to lay the groundwork for the science program. This group should have the responsibility to:

1. Examine existing courses of study and identify those that can be used or adapted to meet the goals that have been established. Special attention should be given to the work of federally funded projects, science textbooks, and courses of study such as those on exhibit at NSTA meetings.
2. Select those items that can be used in developing a viable science curriculum for the system.
3. Plan a comprehensive science program for the system (K–12).
4. Devise a plan and techniques for organizing and teaching the program that will hold the interest and challenge the ability of the students. (Techniques of individualizing learning should be incorporated into the plan.)
5. Survey existing facilities and equipment to identify needs and potentials.
6. Identify gaps in the materials selected in the second step and develop materials for the missing areas. (All of the science teachers and many of the students should be involved in this step.)
7. Find teachers who will volunteer to try out various components

and provide feedback for adjusting the materials to hold the interest and meet the needs of the students.

8. Edit the materials and organize the program.
9. Organize an on-going staff development program to prepare teachers to use the materials effectively. One of the best methods of staff development is to enlist the teachers in the curriculum development project and in the experimental use of the materials to work with the plans for implementation. This is a critical step upon which the success of the project depends.
10. Provide for continuing review and revision.

During this entire process the steering committee should react to the materials and procedures. Such a group can be very helpful in keeping the working group aimed at the major goals of the program, and in recommending revision or replacement when it is needed.

At the same time, a continuing public relations program should be in progress to keep the community, the administration, and the teachers informed about what is going on in the project. It would be helpful to the steering committee and the working group if feedback from the public, parents, and students could be provided. Such feedback might be an important factor in maintaining continuing community support for the program.

Systems components

In using a systems approach to curriculum design, it is important to consider all of the components of the system. These components may be classified under the following headings:

1. The learner. It is easy to lose sight of the fact that the learner is the central figure in a learning system. The system should be designed around his or her needs and interests, instead of trying to fit him or her into a predesigned mold.
2. The staff. This component of the system makes the system operative. A well-designed system is built to facilitate the work of the staff in its role in the learning process. If a system component hinders the staff in its work, the component should be redesigned, instead of asking the staff to work around an impediment to effective operation.
3. The philosophy and goals. This component of the system has already been discussed.

4. The physical facilities. This component of the system is often neglected or taken for granted. It's easy to say, "We can't do that because . . ." A carefully designed facility plan is an essential item in an effective curriculum program. If changes cannot be implemented at once, they can be made a little at a time. Unless a long range design has been worked out, funds may be wasted in making changes that hinder rather than help the program.
5. Materials and supplies. This represents one of the continuing costs of a system, and it is important to get the greatest effectiveness possible for every dollar spent.
6. Teaching procedures and techniques. This is a vital component of the learning system. Teachers, as well as students, are individuals and have individual differences. It is important to permit teachers enough freedom to utilize their skills effectively, as long as the philosophy and goals of the system are met. One teacher may be a total failure if required to use the techniques that another teacher finds eminently successful. The important thing in teaching techniques is balance, rather than conformity.
7. Management procedures. This is often the most neglected component of a learning system. A great deal of time and money has been spent on computer-assisted instruction. This is useful, but at present is not economically feasible without outside funding. Another drawback is that someone has to do the thinking for the computer, and this may result in the development of a rigid set of procedures that cannot adapt to the varying needs of the learner. Most management systems in use today exist in plan books or in the teacher's mind. Other, more effective plans are needed. Many useful techniques, like contract learning, are coming into use.
8. Evaluation and feedback. This is one of the three most important components of a learning system, the other two being the learner and learning techniques. It is important that the stated goals of the system be evaluated, and not something else. It is not uncommon to find very little correlation between the stated goals of the system and what is being evaluated. The most common flaw in the evaluation program is to stress high level cognitive goals and to evaluate low level outcomes. Another weakness is the frequent failure to evaluate affective outcomes at all. Unless *all* the goals of the system are included in designing the evaluation procedures, there is no guarantee that those neglected in the evaluation have been achieved.

Teaching to the test

As long as low-level cognitive objectives are being measured, it is useful to "teach to the test," if the test has been carefully constructed to include the objectives of the teaching. If the student is expected to memorize a set of facts, the only effective way of evaluating this outcome is to test for the student's knowledge of these facts. And if this is the goal, the best method of achieving the goal is to teach the facts that the student needs to know. In such a situation there is every justification for teaching to the test.

When higher levels of cognitive learning are measured, it is not professional to teach the specific answers to the questions being asked. In testing comprehension or ability to judge from external criteria, if the student is given the specific examples used in the test and taught the proper responses, the test items are dropped to the lowest cognitive level of memorization of information.

However, it is perfectly permissible—even desirable—to use similar examples and ask similar questions in helping the student achieve higher cognitive goals. There is some evidence that failure of students to respond satisfactorily to measures of higher cognitive processes may not always be due to the inability of the students to carry on such processes, but may be due to a lack of familiarity with the type of answers being expected.

Another weakness of the testing program in many systems is the failure to feed the information resulting from the test back into the learning system. Feedback that results in modification of the learning system is the only effective way of improving the system.

Physical facilities

The physical facilities of the system must not be permitted to dictate the learning techniques that can be used. The opposite is true: The learning environment that is needed should dictate the characteristics of the physical system. The suggestions for physical facilities that follow assume that the minimum needs of space, temperature, and lighting are provided. The suggestions are intended to be examples, rather than an exhaustive treatment of the subject.

1. Space Allocation. In planning science facilities, adequate space for storage and experimental projects is often neglected. Many equipment set-ups need to be left from one day to the next, and such

items need to be protected from the overly curious student. Another area of concern is adequate and suitable storage space for corrosive chemicals. Such chemicals can do hundreds of dollars of damage each year if they are stored in the same room with scientific equipment. Also, storing certain chemicals together can create fire and explosion hazards. Another hazard is the "dead end" work space in a chemical laboratory. Every student needs an alternative exit in case of an accident.

2. Visibility. It is important for safety, as well as for liability reasons, for the teacher to be able to observe the students at work as much as possible. Adequate visibility will also help reduce loss and damage of equipment, by making it possible to observe careless procedures. The use of glass partitions is one effective way of providing visibility.
3. Usable Equipment. It is better to use equipment made from cans and plastic containers than to use equipment so fragile that the students cannot be permitted to handle it. There is a place for teacher demonstrations, but these should be the exception rather than the rule. It is important for each student to be involved personally in laboratory work, rather than merely being an observer.
4. The Media Center. Often, science planners do not consider the media center as a part of the science facilities. A library which has only printed resource materials and is open only during specified hours is an outmoded concept that does not fit into a well-designed learning system. Visual materials should be available as well as printed materials. Space and facilities for viewing films and filmstrips, and for listening to tapes should be available to the individual student when needed. A student should be free to move from the laboratory to the media center whenever he or she needs to look up information or to view materials related to the laboratory exercise. A good test of the flexibility and effectiveness of a school system is the extent to which students are permitted to use the media center, and the freedom they have to use it when it is needed.
5. Outdoor Facilities. Good science is found outside the school building as well as in the laboratory. A nature area near the school is most desirable, but many alternatives exist when a suitable center cannot be established. There are many plants and animals in a normal environment on city streets, in crevices in the sidewalks, and in vacant lots. None of these potential sources of investigation should be neglected. Are science teachers barred from taking

informal field trips during class hours? This is a typical example of a situation where the system is organized for the convenience and security of the management component, instead of organizing the components to meet the needs of the students.

6. The Home. The home can be a useful adjunct to the science laboratory. By suggesting safe, interesting experiments as homework, it is perhaps possible to steer students away from dangerous or disruptive science activity while increasing motivation and learning on the part of the student. By structuring the homework experiments, one can teach caution and common sense which are worthy objectives for any science program.
7. Student Responsibility. One of the more important lessons for every student is orderliness. If the teacher has to clean up after a lab, this is evidence of a weakness in the management system. Unless the student is willing to accept responsibility for the condition of the laboratory and its equipment, he or she has not yet earned freedom to use the laboratory. A well used laboratory is never spotless—neither is it a junkyard. There is a middle ground between a spotless (and unused) laboratory and a janitor's nightmare.

Time and cost factors

The program outlined is idealistic and ambitious. Both time and money must be expended to make it work. Some districts have spent thousands of dollars and many hours on such projects with questionable results. What can a small district, or even an average sized district, hope to accomplish with limited time and funding?

In the first place, money and time will not make a program. Also, a program cannot be accomplished overnight, or even in a single year. The program suggested is a continuing program, with the initial steps covering a three to five year time span. In this dimension, the time and costs can be spread over a longer time period, and the prospects for accomplishing the program are enhanced.

Secondly, with a broad base of community support, outside time and funds can be found. Often, a smaller community is more willing than a large suburban or city system to provide such support. Teachers will be willing to contribute their time and efforts to a project if they are really convinced that it is worthwhile. An administrator who really believes the project should be carried on will find some funds to keep it going. The support and cooperation of everyone is more important than large sums of money.

Teacher time

The most difficult problem is finding the teacher time and support for the project. Teacher time has been found in many different ways in various communities. Some of the techniques now in actual use were considered impossible a decade ago. The advisability of some of the techniques have been questioned, but each of them has proven effective in at least one community. Some of the techniques are:

1. Enlisting the aid of scientists and engineers in the community to teach classes and free the teachers for other things.
2. Enlisting parent volunteers to assist with the school program.
3. Using teacher aides or student teachers to work under teacher guidance, but with more than customary responsibility for working with students.
4. Shortening the school week to 4½ days, with the approval of the State Department of Education.
5. Developing independent study programs for students.
6. "Doubling up" students for large group instruction.
7. Having administrative and/or supervisory personnel take over classes for teachers.
8. Hiring substitute teachers.
9. Using programmed instruction or other techniques for self-study.
10. Hiring teachers to work during summers or week-ends on the project.
11. Asking the teachers to work overtime.

This last technique is all too common. It is undesirable, and will undermine teacher morale unless some form of compensation is provided for the extra time spent. Also, by the end of a busy school day or week, teachers are usually too exhausted to do good work, or to accomplish worthwhile outcomes.

Student time

When considering time for a program, and time for teachers, let's not ignore the time needs of students. How often has it been necessary to cut an experiment short because the end of the class period is approaching? Do students turn learning on and off with the ringing of a bell, like Pavlov's dogs salivate? Is the class schedule organized for efficient learning, or to give each teacher an equal share of the student's time?

A rigid time schedule for students is not a necessity for good management. Many school systems are using flexible scheduling successfully. Flexible scheduling may be more difficult to plan and manage, but many educators think that it makes a valuable contribution to a well-designed learning system.

Another area where student time is a problem is the semester system that tries to fit every student into equal time schedules in learning. Two learning variables are time and the quantity learned. If one of these variables is held constant, with a representative group of students, the other will follow the normal curve. In designing the learning system, we must ask ourselves whether we want to hold time constant, and permit the amount learned to follow the normal curve, or if we wish to hold what is to be learned constant, and permit the time needed to follow the normal curve. Perhaps neither of these variables should be held constant for many students.

Planning a budget

It was mentioned that there is an irreducible minimum of funds that are required for developing a science program. These funds are needed for materials, staff development, sometimes to pay teachers or substitutes, and perhaps for outside assistance. The amount of concern that an administrator and school board has for improving education can sometimes be measured in dollars. Unless the community is willing to have the administrator include a continuing budget line for staff development and curriculum improvement, there is little incentive for the supervisor and the teachers to be concerned with improving instruction. Happily, most districts have such items in their budgets. Sometimes the problem is to get the funds assigned to the project being planned. This is when a resourceful supervisor and a good public relations program can be of great service.

Conclusion

The suggestions in this chapter are not a blueprint for curriculum change. A viable curriculum plan must be designed to meet the needs of a particular system, and every system is unique. Educational philosophy, community support, availability of funds, teacher interests, student interests, administrator's attitudes, and the supervisor's ingenuity are among the many variables that make each situation unique.

Not only must a specific plan be individually tailored for each system, but the plan must be flexible, and subject to revision again and again as the project progresses. A systems approach to curriculum development forms the framework on which a viable program can be built, and the supervisor is one of the vital factors in the system.

REFERENCES

1. Kramer, S. N. *History Begins at Sumer*. Doubleday and Co., New York, N.Y. 1959.
2. McGregor, Douglas. *The Human Side of Enterprise*. McGraw-Hill, New York, N.Y. 1961.
3. The Science Decision Game. Innovations, Inc. Carrollton, Ga. 1973. (Copies of this game may be obtained at cost and/or permission given to duplicate it for school use. Write to Innovations, Inc., Box 847, Carrollton, Ga. 30117).

Implementing Curriculum Changes

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The purposes of this chapter are to clarify what is meant by implementing curriculum changes, to examine practices of implementation in current use in schools, to offer guidelines for implementing programs, and to take a position stand on the value of strategy planning in implementing curriculum changes.

When a teacher, a department, a school, or a school system goes about planning for a change in curriculum, there are two basic steps in making this change. The first step is the selection of the new program; the second is implementation, or installing the selected program. Mahan has defined curriculum installation as:

The planned introduction of instructional programs into schools with explicit expectations that the program will be taught on a regularly scheduled basis, will be taught to promote teacher and pupil behaviors congruent with the goals of the adopted program, and will remain the accepted and routinely used instructional program of the school until another curriculum with greater potential for meeting district needs has been systematically identified and introduced. [9]

Guba divides the system of curriculum development down into more than two stages:

1. Research
2. Development (includes Invention, Design, Evaluation)

3. Diffusion (includes Dissemination, Demonstration)
4. Adoption (includes Trial, Decision to Adopt, Installation, Institutionalization) [6]

This chapter deals only with the implementing, or installing, phase of curriculum development.

Implementation is often the downfall of an excellent curriculum selection. Eiss states:

Curriculum development is relatively easy when compared with implementation. Teachers are often individualists and do not accept orders without offering resistance. Many of the older teachers have been through several cycles of ineffective curriculum revision, and have developed a quiet, but firm attitude of passive resistance when curriculum changes are planned. For this reason, the supervisor should consider the problem of implementing curriculum change as a selling job, rather than attempting to take an authoritative approach. A curriculum plan needs style and character in order to win the cooperation of the teachers and the community. Any worthwhile goals require continuing, cooperative effort, and it will take a well-planned, carefully structured program to obtain the continuing cooperation that is essential for the success of any project. [3]

Current status of implementation

Some schools make excellent curriculum adoptions but then use poor implementing strategy. For example, School A developed an excellent course of study in the area of elementary social studies but turned the program over to the teachers without implementation strategy or supervision. The result of this adoption was failure in two years. Friedman raises the same question in regard to the implementation of curriculum guides:

It is generally thought that if curriculum guides are constructed by the total body of teachers, they are more apt to be used by them. There is both fact and fiction in this assumption. For one thing, the development of a curriculum guide by many people of varying opinions must represent a certain amount of compromise. Whether or not these compromises are actually implemented in individual classrooms is open to question. [5]

School B selected a nationally developed elementary science program but offered no regulated supervision or coordination and gave the teachers only one brief orientation session supplied by the publisher of the project. The result was continuous problems, dissention from the teachers about the program, and near failure. After a call for help, a consultant was hired and implementation strategy was initiated. Today the program is progessing satisfactorily.

Implementation can be difficult even when a line of strategy is utilized. Trump and Miller have written:

Well-meaning teachers and administrators, in the very process of starting innovations and experiments in their schools, may create barriers to further curriculum improvement. For instance, they may fail to recognize that a systems approach is essential in educational change.

The most important matter of all during the first year of change is close supervision of the teachers involved in the new program. The principal must change his own priorities about how he spends his time and energy. . . . He has to concentrate on the improvement of instruction, working with groups involved in change. Teachers do not change their teaching methods easily, nor do students change their learning habits easily. To facilitate the process, the principal (or supervisor) must ask many difficult questions, help to find answers, point out things that are being done incorrectly, and suggest how to improve procedures. He must work continually at evaluation. [14]

Gordon MacKenzie has summarized well the history of implementing curriculum changes. His description starts with the demonstration techniques of Pestalozzi in the late 1700's, and traces them through to the present time. The change, over this period of time, seems to be from the past when experts disseminated new programs, usually by demonstration, and the user made the most of what he or she could pick up by a sort of process of osmosis. Today, there is evidence of group planning and dissemination. These implementing groups utilize the combined efforts of content experts, methods specialists, psychologists, administrators, supervisors, teachers, and students and parents. These new forces and techniques give rise to new strategies. [8]

To most authorities in the implementation field, strategy is the key to success. Mackenzie defines strategy thus:

The term "strategy" is used to indicate the means which are used both to create curricular innovations and to facilitate their use on a continuing basis. . . . In one sense there is nothing new in the concept of strategies for planned curricular innovation, although the use of "strategy" in an educational context may be of recent origin. [8]

Many researchers offer guidelines for implementing strategy techniques. For example, Lawler lists twenty-one guidelines for developing strategies to introduce planned curricular innovations. [7] Allen and Fantini offer further suggestions for successful implementation with emphasis on inservice teacher training [1, 4]; this viewpoint is shared by Tyler. [15] Additional stress on the importance of strategy in implementing is given by McNally. [11] When an analysis is made of curriculum failures, both past and present, the failure can quite often be traced to a lack of adequate implementation strategy. The use of a strategy might have saved these programs.

Suggestions for implementing strategy

A planned strategy is needed for successful curriculum implementation. This section discusses two systems devised by others and then some comments by this author. The first set of guidelines to be introduced is suggested by Mahan as a result of his implementation work with the Eastern Regional Institute for Education (ERIE). In introducing his guidelines, Mahan writes:

Successful introductions of curricula are very possible, very demanding, and very "messy." Little will happen as a result of speeches, articles, and exhortations. Work on the part of the curriculum proponents is needed—longitudinal work "out there" in the presence of teachers and pupils. If a task-oriented installation strategy is steadfastly implemented by a task-oriented change agent(s), the prognosis for externally stimulated curriculum change is excellent. . . . Guidelines derived from case study are needed for initiating, supporting, monitoring, and sustaining curriculum installations if new curricula are to be more rapidly and more effectively utilized by the Nation's schools. [9]

Mahan's guidelines can be summarized into the following strategies:

1. Begin a curriculum installation only after specific written agreements clearly describing participant roles and responsibilities are accepted.
2. Construct a strategy for curriculum installation, complete with distinct components and approximate implementation dates, and follow the strategy from the start. Do not attempt a "we'll work it out as we go along" approach.
3. The school district must invest an adequate amount of funds to implement the program.
4. Make sure that teachers scheduled in any piloting personally volunteered to participate. Often teachers are "volunteered" by eager administrators.
5. Make sure teachers and principals are familiar with competing or alternative programs. A program must meet local needs.
6. Do not attempt curriculum installation unless curriculum guides (software) and all required equipment (hardware) are available to teachers at the beginning of the school year.
7. Provide intensive inservice workshop program for all personnel involved in the program, including school administrators.
8. Provide a consultant or coordinator to give help and to oversee the program.
9. If possible, utilize more than one teacher for each grade level or subject area. Change is better accepted when shared among teachers.
10. Insist that schools make formal provision for periodic, planned faculty assessment of curriculum implementation and resulting student achievement. Do not assume that a meaningful analysis of an on-going new effort will occur automatically.
11. In a large school system, include at least one subject matter specialist or supervisor in the following phases: planning, selection, preparation, implementation, and evaluation.
12. If available, provide participating teachers with live or filmed models of the instructional methodology used in the new program.
13. Evaluate the program carefully. Do not depend on myth, attitudes, verbal claims, and undocumented publicity. Make sure "the program" is being taught and learning is taking place.

Maxwell and Heitzeg also offer certain guidelines which they think promote successful implementation. [10] Their guidelines stress communication and rapport among those involved in the process:

1. *The Building Administrator.* The Administrator should know, understand, and be sympathetic to the program. He or she should provide support and encouragement to the teaching staff and provide adequate time to the teaching staff for preparation.
2. *The Teacher-Training Program.* Consideration should be given to factors such as the advance selection and training of key people; the thorough planning of the inservice program; installing end-of-the-year orientation programs and refresher orientations in the fall; and in-depth workshops in the methods and content of the program at each grade level.
3. *Good Communication.* Staff, parents, and students should all be involved.
4. *Evaluation.* Both subjective and objective methods should be utilized.

To cap off successful implementation Thier believes *internalization* is necessary. [13] By *internalization* Thier implies meaningful long-term implementation of an instructional program until the program becomes self-sustaining or is ready for modification or change.

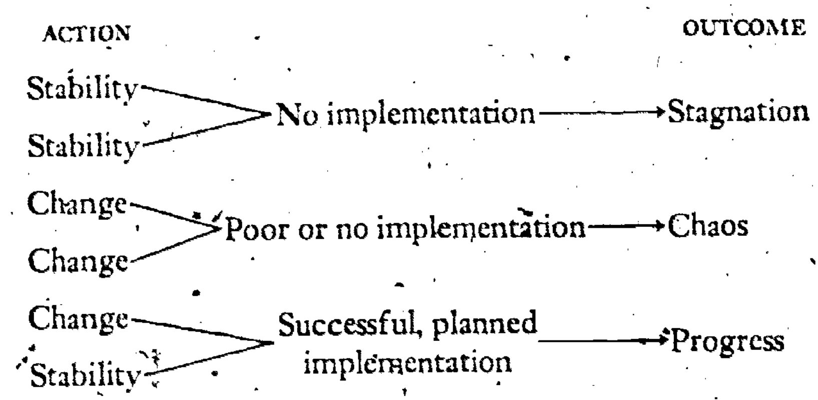
For successful implementation, this author would stress the following points:

1. All involved in implementation should have thorough knowledge of the content and methods of the adopted program.
2. Coordination and/or supervision of the program is a necessity. The supervisor should have extended knowledge of the program. Supervision is often a weak point in the implementation of a program; the responsibility is often delegated to a person already carrying a full load of assignments.
3. Inservice training should be as complete as possible. The new program should be adequately explained, with hands-on experience for those who will be teaching the new program.
4. Communication lines should be developed among all personnel involved in the program.
5. A feedback and evaluation system must be established.
6. A system for modification and change should be a part of the implementing program.
7. Possibly most important, there must be a feeling of openness among all involved in the adoption. Criticism, both pro and con, is most desirable. The key to success is sensitivity to all involved individuals; this sensitivity must be built into the system of implementation.

Position stand

When planned strategy is used in curriculum implementation, a given adopted program will have a much higher probability of success. The program will be better taught, learning outcomes will be evident, and the chance of longevity for the program will be increased.

Miel points out that implementation must be carefully planned or a number of undesirable outcomes may occur. [12] These outcomes are:



The science of strategy in implementation of curricula is just beginning to develop and take effect. Teachers, administrators, supervisors, colleges of education, and publishers must actively explore and utilize systems of curriculum implementation.

REFERENCES

1. Allen, Dwight. "In-Service Teacher Training: A Modest Proposal" in *Improving In-Service Education: Proposals and Procedures for Change*, edited by Louis Rubin. Allyn and Bacon, Inc., Boston, Mass. 1971.
2. Butterfield, Charles E. "The Changing Role of the Department Chairman and the Supervisor" (unpublished, 1973).
3. Eiss, Albert F. "Tactics for Curriculum Change" in *A Sourcebook for Science Supervisors*, edited by Mary Harbeck. NSSA/NSTA, Washington, D.C. 1967.
4. Fontini, Mario. "Teacher Training and Educational Reform" in *Improving Inservice Education: Proposals and Procedures for Change*, edited by Louis Rubin. Allyn and Bacon, Inc., Boston, Mass. 1971.
5. Friedman, Kopple C. "Using Curriculum Guides" in *Contemporary Thought on Public School Curriculum*, edited by George Marconnit. William C. Brown Co., Dubuque, Iowa. 1968.
6. Guba, Egon G. "Methodological Strategies for Educational Change." Paper presented at the Conference on Strategies for Educational Change, Washington, D.C. Nov. 8–10, 1975.

7. Lawler, Marcella. "Guidelines for Developing Strategies for Introducing Planned Curricular Innovations" in *Strategies for Planned Curricular Innovation*, edited by Marcella Lawler. Teachers College Press, New York, N.Y. 1970.
8. MacKenzie, Gordon. "Why A Strategy for Planned Curricular Innovation?" in *Strategies for Planned Curricular Innovation*, edited by Marcella Lawler. Teachers College Press, New York, N.Y. 1970.
9. Mahan, James M. "Overview of a Systematic Effort to Engineer and Monitor Curriculum Change: Emerging Guidelines and Encouraging Findings for Curriculum Installers." Paper presented at the Annual Meeting of the American Educational Research Association, New York, N.Y. February 6, 1971.
10. Maxwell, Donald and Howard Heitzig. *Guidelines for Implementing SCIS.* Science and Mathematics Teaching Center, Michigan State University, East Lansing, Mich. 1971.
11. McNally, Harold J., *et al.* "Criteria for Evaluating the Curriculum Improvement Program" in *Contemporary Thought in Public School Curriculum*, edited by Edmund Short and George Marconnit. William C. Brown Co., Dubuque, Iowa. 1968.
12. Miel, Alice. "Developing Strategies of Planned Curricular Innovation: A Review with Implications for Instructional Leadership" in *Strategies for Planned Curricular Innovation*, edited by Marcella Lawler. Teachers College Press, New York, N.Y. 1970.
13. Thier, Herbert. *Internalization—Essential to Meaningful Program Implementation.* SCIS Center, Lawrence Hall of Science, University of California, Berkeley, Calif. 1969.
14. Trump, J. Lloyd and Deloras F. Miller. *Secondary School Improvement—Proposals and Procedures.* Allyn and Bacon, Inc., Boston, Mass. 1968.
15. Tyler, Ralph. "Inservice Education of Teachers: A Look at the Past and Future", in *Improving Inservice Education: Proposals and Procedures for Change*, edited by Louis Rubin. Allyn and Bacon, Inc., Boston, Mass. 1971.

Evaluating Science Programs

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An integral part of curriculum development is the process of evaluation. Without serious curriculum evaluation, an administrator, curriculum supervisor, or teacher cannot determine if a particular planned learning sequence is meeting the needs of the student, if the content and its organization is valuable, and if the selection of learning experiences, teaching methods, and instructional media contribute to student learning.

The success or failure of a curriculum can be evaluated through the testing of students, individually or in groups. It is through student assessment that a supervisor gathers evidence that can lead to conclusions on the relevance of the curriculum to a group of students, the broad objectives of a school system, and the needs of society.

Student evaluation should concentrate on three major areas. These are: the cognitive domain; the affective domain; and the psychomotor domain. In past years, the majority of student and program evaluations has concentrated in the cognitive area. Currently, some emphasis is being placed on measurement in the affective area and very little evaluation is being done in the psychomotor domain. Science, as a body of knowledge, a process of thinking or decision-making, and a set of skills, lends itself beautifully to evaluation in all three areas.

The production of evaluation instruments and the development of measurement techniques has led to the construction of highly refined standardized tests in the cognitive area. Evaluation, however, can also be accomplished through well-constructed, teacher-made tests. Both types of instruments can play important roles in the assessment of the goals of a curriculum and the success with which the curriculum operates.

Standardized tests

Within the past fifteen years, over 60 standardized instruments have been developed or revised to evaluate student achievement or progress in science. Standardized science tests have been developed in the areas of elementary science, as portions of test batteries, and as single tests in the typical science content areas found in junior and senior high school. These tests can be used to gather information about students on which to base curriculum decisions.

Published standardized tests are most frequently developed by studying the content of textbooks and curriculum guides. Utilizing this information, the expertise of science consultants, and outstanding science teachers who understand both science content and student learning, test developers can identify those objectives that are typical of most science curricula. Test items are then written and refined to measure the most widely accepted of these objectives. By using a standardized test, the effectiveness of the curriculum in the school can be evaluated through the comparison of student performance with national norms. This type of evaluation can only be accomplished if the objectives of the test relate closely to the objectives of the curriculum and the instructional intent, and if the norming sample matches the school population in important characteristics. If the population on which the test is standardized does not match the school population, local norms can be developed. [3]

Through studying the item responses of the student on a standardized test, a curriculum evaluator can locate areas of student (and thus curriculum) strengths and weaknesses. There are several means by which this can be accomplished. If test items are grouped by cognitive taxonomy levels [1], an evaluator can determine the percent of successful responses in each of these categories and will be able to get an approximate idea if the curriculum is conducive to high level mental sophistication in student thinking. Several of the test manuals that accompany standardized tests key each item by taxonomy level for those that wish to perform this type of evaluation.

Test items can be studied by content groupings to gather related evidence of student achievement. When a large number of items are available, test questions can be categorized by content and then by cognitive levels within content. This should be done to check on cognitive response patterns on different units of a subject by the students taking the test.

When piloting a new curriculum in a school, standardized instruments can be used to compare achievement of the students in the pilot group with those in the conventional science class. It should be remembered, however, that the objectives of the pilot curriculum may stress objectives other than student achievement on typical science content. If no significant differences between the scores of these groups occur, or the pilot group performs better than the conventional group, evidence would indicate that the pilot group is performing at least as well as the comparison group in terms of the objectives which the test measures. Subsequent evaluation should be done on the other objectives that the pilot program purports to accomplish or on the instructional goals the teacher wishes to reach. This may be done by gathering information on student attitudes, student skills, understandings of science and scientists, the processes of science and so on.

At the end of this chapter is a list of standardized science tests (with publishers) that may be used for evaluation purposes for pupils in elementary and secondary schools. Before such tests are administered, the examiner should refer to the *Seventh Mental Measurements Yearbook* [2] and *Standardized Science Tests—A Descriptive Listing* [8] for reviews of these tests (publishers' addresses are included in both). After checking these reviews for a preliminary selection of a standardized test, order a specimen set of the test to study the items, the scoring techniques, and test score interpretation as well as the goals or objectives the test measures.

Many of the developers of the presently utilized curriculum projects have seen the need to construct testing instruments which measure the particular objectives of that curriculum. These developers have felt that, since these projects purport to help students reach objectives different from those found in a typical science course, a test must be developed to measure the achievement of these goals. Many of these tests are accompanied by normative and item analysis data gathered on students that have utilized the particular project. Information of this type can be very helpful to curriculum developers and evaluators.

Teacher-made tests

Well constructed teacher-made tests will provide similar information to curriculum evaluators. The reader is referred to *The Specification and Measurement of Learning Outcomes* [5] and *Educational Measurement* [4] for guidelines on proper test item construction.

Of utmost importance in test construction for pupil or program evaluation is the balance and relevance of the total test. Relevance refers to the closeness of the relationship between the objectives and the content area of the test and the objectives and content area of classroom instruction. Balance deals with the proportion of emphasis of the content objectives of the test and their relationship to this emphasis in instruction. Helping to insure the construction of a test with these characteristics is done in several steps. First, the objectives that students are to meet must be written in performance terms. Next, by analyzing the goals of instruction, a table of test specifications is constructed. This is a chart that relates the percentage of instructional time spent by cognitive level and content area. After the teacher records this data, test items should be written to reflect this table. (For example, if 15% of the instructional time has been devoted in the content area of zoology on the cognitive level of comprehension, the test items should reflect this percentage as closely as possible.) Each test should match the goals of instruction and what actually occurred in the instructional process. A test possessing the qualities of balance and relevance will help the classroom evaluator in monitoring the success of the instruction, instructional materials, and student achievement.

Cognitive achievement should not be the singular goal of pupil progress, instruction, and the curriculum. Areas such as the affective and psychomotor domains should also be analyzed. The affective area deals with the attitudes, beliefs, interests, and other emotional responses of the student to the environment. The science curriculum can play an important role in developing stable attitudes and values in our technologically stimulating society. Although measurement in the affective area is presently being delineated and refined, few instruments are available for assessing student interests, beliefs, and attitudes. The reader should refer to a document published by the National Science Teachers Association entitled *Behavioral Objectives in the Affective Domain* [4]; "The Present Status of Science Attitude Measurement: History, Theory, and Availability of Measurement Instruments" [6] (which lists published and non-published science attitude instruments); and to other science education research journals in order to identify the instruments that are presently used. A study of some of the instruments found in these sources may be helpful as models in preparing attitude instruments that are particularly useful for an individual school or classroom. The attitude instrument can take the form of questionnaires, checklists, interview schedules, and rating scales.

Though paper and pencil instruments are commonly used for accumulating information about student attitudes, other less formal methods may be used. Observing the behaviors of students may give a teacher a great deal of information about student attitudes as they are exhibited when they participate in class discussions, work on individual or group projects, and engage in classroom experimentation or other activities. Information on student attitudes can also be derived by the use of inquiry. The data on student attitudes is available to the teacher merely by asking. A wise teacher will use caution in applying this technique because often a verbalized attitude, interest, or opinion may be exhibited differently when the student is confronted with an expression of this attitude in a realistic situation. The inquiry process, therefore, should be confirmed by careful observation.

Perhaps the most critical area in which a science teacher should concentrate is in the promotion of attitude changes. Characteristics such as open-mindedness, verification of experimental results, and valuing the work of science and technology can be changed through the observance of the classroom teacher as a model of these characteristics, and through the opportunity of the student to relate science to the workings of society. These attitudinal changes can be detected through properly constructed instruments, observation, and inquiry.

The laboratory or investigative environment provided in the science classroom lends itself to the observation of the manipulatory skills of students. The psychomotor domain has had little or no emphasis in student or curriculum evaluation. Perceptive teachers can contribute a great deal of information in this area by studying the skills of students during manipulation of laboratory equipment. Here, systematic observation techniques can be employed along with teacher-developed checklists or inventories to assess skills and psychomotor activities of students. Using these methods, the teacher can determine the amount of confidence a student uses in performing a scientific task and can assess the improvement of manipulative skills through observing increases in efficiency, complexity of movements, and smoothness of the task performance.

Curriculum and student valuation should not be limited to the common methods of testing, nor should only one method of testing be used. Direct observation, interviews, and questionnaires can all be used successfully, alone and in combination with other instruments, to supplement decision-making for determining the effectiveness of the science curriculum and its total impact on student characteristics and behaviors.

Evaluation is critical to the development of a good science curriculum for a school, a particular classroom, or individual student. Without a serious attempt at evaluation, we are only paying lip service to providing the proper science curriculum for our students.

ELEMENTARY SCIENCE TESTS

Bormann-Sanders Elementary Science Test. Bureau of Educational Measurements, Kansas State Teachers College.

The Butler Life Science Concept Test. Psychometric Affiliates.

Educational Development Series—Elementary Level—Science. Scholastic Testing Service, Inc.

Metropolitan Achievement Tests—Intermediate—Science. Harcourt Brace Jovanovich, Inc.

Minnesota High School Achievement Examination—Science—Grade 7. American Guidance Service, Inc.

Minnesota High School Achievement Examination—Science—Grade 8. American Guidance Service, Inc.

Sequential Tests of Educational Progress—Series II—Form 4. Educational Testing Service.

Sequential Tests of Educational Progress—Series II—Form 3. Educational Testing Service.

SRA Assessment Survey—Achievement Series—Science. Science Research Associates, Inc.

Stanford Achievement Test—Intermediate II—Science. Harcourt Brace Jovanovich, Inc.

SECONDARY BIOLOGY TESTS

BSCS Comprehensive Final Examination. The Psychological Corporation.

Cooperative Science Test—Biology. Educational Testing Service.

Emporia Biology Test. Bureau of Educational Measurements, Kansas State Teachers College.

General Biology Test. Psychometric Affiliates.

Minnesota High School Achievement Examination—Biology. American Guidance Service, Inc.

Nelson Biology Test. Harcourt Brace Jovanovich, Inc.

Processes of Science Test. The Psychological Corporation.

Tests for Patterns and Processes. The Psychological Corporation.

SECONDARY CHEMISTRY TESTS

ACS-NSTA Cooperative Examination in High School Chemistry. Examinations Committee, American Chemical Society.
ACS-NSTA Cooperative Examination in High School Chemistry (Advanced Level), Examinations Committee, American Chemical Society.
Anderson-Fisk Chemistry Test. Harcourt Brace Jovanovich, Inc.
Cooperative Science Test—Chemistry. Educational Testing Service.
Emporia Chemistry Test. Bureau of Educational Measurements, Kansas State Teachers College.
General Chemistry Test. Psychometric Affiliates.
Minnesota High School Achievement Examination—Chemistry. American Guidance Service, Inc.

SECONDARY GENERAL SCIENCE TESTS

Adkins-McBride General Science Test. Psychometric Affiliates.
Cooperative Science Test—Advanced General Science. Educational Testing Service.
Educational Development Series—Senior Level Science. Scholastic Testing Service, Inc.
Emporia General Science Test. Bureau of Educational Measurements, Kansas State Teachers College.
Fundamentals Evaluation Test—Science. Steck-Vaughn Co.
Metropolitan Achievement Tests—Advanced Science. Harcourt Brace Jovanovich, Inc.
Metropolitan Achievement Tests—High School Science Test. Harcourt Brace Jovanovich, Inc.
Read General Science Test. Harcourt Brace Jovanovich, Inc.
Stanford Achievement Test—Advanced Science Test. Harcourt Brace Jovanovich, Inc.
Stanford Achievement Test—High School Science Test. Harcourt Brace Jovanovich, Inc.
Test of Science Knowledge. The Psychological Corporation.

SECONDARY PHYSICS TESTS

Cooperative Science Test—Physics. Educational Testing Service.
Dunning-Abeles Physics Test. Harcourt Brace Jovanovich, Inc.
General Physics Test. Psychometric Affiliates.
Minnesota High School Achievement Examinations—Physics. American Guidance Service, Inc.

OTHER SECONDARY SCIENCE TESTS

Iowa Tests of Educational Development—Science. Science Research Associates, Inc.
Minnesota High School Achievement Examination—Science Grade 9. American Guide Service, Inc.
Science Tests—Content Evaluation Series—Physical Science. Houghton-Mifflin Company.
Sequential Tests of Educational Progress—Series II—Form 2. Educational Testing Service.
Tests of Academic Progress. Houghton-Mifflin Company.
Test on Understanding Science. Educational Testing Service.

REFERENCES

1. Bloom, B. S., editor. *Taxonomy of Education Objectives; Handbook I: The Cognitive Domain*. David McKay, New York, N.Y. 1956.
2. Buros, O. K., editor. *The Seventh Mental Measurements Yearbook*. The Gryphon Press, Highland Park, N.J. 1972.
3. Educational Testing Service. *Constructing and Using Local Norms*. Princeton, N.J.
4. Eiss, A. F. and M. B. Harbeck. *Behavioral Objectives in the Affective Domain*. National Science Teachers Association, Washington, D.C. 1972.
5. Payne, D. A. *The Specification and Measurement of Learning Outcomes*. Ginn & Company, Waltham, Mass. 1968.
6. Pearl, Richard E., "The Present Status of Science Attitude Measurement: History, Theory, and Availability of Measurement Instruments." *School Science and Mathematics*, 74:375–381; May/June 1974.
7. Thorndike, R. L. *Educational Measurement*. American Council on Education, Washington, D.C. 1971. (Chapters 3 and 4.)
8. Wall, J. E. and L. R. Summerlin. *Standardized Science Tests: A Descriptive Listing*. National Science Teachers Association, Washington, D.C. 1973.

Getting Materials Into Teachers' Hands

Gary Huffman, *Supervisor of Intergroup Relations, Title VII Programs and Services, Indianapolis Public Schools, Indianapolis, Ind.*

From February, 1971 to August, 1974 the Science Supervisor, grades K–12, for the Indianapolis Public Schools and two assistants attempted to implement ESS with approximately 48,000 students in grades 1–6 and ISCS with approximately 16,000 students in grades seven and eight. Needless to say, they had to get many science materials into the hands of teachers.

The mechanics of getting the right materials to the right people at the right time is not a strange and mysterious process. General Motors and other large corporations do a good job of it. There are accounts of how school systems in Colorado and Virginia provided elementary teachers with science materials for activity-based science programs. These school systems used the kit distribution approach. They loaned kits out to teachers and had the kits returned to a central supply center where the kits were refurbished before being sent out again. To keep the cost of kits down they attempted to buy as many items as possible in bulk from local distributors.

In Indianapolis this approach was not used for distribution, mainly because funds were not available to hire personnel to operate a kit distribution center. Instead, original kits were sent to remain in the building, and teachers were provided with order forms by which they could order kit replacements at the beginning of the fall and spring semesters. The staff filled these orders over the summer and at the beginning of the spring semester. The rest of the time in the school year was used to provide on-going, inservice training and trouble shooting activities.

This brief overall sketch of how materials got into teachers' hands might be more understandable if the answers to the following often-asked questions are given.

Q—Wouldn't it have been less expensive to loan kits to teachers? For example, if different teachers used different kits at different times, so many kits would not have to be bought.

A—One kit for every three teachers in a building was provided. The teachers in the building swapped kits and this kept down the number of kits which had to be bought. These teachers would sometimes get a kit and an item would be missing that had not been planned for in the previous semester's ordering. A phone call to the central office would get this missing item on its way to teachers.

Q—How in the world did you provide inservice for all those teachers in the use of ESS and ISCS?

A—To get ESS and ISCS off the ground, training was provided in the summer of 1971. It was impossible to train all 1,350 teachers of grades 1–6 in the use of ESS, so ten primary (grades 1–3) and ten intermediate (grades 4–6) teachers were trained from each of the ten areas in our school district. These teachers were called "Resource Teachers." Throughout the school year the Resource Teachers provided inservice training for teachers in their buildings. The Resource Teachers were the link to each school and could advise the central staff of problem areas so that they could be alleviated.

Inservice meetings were held throughout the year for Resource Teachers and any other teachers in the system who cared to attend. ISCS Level I was implemented in the 1971–72 school year for both seventh and eighth grades; Level II in the 1972–73 school year. During the summers of 1971 and 1972, inservice training was held for teachers in the use of ISCS. As with ESS, inservice training was provided throughout the year in ISCS for those teachers willing to attend.

McGraw Hill and Silver-Burdette provided consultant help for training purposes in the summer and throughout the school year. Many teachers were also able to take advantage of NSF-sponsored Summer Institutes, which were held at that time.

Q—How did you evaluate ESS and ISCS?

A—The ideas listed in the ESS teacher guides were used to evaluate students' progress. The overall goal for the ESS program was to develop in students the ability to state a question and to find the answer through the manipulation of materials. The school system gives a standardized test in science at the eighth grade level. This standardized test showed that ISCS students made a slight but not significant gain over students who had not used ISCS. The standardized test scores were used by the central administration for their purposes. The criterion referenced tests, developed by ISCS, were also used to give teachers a truer measure of what ISCS students had learned.

Q—Where can you buy materials inexpensively (e.g., mealworms, flashlight batteries and bulbs, food dye, kosher salt, etc.)?

A—Call local retailers and ask them where they buy these items, then buy from that source. For example, the manager of the local A&P store was able to identify a source for kosher salt. He gave the name of a company in Cincinnati. A letter to that company made it possible to get kosher salt at about half the retail price. (Who said science wasn't multi-ethnic?)

Q—How do you get started in implementing science programs that require a lot of materials?

A—To begin, you must begin. If too much time is spent getting ready to be ready, the beginning may never be made. By actually starting the system, we were able to keep it going by working out solutions to the problems as they arose. Important decisions—the key trade-offs and resource allocations—cannot always be made ahead of time.

Q—Was it all worth it? Why not just have the kids curl up with a good book?

A—It was gratifying to see the students answer questions through their manipulations of materials, rather than working with the all-too-familiar types of assignments: "Read pages 16–23; answer the questions on page 24 and we will discuss it tomorrow; don't forget the test on Chapter 3 on Friday."

I leave the decision of "is it worth it" up to you. As new formats for learning media appear, new ways of distribution will evolve wherever dedicated staff members make the determined effort necessary to accomplish the task.

Developing Local Curriculum Reform

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The major function of the science supervisor is the improvement of the instructional program. This is accomplished by leadership in three areas:

1. Improvement of the science classroom environment in which the supervisor aids the teacher to improve the components of the discovery-based science lesson.
2. Modification of the curriculum through the subtle effects of revision, addition of new techniques and/or materials, and the impact of new science discoveries taught to teachers in post-observational and departmental conferences.
3. Courses of study modified by altering the organization of topics, the deletion of material, units fragmented and re-distributed, or the addition of new units or materials to meet the local need.

These educational methods are utilized by dedicated science supervisors in their daily tasks in and out of the science classroom. However, at times there is the need for major curriculum reform to meet the needs of a science problem which is indigenous to a local area.

Each state, and many communities, have courses of study or syllabi containing outlines of facts, principles, concepts, or sample lesson plans that the science teacher is expected to follow. But where state or local curricula are limited, or do not meet changing pupil needs, it is the task of the science supervisor to organize the department to fill that need. This chapter outlines the process of curricular reform which this author has implemented in his own department.

Identifying the problem

The nature of the problem in a particular area must be defined before any constructive change can be made. Once a specific problem has been isolated, a complete analysis must take place before the initiation of a curriculum change. In the case of this author's experience, the science department felt that the program for students who excelled in science was in need of major revision. These students were involved in an accelerated program in which they were to complete three years of junior high school science in two, and then complete a course in earth science in grade nine or be given "enrichment topics." Since there was flexibility in the methods used, a lack of teachers with strong earth science backgrounds, and an urban setting for the school, everyone felt that the bright students should be given a new course of study in grade nine.

Leadership role for curriculum improvement

The science supervisor must be able to organize, delegate, and complete the project of curriculum innovation. He or she must have the respect of staff in order to implement change. This can only be accomplished by using the principles of democratic administration and supervision. The supervisor must strike a balance between achieving the goals of the department and meeting the needs of teachers in the group. Some of the qualities which are important in this leadership role are:

1. evidence of continued science scholarship;
2. willingness to explore, experiment, and innovate;
3. accessibility;
4. willingness to assume responsibility;
5. ability to hold effective meetings;
6. ability to involve effective people and move them forward;
7. ability to secure loyalty;
8. appreciation of all ideas;
9. ability to listen seriously and sincerely;

10. ability to maintain high moralé by promoting a good organizational climate.

Initiating curriculum improvement

The science supervisor must decide on the best approach to organize and effect the change. It should be noted that if the supervisor dictates a decision through a hierarchical structure, it will be doomed to failure; the need will not have evolved from the staff which has to implement the decision. A departmental conference should be held to solicit the ideas and recommendations of the staff.

In this author's case, it was decided that an *ad hoc* science curriculum committee should be formed to decide on strategies. Four teachers, a laboratory assistant, and this author comprised the group. The following techniques were implemented:

1. *Open discussion.* All teachers were free to state their philosophies, values, and desires.
2. *Collegial decision-making.* The decision arrived at was cooperatively developed by the department.

Our committee decided that a year-long course in environmental science should be written, including lesson plans, laboratory activities, and extensive field trip guides.

Participation

The science supervisor must give direction in a cooperatively developed program. Teachers must be given decision-making authority, since it is they who will implement the program. Teachers perform three major tasks in curriculum implementation:

1. They work and plan with their students.
2. They develop individual approaches.
3. They share curriculum experiences with their colleagues.

In maintaining the collegial spirit, the supervisor should insure that he or she becomes a part of the working team. Delegation of the "work portion" to the teachers will be self-defeating.

In our experience, once the decision was made to write a year-long environmental science program, members of the committee decided what aspects they would undertake. Each teacher selected a topic to write on from an outline that was developed. The science supervisor allowed staff the freedom to create that part of the program in which the teacher felt he or she had the most expertise and confidence.

Communication

Although each teacher is working on a separate aspect of the problem, the science supervisor must insure that the cohesive nature of the project is maintained. Periodic meetings—both individually and collectively—should be held to direct the work to completion. An "open-door policy" should be maintained to promote vitality in an informal way.

Funding

The development of a new science curriculum is usually based on the concept of discovery learning by student laboratory activities, field trips, and demonstrations. These often require additional scientific apparatus which may strain the limited budget of an individual school. Some districts allocate funds for experimental curriculum designs; in other districts, alternative sources must be investigated. The science supervisor should investigate the mechanisms for writing grant proposals in the search for funding new curriculum.

In the case of this author's experience, the PTA and NDEA Title III Federal Grants have proven successful sources of support. The PTA, with its various fund-raising activities, has been generous in purchasing those pieces of equipment which could not otherwise have been obtained. Through conferences and orientation sessions, parents have become familiar with the science program and are thus most receptive to our requests for financial aid.

Each year, grant proposals for Title III funds are written. By this means, our department has obtained an environmental biotronette chamber, aquarium, and field equipment.

Evaluation

In order to escape provincial bias, any experimental curriculum should be sent to an outside agency for independent evaluation. Evaluation should be an ongoing procedure, and modifications should be implemented as the curriculum evolves through various phases.

Our environmental education program was reviewed by the American Society for Ecological Education. Requests for our program were received from various parts of the country, and their evaluations were incorporated into our program. To complete our evaluation process, we used supervisory observations, teacher evaluations, parent and pupil questionnaires, and pupil test scores.

Similar to the scientific method itself, new procedures are used to replace those methods that do not meet the ultimate objective—students learning the concepts of science.

Science Fairs
One Teacher's Opinion

Gene P. Kingham, *Shelter Island High School, Shelter Island, N.Y.*

There are many differing views on the advantages and disadvantages of science fairs. This educator thinks that the pro's outweigh the con's. The things that a student learns by competing in science fair projects are not easily measured. They include self-confidence, organizational skills, public speaking, data collection skills, interpretation of facts, and integration of new ideas. A science fair provides students with the opportunity to get involved, plan, create, and sense the feeling of achievement.

Those who oppose science fairs hold that such fairs promote the wrong type of thinking about what an academic pursuit should be; that they take up too much class time; that they cause some students to become uneasy because they are asked to "perform." A supervisor or teacher should test the local sentiment regarding science fairs prior to making plans; the support of the community is a necessary asset to any science fair.

Student participation

Students can be encouraged to produce project work so that they can enter the science fair. If students are *required* to produce a project as part of their course work, the number of the participants in the fair will most likely increase greatly. Once they have completed the work, most students feel that they should enter it in competition.

Supervisors and teachers can assist students in choosing a topic for a project. They should be encouraged to explore more seriously a subject in which they are interested. A listing of resources on a variety of topics or of areas that lend themselves to project work should be available.

Once the student has chosen a topic and submitted a title, a progress report schedule should be developed. This will help students pace themselves, and prevent last-minute "cramming."

Planning ahead

There are many practical details which must be set up well in advance of the day of the science fair. Some of these are:

1. *Setting a date:* Check school calendars and listing of community events prior to setting a date for your fair. This will avoid conflicts for both students and parents.
2. *Obtaining judges:* Contact local science facilities, laboratories, colleges, and research facilities. Letters to the directors or administrators of these facilities are usually more effective than letters to individuals. Be sure that you have enough judges to give fair and thorough consideration to each of the projects. (A good ratio is 30 judges for 70 students.)
3. *Awards:* These can vary from trophies to ribbons, depending on funds available for the purpose. Contact local businesses and service organizations for possible support. Order whatever awards are decided upon in plenty of time to have them ready for the presentation at the closing ceremony of the science fair.
4. *Space:* Decide on a location which can be reserved well ahead of time and which will afford sufficient space for the number of exhibits and participants you expect for the fair. Give consideration to necessary electrical outlets, wall space for supporting projects, etc. Design a scale plan of the facility to be used and transfer it to graph paper. Space for the projects can then be designated on a master chart, and duplicated for inclusion in the program.
5. *Program:* The following items should be included in the printed program for the fair: names of judges, participants, and contributors; a listing of the projects and where they are located; and perhaps names of past winners. The program can be an excellent means of involving the entire school in the science fair. Have the

art department design the program cover; the shop department assist in construction of project displays; the English department prepare abstracts of the projects, and the commercial department type the reports for project participants.

6. *Publicity:* Send notices to local newspapers, radio stations, local officials, the board of education, faculty, administration, and parents. Posters for local businesses and "take-homes" for students are also helpful. Include a schedule with all of these materials.
7. *Thank you's:* Send a thank-you letter to each judge, to each administrator who released a judge, and to every contributor. Add a letter to the personnel files of persons involved in making the science fair a success. These post-fair efforts are time-consuming, but they are well appreciated by those who are remembered for their contributions. The post-fair work you do one year will help in ensuring the success of the next year's fair.

One final note regarding science fairs is the director. The person who is in charge of the science fair can make a great difference in the success or failure of the science fair program. The director should be deeply concerned about the development of the science fair program and should add as many new ideas as possible into the existing framework.

How To Have a Better Science Fair

H. G. Hodges, L. A. Popp, and F. G. Robinson

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Each year science fair committees, science teachers, and individual students ask us to give advice and make evaluations in connection with science fairs. Our experience has led us to some fairly explicit conclusions, which we would like to present here for your consideration.

Our purpose is not to criticize science fairs but to encourage their further expansion and improvement. Through collective service as judges of fairs at all levels—classroom, school, community, county, regional, provincial, and national—we have observed them extensively and feel that they have much educational value. Students, we find, are generally enthusiastic about them and organize their project preparation well.

Certain assumptions underlie the science fair movement, even though they are not always explicitly stated. These assumptions are:

—that the values of science fairs are educational rather than competitive and the benefits are shared by all participants and not merely by the winners;
—that the purpose of science fairs is to promote and encourage scientific thinking on the part of the participants;
—that the work going into a science fair is the work of the student involved, although it is recognized that there is merit in his having

some advice from parents, teachers, scientists, and other appropriate persons;

—that there is consensus on the part of the judges, teachers, and students on the criteria for judging. Such criteria are usually concerned with originality, design, organization, neatness, clarity, and accuracy.

Criteria for a science fair should reflect the basic purposes, particularly the encouragement of scientific thinking. In this way, they guide the student in selecting and organizing his project and the judge in evaluating it. Therefore, the science fair committee's first requirement is to prepare a clear statement describing the possible levels of scientific activity that entries may represent and the criteria upon which they will be judged.

There are two important purposes served by identifying a levels system. First, it indicates to students that various levels of scientific intensity can be identified, and that in general projects at higher levels are more deserving of recognition than those at lower levels. Second, it specifies the various levels to be used in categorizing the projects.

We propose the following five-level system as a means of differentiating among the various qualities of scientific investigation.

Level 1: *A diagram, copy, illustration, table, or other display of science information already available in printed or non-print material.* The most common level 1 exhibits are enlargements of tables or diagrams from magazines or science books, or commercial models assembled by the students. Typical examples would be a chart of the life cycle of an insect; a chart illustrating the operation of a dry cell; a standard diagram of the solar system accompained by a table of information on distance, size, length of year, and temperature; and a cross-section of plant or animal material. The student has not developed a novel presentation of the information, nor has he brought together a number of interrelated diagrams or displays on the topic. He has basically selected and reproduced—perhaps with some refinement or modification—material that is generally available.

Level 2: *A chart, illustration, model, collection, specimen, or report based on firsthand investigation by the student.* The vital criterion for this level is that unmistakable evidence of the student's own thought must be apparent in the data, organization, interpretation, or reporting. If the project deals mainly with information already available, it must show novelty of treatment or organization. A very wide range of projects fall into this category. Examples: a report on the care of one or more live specimens, either plant or animal; an unsystematic collection of specimens in a broad classification such as insects or leaves; a display of topical photographs taken by the student; a chart recording the amount of rainfall for a period of time; a student's own static model of the solar system, a rocket, or a building; a diorama showing a typical environment of a plant or animal; a map, chart, life cycle, or similar material. In each case there is clear evidence that the student actually made a contribution rather than merely copying information from a standard reference.

Level 3: *A working model based on an understanding of a scientific principle.* At this level, projects range from replications of standard classroom experiments (with or without improvements) to working models, in each case showing that the student understands the principle involved. A demonstration of an experimental effect also fits into this category. Examples: a working model of a device such as a fuse breaker or a telegraph key; a demonstration of the conversion of energy from one form to another; a home-made thermometer; a fairly complex working system, such as a home-made incubator, in which more than one scientific principle may be demonstrated. Generally speaking, if a student has developed or invented a new application of a principle or a new working device, his project qualifies for this level, but obviously it merits a high rating on other criteria such as originality.

Level 4: *An attempt to answer a question by designing and conducting an experiment or correlational study in which one or more variables undergo testing, but in which circumstances or lack of knowledge prevents adequate control of significant independent variables.* The aim of the project should be to discover a cause-and-effect relationship between two phenomena or sets of phenomena. The test for this level (as compared with level 5) is whether all the important variables are controlled. Typical examples: measurement of the effect of a particular environment on plant growth (without controlling such variables as soil, water, sunlight, and temperature); measurement of the effect of temperature on mealworms (without controlling light, moisture, etc.); a study designed to determine whether varying the length of a column of air in a bottle affects the pitch (without controlling the type or shape of bottle used); or a comparison or the effect of one dietary component on rats (without adequately matching the rats and controlling other variables).

Level 5: *An attempt to answer a question by designing and con-*

ducting an experiment or correlational study in which all the important competing variables are controlled. Although projects at this level are relatively rare at science fairs, they represent a peak in scientific work and should be encouraged. To qualify for this level, a project must meet two main criteria: (a) the experiment will be controlled to the point where alternative explanations of the effect can be ruled out; and (b) the student will show an understanding of the logic of the methodology involved (e.g., how the effects of specified competing variables were eliminated) and of the interpretation of the result (e.g., why the result cannot be attributed to error or chance factor). In most cases, charts or graphs of data will be available for examination. A novel approach to a standard classroom experiment, if the other criteria are met, qualifies for this level. If a problem is identified and the variables adequately treated, it is not essential that significant positive findings result from the project; it must be recognized that the design rather than the results qualifies a project for this level. Outstanding examples of level 5 projects that we have observed are a carefully controlled dietary study of the growth of rats, a study correlating the kinds and numbers of snails in various places in a river with the amount of pollution in each area, and a study of the effects of chemicals on colors of ceramic glazes.

These five levels can be given recognition by a differential awarding of basal points. For example, it might be decided that level 1 projects should have a basal rating of 5, level 2 of 10, level 3 of 15, level 4 of 20, and level 5 of 25. Then up to 75 merit points can be awarded by the judges in accordance with the other criteria agreed upon, and the final score for any project will be expressed as so many points out of 100. Thus, while higher-level projects carry a bonus, it is still possible for outstanding examples of lower-level projects to receive greater scores than average projects at higher levels.

In addition to specifying levels of science activity, we recommend that science fair planning committees consider the following suggestions, which have arisen from our observations and discussions.

1. Students should be made aware of the basic purposes of science fairs and, more particularly, informed of the criteria to be employed in judging. Our discussions with students have frequently revealed that they were not aware of criteria that would undoubtedly have led to better selection, design, and presentation of their projects. It is important that information about criteria be provided at the outset so that students can investigate the various levels before selecting a project.

2. There should be a clear understanding of the amount of outside help students are permitted to receive. The usual criteria do not put enough emphasis on what might be termed 'independent effort.' Since assessing the amount of independent effort is a difficult task for the judges, we suggest that a statement be attached to each project. This statement should be signed by the student and his teacher and should indicate the source of the idea for the project, the student's actual contribution to its development, and the contributions made by the teacher, parents, or others. At the present time there appear to be no guidelines on help from other people, and in the past some highly rated projects have benefited from substantial input from adults. An acceptable guideline would be to allow a small amount of consultation at the original planning stage, but no outside help at the stages of data collection, interpretation, and presentation. Consultation at the planning stage should be limited to helping the student improve the planning of the project he himself has chosen, and should not directly influence his choice, his search for sources of information, or the eventual construction or display of the project.

3. The committee should ensure that the judges agree in their understanding of the criteria and follow them as rigorously as possible. Otherwise a very neat, a very attractive, or a spectacular project may receive a higher rating than it deserves because of a judge's particular bias. Similarly, the judging should not reflect the appeal that certain of the projects may have for visitors—such as spectacular working models or projects involving pets.

4. A clear indication of the total amount of work that the student has invested in the project should be available to the judges. Sometimes projects involving a great deal of work are not spectacular and the amount of effort put into them is not recognized. This is particularly true of projects for which data are collected over long periods of time.

5. Most science fairs include entries that fall under the heading of social studies or sociology—projects such as models of villages, maps showing population densities, studies of voting patterns, and family trees. If the judges are accustomed to thinking in terms of the physical and biological sciences, many of the entries will get less recognition than they deserve. We suggest that a separate category for social and behavioral sciences be established and a person qualified to assess the value of these entries be added to the panel of judges.

6. Steps should be taken to provide feedback to contestants. In most science fairs the lack of feedback is a major weakness. Adjudication of the sort given at music festivals is valuable to contestants,

and we suggest that a similar system be adopted by science fairs. In the past, the small number of judges, the many projects, and the limited time allowed for judging have tended to prevent adequate evaluation and discussion with the student. For this reason, we suggest that the number of judges be large enough so that an individual rating sheet can be completed for each project and given to the contestant. In addition, if possible, each contestant should have an interview with a judge, who will discuss his project, point out its merits, and suggest improvements that might be made. The ideal arrangement is to have the contestants present during and after the judging so that the judges' comments may be communicated to them immediately.

We believe that if science fair committees are guided by these suggestions, the major goals of science fairs will be more fully realized, gradual improvement of entries will be ensured, and broader student involvement will result.

The Planetarium as a Teaching Tool

Catharine Y. Bonney, *Supervisor of Science (retired), Newark School District, Newark, Del.*

Ora Ann Shultz, *Planetarium Director, Newark School District, Newark, Del.*

For some people the concept of a planetarium program is that of a "show," with the person at the controls delivering a "canned" lecture while the audience sits in awe of the spectacle overhead. This definition should not apply to the planetarium programs presented as part of a science education program. In such a program, the audience becomes involved through continuous interaction between the instructor and the student. Two factors which promote this interaction are the advanced classroom preparation geared to the unit plan, and the preliminary involvement which the students experience in an astronomy learning center. When questions arise, the students are involved in developing plausible answers.

There are some who will ask why such an expensive piece of equipment is needed. Why cannot the same results be obtained with ordinary classroom materials? Perhaps the simplest answer is that the planetarium makes the "impossible" possible.

Here are a few of the "impossibles" that are standard procedure during the planetarium programs:

- Sunrise and sunset can occur whenever you wish.
- A day or night can be compressed into minutes.
- The stars can stand still.

- Constellation figures can be projected against their starry background.
- Winter constellations can be seen at any season. (The same is true of any other seasonal groups.)
- Planets can speed up their "apparent wandering" among the stars.
- The moon can rise, set, and go through its month of phases.
- The polar skies, as well as the equatorial scene, can be observed without ever leaving home.
- It can be shown why the dippers are called circumpolar constellations.
- The skies of the ancients as well as of the future can be projected.
- A year of sunrises can be observed, with the sun appearing to ride from its northeast to southeast position on the horizon.
- The "land of the midnight sun" can become real.
- Constellations of the southern hemisphere can be identified.
- By using the coordinates and the geocentric earth, time belts can be projected making it easier to understand our system of time.

A planetarium program which supplements the science curriculum guide possesses a purposeful direction. This has been the case since the inception of the planetarium program in the Newark School District.

Newark's Planetarium, a Spitz A-3P, represents a science teaching tool that has been in operation on a daily basis since its installation in 1963. Over the years, the planetarium has projected the star field on its 30 foot dome for over 75,000 visitors from pre-schoolers to senior citizens. As a part of the regular science program, all students in grades 1 through 5 visit the planetarium yearly. In addition, several middle school classes and most of the earth science classes from the districts are also accommodated. In the evening, classes from Newark's adult school and the University of Delaware, as well as numerous community groups of all ages, hold sessions in the planetarium.

A classroom adjacent to the district's planetarium has been converted to serve as an astronomy learning center. Here, students gather for an orientation before their planetarium visit. Using a three-point focus, the instructor projects slides and transparencies onto three screens to prepare the students for concepts that will be emphasized during the planetarium lesson. This classroom, carpeted and equipped with blackout curtains, is well supplied with all kinds of projectors and visual materials for use in supplementing the astronomy presentation. Models, charts, and sky maps are used extensively as visual aids to reinforce the learning process.

Student involvement in the learning center prior to the planetarium presentation sets the stage for meaningful interaction between the students and the instructor during the time spent under the planetarium sky.

At the start of each school year, elementary teachers are given a schedule of the approximate dates when their classes will visit the planetarium, along with the subject that will be treated at their specific grade level. With the exception of first graders, who are the last to visit, classes come in sequence, starting with grade two. High school earth science students are scheduled for September. By delaying the start of the elementary program, teachers of the younger students have time to prepare their classes for the visit. Since the planetarium is housed in a high school removed from the elementary buildings, all students in grades 1 through 5 must be bused to the site. The majority of students in the district are bused to school, so it is necessary to schedule elementary planetarium programs to fit the hours when busses are free. Clearance for busing is arranged through an agreement with the school involved and the bus transportation system. This insures the smooth transportation of classes to and from the planetarium.

As soon as the bus schedule is established, a unit of resource materials is sent to those teachers whose classes will be making the trip. Included in this material are the bus schedule, previously confirmed by telephone, and a detailed plan which teachers can follow when teaching their astronomy unit. These plans are updated each year to meet current conditions and interests. A typical unit contains the following materials:

1. Instructional objectives
2. Concepts to be developed
3. Description of the program, including classroom orientation and planetarium program outline
4. Vocabulary list
5. Constellations of the month
6. Sky calendar
7. Interesting activities

The planetarium is an instrument which, because of its versatility, can stand alone as a teaching tool. At the same time it opens the door to an endless variety of special effects which can be adapted to enhance the educational program. Installed originally to serve the science population, the planetarium has provided the impetus for involvement by other disciplines.

Copying from an idea common to planetariums, the art department created an imaginative view of the horizon as seen from the school site and secured this to the cove at the base of the planetarium dome. Instead of the skyscrapers, which dominate city scenes, the student artists who created this display took a longer view, incorporating into their design points of interest around the state, including the twin spans of the Delaware Memorial Bridge, the capitol buildings at Dover, the John F. Kennedy Turnpike, Caesar Rodney Square in Wilmington, and the University of Delaware football stadium.

One of the most ambitious involvements by other disciplines was the installation of an "extra-effects" projector system designed and constructed by the electronics class of the home high school. This system, operating independently of the planetarium instrument, is constructed with the capability of controlling twelve extra-effects projectors mounted around the cove. These projectors, adapted with dimmers to facilitate adjustment to lighting conditions in the planetarium chamber, can be operated simultaneously or separately, as desired for carrying out any series of supplementary slide projections relating to the program. In addition, projector types can be varied to include simulated sun and moon eclipses, meteor showers, and various other celestial phenomena that cannot be demonstrated with the planetarium instrument alone.

Teachers from several academic disciplines use this visual aid to help in interpreting concepts of the universe and the terrestrial geography of the Earth. Math classes find the planetarium dome helpful in studying angles and arcs and interpreting the celestial coordinate system as compared with coordinates of latitude and longitude on the Earth. English classes use the planetarium to illustrate celestial theories expressed in poetry and prose.

One of the greatest challenges faced by Newark's planetarium director was to prepare a program that could be presented to the Margaret S. Sterck School for the Hearing Impaired. This audience consists of children with speech and hearing impairments of varying degrees, and represents a wide range of age levels. The darkened planetarium chamber ruled out the use of sign language and lip reading, making spoken communication of little or no value. Written communication was the answer, but projecting a printed message without losing the darkness, which an effective star-projector demands, presented a problem. This was solved by using a photo offset negative with an overhead projector; this gave a complete blackout background for typed instructions projected on the dome. (See Ora Ann Shultz. "Planetarium Astronomy for the Hearing-Impaired," *The Science Teacher* 40:45–46, 1973.)

Each year, new ideas arise for planetarium usage. Among them is the pre-camping orientation for classes preparing for the district's residence camping program. One of the important aspects of the overnight experience is a sky-watch. For students who participate in the experience at the campsite, as well as those who conduct a sky-watch on their home campus, the planetarium program sets the stage for meaningful observations under the real sky.

As in any sound educational program, evaluation is an essential part of the planetarium procedures. Following each visit, teachers are asked to complete a form evaluating each phase of the program: planning and operation, orientation, and planetarium presentation. Data from the evaluation provide the rationale for program changes. Planetarium evaluation is a continuing process, with revisions of the curriculum based on suggestions from teachers involved.

In summary, experience with the planetarium has proved that it is a valuable inter-disciplinary teaching tool. It possesses a far-reaching potential, limited only by the imagination and ingenuity of the instructor.

A Model for Initiating Accountability

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The number of books, monographs, and articles written about educational accountability indicates the spectrum of opinion regarding this concept. Wading through the literature and noting the many obstacles inherent in any change, one is tempted to dismiss the idea as simply another innovative exercise in futility. Yet, to the scientific mind of the professional educator the concept seems both attainable and desirable. This chapter will deal with the development of an initial accountability model based on theory and research bound together with experience and common sense.

What is accountability?

Accountability is an old concept. Ancient Greek and Roman teachers are reported to have been held accountable for their teaching. [2] Today, accountability has been defined as the process of performance contracting. [6] Others suggest that the concept is a philosophy of responsibility, i.e., the schools are responsible for their product. [5]

In a management sense, accountability is defined as the relating of school resources and efforts to result in ways that are useful for policy making, resource application, and compensation. [7] It has been broken down into the categories of fiscal accountability and instructional accountability. [1] The concept is seen as a guarantee that all students will acquire the minimum skills necessary to take full advantage of the choices they will face upon successful completion of schooling. [11] .

Grady suggests that semantics is the problem surrounding the accountability debate and calls for a substitution of "improvement of instruction" for the term "accountability." [4] Finally, accountability is seen as holding someone responsible for certain behavior or actions. [10]

Having considered some of the definitions of accountability, we must now arrive at a working definition. Let us suggest that accountability in education is a basic right of the student, his or her parents, and the public which supports the school itself. Accountability in education results from a series of teacher, supervisor, and administrative actions that contribute to the attainment of a humane and adequate education for all students. What comprises a humane and adequate education is the result of a series of goals derived by local schools with input from society, national organizations in a discipline, parents, students, and teachers. These goals must consist of at least minimal objectives which all students need if they are to fully enjoy their youthful and adult lives. Thus, accountability will improve teaching-learning and will have the school disclosing to itself, to its pupils, and to its supporting tax base the attainments of pupils within its disciplines. Implicit in this reporting would be the ongoing collection of data regarding students and the continual updating of local norms at the same time permitting students, and their parents, to measure themselves against national norms. This use of standardized tests will permit the instructor to become aware of what others regard as important (hence testable) and will permit the student to make a more realistic appraisal of his or her own competence.

Why do we need accountability?

Since the launching of Sputnik I in 1958, science, engineering, and technology have been the focus of public concern. First, in an attempt to narrow a "gap" between Russian and American science, the American people through Congress dispatched massive funds to upgrade the science knowledge of teachers. In a real sense the electorate felt accountable for this perceived imbalance in technology and were willing to provide money to return our nation to pre-eminence in science. Implicit in this movement was the belief that upgrading the scientific knowledge of instructors would result in increased student interest in and knowledge of the scientific disciplines.

During the ensuing two decades, science has lost much of its previous charismatic aura. In the mid-1960's the government released funds only as long as the receiving agency could be held accountable for attaining specific goals which the project would achieve. The 1970's have brought us the Watergate disclosures, and energy and environmental problems. We are facing inflation in a time of recession, and are bombarded with new information regarding governmental agencies and individuals.

As citizens are revising their way of life, individual frugality has become a new ethic. Americans have begun looking at automobile manufacturers, at the giant oil companies, and at the President and Congress. Each is being asked to become accountable to the individual citizen. Most see this concern and involvement as desirable. Yet when this concern focuses on schools, many educators and teachers suggest that they cannot be held accountable. The schools, in times of rising costs coupled with dwindling enrollments, are being asked to report to their public regarding the accomplishment of the institution in educating our youth. It is suggested by some that Bloom, Hunt, and Piaget all cite compelling evidence that most intellectual development and learning occur before the student goes to school and that the advocates of accountability should realize that it is useless and unfair to hold teachers accountable for something over which they have little control. [10] Are we saying that school can only teach those who already have a high intellectual development? If the public cannot feel safe in the knowledge that students learn in school, is there any need to continue to support schools and teachers?

Looking at science education we are aware that the National Science Foundation has spent a great deal of money to upgrade teaching-learning. What are the results? The National Assessment of Educational Progres reports: approximately 65,000 fewer 9-year-olds could answer a typical science question correctly in 1973 than they could in 1970; approximately 70,000 fewer 13-year-olds could respond acceptably to a typical science question in 1970 than in 1969; and approximately 80,000 fewer 17-year-olds could answer the survey questions correctly in 1973 than in 1969. [8] Furthermore, between 1967 and 1974, the number of high school juniors and seniors scoring above 700 on the verbal SAT test fell by half—down from approximately 32,000 to 16,000—while the number of students scoring above

600 fell by a third. [15] Couple this with other reports that many students are not learning to read or compute. Is there any wonder that citizens are asking about what is going on in school?

Yet we should not be dismal. Much learning is taking place in schools. It is, however, a painful fact that schools have not established and reported local norms to indicate what a good job they are doing. The lack of public relations regarding local learning has permitted the national testing groups to monopolize the media with the result that the public is showing concern (and rightfully so). Citizens are merely asking local schools to indicate what they are doing and how well schools are achieving their goals.

A model for initiating accountability

Accountability in education is a basic right of the student, his or her parents, the public which supports the school, and the school itself. Accountability in education results from a series of teacher, supervisor, and administrative actions that contribute to the attainment of a humane and adequate education for all students. Accountability schemes must develop local norms and must also use standardized tests. Local norms can be used as the basis for change in curriculum and/or teaching practices and standardized results will inform the student and his or her parents on how well the student measures with nationwide peers and should permit more realistic expectancies for the individual.

Previously, suggestions have been made regarding items for which teachers could be responsible. [14] The task at hand is to outline the steps in initiating accountability. In one of the few surveys regarding teacher attitude toward accountability, 79% felt positive toward the idea that classroom teachers should be held accountable for their effect upon pupils. [3] We may assume, then, that many instructors have positive feelings regarding accountability. Their real concern is in the use of accountability data. Those who feel uncomfortable with the concept at times suggest that schools need to redefine their goals. [13]

It would seem, however, that the purpose of school and the reason teachers are employed is to bring about desired changes in learners. [2] Armed with a feeling that we know why schools exist and reinforced with research that indicates most teachers favor the idea of accountability, what are the steps to follow in initiating accountability?

1. Department heads and/or supervisors announce to their fellow teachers that an attempt will be made to direct the focus of the department toward improved teaching-learning.
2. The department is asked to examine the philosophy of the school and to derive goals for the department which are consistent with that philosophy. Initially, goals are developed through "brainstorming" and later are cross-referenced within the three domains of educational objectives—Bloom (1956), Krathwohl (1964), and Simpson (1967).
3. During the ensuing year, department members are asked to submit to the department head their objectives for each teaching day. They are told that these objectives will be used during inservice days to develop a model of what the school is trying to achieve during the year. The purpose of the model is to learn what objectives are emphasized, so they can be used as a basis for change if change is warranted. This decision would be made as one compares the school philosophy with departmental goals and with course objectives.
4. The daily objectives will also be used by the individual instructor in developing a list of basics which he or she feels each student must achieve during the school year. There are many ways of developing this list of basics. One might ask a tenth grade science teacher to write a list of basics which he or she feels must be accomplished in ninth grade. Or, as suggested previously, each teacher develops his or her list and then departmental meetings are used to articulate the lists and ensure continuity.
5. Tests, and test questions in particular, which measure each of the objectives are typed on 5 x 8 cards and placed in a master card file in a central area. Teachers are to use only these test items. If they add a new item, it must be typed and placed in the file. The correct answer is placed on the back of the card along with a list of dates and teachers who use the item in their testing. When performance testing is used, the conditions are written on cards and filed under the appropriate heading which the performance is measuring and evaluating.
6. Local norms are developed based on data collected using the items. For example, ninth graders studying cell theory might score 83 one year. The teacher uses similar teaching procedures in ensuing years and finds students scoring 60. Then there is reason to believe that either the testing or the teaching is inappropriate. The

teacher can make changes without any threat of dismissal. The purpose of the testing is to give a basis for change.

7. Standardized tests are also used to identify student achievement compared with national norms. If a student is below average (based on ability) and he or she scores below average on a national norm, we can say that the person is really scoring average for his or her group. Thus, national norms need to be interpreted in relation to the individual. In counseling, students and their parents need to be made aware of their standing. Surveys of parents indicate that parents would like to know more about the school, but feel unwanted and don't know how to become involved in their children's education.
8. All goals and objectives are to be derived locally with input from students, parents, the community, and teachers. The department head and each teacher will have a copy of a chart that details how the school philosophy is realized through departmental goals and teacher objectives.

Philosophy	*Goals (Science)*	*Objective*
A. Student as a citizen → 1., 2.	1. Use scientific method for decisions. → a., b.	a. Given 7 situations involving decision making, the student will use the scientific method in arriving at a solution in 100% of the cases.
	2. Read and comprehend articles on technology	
		b. Memorize with 100% accuracy the steps in the scientific method.

9. Base line data for a school will be collected and published through local newspapers to inform the public regarding the accomplishments of the department.

We have seen how a school supervisor might initiate accountability in his or her department through our nine steps. The purpose of accountability has been to develop data which will support the positive job that the teachers within the department are accomplishing. The data can be used to make changes in curriculum and teaching methodology, as well as for public relations in reporting to parents and citizens. National norms are not ignored; they are used to give pupils and parents a more realistic appraisal of a student's potential. This scheme has flaws as do all attempts to develop a basis for efficient change. Yet it gives the concerned supervisor a starting point from which to develop the data base that is needed to effect change.

REFERENCES

1. De Novellis, R. L. and A. J. Lewis. *Schools become Accountable: A Pact Approach*. ASCD, Washington, D.C. 1974.
2. Dunkin, M. J. and B. J. Biddle. *The Study of Teaching*. Holt, Rinehart and Winston, Inc., New York, N.Y. 1974.
3. Good, T. L., et al. "How Teachers View Accountability." *Phi Delta Kappan* 56: 367–368; January 1975.
4. Grady, R. M. "Accountability: A Personal Point of View." *CAP Commentary*, Colorado Department of Education, Denver, Colorado. 1: 1–5, June, 1974.
5. Krystal, S. and S. Henrie, *Educational Accountability and Evaluation*. Prep. 35, 1972. (ERIC ED067514.)
6. Lessinger, L. M. *Engineering Accountability for Results into Public Education*, 1970. (ERIC ED040155.)
7. Lieberman, M. "An Overview of Accountability." *Phi Delta Kappan* 52: 194–195; December 1970.
8. National Assessment of Educational Progress, Newsletter-Spotlight, December 1975.
9. Ornstein, A. C. "The Politics of Accountability." *The Education Digest* 41: 6–9; December 1975.
10. Ornstein, A. C. and H. Talmage, "Rhetoric and the Realities of Accountability." *Today's Education* 62:70–82; September-October, 1973.
11. Porter, J. W. "The Future of Accountability," in *Accountability in Education: A Research Memorandum*. 1971 (ERIC ED061620)
12. Small, A. A. "Accountability in Victorian England." *Phi Delta Kappan* 53: 438–439; March 1972.
13. Shadgett, J. N. "Open Education-Accountability-Collision Course." *Kappa Delta Pi Record* 12:28–29; October 1975.
14. Starr, R. J. "For What Can/Should Teachers be Held Accountable?" Paper presented to the Eightieth Annual Meeting of the North Central Association of Colleges and Schools, April 7, 1975. Chicago, Illinois.
15. *The Chronicle of Higher Education*. "Fewer Score High on the College Boards." 10:1–7; 1975.

Working in Public Relations

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If one examines the list of duties and responsibilities of the science supervisor, somewhere in that list is the area of public relations. Often public relations is distinguished under other titles or job descriptions. This task might be part of community-school relations, public information, community resources, communication services, or public communication.

What is public relations?

Public relations, under any title or job description, is an operation which helps the school know its community and the community know its school. Public relations work keeps the community informed about the school, its purposes, progress, and programs—and problems. People often equate public relations with publicity, which is the dissemination of information to the public. Publicity is usually a one-way street; public relations must be a two-way relationship.

Whether public relations is carried on by the school, the district, or the science department, it must be an on-going and long-term program. It can not be effective if it is done sporadically; it must be a continual communication between two parties. The purpose of any public relations program is a better understanding and a closer working relationship between the school and community; the science supervisor and teachers; the supervisor and the principal; and the science supervisor and other subject supervisors. The most important communication is between the science staff and the students. Students carry what they have learned in the science classroom into the halls, into other classes, and most importantly, into the home and community. The student is the best public relations agent that the science department and supervisor have.

Basic principles of public relations

The science supervisor's most important role is to improve instruction. Public relations is a means of obtaining the support and understanding essential to the success of the supervisory program. An effective public relations program enables the supervisor to work more easily toward his or her objective of improving instruction. Public relations must account to the public, science teachers, students, and administration. To be successful in public relations one need not justify or defend the educational program. Rather, one informs the public regarding the present program and plans for its development.

The quality of the relationship that the science supervisor establishes among the people with whom he or she comes in contact is of utmost importance. Public relations means dealing with people. The single most important principle to remember is: take time for people.

To a great degree, a good public relations program is based on the amount of confidence that the public, students, science teachers, and administration have in the science supervisor.

Long-term information gathering and dissemination should be a part of the public relations program. When the public possesses such information, it is more competent and willing to cooperate with the school.

A thorough knowledge and understanding of the community is essential. As much information as possible should be obtained about the community's communications media and the contribution each can be expected to make toward improving the overall public relations program.

Why is public relations important?

School personnel may neglect to perform their public relations functions because they are not aware of these functions. Others take the position that what the school does is none of the business of the public. To have the most efficient school, there must be cooperation between the school and community groups. In particular, there must be cooperation between the home and the school. The home should know that the school is working constantly and carefully to advance the welfare of the students.

Expenditures for schools during recent years have increased by leaps and bounds. They have increased much more rapidly than school enrollments and the income of the public. Since public information regarding the schools has not kept pace with school expenditures, a large percentage of the public is disgruntled over these expenditures and is defeating many school budgets. For the public's moral and financial support of the schools, a public relations program is necessary. Science supervisors, therefore, need to plan to systematically provide such information. The public should not have to secure information through hearsay, rumor, or other unreliable sources.

Untruthfulness is worse than no information at all: it lessens confidence. This means telling the bad as well as the good. Always base what you say or do on fact.

Participation in public relations

The following is a list of ideas and suggestions for science supervisors to use in implementing a public relations program. This list is by no means exhaustive; there are many other ways to implement, alter or improve a public relations program.

1. A letter should be sent to parents when a student has done something well, such as participating in science fairs, helping in the stock room, serving as a peer tutor, or winning a contest. Never use form letters.
2. Polls and surveys of students to find out their feelings about course offerings are very helpful. The results should be posted or announced; otherwise the survey will have no meaning. When possible, make changes based upon the poll or survey.
3. When students hold activities outside school hours, even if they are not science department activities, help by offering time or services. Don't wait for the students to ask: volunteer.
4. Attend and participate in PTA meetings. Volunteer to put on a program if possible.
5. When a teacher in your department wins an award, writes a news article, publishes a paper, or participates in an extracurricular activity, write a letter of commendation and place it in his or her file. Be sure he or she gets a copy.
6. Whenever possible, offer your services to the local civic groups

and clubs. Generally, word gets around if you once volunteer and serve cheerfully.

7. When a new person is elected to the Board of Education, send a congratulatory letter and invite him or her to visit your science department.
8. Visit feeder schools or the schools that your students later attend. Find out about their programs. Ask how you can help. Lend equipment to the elementary feeder schools. Respond when asked for advice. Become familiar with curricular guides of the schools with which you come in contact. Conduct assemblies for these schools by using former students that have attended the particular school.
9. Arrange for tutoring of absentees, using peer-peer, parent-student, or paraprofessional-student tutoring.
10. Prepare slide shows for functions such as PTA meetings, open school nights, student orientation, and civic groups.
11. Provide a constant flow of news releases to the local newspapers. Include pictures when possible. These should be interesting, understandable, adaptable, and in proper format for the intended readership.
12. Develop a curricular handbook for parents and students.
13. Institute and maintain an area where students may obtain information and counseling on science careers.
14. Use parent volunteers as tutors, clerks, secretaries, science resource center supervisors, and lab aides.
15. Acquire knowledge of the community and its expectations for the school and students so that you can understand it and respond accordingly.
16. Provide opportunities for the staff to evaluate the public relations program so that improvements can be made.
17. When you attend conferences, workshops, or conventions, bring back copies of meetings, speeches, or handouts for the teachers. Write a report on the trip, and submit it to the administration.

If your school does not have a program of public relations, use some of these ideas in this chapter to institute such a program. If your school does have a public relations program, apply concepts from this chapter which your program does not include. In summary, a good public relations program is the development of a cooperative relationship between you, the science supervisor, and all the persons with whom you come in contact during the school year.

Section 3

Education for the Science Supervisor

The Continuing Education of the Supervisor

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Science supervisors usually feel the need for continuing self-education long after all formal academic requirements have been satisfied. Knowledge of new discoveries, theories, techniques, and principles in biology, chemistry, earth science, and physics constitute a major thrust in the continuing education of the science supervisor. Frequently, the supervisor is regarded by the faculty as an expert in scientific information. The supervisor is expected to lead the department in developing faculty mastery of subject matter. College courses, National Science Foundation Institutes, and a wide variety of books and journals provide access to current trends in science. A thorough daily reading of a comprehensive newspaper is an efficient method of identifying the advances in science relevant to the curriculum.

Processes of learning

Of course, in order for the science supervisor to be effective, his or her understanding of scientific facts and principles must be combined with an appreciation of how children learn these concepts. Theories of learning have been amplified in recent years to include affective considerations. The need for students to develop a positive self-concept by experiencing success rather than repeated failure in learning science has been widely discussed.

Emphasis upon the processes of science, as well as its content, is one method of promoting student achievement. Having students raise questions, make observations, and predict results involves them actively in learning science. The supervisor should recognize what kinds of classroom environments are conducive to this approach, and he or she should be able to help teachers provide it. If teachers are to encourage student inquiry, then the supervisor must be aware of questioning which facilitates inquiry. The supervisor can then evaluate and assist the staff in developing open-ended teaching styles. A major part of this approach involves laboratory experiences for the students. Simple manipulation of apparatus to obtain predetermined results does not create learning situations. The supervisor should be knowledgeable about approaches which require students to recognize and define problems, devise methods of attack, become familiar with the limitations of data, and exercise caution in drawing conclusions. The supervisor must know how to prepare experiments that have unexpected answers so that students will be able to develop some confidence in their own efforts and will learn to account for their errors.

Psychologists, such as Jerome Bruner, Robert Gagné and Jean Piaget, have advanced theories of learning which have profound implications for teaching and learning science. The science supervisor should be familiar with their writings, and should be in a position to encourage staff discussion of their ideas. In addition, the science supervisor should investigate the elementary school science curricula (Elementary Science Study, Science—A Process Approach, and Science Curriculum Improvement Study) which are based upon the works of these psychologists. The *Journal of Research in Science Teaching* and *Science Education* regularly publish the results of studies in the field. The science department library should include these publications.

Continuing education in the above areas would not be complete if the science supervisor did not meet and confer with colleagues at local, regional, and national science conferences. A sharing of ideas and a discussion of problems enables the supervisor to broaden his or her perspective. Conventions also serve as excellent sources of information for science concepts, teaching processes, and new curricula. As a curriculum in science develops, the designers present its highlights at these conventions. Attending these meetings and talking with curriculum proponents enables the science supervisor to develop insights not available from the printed word. Specialized publications listing science curricula can be used to augment convention attendance. Several National Science Foundation publications as well as the *Report* *of the International Clearinghouse on Science and Mathematics Curricular Developments* are useful in this regard.

Science and society

Another important concern in terms of self-improvement is the need for the science supervisor to appreciate the impact of science upon society. The supervisor acts as a leader in promoting growth among the faculty. Teachers must be encouraged to explore the facets of science which directly affect the lives of their students. Both teachers and students should be able to identify issues involved in current controversies; to isolate variables and to suggest what data are necessary to make a judgement; to predict results of certain actions; and to infer the consequences for society from these actions. If the science supervisor wishes to provide direction by example, he or she must be familiar with the issues involved. *Science and Society*, a publication of the American Association for the Advancement of Science, is an excellent source of articles and books on this subject.

The supervisor as leader

Exercising leadership effectively sets the supervisor's position apart from that of other teaching colleagues. An awareness of how to identify and utilize the varied talents and personalities of faculty should be an important outcome of continuing education. How to win cooperation, when to delegate authority, and to whom, and how to gain acceptance for innovative techniques are but a few of the tasks that confront the supervisor. Often these skills are learned through on-the-job experience. A more formal approach might be to participate in a human relations training seminar. These sessions can provide insight into processes of group problem solving, facilitating group consensus, and evaluating personality types.

The supervisor can then help teachers become more self-analytical in terms of their teaching personalities. He or she will be able to act as the leader of a group dynamics session at a departmental meeting. Contrasting dependent, independent, and counterdependent types is a valuable experience. Some teachers and students rely on structure, leader, group, or agenda. Others feel comfortable without a structure, whereas some rebel against almost all forms of structure. How do these traits influence teaching and learning? Intimacy needs are also revealing. Some teachers have a need to keep the group on a personal level. Others encourage and generate personal relations when appropriate; whereas some need to keep relations with others formal and impersonal, and have a need to keep group interaction formal and impersonal.

Colleges, school districts, and specialized groups offer courses in human relations. School counselors should be able to direct science supervisors to appropriate sources of information.

Value systems

As the supervisor becomes more involved in this aspect of personal growth, he or she becomes more aware of value systems and how they influence the teaching-learning process. Each learner and each teacher brings a different set of priorities of moral preferences to the classroom. Questions on population control, genetic manipulation, pollution, ozone layers, and drug use involve the value systems of the investigator.

Some teachers and students make judgements on the basis of their own personal concerns and well-being. Others will accept external rules of morality as determined by the society of which they are a part. Absolute moralities (so-called "higher moral principles") determine the judgement of others. Values clarification studies may hold great promise in helping students develop better self-concepts and attitudes toward learning. Science supervisors should understand these values as well as the values of science. Much has been written about using values in social studies. The alert science supervisor will wish to consult colleagues who supervise that subject.

Accountability

A persistent movement within education, quite removed from values and human dynamics, is the effort to promote accountability within school systems. Supervisors must be conversant with the specialized literature of projects in this direction. State legislatures throughout the country have mandated various accountability systems. They range from competency-based teacher educational programs to performance based evaluation criteria for teachers and/or students. Teachers are asked to describe long range goals for their courses in terms of student performance. Consequently, teachers must become more specific in describing what students can do. A key element in this design is the identification of measurable, behavioral objectives for students. The science supervisor should assure that teachers include the affective as well as the cognitive in developing competencies lists.

Proposal writing

Knowledge of how to write behavioral objectives is valuable when writing grant proposals. The Federal and State governments provide aid to education in a variety of ways. Funds for material and supplies, initiating new programs, professional improvement, and research projects are available under titles of education laws. Environmental education, metric education, and bi-lingual education are some broad topics under which grants may be written. There is a particular style and language to be used in writing grant proposals; the science supervisor should acquire the necessary expertise in this area. *The Catalog of Federal Domestic Assistance* and *The Guide to Federal Assistance for Education* provide listings and information about government supported programs.

Summary

The courses of action suggested in the previous pages are only a part of the continuing education necessary for the science supervisor. What remains are areas in which the supervisor must constantly improve skills and abilities as the specific situation requires. For example, the school student body changes as population shifts. Science classes are no longer filled with academically oriented, middle class students. They may have been replaced by economically and educationally disadvantaged pupils. How does the science department respond? What leadership does the supervisor provide?

There are no books or courses which can provide specific remedies in such instances. However, the supervisor should be in a position to draw upon his or her knowledge of learning in science, the nature of the learner, value systems, and process approaches to suggest several plans of attack. Human relations experiences and an involvement in community affairs are helpful assets in facing this type of problem.

Continuing education must be more than occasionally reading the literature or taking a course. A degree of planning and preparation should precede the development of a program for continuing self-education. The supervisor might draw up a list of all the areas which are important to the performance of his or her work. Self-analysis of strengths and weaknesses could identify what aspects are in need of improvement. Then a time-table, perhaps over a three year period, could be developed so that improvements are achieved.

Continuing education for the science supervisor is more than incidental learning. It is the result of a clearly thought out plan of self-education which actually helps to improve the supervisor through a specific "curriculum" of his or her own choosing. There are no degrees, honors, or awards granted at the end of this course of study. In fact, there is no end. After the three years are over, one probably needs a new plan. There is however, the reward of realizing self-improvement and both personal and professional growth.

Utilizing Community Resources for Teacher Education

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One of the most important functions of science supervision is to provide meaningful experiences which lead to staff improvements. A major item on George's listing of specific duties of the science consultant [1] is to carry out a continuing inservice program designed to provide "seminars, workshops, or other group activities for professional improvement and development of the science teacher's background." Because the supervisor has knowledge of the school science curriculum and of the strengths and weaknesses of the staff, he or she must be instrumental in planning inservice programs for teachers. Colleges and universities have long been utilized to implement such programs. Less formal programs are often administered by supervisors themselves. However, local community institutions and organizations have often been overlooked as a source for teacher education. Local community resources may provide programs which range from an informal afternoon session for studying local fossils to a formal, college-credit course to learn how to use the planetarium as a science resource.

The following examples illustrate methods of utilizing a variety of community resources for teacher education.

Amateur and hobby organizations

Often the science supervisor may find that a situation arises in which it is expedient to offer a meeting or workshop for a very specific purpose. As an example, a group of elementary teachers may find that they do not have the skills for identifying the local rocks and minerals or are not familiar with local collecting areas. The science supervisor may arrange to have a group from an amateur rock and mineral organization take the teachers for an afternoon field trip to a rock outcrop to learn first-hand the field tests for distinguishing the minerals calcite and quartz.

Paleontological societies can furnish the expertise for fossil identification sessions and perhaps even provide some specimens for the teacher's classroom. Astronomical organizations may be contacted to help in setting up a descriptive astronomy workshop.

Similarly, other local amateur groups may be called upon to provide short term workshops in such areas as wildlife identification, photography, environmental legislation, or outdoor education techniques. Other organizations such as the Humane Society of the Animal Protective Association can provide speakers and materials for programs dealing with the care of classroom pets.

Health organizations

Health agencies, such as the American Cancer Society, American Red Cross, Heart Association, and the American Lung Association, are more than willing to provide assistance in the form of materials and speakers for teacher education programs. To illustrate, when a school system initiated a smoking and health unit for its 5th grade classes, a short workshop was held in cooperation with the local unit of the American Cancer Society as a part of an overall inservice program for the teachers. A physician spoke on the topic of health hazards of smoking for children, a packet of materials was provided for each teacher, and pertinent audio-visual materials were previewed. Local units of the American Red Cross often have instructors to give classroom teachers a course on the basics of first-aid so that they can certify their students in first-aid.

Professional organizations

The science supervisor should also be alert to teacher education opportunities offered by local, state, and national science organizations. Workshops, short courses, and seminars are parts of convention programs of professional science organizations. The National Science

Teachers Association (NSTA) offers a number of short courses and seminars each year at its annual convention. The popular NSTA-Sunoco Science Seminars have covered a wide variety of topics such as oceanography, chemical evolution, nutrition, and atmospheric science. The supervisor has the responsibility to find out what meetings will be held in the area and to inform teachers of these offerings. The "Calendar" featured in NSTA journals is a good lead on finding the dates and places of national science meetings.

Cultural institutions

Cultural institutions such as science museums, botanical gardens, zoos, aquariums, planetariums, and nature centers are heavily used by teachers and their students for field trips. However, these institutions should also be considered as resources for teacher education programs. A UNESCO publication of 1968 describing the role of the museum in education indicated that there is a "growing realization among school teachers and administrators that the museum experience has something very special to offer. . . ." [4] The federal government has also recognized the value of cultural institutions in teacher education endeavors when museums and related agencies were included in the definition of educational institutions for purposes of applications for specific federal grants.

Youngpeter states that "as museums look for new images and new roles, surely one of these must be that of teacher resource center so that teachers themselves will not only learn what facilities the museums have available, but what experts, references, and collections are available to them in their pursuit to become increasingly more competent and current in their daily work." [5]

The science supervisor can be a facilitator in arranging school-museum cooperative programs. A workshop or short course held at the institution can not only familiarize teachers with its offerings and lay the foundation for conducting a better field trip, but it can also be an opportunity to provide a review of basic science.

An illustration of such a program is the very successful workshop developed at the St. Louis Zoo for elementary teachers. "The Zoo as a Science Resource" is a one-credit course offered in conjunction with a local teachers college. The course is designed to give information concerning the natural history of vertebrates, the behavior of zoo animals, and the operation of the zoo. The lectures are given by members of the zoo staff, visiting biologists from the local universities, and the science supervisor. [2] The Brookfield Zoo in Chicago has a cooperative program of a similar nature.

Other institutions across the United States are involved in teacher education programs. Roger's survey of nearly 3000 museums indicated that 68 percent had formulated some type of working relationship with elementary schools, secondary schools, or colleges. However, only 11 percent of the institutions were involved in teacher education programs. [3]

Some suggested examples of workshops and seminars that can be provided by cultural institutions are in the accompanying table. Note the wide variety of topics. Many are applicable to both elementary and secondary teachers.

WORKSHOPS FOR TEACHERS

Institutions	*Topics*
Planetariums	Celestial Mechanics New Planetary Knowledge Stellar Evolution
Botanical Gardens	Classroom Plant Propagation Techniques Food Plants
Zoos	Care of Classroom Animals Zoogeography Ecology
Science Museums	Dinosaur Evolution Dynamics of Flight Meteorology
Historical Societies	Anthropology Pioneer Medicines
Nature Centers	Urban Ecology Environmental Science
Aquariums	Underwater Photography Marine Biology

Art museums have also been active in science teacher education programs and such topics as archaeology, the history of science through art, and scientist-artists help to foster an interdisciplinary spirit.

Cultural institutions can become involved in teacher education by offering consultant service for curriculum evaluation and development. Perhaps best known in this field are the activities of the Oregon Museum of Science and Industry. Science institutions also produce a number of study guides, information sheets, etc., which provide an indirect source of teacher education.

The use of community resources allows many avenues for providing a wide range of inservice activities for the professional growth of teachers.

REFERENCES

1. George, Kenneth D. *How to Utilize the Services of a Science Consultant.* National Science Teachers Association, Washington, D.C. 1965.
2. Ortleb, Edward P. and Charles H. Hoessle. "Zoo Workshop for Teachers." *Missouri Science News*, December 1969.
3. Rogers, Lola Eriksen. *Museums and Related Institutions: A Basic Survey.* U. S. Department of Health, Education and Welfare, Office of Education, Washington, D.C. 1969.
4. UNESCO. *The Role of the Museum in Education and Cultural Action.* ICOM Secretariat, Maison d'UNESCO, Paris. May 1968.
5. Youngpeter, John Michael. *Science Museums and Elementary Teacher Education: Organizing and Implementing Programs in Natural Sciences.* Unpublished doctoral thesis, Teachers College, Columbia University, New York. 1972.

The Graduate Education of a Science Supervisor

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A teacher is concerned about a new science curriculum. A problem exists in obtaining supplies and materials. The need arises for a change in instruction to meet new demands of students with special learning needs. The science supervisor is the source for help in all these instances. A budget committee needs to know how much money to allocate for science instruction. The science supervisor, who is familiar with district needs and goals in instruction, is the logical person to answer these questions. School administrators must rely upon the information of their instructional supervision staff. Thus, the responsibilities of the science supervisor are essential to effective science instruction and securing resources for that instruction.

Preparing a person to serve as a supervisor is a challenging task. One factor is formal academic training in which the science supervisor gains essential knowledge and skills. To select those courses most suitable for developing needed skills, one must make a needs assessment of what a science supervisor may be called upon to do in the performance of duties, and then design experiences to fit those needs.

Functions of a science supervisor

A science supervisor performs an integral and important role in the total instructional process. The kinds and qualities of services performed by the science supervisor will affect the science program of the entire district, as well as that of individual classrooms. Depending upon circumstances, and the school district administrations, a science supervisor may be called upon to demonstrate skills in any or all of six areas.

1. *Information Source.* Science as a content area has a unique challenge. The subject matter of the discipline is constantly being added to, revised, altered, or deleted as new data are derived and analyzed. In addition to the need to keep up with this changing knowledge base, there is an equally important challenge to keep current with new instructional programs and techniques developed to meet the changing learning needs of pupils. Keeping teachers aware of these alternatives is a second challenge for the supervisor. For these reasons, one of the most important responsibilities of a science supervisor is that of acting as a source of information about alternatives in science curricular material. This process of helping teachers maintain an effective knowledge level in new techniques and programs is of extreme importance in maintaining a high quality of science instruction. Thus, a science supervisor needs a strong knowledge base in the teaching of science at all levels K–12.
2. *Communication Link.* Communications between groups of people are often difficult to establish and maintain. In schools where everyone is working toward the same goal, communications are hindered by real and imaginary barriers. Helping to break those barriers by developing and extending lines of communications between teachers at different grade levels, between teachers of different subject areas, and between teachers and administrators is an important role for the science supervisor. Transmitting concerns and expectations between groups is facilitated by someone who works within all levels in a system and has first-hand knowledge of concerns and problems faced by a wide range of teachers. Thus, a science supervisor needs a broad understanding of the curriculum goals of a school and ways in which different teachers are functioning to meet these goals.
3. *Planning and Implementation.* Another function of a supervisor is that of planning and coordinating instruction. Through observation of the whole of science instruction rather than discrete pieces, the supervisor is able to plan and coordinate the integration of instructional efforts at all grade levels. Implementation of new

programs in science is facilitated by a knowledge of how that approach will help to meet the objectives of science instruction. As a part of the planning role, the supervisor is also in a position to help formulate those objectives. As is true with an orchestra director, the supervisor needs to know both the total score and how to help individual performers fit into that total picture. Thus, a science supervisor needs to know how to communicate a total curriculum picture and secure commitment from individual teachers for their individual parts.

4. *Model.* In most cases, introducing an innovation or an alternative strategy to teachers will not ensure its adoption. The supervisor must demonstrate how that innovation or alteration may be effectively used in the classroom to meet special needs of pupils. This direct demonstration of expected performance can serve to better illustrate techniques and relieve anxieties. Thus, the science supervisor needs to be a master teacher with a wide repertoire of instructional and management skills.
5. *Sources of Feedback.* Improvement of classroom instruction in science begins with teachers' evaluations of their teaching performance and continues with specific suggestions for improvement. The science supervisor is a logical person to assist a teacher in this self-assessment. At other times, the supervisor may be called upon to provide feedback for the evaluation of teacher performance for purposes of retention or hiring. In both of these situations the supervisor needs to have a variety of observation and feedback strategies and the ability to distinguish what feedback is being requested.
6. *Manager.* Science instruction relies upon material resources, equipment, and supplies. The supervisor is usually responsible for the management of these resources. This task involves developing budgets to obtain needed materials and allocating existing resources. Careful planning is required to ensure that needed materials are available without waste or loss of money. Thus, the science supervisor needs skills in finding needed materials and is "selling" the need for these to the school administration.

Personal qualifications of a science supervisor

What kind of a person can best fulfill these six functions? Can any science teacher become an effective supervisor of science instruction? In terms of prerequisite personal qualifications, a potential supervisor should be:

1. *Flexible.* A supervisor must be able to work with people at all school levels, communicate with them, and contribute leadership in dealing with their personal concerns.
2. *Creative.* Creativity is essential in developing, implementing, and assessing curriculum materials and instructional materials in science.
3. *Reflective.* A supervisor must be reflective in order to identify societal needs of significance to science instruction and judge the merits of alternative learning environments and models of science instruction.
4. *Sensitive.* To help others assess their teaching and make necessary modifications, the supervisor must be sensitive.

Professional qualifications for a science supervisor

A science supervisor must also possess specific professional qualifications.

1. *Competence in Interpersonal Skills.* This area includes the enhancement of a teacher's self-concept and the formation of a set of values that can serve as a reference point for reflective thinking and change. This includes knowing how other teachers and administrators perceive you in a variety of roles as an educational leader, and skill in listening to what people say. The ability to interpret and act upon input from others in sensitive and constructive ways is essential.

   Human relations training, as a part of an intensive study in psychology would be an important part of graduate study for supervisors. Much of a supervisor's work depends on the quality of interpersonal relationships developed. Such competencies would include observational and communication skills, as well as training in group process skills.
2. *Competence in Science.* Individuals who expect to deal with a wide range of science learning environments within the educational system should have considerable breadth of learning in science. Such knowledge should foster creative thinking about the relation of different branches of science, the interdependence of science and society, the processes and styles of scientific pursuit that distinguish

it from other intellectual endeavors, and the procedures and styles which link science to other intellectual pursuits.

Before accepting the responsibilities of a science supervisor, it is assumed that a person would possess knowledge in some area of science at or above the Masters' Degree level. Competence in all areas of science is an unrealistic expectation, but a science supervisor should have a broad knowledge base in science. Anything less may act to impair communication with teachers and decrease the effectiveness of the supervisor.

3. *Competence in the Social Context of Education.* This area requires an understanding of school organization, its structure, and sociology. The science supervisor should recognize the socioeconomic and political forces which have shaped education in general, and science education in particular, in the past and which continue to influence both the systems. Of particular importance is the need to understand those processes by which changes in schools occur, and how both teachers and administrators learn to cope with the changes or participate in the processes.

   Thus, the graduate program of a supervisor should also be related to the topic of schools as entities and as extensions of society. Such studies should concern the role of schools in affecting societal change and act in response to the needs and desires of society. Without such competencies and the ability to communicate them, assessing curricular programs in a total context would be difficult.

4. *Competence in the Design of Curriculum.* The development of science curriculum materials, implementation models, and science teacher preparation schemes depends upon the application of principles from associated fields such as sociology, anthropology, psychology, and communication research. The science supervisor's competence in these areas is essential to the extent that these areas contribute to science curriculum decisions. Supervisors must recognise and use various models for development and learning.

   Thus, the program of graduate study should also include an emphasis in course work on competencies in curriculum development and assessment. A part of such study should emphasize approaches to integrating areas of the curriculum, a rationale for such efforts, and specific techniques in development and implementation of an integrated curriculum.

5. *Competence in the Instructional Process.* The function of a science

supervisor requires skill in analyzing and evaluating plans for curriculum design, instructional materials, and teaching strategies. Such skill includes knowledge of available materials, technology, and alternative instructional techniques. It also includes the ability to adapt materials and strategies to new situations, to recognize effective innovations, and to suggest appropriate alternatives.

6. *Competence in Instructional Evaluation.* Instructional evaluation requires two skills: the ability to interpret results objectively in relationship to the context from which they were obtained, and the ability to communicate with science teachers in such a way as to stimulate them to examine their own teaching processes.
7. *Competence in Administration.* For a science supervisor to function within schools and their related agencies, he or she must be able to communicate the design of a project in such a way as to successfully secure support from appropriate sources, and to administer funds or resources once they have been secured.

Thus, specific competencies related to the managerial portion of a supervisor's responsibilities are essential. Information on the derivation of school budgets, the preparation of such budgets, and the management of allocated resources are essential elements in maintaining a system-wide science program.

While each of the preceeding seven competency areas may be developed in a variety of ways, they should all be a part of the planning of a program of graduate study. Designing such a graduate program requires the recognition and acceptance of three assumptions:

1. The responsibilities of a science supervisor vary widely from position to position. Variables such as the size of the district and its geographic location will dictate whether the supervisor has responsibility for the science program K–12 or some subset of that whole. This will in turn dictate the managerial responsibilities assigned to the supervisor.
2. Persons preparing to serve as science supervisors vary in their professional background and experience. Depth of knowledge in the content of science and the extent of classroom experience are two variables which should influence the specific emphasis in graduate study for a science supervisor.
3. Graduate programs and courses available to a science supervisor vary greatly from one geographic region to another. Whatever type of program of study is recommended, one must realistically

assess the availability of graduate instruction. Another factor is the incentive provided to induce graduate study.

Granting these assumptions strongly implies that a graduate program of study for science supervisors will, like the supervisors themselves, display a great deal of flexibility. The program must be tailored to meet the individual needs of the supervisor, taking into account the resources available. Based on the broad outline of a graduate study program in the seven areas of competence, a program for a specific supervisor will include the necessary competence building upon an already existing framework of knowledge and experience.

In addition to formal course work, it is essential to provide supervised practical experience in the graduate program of a science supervisor. A component of this internship or practicum should enable the supervisor to apply the competencies directly to real problems. This opportunity to test ideas and procedures would add to the dimension of flexibility which appears so necessary in the preparation of a science supervisor.

Planning for Safety

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One of the most important professional leadership responsibilities of the science supervisor is safety. This responsibility is assumed through the basic understanding of science educators that safety is an integral part of science instruction.

Safety may be defined as an avoidance of dangerous circumstances related to a science instructional activity (student laboratory experiment, teacher demonstration, school-sponsored field trip, or a student home project assigned or encouraged by a teacher or textbook).

School authorities often consider the science supervisor an expert in all areas of science and safety; therefore, it is imperative for the supervisor to develop a plan for safety. The plan must integrate the best practices of scientific and educational methods: observation, analysis, and conclusion leading to recommendations or program of action.

To function effectively, the supervisor should have up-to-date knowledge about his or her responsibilities as they relate to the following:

1. What are the safety laws, published policies, and directives in use in the school system?
2. Does the employer carry tort insurance to protect you and the science teachers?
3. What science and other safety records are maintained by the system?

4. Is there a science accident report form available for use by the science teachers?
5. Are there science facilities safety inspection reports completed by teachers or safety personnel?
6. Does your office have a complete inventory of the science facilities, equipment, and materials for each school in the system?
7. Does the inventory list indicate the hazardous materials and dangerous equipment?
8. Are there unlabeled reagents and unknown items stored in the science department of any school?
9. Do you have the services of a legal advisor?

The supervisor should not be discouraged if the answers to a majority of these questions are negative. Such answers will provide at least one reason why the supervisor should visit each science laboratory, classroom, and storage area with the science teacher(s) using the facility and ask to be shown the safety equipment, and the master cut-off switch or valve for the services used such as electricity, gas, and water. On such visits, don't forget to wear the necessary safety equipment (goggles, etc.) and don't hesitate to inquire about the frequency with which fire extinguishers and other safety equipment are used, as well as refill or replacement procedures. Copies of student safety instructions used by the teacher should be requested. By following this procedure, the supervisor establishes an awareness for safety if it did not exist, and has let the teachers know of his or her concern for safety.

When visiting schools, the supervisor should inquire and/or observe if it is possible for the teachers to secure the laboratories and storage areas to prevent unauthorized and unsupervised use. How are hazardous materials and equipment stored? What concerns do the science teachers have for safety? It is the supervisor's duty to discuss concerns for safety (in a confidential conference with the teachers), and to offer suggestions for correcting unsafe conditions observed for the first time. Positive enforcement of desirable safety practices is also useful.

Ask the teachers if they have any objections to your returning later to take photographs of good science safety procedures. The media center may help with this project.

Following a tour of the facility, the supervisor should analyze conditions observed and suggest a plan for improvement which includes sanitation, housekeeping, safe storage and use of hazardous materials, student safety practices, and teacher safety practices.

The supervisor should report to his or her immediate superior what has been done, and if necessary, request permission to meet with all of the science teachers to discuss safety practices and plans for a cooperative safety program. It is important that the teachers feel that the supervisor is trying to help them and is concerned about their safety and that of their students.

Teacher input in the safety program is important. Efforts should be made to obtain from each teacher a safety check list of the facilities, student experiments, etc. Teachers should be organized into working committees for safety. This should not take a great deal of time and more than likely, the results will be extremely helpful to them should a case arise involving legal action. Communication between the teacher, administrator, and the supervisor is essential for a good safety program. A daily safety report filed by the first teacher using a science facility can be included on the attendance report sent to the administrator's office. It may contain the word "safe" or "unsafe." The person receiving this report should be instructed to notify the supervisor and other appropriate personnel at once. School administrators should be asked what course of action they wish teachers to take when the room is considered unsafe.

Money for a safety program may not be readily available. In such instances use may be made of free services for teacher inservice programs such as a course in first aid given by the local rescue squad, legal interpretations of safety legislation by appropriate legal authorities, and safety inspection checks by the local health, fire, and police departments. Safety seminars by local professional societies such as the American Chemical Society might be available, and college instructors may be willing to render free services on safety.

Try to establish a location within a meter of the room exit door for fire extinguishers, fire blankets, and other safety equipment. An inexpensive shower and eye wash fountain can be provided with a portable hair rinse shower. Labels should be made for all reagents placed in unmarked containers. "Safe use" instructions should be obtained from suppliers prior to the purchase of new or hazardous materials.

Each student laboratory experiment should be examined to determine a risk scale ranging from safe (1) to unsafe (10). All textbooks should include an appropriate warning regarding the use of hazardous materials or procedures.

Perhaps some day international safety symbols will be available to encourage science safety for teachers and students. In the meantime, "Have a safe day" is a most appropriate way for science teachers to greet each other and their students.

The Supervisor and Teachers in Liability

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Supervisors have a responsibility for leadership in the area of legal liability. Leadership in this context means: assuring awareness of the topic and its implications by both the supervisors and their teachers; planning for prevention or avoidance of incidents for which they or their teachers could be considered liable, and serving as a resource on such matters.

Awareness

Supervisors are usually aware of areas of the law such as children's and teacher's guaranteed rights under the Constitution, the rights of freedom of speech, freedom from illegal search and seizure, and basic due process. However, legal liability for negligence or the law of torts is an area that few understand. Therefore, supervisors should become knowledgeable about this area of the law and then help their teachers build awareness.

Because teachers work for a local board of education, they are often under the false illusion that injuries which might occur to one of their students is the responsibility of the board, particularly if legal action for monetary redress of the injury is initiated. In some states nothing could be further from the truth. Teachers can be and sometimes are held legally liable as individuals.

Certain key principles are essential to understanding legal liability.

These principles are:

Sovereign Immunity—Very simply stated, sovereign immunity means that the government and its subordinate units (including school boards) may not be sued in cases of bodily injury that result from the negligence of an employee. This principle is a hold-over from English Common Law and applies in one form or another in most states, except where it has been rescinded by court or legislative action. For example, in California the principle is not operant, but in Michigan it is.

Law of Torts of Legal Liability for Negligence—This legal principle is defined as a civil wrong committed against another person which results in an injury.

Duty—Both teachers and supervisors have specific functions or duties that they are expected to perform either implicitly as a result of their role or explicitly as outlined by board of education rules or the master agreement.

Breach of Duty—When a duty has not been performed in a reasonable or responsible manner a breach of duty is said to have occurred.

Proximate Cause—In tort cases this principle refers to the closeness of the teacher to the cause of the injury. If an injury has been sustained by a student that might have been prevented had the teacher been performing his or her duty in a reasonable way, the teacher might be the proximate cause for the injury.

Injury—In most tort cases, injury refers to a visible physical injury of some severity suffered by an individual. Severity in this instance is considered to be an injury which might impair the normal functioning of the individual over an indefinite period of time, such as the loss of a finger or an eye.

Absolute Insurer—What is meant specifically is that no teacher can absolutely insure that injury will not occur to a child. The point here is that although every precaution for children's safety may have been taken, a child might still be injured. In general, the courts have utilized this principle in court cases to absolve a teacher's alleged guilt.

Reasonableness—Simply stated, reasonableness means a teacher or supervisor has acted as any teacher or supervisor would in a like situation. This term is very important in tort cases because the plaintiff usually must prove that the teacher has acted unreasonably.

In cases of torts the general rule is to apply this equation:

Duty + Breach of Duty + Proximate Cause + Injury = Tort Liability

Given this rule and the above definitions, the following cases are offered as examples.

Example A—If teacher A had breached his duty by being out of the classroom for an extended period of time and if it could be shown that had he been in the room the injury might not have happened, he could be the proximate cause. Therefore, the teacher in all probability would be in serious jeopardy. In this instance the plaintiff's lawyer would most certainly subpoena other teachers to determine the reasonableness of the defendant's action. Additionally, if a teacher testified that a reasonable teacher would not have left the classroom, then the defendant is in double jeopardy.

Example B—Teacher B has been threatened with suit because of an injury to a student. However, investigation revealed that her duty was being performed in a reasonable manner. It was not proven that she had breached her duty or that she was the proximate cause. In this instance it is extremely doubtful that any lawyer would press such a case or that a court would find her guilty.

Supervisors have a responsibility to create an awareness of legal liability in their teachers. By knowing the above principles and by investigating the laws of their states, supervisors will have taken the first step toward preparing themselves to help teachers understand legal liability. Problems of liability can be prevented or at least minimized when a teacher understands the law and acts accordingly.

Prevention

Creating an awareness of legal liability is step one; step two is avoidance of situations for which liability is applicable. Helping teachers to put knowledge into practice is the responsibility of conscientious supervisors. If teachers will stop and think, many problems can be avoided. Think: What is my duty? Am I violating my duty? Am I doing everything a reasonable person would do in the same situation?

The most common responsibilities of science teachers, both elementary and secondary, in addition to actual teaching, are supervising, identifying hazards, informing students of safety rules, and requiring adherence to those safety rules. Teachers must avoid creating situations in which unreasonable danger is present and must provide for the supervision of their students. Leaving the class in order to respond to a call from the principal may produce an unreasonable chance of danger and a breach of duty. Teachers must exercise foresight into a potentially dangerous situation and eliminate the dangerous conditions or activities. Ignoring the actual or potential danger may be considered negligence. Allowing students to use faulty equipment could produce an unreasonable chance of danger. Supervisors should encourage teachers to keep all equipment in good repair or remove the faulty items from the access of students. "Equipment" includes chairs and desks as well as electrical or mechanical items.

Teachers must make and frequently communicate safety rules to their students. Telling a student once, on the first day of school, that safety goggles must be worn during manipulative activities is inadequate. In addition, simply informing students is not adequate prevention of danger. Rules must be enforced. If a student breaks a rule, steps must be taken to preclude its happening again. Teachers have not only the responsibility but also the authority to make and enforce rules. The acceptance of the duties of teaching gives teachers the right to expect certain behaviors from students within the boundaries of what is reasonable under the circumstances. Therefore, supervisors should insist that their teachers make and enforce reasonable safety rules.

A constant vigil of urging teachers to put knowledge into practice will return great dividends. Preventing even one injury or even one teacher from a verdict of legal liability will show all the efforts to be worthwhile.

Serving as a resource

Science supervisors can provide a valuable service to teachers by serving as resource persons in the area of legal concerns. This is not to say they should be experts or lawyers. Supervisors can assist teachers by providing the answers to questions such as: "What is our policy?" or "How can I find out?" Knowing how to find out is as important as knowing the answer in many instances. Certainly the wisest step is to consult a competent attorney. But a rudimentary knowledge of the tools available to inform a person of school law is essential to supervisors.

As an absolute minimum, a copy of the written school board policies, the master contract, and the state's school laws should be available in the central office. Usually a compilation of the state's school code is available at minimal cost through the state education agency or the state's bindery. A copy of the federal education laws may be obtained from the Joint Committee on Education and Labor of the U.S. Congress, [7] but its usefulness is limited for a layperson. For the supervisor's office, a book of Landmark Supreme Court Decisions on public school issues would be valuable. [2] *Science Teaching and the Law*, by Brown and Brown, can be obtained from the National Science Teacher's Association. [3] Textbooks such as *Principles of School Law* by Drury and Ray [4] serve to build a foundation of knowledge in the area. The American School Law Series published by the W. H. Anderson Company is recommended. [1]

Suggestions for implementation

Supervisors should provide leadership by assuring awareness, planning for prevention, and serving as resource persons. Some specific suggestions as to how these things might be accomplished are offered below.

AWARENESS:

Plan and carry out at least one inservice seminar each year on the topic of liability. The professor of school law at your local university or a local attorney would probably be more than willing to assist in this vital activity. Be sure that every teacher has a working definition of tort liability.

PREVENTION:

1. Urge your teachers to identify their duties as stated by contract and implied by board policies, past practices, and rules. Assist them in doing this.
2. Insist that your teachers establish and enforce safety rules.
3. Monitor equipment condition and require constant checks on safety of all equipment.
4. Remind your teachers of your concern for their legal safety as well as your concern for the children's physical safety.

RESOURCE:

1. Inform yourself. Read your school policies, master contract, and state code. Read a textbook on school law.
2. Establish a reference shelf in your office including at least a textbook on school law, a current copy of your state's school laws, a

current copy of the written board policies, your district's master contract, and a copy of *Science Teaching and the Law.*

3. Establish and maintain a file for information on all liability cases in your system, region, or state that involve science. Perhaps a master file of all liability cases is or could be established at the central office for which you could be responsible for maintaining and/or monitoring the science section. Few laws are actually written in the realm of educational liability. Most information can be obtained by reading specific cases. Knowledge of the action taken on a case is the clearest indication of the law. Establishing a file and finding past cases will be time-consuming but can be done. Keeping current should present little trouble.

Summary

Assisting teachers in the area of liability is acknowledged as only one of a multiplicity of supervisors' responsibilities. It is a crucial one and needs constant attention. Supervisors must recognize their responsibility and assist teachers. Prevention is so much better than remediation or sorrow. Awareness is the first step. Serving as a resource reinforces the efforts put forth by teachers. Admittedly the task is not an easy one. Perhaps the suggestions given in this chapter will help to keep supervisors advised of their responsibilities in the area of legal liability.

REFERENCES

1. Bolmeier, Edward C. *Teachers' Legal Rights, Restraints and Liabilities.* American School Law Series. The W. H. Anderson Company, Cincinnati, Ohio. 1971.
2. Bolmeier, Edward C. *Landmark Supreme Court Decisions on Public School Issues.* The Michie Company, Charlottesville, Va. 1973.
3. Brown, Billye W. and Walter R. Brown. *Science Teaching and The Law.* National Science Teachers Association, Washington, D. C. 1969.
4. Drury, Robert L. and Kenneth C. Ray. *Principles of School Law.* Appleton-Century-Crofts, New York, N.Y. 1965.
5. Gatti, Daniel J. and Richard D. Gatti. *The Teacher and the Law.* Parker, West Nyack, N.Y. 1972.
6. Hazard, William R. *Education and the Law.* The Free Press, New York, N.Y. 1971.
7. U.S. Congress. Joint Committee Print. House Committee on Education and Labor, and the Senate Committee on Labor and Public Welfare. *A Compilation of Federal Education Laws.* Government Printing Office, Washington, D.C. 1975.

Science Education Research

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When a science supervisor starts wondering what he or she should know about science education research, the first caution is not to become too serious about the matter. Although everyone hopes that the research projects that they carry out will drastically improve science teaching of the future, most of us have come to know the meaning of the phrase "no significant difference." Too often the work that we do has so many variables associated with it that we're unable to show any positive correlations, let alone any cause and effect relationship. This means that we need to be cautious about any wild hopes that our research is going to make major changes in science classroom teaching. What we can hope for, however, is that is keeps us interested in improving our teaching so that it does bring about more efficient learning by our students.

A major concern of science supervisors, in terms of research, should be where one goes when one does need help, as well as basic information about the philosophy and objectives of outstanding researchers. A good place to look for the philosophical base is the addresses of past presidents of the National Association for Research in Science Teaching (NARST). In his Presidential Address in 1970, Williard Jacobson pointed out what he considered to be four different types of science education research: empirical, philosophical, policy, and developmental or formative studies. He noted that they are interrelated and that frequently more than one approach to research is used in any particular study. Often, the hardest part of a researcher's work is to define the problem.

Jacobson pointed out, also, that there are two major sources of problems in science education that can be used for studies: one theoretical, the other practical. In the theoretical area, there is some lack, inconsistency, or vagueness, such as theory as applied to science education. For the practical, some problem is sensed as one works with students, or struggles with problem planning, or feels a lack of effective science materials. Jacobson pointed out that it is important that we continue the struggle until we find problems both with theoretical and practical situations.

Jacobson also noted that "empirical studies" usually involve the collection of data concerning the behavior of students, teachers, or other subjects of study. "Philosophical studies" involve the analysis of assumptions underlying positions or actions, the nature of problematic situations, the delineation of problems within problematic situations, and the possible consequences of proposed actions. Jacobson noted that one of the functions of philosophical analysis is to clarify, if possible, consequences of actions. He defined "policy studies" as those that might include historical studies in which policy decisions and the consequences are analyzed, comparative science education studies to learn from the experience of others, and futuristic studies to project possibilities or predict consequences of various proposed policies for the future. "Developmental research" includes studies which involve the preparation of new educational materials, procedures, or programs, and systematic try-outs in which feedback is gathered and used for improvement.

Jacobson noted that he had not mentioned "evaluational research," in which the effects of using innovation and other materials or procedures are compared. Sooner or later teachers or instructional leaders have to choose materials and procedures, and it would be desirable to have these decisions based upon research. But, Jacobson pointed out that "it would be difficult, and usually suspect, for developers to undertake this kind of evaluation research and that it probably should be done in the light of local conditions anyway." This would certainly encourage science supervisors to see that the evaluation of innovations is done within a particular school district under existing conditions. Jacobson closed with implications and suggestions for further research and pointed out the admirable ethic in research that researchers should not go beyond their data in reporting their results. On the other hand, he notes that researchers do have the responsibility to utilize their data to the fullest; that "suggestions for further research" sections of reports should be taken quite seriously as one of the most important results of the research completed.

Ralph W. Tyler, who has made major contributions to curriculum development and evaluation (not only in science, but in all fields of education), presented two invited papers to the Council for the Advancement of Research in Science Education (CARSE). In the first paper, Dr. Tyler summarized what he found science education research to have been during the previous 10 to 15 years. His second paper suggested that there should be more emphasis placed on science education research in this country. He developed a "map" of science education with the total "terrain" divided into eleven particular areas:

1. objectives of science education—what to teach
2. the teaching-learning process
3. the organization of learning experiences
4. the outcomes of science education—what is actually learned
5. students' development
6. the development of teachers
7. objectives of education for science teachers
8. the teaching-learning process of teacher education
9. the organizations of teachers' learning experiences
10. the outcomes of teacher education
11. the processes of change in the programs of science education.

He concluded that there needed to be a greater commitment of faculty time and graduate education support of facilities and of research assistants to bring about good research in those eleven areas. He noted that most of the research that has been done in the past has been carried out by graduate students (who have little time to devote to these efforts) and that most faculty members, classroom teachers, or, science supervisors never get enough time to even think about such things.

In a talk before the 1973 Annual Meeting of NARST, Dr. Tyler alluded to his earlier program review. He said that he had felt in 1965 that not more than 10% of the studies he reviewed had reasonable technical criteria. But by 1973 he had found that these technical inadequacies were less distressing and there were fewer weaknesses in the content and the logical structure in at least four out of five of the studies reported since. He agreed with the view of William W. Cooley and Kenneth D. Anderson that the particular value of research for improving science teaching was not being realized. A considerable explanation seemed to lie in the lack of a cadre of professional research people deeply concerned with research in science education. Such people, he felt, need to "devote major time to this work, and, among themselves and with scholars in other fields, must seek to gain greater perspective, more adequate conceptualizations to guide their study, and better instruments for research."

In this talk, he also pointed out that he had now reviewed 50 more investigations in science teaching from the past eight years and felt that the current research studies were of a higher quality than the earlier ones. The technical criteria were being met better and the variables were more clearly defined and more adequately controlled. Greater recognition was being given to the variety of outcomes resulting from science teaching and the complexity of the classroom processes. Current research depended much less upon the work of graduate students than was true earlier, and it appeared that a cadre of professionals were engaged in these studies. His distress this time, was "that we have been greatly pre-occupied in investigating learning as this process is commonly perceived by the teacher or curriculum maker, in which the task is to direct the learning of students in the classroom or laboratory. We have largely neglected to look at the way learning is viewed by the student himself. Yet the map of the learning process as seen by the individual learner is a significant part of the context of which education, while including science education, takes place."

Dr. Tyler pointed out that the function of research related to education is to provide a basis for understanding the educational process or parts of it and for planning and developing educational programs. He said it is important to note that "educational research rarely furnishes an answer to specific questions about educational practice. Much more often, research provides a basis for practice in terms of the concepts it furnishes the practitioners, the outline it formulates of the dynamics of the processes of which the practitioner is concerned, the relations it establishes among the concepts, and the estimates it gives in the parameters of the dynamic models that are proposed. That is to say, the value of the research lies in providing the practitioner with broader and more detailed maps of the terrain of education than he could have developed from his own experience alone. The lines of research proposed should help to develop this map."

Dr. Tyler learned that there are other potential contributions to proposal research—namely, the tools by which information about students' lives and the forces influencing behavior may be obtained. The teacher gains some help in planning and conducting science courses by the characteristics and parameters in the life of children and youth. But, he or she still needs to know more specifically about individual students. The methods and tools used to study students are likely to be developed by the researcher rather than by the teacher. Dr. Tyler suggested that in order to understand the learning of students, who are not now learning or trying to learn in science classes, we need the results of research concerning the dynamics of these students, which includes their purposes, drives, habits, and means by which they achieve psychological equilibrium. We need to develop instruments and methods for studying students that teachers can use. We need reviews of potential resources in science from these students. We need experimental studies in which educational programs are designed to utilize "things" from science as resources students can use in their lives. He concluded his paper by stating the major problem confronting science education in America today: To reach students who do not really learn (internalize) anything of importance in science. Dr. Tyler believes that research in this context can help.

Nathan L. Gage of Stanford University is well known for his leadership in educational research. In a recent presentation at the University of Maryland, Dr. Gage defined research as "the process of seeking relationships between variables. That simple definition applies to any discipline, whether it be in the natural or the behavioral sciences. To understand, we search for logical relationships. To predict, we search for temporal relationships. To control or improve, we search for causal relationships. Understanding, prediction, and control are the purposes of all scientific activity, including that which is concerned with teaching."

Gage went on to define teaching as "any kind of interpersonal influence aimed at improving the learning of another person." Gage then combined these two to note that research on teaching "becomes the search for relationships between variables where at least one of the variables is a behavior or a characteristic of teachers. The teacher variable may be an independent variable, a dependent variable, an intervening variable, or some other kind of variable, but at least one teacher variable must be involved if the research is to be considered research on teaching. It follows from this definition that research on teaching is only a part of the larger field called educational research. Not all educational research is research on teaching, but all research on teaching is a part of educational research."

In his discussion on the methods of determining relationships, Dr. Gage expanded on the two major methods. The first he called the "correlational or survey method" in which one measures variables as they occur under natural conditions and in which one uses some statistical device, such as a correlation coefficient, to describe the ways in which two variables co-vary. He pointed out that "the advantage of correlational methods is that they permit us to study the relationships between large numbers of variables with relatively little effort or expense. The main disadvantage of correlational methods is that they give us little or no assurance that the relationships between the two variables are causal relationships."

The second method he called "experimental" in which one of the variables is manipulated by the investigator. In this type research "one applies different amounts, or qualities, of that variable to different groups of persons, who have been assigned at random to the groups receiving the different amounts or kinds of the manipulated variable, such as student achievement, and determines whether there are different average amounts of achievement associated with each of the different levels of the manipulated variable. . . . So the main advantage of experiments is that they do permit us to infer a causal connection between the manipulated variable and the other variables that are found to differ after the manipulation. But the disadvantage of experiments is that they are relatively costly."

Dr. Gage went on to show how it is also possible to combine the correlational and experimental approaches so that one not only manipulates variables, but also measures some characteristic of one's students that may be related to how much they learn. These studies, he noted, have been labelled "aptitude-treatment interaction studies" (ATI studies). In a typical ATI study, some relevant characteristic of students is measured, the students are taught by two different teaching methods, and, finally, student achievement is measured. Correlations are then obtained separately and a regression line formulated and evidence of an aptitude-treatment interaction may be evident.

The book by Dunkin and Biddle entitled *The Story of Teaching* was cited by Gage as the best formulation of the types of variables in research on teaching. He noted them as:

1. *presage variables* that are considered to have some value for predicting the ways in which teachers will behave.
2. *context variables* that describe the environment and conditions in which the teacher works
3. *process variables* that include the kinds of behaviors that are exhibited in the classroom by the teacher and his or her students
4. *product variables* that include the student's immediate achievement of educational objectives and also long-range effects on students, of the kinds of achievement, personality, and adjustment that they manifest after they have left the influence of a given teacher.

Gage noted that these four variables should be arranged in an order reading from left to right, with arrows pointing to the right to indicate what is presumably the direction of the causal influence between these kinds of variables.

As early as 1934, Morris Cohen and Ernest Nagel argued that no inquiry can get under way unless some difficulty is felt in practical or theoretical situations. Richard Suchman's "Discrepant Event" film-loops stimulate inquiry and observation of variance. This has led to further work by others with science students on problem identification, theory hypothesizing, and even problem-solving types of research studies. And then there are the discussions on "applied" and "basic" research; defined as "applied" when it attempts to manipulate observed variance and "basic" when it is simply interested in explaining observed variance or the lack of it.

And in science education research we also hear such names and terms as Piaget and "Learning Levels," Ausbeil and "Advance Organizers," Bloom and "Cognitive Taxonomy," Bruner and "Process in Education" alongside Gagne and "Processes in Science," Flanders and "Interaction Analysis," Welch and "Evaluation Techniques," Blosser and "Questioning Techniques," Postlewaite and "Audio-Tutorial," Walbesser and Harbeck on "Behavioral Objectives," Rowe on "Wait-Time" and then we think maybe we had better stop and "wait" ourselves.

But we can't stop and wait in our work, so we, too, must continue to learn as our students do. We need to keep abreast of what topics are "hot" this year and learn to ask the right critical questions for our own school system and our own students. Knowing where to go to find the answers may be just as valuable as actually finding them.

From the philosophical to the practical

One of the apparent needs of science supervisors is to be able to analyze research papers on their own and know what to look for. Samuel Strauss, a former high school science teacher, and later a professor at the Johns Hopkins University, published an article in the *Journal of Educational Research* that gave basic guidelines for analyzing educational research reports. The twenty points listed that should be analyzed were as follows:

1. problem raised
2. previous work cited
3. objectives stated
4. hypotheses formulated
5. assumptions made
6. population studied
7. sample drawn
8. instruments used
9. design examined
10. procedure followed
11. safeguards taken
12. observations recorded
13. findings assembled
14. statistics interpreted
15. interpretations discussed
16. conclusions reached
17. limitations recognized
18. further work projected
19. improvements suggested
20. clarity of the report.

Although his paper went on to discuss in more detail each of these items, this simple listing points up the major points one looks for when analyzing most science education research papers.

Statistics in the language of science

Although a science supervisor could get very excited about the statistics that are used in science education research, there are really only a few basic concepts in the field that one would feel comfortable with without going into a great deal of additional study. If one does want to get more background, there are a number of very good educational statistics books that could be studied. But a good, easily understood, and basic introduction to statistics, which can be helpful in science as well as science education, is found in Chapter Five of the NSTA publication entitled *The Language of Science* by Alan Mandell. In that chapter the author covers collection of data; organization and analysis of data; measures of central tendency; standard deviation; interpretations of data; standard error; the standard error of the difference between means; Chi-square; correlation coefficients; and a good but short bibliography on references for further reading.

One of the real classics that enables high school students (and their teachers) to get a good feeling for science research and how good experiments are set up is *Experimentation and Measurement* by W. J. Youden. This was a 1962 paperback book NSTA produced in the "Vistas of Science" series. The late author was then the coordinator of the research studies conducted by the National Bureau of Standards. It goes into simple experiments one really can relate to and if a supervisor hasn't read it, it certainly would be strongly recommended. It's short, concise, and excellently written.

Literature searching

When a science supervisor wants to find information in a hurry on a particular research topic, he or she probably need only to go to a few basic sources. One of these, obviously, would be a library to check through the card catalog and the Reader's Guide for Education. But a more direct source to get into the research in science education would be the use of Dissertation Abstracts, DATRIX, and the ERIC system.

The journal entitled *Dissertation Abstracts*, published by Xerox, contains abstracts of dissertations from the past year or so on any particular topic. Formerly administered by University Microfilms, microfilms are still available for a minimal cost of approximately $5.00. But, one does need a microfilm reader to read these films. The abstracts have the advantage of being regular printed material in the summary form. The technique needed is to find the best possible locater words and then to get into the right section.

Another way to do the search is to actually contract with Xerox and their search system called DATRIX. Again, the use of proper key locater words and phrases is crucial. These are simply filled into a standard form and submitted to DATRIX which gives you a print-out of all the bibliographic references for articles or dissertations on the topics requested. You can then follow up by selecting those on which you want more detail.

Another kind of research searching is that done under the Educational Research Information Clearinghouses (ERIC System). They have developed a *Thesaurus of Descriptor Terms* from which one selects the key words. Then the search is made through any one of the dozen-and-a-half ERIC Clearinghouses across the country. Since ERIC is somewhat limited to non-copyrighted material, and Dissertation Abstracts has gotten almost all the dissertations in the United States copyrighted so that they can have it in their system, it is best to use both systems in your "searching operation." (ERIC can get a copyrighted document by getting special permission, but, frequently doesn't do this for dissertations.)

ERIC/SMEAC

One of the major activities of the National Institute of Education that is most helpful to science supervisors is that known as the ERIC Informational Analysis Center for Science, Mathematics and Environmental Education (ERIC/SMEAC) that operates in Columbus, Ohio. Many of their publications are available directly from the Center for Science and Mathematics Education at Ohio State University, 244 Arpes Hall, 1945 North High Street, The Ohio State University, Columbus, Ohio, 43210.

In addition to being able to furnish to science supervisors microfiche of the various documents that are in the ERIC System, they also have a number of regular paper printouts of the documents in the computerized system. (Incidentally, the material from the Ohio State Center seems to be less expensive than to get them directly from the national ERIC Document Reproduction Service (EDRS).) Among the documents that science supervisors certainly should be aware of and may want to purchase some are noted below. There are many others and the complete publication lists can be obtained from Robert Howe, Director of the Center for Science and Mathematics Education at Ohio State. Some of the representative titles that could be important for supervisors might include these:

502S—*How to Use ERIC: Science Education*, and 501E—*How to Use ERIC: Environmental Education*; 004E—*A Review of Research Related to Environmental Education* and 008E—*Environmental Edu-*

cation, Abstracts and Index to Research in Education 1966–1972; 100F—*Research in Earth Science Education: an Annotated Bibliography*; 103S—*A Summary of Research in Science Education for the Year 1965–1967, Secondary Level*; 104S—*A Summary of Research in Science Education for the Year 1965–1967, Elementary Level*, and 105S—*A Summary of Research Education for the Years 1965–1967, College Level*. It should be noted that similar summary papers were prepared for the years preceding and following the ones just noted. There is, for example, an all-level one, 11S—*Summary of Research in Elementary, Secondary and College Level Science Education for 1970* and on up to the present.

Another type of paper reproduced by the ERIC Center are those presented by major speakers at the annual NARST meetings. For instance, that by Ralph W. Tyler on *Research in Science Teaching in the Larger Context (No. 119S)*, James Rath's paper *The Emperor's Clothes Phenomenon in Science Education (No. 122S)* and H. S. Broudy's paper *Can Research Provide a Rationale for the Study of Science? (123S)*.

Papers reproduced by the ERIC group at Ohio State also include abstracts on the papers presented at the annual NARST Meetings. They have been available since the meetings of 1969 and are released each year. The 1976 issue for the San Francisco meetings was a 165-page paperback booklet containing all the abstracts. Stan Helgeson, Associate Director of the ERIC Center, and Bob Howe, Director, have also compiled item 137S—*Science Education, Abstracts and Index to Research in Education 1966–1972* and are now editing a new series 300–301S, 305S—*Investigations in Science Education (ISE)*. These issues, started in 1974, contain about 70 pages per issue of abstracts of research articles and documents with a critical analysis of each report prepared by leading science educators. It would be important for the science supervisor to get on the mailing list for the publications list of the ERIC Center.

The International Clearinghouse on Science and Mathematics Curricular Developments

For science supervisors who need to keep up to date on the developments in science and mathematics curricular developments in this country and abroad, there are the biennial reports of The International Clearinghouse at the Science Teaching Center, University of Maryland, College Park. The Clearinghouse was established in 1963 and has produced (with NSF support and the cooperation of AAAS) nine reports and was working on the tenth report in 1976. The typical format of the reports are detailed project summaries written by the project directors themselves. The information is taken from a questionnaire that asks the same kinds of questions that the Clearinghouse staff has been asked over the previous years. Any particular volume contains only the projects that were ongoing at the time of the two-year period that the volume spans. The exception to this rule was the *Ninth Report* published in 1975. That volume, entitled Science and Mathematics Curricular Developments Internationally, 1956–1974, allowed one page to each of the science and mathematics curriculum projects from the beginning of PSSC Physics and SMSG mathematics in 1956 on through 1974. That particular overview volume is a good basic one to have in any science supervisor's library. For more detailed information on any of the projects, one would want to use the other editions particularly the seventh, eighth, and tenth. (They usually cost $5.00 or less, depending on which volume you purchase.)

One also should be aware that the actual "soft-ware" of each of the projects from around the world are housed in The International Clearinghouse Archives Collection at the University of Maryland and this material is available for anyone to come and peruse or use at the Center for their own curriculum development work. Literally hundreds of domestic and foreign visitors visit The International Clearinghouse each year and certainly science supervisors make up a large number of visitors. Write or call the Director if you would like to visit or use the materials at the Clearinghouse.

Curriculum analysis

A major task of many science supervisors is to be appropriately aware of the ongoing developments in science and mathematics curriculum work. This is necessary so that one is prepared to make proper suggestions and to be aware of any developing trends.

While the reports of The International Clearinghouse on Science and Mathematics Curricular Developments of the University of Maryland can be very helpful in this regard, there is also a need to know of the curriculum analysis work that is additionally being done there, as well as at other institutions. A supervisor should be familiar with the studies conducted at IPN in Kiel, Germany; by the group in

Sussex, England; by the Social Sciences Consortium at Boulder, Colorado; and by the Educational Products Information Exchange (EPIE) in New York City. Each of these groups, along with the International Clearinghouse, are conducting research on just what does, and should, go into science curricula. At Maryland for instance, studies are underway on what "values" from the affective domain might be identified in any particular curriculum project. Another curriculum analysis study is concerned with the criteria considered important by school districts and matching these up with existing curriculum projects housed in The International Clearinghouse collection.

Since most of these projects are "open-ended," science supervisors are frequently more than welcome to actively participate in the research and "learn by doing." Contact the appropriate group's director to become involved.

Publications of particular interest to science supervisors

One organization in the United States particularly dedicated to research on science education is the National Association for Research and Science Teaching (NARST). The organization has been in operation for quite a number of years and the outstanding papers that are presented each year at the annual meeting in March or April are reproduced in the association's official publication, the *Journal of Research in Science Teaching (JORST)*. In addition, the abstracts of the papers are published separately and are released through the ERIC Center at Ohio State. Among the four issues of each year's volume are sections entitled Research Papers and Research Reports along with some book reviews and occasionally a special volume.

The annual meetings of NARST are held on an alternating basis for one year in the same city at approximately the same times as annual meetings of the American Educational Research Association (AERA). In this way they have a chance to get their members involved in these two important professional organizations and certainly bring good input to both groups.

A special volume of *JORST* that would be most appropriate for science supervisors to read is Volume Eleven, 1974 Issue Three—September Edition. It was a special volume entitled *Methods and Research in Science Education*, organized by Robert G. Bridgham. It included a number of excellent papers including: one by Wayne W. Welch on the process of evaluation; another by Audrea B. Champagne and Leo E. Klopfer entitled "Formative Evaluation in Science Curriculum Development"; another by the *JORST* editor at that time, O. Roger Anderson, entitled "Research on Structure in Teaching"; and one by Mary Budd Rowe, "Reflections on Wait-time Methodological Questions." The whole issue was particularly directed at research methods and would certainly be worth investigating.

Other associations that have an interest in research in science education give space in their journals for such reports also. The Association for the Education of Teachers of Science (AETS) (*Science Education*), The National Association of Biology Teachers (*The American Biology Teacher*), the American Association for Physics Teachers (*The Physics Teacher*), the National Association for Geology Teachers (*Journal of Geological Education*) and the Central Association for Science and Mathematics (*School Science and Mathematics*) have all included occasional articles that certainly should be read by science supervisors.

The three NSTA journals, *The Science Teacher*, *Science and Children*, and the *Journal of College Science Teaching*, include a series of articles organized by the NSTA Committee on Research in Science Teaching. The series attempts to inform teachers about research which is directly relevant to improving classroom instruction.

The only national organization outside the United States that is particularly dedicated to science education and has a special journal is one in Australia. Its name is the Australian Science Education Research Association and they publish an annual journal entitled *Research*. This is available from Leo West, School of Education, Monash University, Clayton, Victoria, Australia. Two of Dr. West's associates at the same university, Peter J. Fensham and R. P. Tischer, would be additional contacts. They also have an annual meeting at which their science education research papers are presented.

One other journal outside the United States that is particularly concerned with science education research is that edited by David Layton at the Center for Studies in Science Education and has an annual subscription rate including postage of $6.50. Subscription inquiries would be directed to the Business Manager, *Studies in Science Education*, The University, Leeds LS2 9JT, England.

It might also be worth noting that there are such reviews in the curriculum development section of the British Association for Science Education journal entitled *School Science Review* and that there is a research note section in the Australian Science Teachers journal.

The American Educational Research Association (AERA)

Supervisors concerned with educational research should be acquainted with the AERA, an important national organization. A number of their publications and activities could be of real assistance.

As noted earlier, the NARST feels that annual meetings of this group are so valuable that they alternate their meetings between AERA and NSTA. In 1976, NARST met immediately following the AERA San Francisco meeting. Some of the AERA meetings are preceded by their research training institutes that would be of interest to supervisors also. These training "short courses" have covered a number of basic topics over the years and are held across the country in addition to the annual meeting sessions.

Among AERA publications that may be of interest are: *Educational Researcher*, a monthly magazine with news and feature articles; the *AERA Journal*—four issues per year; *Review of Research in Education*—Annual Editions since 1973; AERA *Monographs* on special topics; the *Handbooks of Research on Teaching*—1963 edition edited by Gage and the 1973 one by Travers; the *Encyclopedia of Educational Research*—the fourth edition edited by Ebel was published in 1969. One should check with AERA for their other publications.

Instruments in science and science education

In addition to the data available from the publishers of standardized tests, the publications of Oscar K. Buros can be of considerable help in this area. In 1972, Gryphon Press in Highland Park, N.J., released Volumes I and II of the Seventh Mental Measurement Yearbook which very succinctly summarizes the information on all published standardized tests. *Science Tests and Reviews* and *Mathematics Tests and Reviews*, both published in 1975, should be of value to supervisors.

Other books on science education research

Many in science education know the fine work of Francis D. Curtis. But many may not know that Columbia University has reissued his "investigation digests." The three already released are: *A Digest of Investigations in the Teaching of Science in the Elementary and Secondary Schools*, 333 pages, 1971; *Second Digest of Investigations in the Teaching of Science*, 413 pages, 1971; and *Third Digest* *of Investigations in the Teaching of Science*, 408 pages, 1971 (all from Teachers College Press in New York City).

Teachers College Columbia also released: Robert W. Boenig's *Research in Science Education, 1938–1947*, 294 pages, 1969; J. Nathan Swift's *Research in Science Education, 1948–1952*, 190 pages, 1969; and Elizabeth Phelan Lawlor's *Research in Science Education, 1953–1957*, 112 pages, 1970. All three volumes summarize science education studies going through the purpose, procedure and results of the research of those periods.

For those who are interested in research design, the classic work is by Donald T. Campbell and Julian C. Stanley entitled *Experimental and Quasi-Experimental Designs for Research* (76 pages, 1963, published by Rand McNally). It appeared first as a chapter in Gage's *Handbook of Research in Teaching*.

It must be apparent by now that the listings are endless depending on one's needs and background. The items presented here are ones the author and his colleagues, including his students, find helpful. Add your own favorites to the list and check with other supervisors as to their favorites. Then you will have a good basic list that you will find best for your purposes.

Section 4

Resources for the Supervisor

Educational Funding: Planning for Involvement

Gary L. Awkerman, *Director of System Planning, Charleston County Public Schools, Charleston, S.C.*

A systematic review of the educational enterprise suggests that many educational subsystems may be identified and described, all of which combine to serve the purpose of providing for student learning. Given the assumption that a science supervisor has some role in nearly all the operational subsystems, it is axiomatic that the role does "make a difference." All interacting components of a system contribute to the outcomes, although the exact contribution is often not clear because of the very character of the interactions.

Nearly all educational subsystems (e.g., food services, transportation, and curriculum development) have financial components and processes. If the science supervisor has any kind of role in the subsystems, it becomes apparent that he or she is part of the financial picture. There is no escape from the reality of financial involvement. Even no apparent action is in fact action; the outcome is affected.

Money is tight this year—and next year, and next year and next year. Everyone in the educational arena is competing for the dollar. Seldom are compiled budget estimates lower than estimated revenues. What's wrong with things? When are they going to get better? Let's step back and take a critical look at the situation.

The leaders in science education appear to have a fundamental choice. They can either sit back and wait for someone to tell them what their operational resources are to be, or they can get involved with the total resource package of their organization and community. But first they must tell themselves that no one has absolute claim to any resource. All resources are there to make a difference in the child's learning process so that learning is at least better than what would occur by chance if no formal schooling existed.

Planning for involvement in the allocation of an organization's resources is an important facet of the supervisor's role. Before the supervisor can become fully involved with the resource allocation process, he or she must first attempt to understand the full scope of the system's resources. The first section of this chapter provides general information of the primary resource—money. A cursory status review of educational finance and the identification of funding sources at the federal, state, local, and foundation levels is given. The second section includes discussions on communication, community resources, personal planning, and grantsmanship.

Educational funding

Most sources and controls of funding for educational institutions are in a state of flux. The one certainty that appears to exist is that school costs are rising. The current estimated revenue of $46.6 billion from all sources for public schools falls far short of the 1976–77 estimated need of $70.97 billion dollars. [10] What will be the source for the additional revenues?

The heavy reliance upon property tax revenues has already resulted in numerous lawsuits anchored in the equal protection clause of the Fourteenth Amendment. [16] It is argued that most school finance systems discriminate on the basis of the district's wealth. Wealthy school districts can gain more revenue from even a lower tax rate than a poor school district simply because their real property has much higher assessment. [14] The fiscal disparities are usually not successfully compensated for by the present levels of either state or federal aid.

Webb clearly points toward the critical need for greater state and federal general aid. [20] He suggests that a reasonable goal for the federal government is to contribute forty cents of the school dollar instead of the present average funding level of less than seven cents. Increased federal aid to various high priority programs such as career and early childhood education, and stronger state interventions in the schools are cited in the recommendations from the President's Commission on School Finance. [12]

Several printed sources that review the many federal aid programs are available to the science educator. The Croft Federal Aid Reference Manual describes the benefits, provisions, regulations, and procedures for application to approximately 25 programs and their various titles. [17]

The few educators who are totally involved in preparing proposals and those who simply need up-to-date information on funding sources may go to any of several newsletters, some of which are quite costly. A few of these newsletters are: *AASA Hotline*, *Washington Monitor*, *Washington Perspective*, *Educator's Dispatch*, *PNAC Notes*, *Behavior Today*, *Education Funding News*, *Trends* and *The Croft Federal Aid Service*.

Personal contacts are another information source that cannot be overestimated. Because program funding authorizations and their actual funding levels seldom match, it is wasteful to pursue leads that sound appropriate to needs according to source descriptions but in reality have little or no current funds for new projects. Don't be afraid to make a few telephone calls and ask plenty of questions.

In state departments of education, many people have information on past, present, and future funding sources. Discussions with state department educators can be generally informative and can provide answers to specific questions regarding state and federally funded programs.

Title I of the 1965 Elementary and Secondary Education Act (ESEA) represents the largest single federal program designed to assist school districts in meeting educational needs of children from low-income families. Although some organizational attempts have been made to encourage the school-community development of meaningful educational programs, most Title I programs are still planned and controlled by administrators within each of the 15,300 school districts receiving grants. [6] The management and guidelines for the program continue to be weak.

The science educator should study his or her district's Title I proposal to identify existing expenditure areas. Perhaps some funds are allocated or could be allocated to science or science-related programs. Some possible suggestions include: nature trail development, field trips, purchasing high interest science readers for low reading-level students, development of teaching strategy models, limited facility improvements, and limited stipends for teacher inservice workshops on basic skills and teaching strategies.

As of August 1974, a major change in the law has shifted several funding categories that were appropriate to science educators' usage. Titles II and III of ESEA and Title III of National Defense Education Act (NDEA) have now been consolidated into Title IV, Parts B and C. The Education and Labor Committee of the House created an ESEA "support and motivation" category (former Titles III, V, and VIII of ESEA) and a "libraries and instructional resources" category (NDEA Title III, ESEA II and guidance-counseling part of Title III). The new law (PL 93-380) may be reviewed in *A Compilation of Federal Education Laws as Amended Through December 31, 1974.* [2]

Title IV, Part B provides for library and learning resources. The science educator should work with the instructional aids coordinator, school librarians, or other appropriate personnel to assure input into the yearly purchases. Nature field guides and identification keys at all levels of sophistication covering many nature topics represent one good purchase area among numerous possibilities.

The former Title III of NDEA, now in Title IV, is also a source for the purchase of instructional aids. It requires 50 percent local matching funds on all purchases. In the past, science equipment has been purchased through NDEA. Much to the chagrin of some educators, the purchases have not always been wise.

The former Title III-ESEA, now in Title IV, Part C, is designed to produce innovative and exemplary programs. It is primarily a state program, although USOE often reserves approximately 15 percent of each state's allocation for discretionary purposes. Each state establishes its own educational funding priorities, often based on surveys of school district's needs or long-term plans for improving education from governor and state superintendent *ad hoc* committees. Proposals submitted to state departments of education for approval are usually quite elaborate, much more so than Title I proposals. It is suggested that copies of old proposals be used as models.

Science proposals may or may not be Title IV, Part C priority areas for funding. Priorities change from year to year and from state to state. Don't become discouraged if science is not a priority. A good proposal may still have components which include aspects of science. Science, an intrinsically interesting field, may become an integral part of projects in such areas as career education, dropout prevention, and environmental education.

Other specific federal aid programs that may have application to the science educator include: former Title VIII ESEA—Dropout Prevention Projects, Drug Abuse Education Act of 1970; Environmental Education Act, Gifted and Talented Children's Education Assistance Act, and Science Club Law (no present funding).

The dropout prevention programs are now administered by the Bureau of School Systems. In fiscal year 1976, the Commissioner of Education used about $2 million in discretionary funds for dropout prevention. [8] Getting the potential dropout "back to nature" is not an unproven concept.

The Federal Property and Administrative Services Act of 1949 (PL 81-152, amended) may be a possibility for the science educator to acquire science equipment at a very low cost. A surplus property warehouse is maintained in almost every state. An interested science educator must first get in touch with his or her state agent and school district superintendent to get an authorization to visit the warehouse as the school district representative. Each visit to the warehouse will be different. Sometimes the state agent can be persuaded to discuss the latest holdings via telephone.

If a science educator is currently enrolled as a graduate student in an institution of higher learning or serves as an instructor or assistant professor, he or she may consider the possibility of applying for an educational research grant from the National Institute of Education. The small grants available do not require extensive proposals.

The National Science Foundation, established by a Congressional Act in 1950, has been one of the strongest proponents of science education reform. Its major education programs include: Academic Year Institutes for Secondary Teachers and Supervisors; Inservice Institutes for Secondary Teachers; Summer Institutes for Secondary School Teachers of Science, Mathematics and Social Studies; Science Training Programs for High Ability Secondary School Students; College Teacher Programs; and Cooperative College-School Science Programs.

The Cooperative College-School Science Program (CCSS) offers an excellent opportunity for colleges and school systems to participate in joint ventures to improve facets of elementary or secondary science instruction. A simple analysis derived from the 1971–72 and 1972–73 funded programs listings indicated that 34 states had three or less currently funded programs, seven states had either four or five currently funded programs and only five had six to nine currently funded programs. Comparing the directors and institutions holding the grants between 1971–72 and 1972–73 years, it was found that 66 percent of directors were different and 55 percent of the institutes were different. It is apparent that a school district new to CCSS does have a chance to submit a proposal for possible funding because of the high turn-over of directors and funded institutions.

NSF is far from a static organization. Its current emphasis, like that of other funding agencies, should always be reviewed before proposals are submitted. Recent educational issues that will probably relate to shifting NSF emphases include interdisciplinary studies, non-science major curriculum materials, technician curriculum materials, and the application of scientific principles to the education process. [5]

The science educator should contact the finance office of his or her state department of education to locate information on educational funding. The vast majority of state monies is usually committed to teacher and administrator salaries, transportation, school district operational aid, and building funds. Most states have some flexibility in their educational funding. For example, the state of New Jersey supported the Teacher Innovation Project by providing 198 mini-grants (up to $1,000 per grant) to classroom teachers for personal innovative projects. As previously mentioned, Title III ESEA (now in Title IV) is under strong state control and is therefore a possible source for science education projects.

The ambitious educator may want to attract the attention of foundation support for his or her proposal. *The Foundation Directory*, [18] and *Foundation News* are two good sources on foundation support.

Often, educators are less aware of local or community funding sources and foundations than they are of federal sources even though they are much closer to them. If teachers are to effect change in the schools, they must start by developing community awareness.

Community, communication, and common sense

The community should represent a mandatory educational resource for the science educator. Teachers should frequently refer to aspects of the community during instruction. It is not possible to do so unless a repertoire of community facts, concepts, and principles are directly available to the educator.

A large-scale effort to identify resources should be made through organized school-community study groups composed of individuals from such areas as manufacturing, businesses, libraries, theaters, museums, service organizations, military, parks, higher education, and the schools. The product of the school-community cooperative effort could include a catalog of community resources with a listing of people with special skills and equipment, an extensive set of teaching materials, and "a wealth of real world situations upon which the teacher can draw to plan community laboratory experiences both in class and in the community laboratory." [48] Inservice programs designed to provide teachers with "real world" examples and teaching materials must also be cooperatively organized if they are to be effective. [1] Cooperation and communication are necessary for effective change.

Small schools and school districts usually are much slower to accept change and innovation because of limited financial and personnel resources, physical isolation, and apathetic communities. [13] Cooperation and communication are necessary to generate change in the small schools. Meetings should be arranged to explore new ideas with outside consultants, to display new teaching materials and programs, and to create a sense of cooperation within interest groups. A bus designed as a moving laboratory could travel between communities in an effort to expose isolated schools to innovative practices. Teachers could be selected for cooperative teaching for a group of small schools. Shared services in many areas could be an asset to small schools, especially in fianancial matters. Shared specialists could be hired in subject areas to assist in curriculum development and evaluation, inservice sessions, and proposal writing for grants. With their salaries supported by various grants, specialists or supervisors can provide expertise for a shared-service group or a large school district.

The science educator should become familiar with the roles of any supportive personnel available at the local and state levels. One of the local supervisor's roles, for example, is to demonstrate and disseminate information to effect diffusion and acceptance of an innovative educational practice. [7] The state science supervisors should be contacted directly since the state directly controls various sources of funds.

Educators sometimes think that innovative practices are occurring some place other than in their own community or state. A survey of exemplary teaching practices at Utah University indicated the significant extent of innovation occurring within a single institution.[1] At the University of Michigan, a four-year test was completed in "the viability of utilizing the resources of a state-wide teacher organization in the identification and diffusion of promising teacher innovations." [4] Such studies indicated that "things are happening on the home front, be it at the regional or state level." If dissemination efforts were greater, educators would be exposed to more innovative ideas and not "rediscover gravity" quite as often as they now do.

Science educators should be encouraged to observe instructional settings that are new to them. A visit may be arranged to the next room, the next school, or the next state. A greater effort should be made to provide for educators to personally observe new or innovative instructional settings.

The personal planning of the science educator is worthy of some discussion at this point. Everyone knows that planning ahead has merit. In the planning effort needed by a teacher in a laboratory course, or an instructor of an inservice course, or a professor of a college science methods class, one can find some commonality. For every class activity there should be a realistic inventory of necessary instructional supplies and equipment, in advance of the activity. For example, some activities will suggest group demonstrations, two-student teams, or perhaps six-student teams. When limited funds are available, it is most important to purchase for minimum needs as dictated by pre-selected teaching strategies to maximize usage of funds.

If the particular needs of a science educator are clearly defined, he or she can then start locating materials. Simple exchanges of chemicals or glassware between schools, for example, may be a means of obtaining materials quickly at no cost while decreasing inventory excesses on certain items. Advance planning may also allow the educator to identify alternative instructional components for specific learning functions. It is most important, however, that available instructional components do not determine what is to be taught. For example, just because 65 science filmstrips are available does not mean they all must be used.

The science educator may want to attempt to develop a formal proposal for possible funding. The writing effort should be initially given considerable thought and study. It is doubtful that a grant attempt should be made unless the educator is highly motivated. Weeks or perhaps months of work put into a proposal may result in a "no" reply.

A careful review of the available sources that may support the proposal is always a prerequisite. There is no substitute for good personal contacts with funding sources. One must follow the particular proposal submission guidelines for each program, even though they are often quite similar. Obtain old copies of successful projects that were written following the particular guidelines in question. The phraseology used in the proposal can have a definite effect on the field readers. [9] Each proposal should show good planning with realistic objectives, methods, and evaluation. Esoteric education jargon cannot conceal a weak proposal design. If a professional grantsman is available, his or her expertise should be used.

After obtaining a grant, the work has just begun; reports will be due and site visitations can be expected. Amateurs may suddenly find themselves involved with payroll departments, federal program offices, community advisory boards, personnel directors, auditors, maintenance departments, architects, local politicians—and students. Although grantsmanship is not easily developed, it is worth the effort. Direct involvement in several winning and losing proposal efforts has no learning substitute.

REFERENCES

1. Awkerman, G. L. "Inservice Course Through Industry." *The Science Teacher* 37: 45–46; 1970.
2. *A Compilation of Federal Education Laws as Amended Through December 31, 1974.* House Committee on Education and Labor and the Senate Committee on Labor and Public Welfare, U.S. Government Printing Office, Washington, D.C. February, 1975.
3. Fontaine, T. D. "Federal Programs for the Improvement of School Science and Mathematics." *Science Education* 54: 209–212; 1970.
4. Fox, R. A. & R. Lippitt. The innovation and sharing of teaching practices-II: Procedures for stimulation adoption and adaption of selected teaching practices. Final Report. Michigan University Center for Research on Utilization of Scientific Knowledge, Ann Arbor, Mich. 1967. ED 030297.
5. *Grants for research in education.* National Institute of Education, Washington, D.C. 1975.
6. Glickstein, H. A. "Federal Educational Programs and Minority Groups." *Journal of Negro Education* 38: 303–314; 1969.
7. Hughes, L. W. & C. M. Achilles. "The Supervisor as a Change Agent." *Educational Leadership* pp. 840–843; May 1971.
8. *Innovations in Education.* National Advisory Council on Supplementary Centers and Services, Washington, D.C. May/June 1975.
9. Knezevich, S. J. "The Fine Art of Research Grantsmanship in School Health Education." *The Journal of School Health* pp. 179–186; April 1970.
10. Lambert, S. M. "Financing a National Standard of Education." *Today's Education* pp. 42–43, 65–66; April 1972.
11. Murphy, J. T. "Title I of ESEA: The politics of implementing federal education reform." *Harvard Educational Review* [illegible]: 35–63; 1971.
12. Piele, P. K. *The President's Commission on School Finance.* Eric Clearinghouse on Educational Management at the University of Oregon, Eugene, Oregon. Spring 1972.

13. Rogers, T. M. & L. Svenning. *Change in Small Schools*. Eric Clearinghouse on Rural Education and Small Schools at New Mexico State University, University Park, New Mexico: (ED 029749) May 1969.
14. Rudiger, C. W. & R. Pollack. "Wealth's Effect on Education." *School Management*, pp. 16–20; February 1972.
15. *Seeking Program Funds: A Funding Manual for Community Organization.* Center for Community Education of Columbia University, New York February 1971. (ED 050194)
16. Shannon, T. A. *Has the Fourteenth Done It Again?* American Association of School Administrators, Washington, D.C. 1972.
17. *The Croft Federal Aid Reference Manual*. Croft Educational Services, Washington, D.C. 1972.
18. *The Foundation Directory*. Columbia University Press, New York 1971.
19. *Title I Can Change Your School*. Center for Community Education, Columbia University, New York 1970. (ED 050195)
20. Webb, H. V. "A Realignment of Educational Finances." *The Education Digest*, pp. 1–3; March 1970.
21. Willis, B. C. "Suburban-urban Educational Resources." Paper presented at National School Boards Association Annual Convention, Philadelphia, Pa. April 3–6, 1971. (ED 051575)

Professional Journals*
Educational Journals for the Science Teacher

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Reprinted with permission from *The Science Teacher*. Vol. 41, No. 3, March 1974, pp. 33–35.

Science teachers, with their training in the processes of science, would seem to be uniquely motivated to make use of research evidence related to teaching effectiveness and curriculum choices. Research of interest to science teachers is carefully indexed in the monthly issues of the *Current Index to Journals in Education (CIJE)* [1] and in *Research in Education* (RIE). [2] These sister journals divide the work, with the CIJE indexing approximately 700 journals and the RIE indexing approximately 1,000 reports a month. Science and mathematics teachers on the mailing list for the *SMEAC Newsletter* [3] are periodically alerted to reports and articles which are being announced in the RIE and CIJE. The editor of the *SMEAC Newsletter* will provide teachers with a list of library centers in a particular state where complete microform holdings of reports listed in RIE are available to the reader. The obvious difficulty in retrieving articles indexed in the CIJE is in

* *Editor's note:* The subscription rates given in the two articles in this chapter were current at the time of their initial publication. Some rates may have since changed. It would be best to contact the publishers for current rates.

finding the periodicals, particularly since most libraries do not subscribe to all the journals of interest to science teachers.

The selection of the journals listed in this article was based, in part, on correspondence with a small sample of ten science teachers, supervisors, and other science educators. The journal descriptions were gathered from a number of sources, and the information in nearly all cases was reviewed by the journal editor.

Problems and research in science teaching

The Science Teacher, edited by Rosemary Amidei, is published by the National Science Teachers Association (NSTA), 1742 Conn. Ave., N.W., Washington, D.C. 20009. It is included with secondary ($18), comprehensive ($32), and life membership in NSTA. Subscriptions are available at $25 per year; single copies are $1.70 per issue. Circulation is 23,000. Publication began in 1934. Presently there are nine issues a year, September through May. The index for the year appears in the December issue. The journal is an excellent source of new teaching methods, aids, and demonstrations in the classroom and laboratory, and new developments in science and science education.

Journal of Research in Science Teaching, edited by O. Roger Anderson, is sponsored by the National Association for Research in Science Teaching and published by John Wiley and Sons Inc., 605 Third Avenue, New York 10016. Subscription is $10. Publication began in 1963. Presently there are four issues a year, in March, June, September, and December. The annual index of authors and volume contents appears in Issue 4 (December). The *Journal* contains research articles on such topics as instructional strategies, teacher effectiveness, and student achievement and attitude studies.

Science and Children, edited by Phyllis R. Marcuccio, is published by the National Science Teachers Association, 1742 Conn. Ave., N.W., Washington, D.C. 20009. It is included with elementary membership ($12) and comprehensive membership ($32); subscription is $14 per year. Circulation is 28,000. Publication began in 1963. Presently the journal appears monthly from September through May except for January. An annual author and subject index appears in Issue 8, May. Prior to May 1968, the volumes were indexed biennially. The articles are written to assist the elementary school teacher in planning interesting laboratory and classroom science activities.

Science Education, edited by N. E. Bingham, is sponsored by the

Association for the Education of Teachers of Science, and is published by Wiley-Interscience Company, 605 Third Avenue, New York 10016. Subscription is $12 per year; circulation is 2,000. Publication began in 1916. Presently there are four issues a year, January-March, April-June, July-September, and October-December. The annual index appears in the October-December issue. This publication provides informational and research articles on curriculum development, teacher education programs, and other aspects of science education for the elementary through junior college levels.

School Science and Mathematics, edited by George C. Mallinson, is sponsored by the School Science and Mathematics Association, Inc. The publisher is Dale Schafer, Lewis House, P.O. Box 1614, Indiana University of Pennsylvania, Indiana, Pennsylvania 15701. Subscription is $10 in the United States and Canada and $12 overseas; circulation is 7,500. Publication began in 1901. Presently there are eight issues a year, October through May. The annual index appears as the centerfold in Issue 3 in December. A Sixty-year Cumulative Index of articles appearing 1901-1960 is available, as is a 197-page, hard-cover book, tracing the development of science and mathematics education. Book reviews and mathematics problems are also presented.

Journal of Educational Research, edited by Wilson Thiede, is published by Dembar Educational Research Services, Inc., 2018 N. Sherman Avenue, Box 1605, Madison, Wisconsin 53701. Subscription is $10, and circulation is 6,000. Publication began in 1920. Presently there are 10 issues a year with Issue 9 for May and June. The author and article index for the year appears in the tenth issue, July-August. The *Journal* contains short well-documented articles on school problems in the elementary through the graduate school levels. It also contains research articles and critiques designed to advance the scientific study of education and improve field practices.

Review of Educational Research, edited by Sam Messick, is sponsored by the American Educational Research Association, 1126 16th Street, N.W., Washington, D.C. 20036. Subscription for nonmembers is $10, and circulation is 14,000. Publication began in 1931 with five issues per year. In January 1972, the RER became a quarterly. The *Review* publishes not only reviews of educational research, but also research in the social and behavioral sciences, management, and humanities, so long as they bear on educational issues.

Journal of College Science Teaching, edited by Leo Schubert, is published by the National Science Teachers Association, 1742 Conn.

Ave., N.W., Washington, D.C. 20009. Subscription is $14 and circulation is 3,000. Publication began in 1971 and from October 1971 to April 1973, the *Journal* was published quarterly with the volume ending in April. In 1973-74, the *Journal* was issued five times per year in the months of October, December, February, April, and May.

The *Journal* is addressed primarily to college science teachers of introductory courses. *Journal* articles deal with such topics as historical and philosophical problems in science education, laboratory innovations, and multidisciplinary approaches.

Scientific American, edited by Dennis Flanagan, is available from the publisher at 415 Madison Avenue, New York 10017. Subscription rate is $10 a year; circulation is 525,000. Publication began in 1845. The journal is issued monthly with an annual index in the December issue. This journal is considered to be the best general science publication for both the student and the scientist. The articles provide interpretations of scientific advances in the physical, life, and behavioral sciences.

Science, edited by Philip H. Abelson, is sponsored by the American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005. The annual subscription is $30; school year subscription for nine months is $22.50. The circulation is in excess of 160,000. Publication began in 1880. *Science* is published weekly, except the last week in December, but with an extra issue in November. Indexes appear in the last issue for March, June, September, and December. *Science* is a forum for the presentation of issues related to the advancement of science. Sophisticated research articles, general essays, and book reviews are features of this publication.

Biology education

American Biology Teacher, edited by Jack Carter, is sponsored by National Association of Biology Teachers, 1420 N Street, N.W., Washington, D.C. 20005. Subscription is $15, with a circulation of 14,200. Publication began in 1938. The journal is issued monthly except for June, July, and August. All volumes have nine issues except for Volume 9 (1947) which had eleven issues. The index for the year is in the December issue. The articles, which are written by both educators and scientists, are concerned with current events affecting biology education, new teaching methods, aids and demonstrations in the classroom and laboratory, as well as with interpretations of technology and research.

Journal of Biological Education, edited by B. Gregson-Allcott, is sponsored by the Institute of Biology. The publisher's address is Institute of Biology, 41 Queen's Gate, London SW7 5HU, England. Subscription rate is $12 a year with circulation of 2,500. Publication began in 1967. Volumes 1-4 consist of four issues; volumes 5 onward consist of six issues, appearing in February, April, June, August, October, and December. The annual index appears in Issue 6, December. The *Journal* discusses biological education at the secondary through undergraduate levels. The articles focus on laboratory experiments, course and curriculum development, instructional aids, and apparatus. Book, film, and equipment reviews are also included.

Natural History, edited by Alan Ternes, is sponsored by the American Museum of Natural History, 79th Street and Central Park West, New York 10024. Subscription is $8 a year, with a circulation of 350,000. Publication began in 1900. There are ten issues a year: monthly (October-May) and bimonthly (June-September). The annual index is printed separately and is available on request. The journal is indexed by the *Reader's Guide to Periodical Literature* but not by CIJE. This journal represents an excellent approach to conservation, anthropology, geography, and all types of nature studies through authoritative articles written in a semipopular style featuring outstanding photographs.

National Geographic Magazine, edited by Gilbert M. Grosvenor, is sponsored by National Geographic Society, 17th and M Streets, N.W., Washington, D.C. 20036. Subscription is $9; circulation is 8,800,000. Publication began in 1888 with monthly issues. The annual index appears as a separate volume. The articles about interesting people, places, customs, and organisms are beautifully illustrated.

Journal of Environmental Education, edited by Clay Schoenfeld, is published by the Dembar Educational Research Service, Inc., Box 1605, Madison, Wisconsin 53701. Subscription is $10; circulation is 2,700. The publication began in 1969. The *Journal* appears quarterly with the annual index in the summer (No. 4) issue. The *Journal* contains research articles, project reports, and critical essays designed to advance the scientific study of ecological communications and improve field practice in environmental education.

Chemistry education

Journal of Chemical Education, edited by W. T. Lippincott, is sponsored by the Division of Chemical Education of the American

Chemical Society, with editorial offices at the University of Arizona, Tucson. Subscription is $6 for one year; circulation is 25,000. Publication began in January of 1924 with monthly issues. The annual index is in the December issue. The *Journal* contains review articles summarizing recent developments in chemistry. Also included are summaries of tested and successful approaches in curriculum revision, in course development, in laboratory design, and instrumentation and experiments.

Chemistry, edited by O. Theodor Benfey, is sponsored by the American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036. Single subscription is $6; 10 or more with single payment, $4.50; 10 or more covering a 9-month academic year to a single address, $3.70. The journal is published monthly, except for the July-August issue, with an annual index in the December issue. The journal presents articles on the interpretation and application of chemical research, historical aspects of chemistry, and related articles written for the beginning student in chemistry.

Physics education

Physics Teacher, edited by Clifford E. Swartz and Thomas D. Miner, is sponsored by the American Association of Physics Teachers of the American Institute of Physics, 335 E. 45th Street, New York 10017. Subscription is $10 a year, with a circulation of over 10,000. Publication began in 1963. Presently there are nine issues a year, September through May. The annual index appears in the December issue. In each issue the journal contains three to four authoritative articles on topics in physics of interest to teachers of the introductory course, whether at high school or college level. The journal also provides articles on new classroom techniques, laboratory demonstrations, new equipment, and book reviews.

American Journal of Physics, edited by Edwin F. Taylor, is sponsored by the American Association of Physics Teachers and published by the American Institute of Physics, 335 E. 45th Street, New York 10017. Subscription is $25 a year, with a circulation of 14,000. Publication began in 1933. At the present the *Journal* is published monthly. The annual index appears in the December issue. The *Journal* articles range over the entire field of physics and emphasize three types of papers: expository articles, historical or philosophical works, and exemplary instructional methods for the classroom or laboratory. Book reviews appear monthly.

Earth science education

Journal of Geological Education is published by the National Association of Geology Teachers, 2201 M Street, N.W., Washington, D.C. 20037. Subscription is $10 a year or $8 membership fee for individuals only. Publication began in 1951. Presently there are five issues yearly: January, March, May, September, and November.

The *Journal* contains review articles in geology, articles on improvements in teaching, reviews of books and films, classroom projects, and laboratory and field work techniques primarily of interest to earth science teachers at the secondary school level and instructors in geology at the college level.

Sky and Telescope, edited by Charles A. Federer, is sponsored by the Harvard Observatory and published by Sky Publishing Corporation, 49-51 Bay State Road, Cambridge, Massachusetts 02138. Subscription is $8 a year, with circulation of 58,000. Publication began in 1941. Presently there are 12 issues per year in two volumes. The indexes are contained in the June and December issues. The journal interprets the advances in the astronomical sciences and includes reports on amateur astronomers, an observer's page, and monthly evening sky maps.

Postscript

The following two additions to the list of periodicals reflect the concerns voiced to the author after the initial publication of the article. Science teachers may also wish to review *Ulrich's International Periodicals Directory*. [7]

Bioscience, edited by John A. Behnke, is the official publication of the American Institute of Biological Science, 1401 Wilson Blvd., Arlington, Virginia 22209.[1] Individual subscription available only through AIBS membership: with individual $25/year; student $12.50/year; institutional subscription $32/year. Circulation is 17,300. Publication began in 1951 and the monthly journal is indexed annually in the December issue. *Bioscience* interprets advances in the biological sciences through concise news items and educational articles.

Science News, edited by Kendrick Frazier, is published by Science Service, Inc., with subscription department at 231 West Center Street, Marion, Ohio 43302. Annual subscription rate is $10 for the weekly news magazine of science. Circulation is 110,000. Publication began in 1922 as the *Science News Bulletin*, became the *Science News Letter* in 1926, and was abbreviated to *Science News* in 1966. Semi-annual indexes appear in the last issues in June and December. The publisher estimated that this weekly summary of current science is read by over 50,000 teachers and over 70,000 students per week during the school year.

REFERENCES

1. U.S. Department of Health, Education, and Welfare, National Institute of Education. *Current Index to Journals in Education*: CCM Information Corporation, a subsidiary of Crowell-Collier and Macmillan, Inc., 909 Third Avenue, New York.
2. U.S. Department of Health, Education, and Welfare, National Institute of Education. Educational Resources Information Center (ERIC). *Research in Education*. U.S. Government Printing Office, Washington, D.C. 20402.
3. Science, Mathematics, and Environmental Education Information Analysis Center. *SMEAC Newsletter*, 400 Lincoln Tower, The Ohio State University, Columbus, Ohio 43210.
4. R. R. Bowker Company, *Ulrich's International Periodicals Directory, Sixteenth Edition*, New York, 1975–76. Includes entries for approximately 50,000 periodicals published throughout the world.

Periodical Literature for Science Teachers and Their Students

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Reprinted with permission from *The Science Teacher.* Vol. 42, No. 4, April 1975, pp. 31–35 and 47–49.

In the March 1974 issue of *The Science Teacher*, William S. LaShier, Jr., described 21 major journals of interest to science teachers: *The Science Teacher, Journal of Research in Science Teaching, Science and Children, Science Education, School Science and Mathematics, Journal of Educational Research, Review of Educational Research, Journal of College Science Teaching, Scientific American, Science, American Biology Teacher, Journal of Biological Education, Natural History, National Geographic, Journal of Environmental Education, Journal of Chemical Education, Chemistry, Physics Teacher, American Journal of Physics, Journal of Geological Education, Sky and Telescope.* This was a selective, not comprehensive list. These 21 journals are certainly the key periodicals for science teachers.

The purpose of this article is to suggest some valuable but lesser known periodicals, and others omitted from the previous list. Every reader should find at least one publication here that will open countless doors to himself and/or his students.

Readers are advised to select titles that appear (from the annotations) to be of interest and value and request sample copies for review from the editor or publisher. Most journals will gladly honor such requests if there is sincere interest expressed in their publication. It is advantageous for journals to respond favorably to these requests since individual or library subscriptions often follow in due course. Yet there is never any obligation to subscribe. *Be selective* in sending out letters. Do *not* deluge journals with indiscriminate, blanket letters from students.

The periodicals listed and annotated here are grouped under the following 12 arbitrary categories:

I. Periodicals devoted to current books in science and technology
II. Periodicals devoted to the film medium in science and technology
III. Three broad-coverage periodicals
IV. Something unique and special
V. Science and society and a cultural approach to the teaching of science
VI. Science education research
VII. Environmental science/education
VIII. Physical science
IX. Earth and space sciences
X. Biological science
XI. Periodicals of general interest to science teachers
XII. Curriculum/nondescript titles/hidden science education research

In addition, there are two concluding sections:

- Science teacher's periodicals, worldwide
- Omissions and perspective

Information given in the annotations was obtained, in most cases, from several current issues of the journal and was checked with the editors. Thus, so far as possible, the information given is up-to-date.

I. Periodicals devoted to current books in science and technology

AAAS Science Books, edited by Kathryn Wolff, is published by the American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005, Attention: Keith Rath. Subscription rates: $12 per year; additional subscriptions to the same address, $11 each. Single copies are $3.50 each. AAAS members' rate: $11 per year. *Science Books* is published quarterly (in

May, September, December, and March) as one of the activities of the AAAS for the improvement of science education and for the facilitation of the public understanding of science. The magazine contains reviews of new trade books, textbooks, and reference work in the pure and applied sciences which are intended for students in the elementary and secondary schools and in the first two years of college. In addition, new books on scientific topics intended for the general reader are reviewed, as are selected advanced and professional books useful for reference by students and teachers.

Reviews are provided by professionals from the various fields of science. The evaluations are the personal appraisals of the reviews and of the editors and do not represent official recommendations or decisions of the AAAS. Each book is reviewed by a qualified specialist, and the published annotations are prepared by the editorial staff from the comments of the science specialists. *AAAS Science Books* is now in its tenth year of publication. About 900 text and trade books are reviewed each year. The books are described in a 100- to 200-word annotation, and they are rated for scope, clarity, accuracy, quality of illustrations, reading level, and so on. Each issue also contains a brief article on some science area of current importance and a reading list for that topic.

Science Books is included in *Book Review Digest*. Complete volumes are on microfilm, available from University Microfilms, Ann Arbor, MI 48106.

Appraisal, edited by Frances Doughty, Box 25, Center Sandwich, New Hampshire 03227, is published three times a year by the Children's Science Book Review Committee, a non-profit organization sponsored by the Harvard Graduate School of Education and the New England Round Table of Children's Librarians. Subscriptions should be sent to Shirley Roe, *Appraisal*, Longfellow Hall, Harvard University, 13 Appian Way, Cambridge, Massachusetts 02138. Rates: Domestic—\$4.00/year; \$7.50/2 years; \$1.50/copy. Foreign—\$4.75/year; \$8.50/2 years; \$2.00/copy. (Foreign by International Money Order only.) Each book is reviewed by a children's librarian *and* a science specialist. Both rate each book as excellent, very good, good, fair, or unsatisfactory, in addition to their annotations. The Children's Science Book Review Committee believes that "science books deserve the same careful attention as literary works for children and that they should be entirely worthy of a child's attention." The Spring 1974 issue contained 68 reviews of science books for children.

II. Periodicals devoted to the film medium

Science Film, edited by Suzanne Duval, is published by the International Science Film Association (ISFA) at 38 avenue des Ternes 75017, Paris, France. This is a quarterly journal and the official publication of ISFA, whose members come from 28 countries including the United States. Subscription to the journal (which does *not* include membership in ISFA) is 30 francs or $10 which includes postal delivery via airmail from Paris to the United States. The current issue (when this article was written) was Volume 1974, Number 6, and contained 72 pages (36 in French and 36 in English). Contributors and contributions are worldwide. This visual medium, the science film, cuts across language and political barriers, involves an international enterprise, namely science, and by virtue of these attributes is one of the few common meeting grounds between East and West.

ASFA Notes, edited by Malcolm S. Ferguson, is published by the American Science Film Association at the University City Science Center, c/o Dr. Randall M. Whaley, 3508 Market Street, Philadelphia, Pennsylvania 19104. This is a quarterly newsletter designed to inform ASFA members on matters related to the several motion media and their contributions to science and technology. Membership in the Association, which includes *ASFA Notes*, is $15 for individuals and $35 for libraries.

Through *Science Film* and *ASFA Notes* one can learn of current, stimulating, informative, and avant-garde films on topics in science and technology. Many of these films, produced around the world, are works of art and winners of numerous awards. They should find their way into schools and colleges at all levels of education.

III. Three broad-coverage periodicals

Science Education News, edited by Orin McCarley, is published by the Commission on Science Education, American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005. Partial support for publication of *Science Education News* is provided by the National Science Foundation. It is published in January, March, May, August, October, and November. Starting this year two issues of the six will be on a single theme. Every issue contains useful information of interest to science teachers and others in the science education field. This includes notes on workshops, conferences, new publications, curriculum projects around the country and around the world, abstracts from certain journals the science teacher is not likely to see (e.g., *The Chronicle for Higher Education*, *Instructional Technology*, others), information on films and other media, and other topics. Subscription to *Science Education News* is free upon request.

Science News, edited by Kendrick Frazier, is a Science Service Publication, and originates at Science Service, 1719 N Street, N.W., Washington, D.C. 20036. Science Service, an Institution for the Popularization of Science, was founded in 1921. *Science News* (incorporating Science News Letter), is published every Saturday throughout the year. *Science News* reports the week's developments in *every field of science*, describes new books and films (16mm and 8mm) and contains a section on new products coupled to a Reader Service Card that can be mailed to bring more information on a designated product. In the third number of each month is a page or two by James Stokley on the sky events of the coming month. A "Celestial Timetable" is included in this feature. E. G. Sherburne, Jr., the publisher, reports that "*Science News* is the only weekly news magazine of science in the United States, and its roughly 100,000 circulation is divided among scientists and engineers (who read it for news out of their own fields of specialty), science teachers, students, and interested laymen." Subscription Department is at 231 West Center Street, Marion, Ohio 43302. Subscription rate for 52 issues: 1 year, $10; 2 years (104 issues), $13; 3 years, $25 (add $2 a year for Canada and Mexico, $3 for all other countries).

Mosaic, edited by Bruce Abell, is published by the National Science Foundation, Office of Government and Public Programs, 1800 G Street, N.W., Washington, D.C. 20550. Subscription is $4.50 per year in the U.S. and Canada and $5.75 foreign. Single copies are $1.25. Send check or money order to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Published four times yearly as a source of information for the scientific and educational communities served by the National Science Foundation. Winter 1974 issue (Volume 5, No. 1) contained articles on: "Tundra: The Cold Ecosystem," "Armchair Tours Through Miniature Cities," "How Do You Move a Lunch Line Faster" (relates to a new NSF-funded elementary school mathematics/science program, USMES), "A Nobel Prizewinner One Year Later," "The Sea Turns Over," "Research Notes," and "Decrease in Doctoral Growth Rate Continues—Proportion of Women Doctorates Increases."

IV. Something unique and special

CSLP Weekly Even Notification Report Cards and *Annual Report* are published by the Smithsonian Institution Center for Short-Lived Phenomena (CSLP), 60 Garden Street, Cambridge, Massachusetts 02138. Subscription to the Center's event notification and information card service is $15 per year for any or all categories of events issued by the Center. Event cards are mailed at the end of each week. The categories covered are Earth Science Events, Biological Science Events, Astrophysical Events, Urgent Anthropological Events. *It Happened Last Year*, the annual report and review of events, published in September 1974, contains information on the short-lived events the Center reported in 1973. This was the fifth *Annual Report* published by the Center. Events include volcanic eruptions, earthquakes, landslides, floods, a cyclone, storms, sea surges, oil and chemical spills, air pollution incidents, animal mortalities, a leaf-cutting ant plague, a Brazilian bee infestation, animal migrations, a red tide, beached whales, forest fires, fireballs, and a lunar meteorite impact. Reports include photographs, information contacts, bibliographies on related scientific reports, and preliminary results of field research. This document and the other *Annual Reports* can be ordered directly from the Center for $5 each, postage-paid. Send check or money order to CSLP, 60 Garden Street, Cambridge, Massachusetts 02138, U.S.A.

In addition to the *Weekly Event Cards* and *Annual Reports* described above, the Center coordinates an International Environmental Alert Network. This is an action-oriented program involving participants in 27 countries and the United States. In the United States there are 800 secondary schools and colleges participating in this network/program.

Cornell Science Leaflet, a quarterly periodical, authored and/or edited by Verne N. Rockcastle (for more than fourteen years) was a continuous project of the Department of Education and the New York State College of Agriculture at Cornell University since 1896. The *Cornell Science Leaflet*, issued at $1 per year in recent years, was originally (and for many years) called the *Cornell Rural School Leaflet*. After a long, distinguished history, publication terminated in 1969. However, subsequent to that date, back issues, from a list of 41, were available from Cornell at prices ranging from 10 cents to 25 cents each. Many titles are still available from *Cornell Science Leaflet*, Mailing Room, Building 7, Research Park, Cornell University, Ithaca, New York 14850. Libraries may have bound copies of the entire series.

Each *Leaflet* is a gem of creative writing and clever ideas packed into 32 pages of bright, clear text with abundant illustrations and photographs (usually by Verne Rockcastle, an accomplished photographer), experiments, activities, and suggestions for further reading. The *Leaflet* can be read and enjoyed by upper elementary school children and above. More important, this is an extremely useful and significant reference for elementary and junior high school teachers and parents. A flyer/order form, listing the 41 titles that are still in print, is available from the above address.

V. Science and society and a cultural approach to the teaching of science

Bulletin of the Atomic Scientists, edited by Samuel H. Day, Jr., is published at 1020-24 East 58th Street, Chicago, Illinois 60637. Issued monthly, September through June; subscription, $10 per year. Its articles, for the most part, are written by scientists (rather than staff writers) and deal with the impact and important linkages between science, technology, and public affairs. Back issues of the *Bulletin* are an important source of information in this field. See also *The New Scientist*, published in England, and *Technology Review*, published at the Massachusetts Institute of Technology. In the case of *The New Scientist*, the articles, for the most part, tend to be written by staff writers rather than scientists. However, all three of these journals are prime sources of material relevant to the crucial issues involving science, technology, and society.

Federation of American Scientists Public Interest Report and its *Professional Bulletin* are both published at 307 Massachusetts Avenue, N.E., Washington, D.C. 20002. The subscription rate for the publications is $30 per calendar year, but members receive them free and pay $15.

Interchange, edited by Judith Seltzer, is published by the Population Reference Bureau, Inc., 1755 Massachusetts Avenue, N.W., Washington, D.C. 20036. A bimonthly newsletter. A population education newsletter for secondary school level teachers and curriculum supervisors. Designed to (1) promote understanding of current population trends and issues; (2) provide information on training opportunities and teaching materials; and (3) outline instructional activities useful in the classroom for illustrating population subjects.

Isis, edited by Robert Multhauf, is published at the Smithsonian

Institution, Washington, D.C. 20560. This quarterly is the official journal of the History of Science Society. Subscription to individual members is $18; $9 for students; $21 to libraries and other institutions. Publication is in March, June, September, and December, plus a Critical Bibliography issue. This is a scholarly journal containing articles on both past and contemporary history of science. George Sarton, I. Bernard Cohen, Everett Mendelsohn, Gerald Holton, and many other distinguished scholars in the field have at one time or another been associated with *Isis*.

Smithsonian, edited by Edward K. Thompson, is published at 900 Jefferson Drive, Washington, D.C. 20560. A monthly publication for National Associate Members of The Smithsonian Institution. Membership, including subscription to *Smithsonian*, is $10. This is considered a special interest magazine and contains articles on a variety of topics including natural and hard science and technology, the arts (fine and folk) and history.

See also the periodicals listed under ENVIRONMENTAL SCIENCE/EDUCATION.

The OECD Observer is published bimonthly, in English and French by the Organisation for Economic Co-operation and Development. Editor is Anker Randsholt. Annual subscription is $4.50, and the English edition may be ordered from the OECD Publications Center, Suite 1207, 1750 Pennsylvania Avenue, N.W., Washington, D.C. 20006. The Organisation includes countries of Europe, Asia (Japan), North America, and Australia and New Zealand. In addition to news of the OECD itself, the *Observer* carries articles of general interest on current problems such as energy and the environment, agriculture, urban planning, and educational developments in the member countries. Particularly valuable for the broad view of current issues.

VI. Science education research

Studies in Science Education, edited by David Layton, is published by the Centre for Studies in Science Education, The University of Leeds, Leeds LS2 9JT England. This is a new journal with Volume One being published in January 1974. Annual subscription in the United Kingdom and elsewhere overseas is £2. In the U.S.A., $6.50. Postage is included in each case. Remittances from overseas should be in sterling. Cheques, etc., should be made payable to "University of Leeds" and crossed. Contains some significant reports by scholars of international reputation. Is a valuable research tool for the science educator in that it gives some useful leads as to research completed and in progress outside of the United States, especially in England, Scotland, Australia, and West Germany. This information is not easy to come by through most sources readily available in the United States. "As an instrument of research and criticism, it is not the intention of *Studies in Science Education* to compete with existing journals, but to complement them by providing reviews of research on specific aspects of science education and by drawing together, in analytical surveys, recent contributions which may be published in widely scattered sources. It will publish work which reflects a wide variety of standpoints, including those of administration, curriculum, history, linguistics, philosophy, politics, psychology and sociology." Most of the articles will be invited but the editor will welcome approaches from prospective authors who feel that their research experience qualifies them to write a comprehensive review of studies in a particular field.

Science Education: Research (Title to be changed to "Research in Science Education," followed by a volume number—1974 edition is volume 4) is published annually by the Australian Science Education Research Association. Inquiries should be addressed to: Series Editor, Research in Science Education, Professor R. P. Tisher, Faculty of Education, Monash University, Clayton, Victoria, Australia, 3168.

Science Education: Research 1971—*SE: Research* 1974 cover proceedings of the annual conference of the Australian Science Education Research Association. These volumes contain reports covering a wide range of issues in science education and a special section dealing with research techniques (the latter section, starting with the 1973 volume). The volumes are the Australian counterpart of *Abstracts of Presented Papers*, National Association for Research in Science Teaching (USA) —1974 and previous volumes published by ERIC at Ohio State. However, there are several differences between the Australian volume and ERIC/NARST publication. The former contains a relatively small number of full-length papers and reports, whereas the latter consists of a rather large number of brief abstracts.

VII. Environmental science education

Audubon, edited by Les Line, is published by the National Audubon Society at 950 Third Avenue, New York City, New York 10022.

This is a bimonthly publication with a circulation of 248,762 as of March 1974. Membership is $15 or $7 for students. A subscription without membership privileges is $13. *Audubon* is a vividly illustrated and informative magazine and a leading voice in the fields of nature, wildlife, conservation, and environmental protection. Every issue contains superb color photographs and paintings and timely articles by some of the nation's most renowned nature and environmental writers. Some issues center on certain themes. For example: July 1973, the Southwest desert; September 1973, the Galapagos; March 1973, the Antarctic; July 1974, Alaska, including information on new parklands. Every issue contains a special news section on conservation issues.

The Conservationist, edited by Robert F. Hall, is published by the Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12201. A bimonthly publication with a paid circulation of 185,000. Subscription is $2 per year or $5 for three years. Schools in New York State may subscribe for $1 per year. Subscription correspondence should be sent to P.O. Box 2325, Grand Central Station, New York, New York 10017. Contains much useful information of interest to teachers. For example: "Some Tips on Studying Water as a Resource," by John A. Weeks, 25:48-49, February/March 1971. A Teacher's Guide is available, upon request, in conjunction with each issue. Two regular features are "Youth and the Environment" and a section of short reports on various environmental issues. Similar in many respects to, and of the same high caliber as, *South Carolina Wildlife*.

Environmental Science and Technology is published by the American Chemical Society, 1155 Sixteenth Street, N.W., Washington, D.C. 20036. One year subscription for ACS members is $6; nonmembers, $9. Three-year subscription for ACS members is $15; nonmembers, $22. The journal includes, each month, current government pollution legislation and guidelines, information on efficient engineering techniques, articles on fundamental research developments, news of productive equipment coming on the market, case histories of how problems are being overcome, and other items of interest in this field. It features current information on the economics, laws, and feasibility of new techniques being developed to avoid contamination of air, water, and land.

National Wildlife, edited by John Strohm, is published by the National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036. Published bimonthly by the Federation, a non-profit corporation, this is a membership publication (like *National Geographic*, *Audubon*, and many others) available only to Associate Members and not sold on a subscription basis. Associate membership annual dues $6.50. Editorial offices: 749 North Second Street, Milwaukee, Wisconsin 53203. This is one of many conservation-oriented magazines and is indexed in the *Readers' Guide to Periodical Literature.* It contains high quality color and black-and-white photographs, informative articles on a variety of topics, and other features. Occasionally there will be a theme issue, such as the one on endangered species published in April/May 1974. A companion periodical, published by the Federation, is *International Wildlife.* This is a bimonthly published in alternate months during which *National Wildlife* is not published. Subscription is $6.50 per year. World membership includes both periodicals and is $11 per year. *Ranger Rick's Magazine* is edited and published for the entire elementary school age level. This magazine for young people is devoted to understanding our birds, air, soil, water, woods, wildlife, and other animals. Exciting, informative color photographs, text material, and fun features are included in each of the ten issues per year. Subscription is $6 per year.

National Parks and Conservation Magazine: The Environmental Journal, edited by Eugenia Horstman Connally, is published by the National Parks and Conservation Association, 1701 Eighteenth Street, N.W., Washington, D.C. 20009. Annual membership dues, including subscription to the magazine, are $12 for Associate. Student memberships are $8. Single copies are $1.50. The magazine is published monthly. The National Parks and Conservation Association, established in 1919 by Stephen Mather, the first Director of the National Park Service, is an independent, private, nonprofit, public service organization, educational and scientific in character. Its responsibilities relate primarily to protecting the national parks and monuments of America, in which it endeavors to cooperate with the National Park Service while functioning as a constructive critic, and to protecting and restoring the whole environment. Among the articles contained in the July 1974 issue were "This Crowded Planet," "Haven for Rare Butterflies" (Biscayne National Monument), "New Hope for Bay Area Wildlife"; also several regular features: NPCA at Work, News Notes, and the Conservation Docket in Congress.

Animal Kingdom, edited by Eugene J. Walter, Jr., is the magazine of the New York Zoological Society and published by the Society at The Zoological Park, Bronx, New York 10460. Published bimonthly.

Subscriptions: $6 a year; single copy, $1.25; outside the United States, $7 a year. Revealing color and black-and-white close-up photographs in each issue.

The Conservation Foundation Letter is published by and available from the Conservation Foundation, 1717 Massachusetts Avenue, N.W., Washington, D.C. 20036. A monthly report on environmental concerns. The subscription rate is $10 per year in the U.S., $12 elsewhere. Single issues are available from the Foundation. Up to 10 copies are $1 each; 11-50 copies, $.75 each; 50-99 copies, $.60 each; over 100 copies, $.40 each. There is a discount of 25 percent to teachers and libraries.

South Carolina Wildlife, edited by John Culler, is published by the Department of Wildlife and Marine Resources, Box 167, Columbia, South Carolina 29202. Published bimonthly. Subscription is $3 per year. Similar in many respects to, and of the same high caliber as, *The Conservationist* published by the New York State Department of Environmental Conservation. Both publications have a large circulation that extends well beyond their own states.

Environment, edited by Julian McCaull, Sheldon Novick, and Kevin P. Shea, is published by the Scientists' Institute for Public Information, at 438 North Skinker Boulevard, St. Louis, Missouri 63130. Published monthly except January/February and July/August when it is bimonthly. Subscription rates are: 1 year $10, 2 years $18.50, 3 years $27, student $7.50, foreign subscriptions $2 per year additional. Subscription and change-of-address information should be addressed to Circulation Department, *Environment*, Post Office Box 755, Bridgeton, Missouri 63044. Indexed in *Readers' Guide to Periodical Literature*. Entitled *Scientist and Citizen* previous to the January/February 1969 issue. The articles, many of which are written by staff writers, are prepared with both layman and specialist in mind.

The Curious Naturalist, edited by Judith Hubley, is published by the Massachusetts Audubon Society, Lincoln, Massachusetts 01773, nine times a year, from September through May. Subscription is $3.50 per year. Bulk rates for 20 or more are available. Each issue is devoted to a single topic, such as pollution, animal camouflage, sound, biological succession and the like. In addition there are yearly themes that pervade all the issues. In 1973-74 the theme was "Biomes." In 1974-75 the theme is "Energy." Issues will treat the natural history as well as the physical science aspects of energy. *The Curious Naturalist* is basically a children's science magazine, but is also of interest and value to elementary and junior high school teachers (and parents). Each issue contains background information on the topic, suggested experiences, projects, and illustrations; also children's letters and stories in many issues.

National Geographic School Bulletin, edited by Ralph Gray, is published by the National Geographic Society at 17th and M Streets, N.W., Washington, D.C. 20036. Published 30 weeks during the school year, September into May. Subscription rates are $3.25 for one school year (30 issues) in the United States; $4.25 in Canada and elsewhere. U.S. only, 3 years for $8.50. Superb color photographs, authoritative text, appealing layout. Useful to teachers and pupils at various levels, but particularly in the elementary and junior high school. Articles on many aspects of science as well as geographic topics. Both this leaflet-size publication and the senior version, the *National Geographic*, are among the biggest bargains to be found in the entire expanse of periodical literature.

The Living Wilderness is a quarterly magazine published by The Wilderness Society at 1901 Pennsylvania Avenue, N.W., Washington, D.C. 20006. Membership in the Society is $10 and includes subscription to the magazine. (Preferential rate of $5 for students, schools, and libraries.) The Society is an educational, non-profit, national conservation organization formed in 1935. The Society exists to help interested persons and citizen leaders work together effectively to protect our wild lands and their wildlife. The Society receives no governmental support and depends upon contributions and membership dues to carry out its work.

Yearbook of the U.S. Department of Agriculture, an annual publication available from the Superintendent of Documents, Government Printing Office, North Capital Street, N.W., Washington, D.C. 20402. Many of these *Yearbooks*, published for quite a number of years, have become classics in their field. See, for example, the 1949 volume, *Trees*. Others have been devoted to topics such as soil, grass, and insects. Choice reference.

Kansas School Naturalist, edited by Robert J. Boles, is published at the Department of Biology, Kansas State Teachers College, Emporia, Kansas 66801. The publication is issued in October, December, February, and April. Subscription is free (upon request) to Kansas teachers, school board members, administrators, librarians, conservationists, youth leaders, and other adults interested in nature education.

Journal of Outdoor Education, edited by Robert Vogl, is published at Lorado Taft Field Campus, Northern Illinois University, Box

299, Oregon, Illinois 61061. Issued two times a year: Fall and Spring. Subscription is presently free upon request to the editor.

A Golden Guide to Environmental Organizations, compiled by Bruce W. Halstead, is published by Golden Press, New York; Western Publishing Company, Inc., Racine, Wisconsin. 1972. $0.95. 63 pp. Product no. 24500. An extremely comprehensive directory of 354 organizational sources where reliable information can be obtained as to the state of man's environment. Many of the organizations listed publish a journal, magazine, or newsletter. Although this information is not provided in the annotations it could be obtained through correspondence with selected organizations of interest to the reader. The book is organized as follows: International Organizations; International, National, and Interstate; Federal Agencies (listings under each of seven departments); United States Government—Independent Agencies; State Agencies and Citizens Groups; Canada (Federal Agencies and Agencies of Provinces).

Aware, "the socio-environment magazine about electric power," is designed to present material of value that may aid an individual to a better understanding of the social and environmental ramifications of electric power. The articles are brief, clearly written, and extremely timely. *Aware* is published by Community Performance Publications, Inc., Suite 12, 2038 Pennsylvania Avenue, Madison, Wisconsin 53704, $9 per year.

Soil Conservation, published by the Soil Conservation Service of the U.S. Department of Agriculture, is the official SCS magazine. Edited by Diana Morse, it is designed for the general reader and contains many articles and descriptions of projects that could suggest educational projects for teachers and students. Subscriptions are available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, for $5.65 per year.

VIII. Physical science

Physics Today, edited by Harold Davis, is published by the American Institute of Physics at 335 East 45th Street, New York City, New York 10017. A monthly journal. Included in AIP membership. Subscription for non-members is $12 per year in the USA, Canada, and Mexico. Includes articles by scientists (rather than staff writers) for the most part, a technical news feature, and a nontechnical news feature (including manpower concerns), book reviews, people news, and a calendar of events of interest to those in the field. Approximately half the readership is in colleges and universities.

Chemical and Engineering News, edited by Albert F. Plant, is published by the American Chemical Society at 20th and Northampton Streets, Easton, Pennsylvania. The ACS is located at 1155 16th Street, N.W., Washington, D.C. 20036. Published weekly since 1923 and included in membership in the ACS, *Chemical and Engineering News* is available to non-members at $9 per year. The quarterly subject/name-index contains a section on education as well as one on research. Articles, bibliographies, book reviews, and charts are found in each issue. The publication is both the official organ of the ACS and a newsmagazine devoted to current happenings in the chemical world. Its natural emphasis on industrial events may be useful to some secondary school teachers for certain purposes (e.g., in career guidance). However, because of its nature, it would be of lesser value to the high school teacher than either the *Journal of Chemical Education* or *Chemistry*. *Chemical and Engineering News* is indexed in *Biological Abstracts* and *Chemical Abstracts*.

Metric Association Newsletter, edited by Louis F. Sokol, is published by U.S. Metric Association, Sugarloaf Star Route, Boulder, Colorado 80302. Published quarterly. Membership in the Association, which includes the *Newsletter*, is $3 a year for individuals and $25 for corporations. Contains information on metrication developments and sources of other metric information.

American Metric Journal, edited by Robert A. Hopkins, is published by AMJ Publishing Company, Drawer L, Tarzana, California 91356. Published bimonthly. Single subscriptions are $35. Special group rates are available for multiple subscriptions to one address. The general thrust of the journal is to bring out and make available little-known facts pertinent to the metric system and the International System (SI) of weights and measures. Articles are solicited from experts in the field. Revealing and instructive charts and graphs are included in each issue. Comprehensive in scope. Of interest to science and mathematics educators as well as those in industry.

Dimensions is the Technical News Bulletin of the National Bureau of Standards, available through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription, $6.50. It reviews and highlights issues like energy, fire, building technology, metric conversion, pollution, and consumer-product performance.

IX. Earth and space sciences

Weatherwise, edited by David Ludlun, is published by the American Meteorological Society at 45 Beacon Street, Boston, Massachusetts 02108. Issued bimonthly since 1948. Subscription is $8 per year. Back issues are a valuable source of information on demonstration ideas for teaching aspects of weather study (e.g., construction and use of a nephoscope, working model of a tornado, apparatus to demonstrate mist, fog, cloud, and rain formation, etc.).

Geotimes, edited by Wendell Cochran, is published by the American Geological Institute at 5205 Leesburg Pike, Falls Church, Virginia 22041. Subscription is $6 per year for members of AGI societies, $9 per year for non-members, plus $2 postage outside North America. Its 12 issues per year carry newsworthy articles on the earth sciences, book reviews, information on new films, maps, and the like. A useful and interesting publication for the earth science teacher.

Mercury, edited by Richard Reis, is published by the Astronomical Society of the Pacific, at 75 Southgate Avenue, Daly City, California 94015. Issued bimonthly. Subscription is $10 per year, which includes membership in the Society. A regular feature of this publication is "Universe in the Classroom." Another feature useful to teachers is a "High School Supplement," which relates astronomy to other disciplines. *Mercury* replaces an eight-page pocket size *Leaflet* published by the Society monthly until December of 1971. The *Leaflet*, designed primarily for nontechnical readers, included one issue which gave a wide range of astronomical data for an entire year. Some back issues of the *Leaflet* are still available from the Society. The Astronomical Society of the Pacific was *formerly* located at the California Academy of Sciences in Golden Gate Park, San Francisco.

The Griffith Observer, edited by William Kaufmann, is published by the Griffith Observatory at Post Office Box 27787, Los Angeles, California 90027. Subscription is $3 per year for 12 issues. In addition to a sky calendar and sky map, each issue contains short articles of general interest and a major article on some significant topic in astronomy.

The Review of Popular Astronomy was published bimonthly by Sky Map Publications, Inc., at 141 South Meramec, St. Louis, Missouri 63105. *The Review*, published from 1951 until 1970, contained regular features in each issue such as "The Naked-Eye Sky Watcher." In some respects this periodical was more useful to the amateur astronomer (e.g., in planning "Star Parties" or "Evenings of Sky

Watching" for classes) than *Sky and Telescope*, so it is unfortunate that publication terminated in 1970. However, it is included here since back issues are available in libraries and these should be of interest to both students and teachers.

Aerospace Bibliography, Sixth Edition, compiled for the National Aeronautics and Space Administration by the National Aerospace Education Council. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Stock Number 3300-00460. Price, $1.40. Part III of this Bibliography contains an annotated listing of 19 periodicals relevant to aerospace science technology and education. Included here are *Aerospace Technology*, *Astronautics and Aeronautics*, *Aviation Week and Space Technology*, *Model Rocket News*, *Skylight*, *Space/Aeronautics*, *Space World*, *The Student Rocketeer*, and others. The reader is advised to obtain the latest edition of this Bibliography since the status of these periodicals changes rapidly. Some terminate publication. Others come into existence.

Popular Astronomy is published by Philip Seldon at 245 East 25th Street, New York, New York 10010. A monthly magazine to begin publication in April 1975 (Volume I, Number 1) at $12 per year.

Space World is published by Palmer Publications, Amherst, Wisconsin 54406. Annual subscription, $12. Carries articles and news of the exploration of space.

Oceanus, a quarterly publication from the Woods Hole Oceanographic Institution, carries well-written highly readable articles on oceanography and related meteorology. Subscriptions are available at $8 per year from Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.

Sea Frontiers and *Sea Secrets*, edited by F. G. Walton Smith, are published bimonthly on alternate months by the International Oceanographic Foundation, 10 Rickenbacker Causeway, Virginia Key, Miami, Florida. Annual membership subscription is $10.

Underwater Naturalist is a quarterly journal published by the American Littoral Society, D. W. Bennett, Executive Director, at Highlands, New Jersey 07732. Membership in the Society is $10 per year and includes the above quarterly, newsletters, conservation alerts, and two occasional publications, an educational bulletin and Marine Resources book. These items contain useful information for teachers and students, K–12, related to life in coastal waters, marshes, and estuaries.

Skylook, the UFO Monthly, edited by Dwight Connelly, is published at 26 Edgewood Drive, Quincy, Illinois 62301. Subscription rates: United States and Canada, $5 per year; 50 cents per copy. In 1969 *Skylook* was designated as the official publication of MUFON (the Mutual UFO Network), and works closely with this international organization, although the two are financially separate. Since 1967 *Skylook* has been reporting the current UFO sightings and research. (See also the *News Bulletin* of the Center for UFO Studies, listed under "Project Newsletters.")

Flying Saucer Review, edited by Charles Bowen, is published by FSR Publications Ltd., c/o Compendium Books, 281 Camden High Street, London NW1, England. This is an international journal (of high caliber despite the colloquial title) devoted to the study of Unidentified Flying Objects or UFOs and presently in its 20th year of publication. Annual subscription USA and Canada $7.50. Contains technical *and* nontechnical reports, statistical studies, letters, news of current books and other publications.

X. *Biological science*

BioScience, edited by John A. Behnke, is published by the American Institute of Biological Sciences, Inc. (AIBS), 1401 Wilson Boulevard, Arlington, Virginia 22209. Issued monthly and included in membership to AIBS, which is $16 per year; $8 for students. For more information on this journal see a letter from the editor published on pp. 4–5 of *The Science Teacher*, May 1974.

AIBS Education Review, a quarterly, is edited by Richard A. Dodge, and also published by the American Institute of Biological Sciences. *Included* (along with *BioScience*) in AIBS membership which is $16 per year; $8 for students. It contains very helpful reports and articles on educational developments, programs, and methods.

American Psychologist is the official publication of the American Psychological Association and includes general articles as well as news of the Association. Published by the APA at 1200 17th St., N.W., Washington, D.C. 20036. Subscription, $12 per calendar year.

Agricultural Research, published by the Agricultural Research Service of the U.S. Department of Agriculture, is a newsy, well-illustrated publication with short articles on current research in agriculture. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $3.60 per year.

American Journal of School Health, edited by Herman S. Bush, is the official journal of the American School Health Association, Kent, Ohio 44240. Published monthly at $15 per year. A frequent feature of the Journal is "New Aids for Instruction."

Journal of Nutrition Education is designed for "those persons who are interpreters of nutritional sciences and motivators for the development of good nutritional practices." Published at 2140 Shattuck Avenue, Suite 1110, Berkeley, California 94704. Subscription rate, $8 per year.

XI. Periodicals of general interest to science teachers

Science Activities, edited by Theodore L. Stoddard and Jane Powers Weldon, is presently under new ownership and published bimonthly by Heldref Publications, 4000 Albemarle Street, N.W., Washington, D.C. 20016. Annual subscription rates are $12 for institutions and $9 for individuals. Single copy price is $1.50. Add $2 for subscriptions outside the U.S. and Canada. Copyright © 1974, Helen Dwight Reid Educational Foundation. All issues of *Science Activities* are available on microfilm or in Xerox copies from University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106. The present editorial policy is to consider for publication original articles about science activities for elementary, junior high, and high school students and teachers. Until December 1973, *Science Activities* was edited by Charles A. Martin and published monthly except July and August at 8150 Central Park Avenue, Skokie, Illinois 60076 by Science Activities Publishing Company. "Nuts-and-bolts" articles, book reviews. Useful periodical.

The Australian Science Teachers Journal, edited by Ian D. Thomas, is published by the Australian Science Teachers Association (ASTA), the counterpart of NSTA, c/o Mr. N. M. Niemann, 66 Illawarra Road, Hawthorn, Victoria, Australia 3122. It is distributed to members of affiliated associations as part of their membership entitlement. As of 1974, price of single copies is $3 (Australian) plus postage (20 cents). Annual subscription for libraries and nonmembers, 1975: $8.25 (Australian) per volume, three issues, including postage. *Cumulative Index* covering the first 50 issues: $2 (Australian) per copy plus postage (20 cents). Contents indexed in *Australian Education Index* (ACER) and *Current Index to Journals in Education* (ERIC, Ohio, U.S.A.). As the official journal of the Australian Science Teachers

Association, it aims to communicate theory and practice in a professional manner as a basis for improving science education. It is intended to assist with the daily needs of the classroom practitioner, to provide evidence and a rationale for improving science education, and to serve as a chronicle of the advancement of science education in Australia. The current editorial policy is to publish, in most issues, a number of articles related to a specific theme. Emphasis is upon the Australian context. Proposals for future themes will be welcomed by the editor. However, the use of these themes in no way precludes the publication of other worthy contributions. In addition to an assortment of articles on a wide range of topics, each issue contains a Research Section; a section entitled "Around the States," Techniques for Teachers, and book reviews. The *Journal* is published in the months of May, August, and November.

The Crucible, edited by Don Galbraith, is published by The Science Teachers' Association of Ontario, as its official journal, STAO Membership Office, Suite S904, 252 Bloor Street West, Toronto, Ontario, Canada M5S 1V7. The Science Teachers' Association of Ontario was organized in 1890 and is the Science Section of the Ontario Education Association. The membership fee of $10 includes a subscription to *The Crucible*. Library subscriptions are $8 and single copies $1.50. Subscribers and contributors to *The Crucible* extend beyond the boundaries of Ontario. They include people in other provinces and the United States. Carries an interesting, diverse assortment of articles and features in each of its six issues per year.

Pennsylvania Clearinghouse on Methodology in Elementary Science, edited by Donald A. Vannan, is published at Bloomsburg State College, Bloomsburg, Pennsylvania 17815. Published annually. Copies are available for $1 each, payable in advance to the Bloomsburg State College Trust Fund #477T and sent to the Editor. Contains articles of interest to those in preservice or inservice elementary school science teacher preparation. Contributors and subscribers extend beyond the borders of Pennsylvania and come from many states around the United States.

The School Science Review, edited by A. A. Bishop, and *Education In Science*, edited by B. G. Atwood, are the journals of the Association for Science Education, College Lane, Hatfield, Hertfordshire, England AL 10 9AA.

Science Dimension is published by the Public Information Branch, National Research Council of Canada, Ottawa, Ontario, Canada K1A OR6.

Lab World, News Magazine of the Bioclinical Laboratory Field, is published by Sidale Publishing Company, 2525 West 8th, Los Angeles, California 90057. Annual subscription, $12.

Out-of-School Scientific and Technical Education is a journal published with the assistance of UNESCO by the International Coordinating Committee for the presentation of science and the development of out-of-school scientific activities (ICC). The journal reports news of out-of-school science activities for young people from many countries. Published four times a year; price, $5; available from ICC, 125, rue de Veeweyde, 1070 Brussels, Belgium.

Current Science is published by Xerox Education Publications, 245 Long Hill Road, Middletown, Connecticut 06457. Issued 28 weeks during the school year. Classroom subscription price for 10 or more copies to one address: 80 cents per semester or $1.35 per school year per student. This publication on newsprint is designed for student reading and use.

XII. Curriculum/nondescript titles/hidden science education research

The journals in this group are examples of periodicals which are not readily identified by their titles as having a concern for topics in science and science education. Yet, these and many other journals make up a diffuse literature in which there are widely scattered results of research in science education. There may be one or two articles per issue (or none at all) which are of interest to the science education researcher. However, one does find some valuable material in these journals.

Curriculum Theory Network, a journal edited by Joel Weiss, is published by the Department of Curriculum, The Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto, Ontario, Canada M5S 1V6. Subscriptions (four issues): individuals $8; libraries and other institutions $10; $2.40 per single issue. Back issues may be obtained from Publications Sales at the address given above.

Education, the journal of the School Publications Branch, Department of Education, Wellington, New Zealand.

Journal of Curriculum Studies, edited by P. H. Taylor, is published by William Collins, Kirkintilloch Rd., Bishopbriggs, Glasgow, G64 2PW, Scotland.

Directory of Science Teachers' Associations Worldwide, published for International Council of Associations for Science Education (ICASE), is available through correspondence with Bryon G. Atwood, the Association for Science Education, College Lane, Hatfield, Hertfordshire, England AL 10 9AA. Information from 32 countries is compiled. For each association included, the compilers have attempted to list: (a) Name and address of secretary or official correspondent and name of the association, (b) Membership, (c) Services to members, (d) Associated organizations. Contains much information on periodical literature sponsored by science teachers organizations around the world. J. David Lockard is President of the International Council of Associations for Science Education (ICASE). He is Director, International Clearinghouse, Science Teaching Center, University of Maryland, College Park, Maryland 20742. The Council (ICASE) is planning to publish a quarterly newsletter, the first of which came out in 1974.

NASA Report to Educators is published four times per year for the community of educators, especially at the elementary and secondary levels. Free upon request. Contributions and recommendations are solicited from readers, and should be addressed to the Educational Programs Division, Office of Public Affairs, Code FE, National Aeronautics and Space Administration, Washington, DC 20546. Contains news on all sorts of space-related topics and ideas for using the stories/reports in the classroom (e.g., problems to research).

Omissions and Perspective

The foregoing bibliography/directory—along with the 21 major journals described by William S. La Shier in *The Science Teacher* in March 1974—may be considered comprehensive but not exhaustive. It is far from complete. No such effort could ever include all periodicals at every level of sophistication in every field.

Some of the many omissions are *American Forest*, *Science World*, *Environment Action Bulletin*, *The New Scientist* (England), *Technology Review*, *Ward's Biology Newsletter*, *Consumer Reports*, *Nature* (England), *Science Counselor*, *Carolina Tips*, *The Mathematics Teacher*, *The Arithmetic Teacher*, *Turtox News*, *Focus*, *Audiovisual Instruction*, *The American Scientist*, *Psychology Today*, *Endeavor* (England), *Welch Physics and Chemistry Digest*, *Welch General Science and Biology Digest*, the *Colorado Science Teachers Association Newsletter*, newsletters and bulletins published by other state affiliates of NSTA, the *New Jersey Association for Environmental Education Newsletter*. A few of these periodicals are no longer published, but bound volumes of back issues are in libraries. Others are still being issued and expanding their coverage.

Nor does it include journals and magazines devoted to tropical fish, electronics, photography, microscopy, cinematography, the philosophy of science, oceanography, medicine, microbiology, the sociology of science, psychokinesis—topics of interest to many science teachers and their students. It was beyond the scope of the present effort to include these periodicals.

No attempt was made to even touch upon the vast literature of highly technical, specialized or esoteric journals.

Nevertheless, it is probably instructive and interesting for teachers and their more able students to become aware of the existence of such journals worldwide. This is significant since science is an international enterprise and open communication between scientists, via professional journals such as those listed above, is one of the cornerstones of scientific inquiry. So, too, is the professional journal part of the lifeblood of science education.

Curriculum project newsletters

During the decade-and-a-quarter beginning in 1957 there was an unprecedented period of curriculum development in the United States. [1] Fontaine reported that through 1969 there were more than 400 projects at the precollege and undergraduate level, supported by two different divisions of the National Science Foundation, at a cost of 142 million dollars. [2]

It was no easy task, during that period, for the science teacher to keep up-to-date on who was doing what. However, the newsletter was one of the periodicals which kept teachers, administrators, and others informed of curricular developments by the funded projects.

Today there is considerably less activity insofar as federally funded projects are concerned. The thrust in this decade is, or should be, on implementing the most promising developments of the 1960s. Nevertheless, despite the precipitous drop in federal funding, there are still a few very interesting projects underway and newsletters published by these projects.

It is the purpose of this section to provide an annotated list of some of the curriculum project newsletters currently being published around the world.

Human Behavior Curriculum Project Newsletter is published by the American Psychological Association (APA) as a companion to *Periodically*. It is available by writing to Margo Johnson, Educational Affairs Office, APA, 1200 Seventeenth Street, N.W., Washington, D.C. 20036. The American Psychological Association has received a $152,000 grant from the National Science Foundation for a Human Behavior Curriculum Project. The project is developing 30 self-contained teaching units, modules on human behavior for use in high schools. The grant is to support the first year of a five-year project. The project is located at Carleton College in Northfield, Minnesota, and is under the direction of John K. Bare, professor of psychology. Teams of behavioral scientists, teachers, and students will develop the modules, the study of each lasting two to three weeks. The modules could be used in classes of psychology, biology, anthropology, sociology, social problems, and sex and drug education. The project is designed to illuminate a variety of topics in human behavior for the average high school student and to be suitable for students with varying levels of ability and teachers with varying degrees of experience in teaching the behavioral sciences. Inquiries should be addressed to Dr. John K. Bare, Carleton College, Northfield, Minnesota 55057.

OBIS Newsletter, edited by Kay Fairwell, is published by the Outdoor Biology Instructional Strategies Project, Lawrence Hall of Science, University of California, Berkeley, California 94720. Reports on a new project supported by a grant from the National Science Foundation. Subscription to the *Newsletter* is free upon request. This project is producing some really new and exciting outdoor biology experiences primarily for community groups serving 11- to 15-year olds.

Portland Project Newsletter is published by Portland State University, Duplicating Service Center, P.O. Box 751, Portland, Oregon 97207. The *Newsletter* reports recent developments in a three-year integrated science sequence produced by the Portland Project, based on the unified science concept. Subscription to the *Newsletter* is free upon request.

Prism II is published by the Center for Unified Science Education, Box 3138, University Station, Columbus, Ohio 43210. The quarterly publication is free on request as the program is supported by a grant from the National Science Foundation. It contains articles about unified science curriculum developments and unified science philosophy, descriptions of specific programs, announcements of Center activities, and listings of Center resources available to teachers by mail or direct contact. A recent issue was devoted to 16 guidelines for developing an ideal unified science unit. These are intended to be used by teacher teams in all grade levels, kindergarten through 14. For further information, write to the Center.

STEP Information Bulletins, published by the Science Teacher Education Project, School of Education, University of Leicester, University Road, Leicester LE1 7RF England. A Nuffield Foundation sponsored project.

Intermediate Science Curriculum Study Newsletter, published by ISCS, c/o George Dawson, Director, Room 705, 415 North Monroe Street, Tallahassee, Florida 32301. ISCS is an instructional research project supported by the National Science Foundation and the Florida State University. Subscription to the *Newsletter*, a biannual publication of the ISCS, is free upon request.

BSCS Newsletter, edited by George M. Clark, is published four times during the school year by the Biological Sciences Curriculum Study, P.O. Box 930, Boulder, Colorado 80302. Subscription to the *Newsletter* is free upon request. Carries some articles of general interest in addition to those directly related to information about materials produced by the Biological Sciences Curriculum Study. A partial listing of articles in Number 56 (September 1974): "Minicourses in Introductory College Biology," "The BSCS Program for the Educable Mentally Handicapped," "Biology in Three Dimensions," "Elementary School Sciences Programs," "Environmental Module."

SCIS Newsletter is published by the Science Curriculum Improvement Study, Lawrence Hall of Science, University of California, Berkeley, California 94720. Subscription to the *Newsletter* is free upon request. The *SCIS Newsletter*, formerly published several times a year, will now be published twice a year. Contains up-to-date information on a major curriculum project in elementary school science that is being widely implemented around the country. Current issue contains news on several recent developments: the kindergarten level SCIS Teacher's Guide, evaluation supplements for all 12 units, and a useful *Teacher's Handbook*.

EDC News is published by Education Development Center, Inc., 55 Chapel Street, Newton, Massachusetts 02160. Education Development Center is a publicly supported nonprofit corporation engaged in educational research and development. This publication replaces the *Elementary Science Study* (ESS) *Newsletter* which terminated with issue Number 24 in April 1972. At that time EDC was reorganized so that all its projects fall into several areas: Science and Math, Social Studies, Media, International and Open Education and Special Projects (such as two recently begun in Career Education). All of these projects are now reported in one newsletter, *EDC News*. Subscription is free upon request to the EDC Publications Office. One of the many projects reported in recent issues of the newsletter is the Unified Science and Mathematics for Elementary Schools (USMES) project formed in response to the recommendations of the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools. This is an NSF-funded project. Should be of interest to teachers at all levels.

Minnemast News, published by the Minnemath Center, University of Minnesota, 720 Washington Avenue, S.E., Minneapolis, Minnesota 55455. Current news on an NSF-funded primary grade science and mathematics program. Subscription to the tri-annual newsletter is free upon request. It will be published in the Fall, Winter, and Spring. Some very interesting materials are available from this source.

"Progress in Learning Science" Information Papers, published by the project at the School of Education, University of Reading, London Road, Reading RG1 5AQ England. Information Paper Number 3, published in June 1974, reports on the work of this new project begun in April of 1973 and directed by Wynne Harlen. The Director was formerly associated with the Science 5/13 Project (as its evaluator) based at the University of Bristol. Of interest to educators concerned with elementary and junior high school science. "The general aim of the project is to produce material for teachers to use in assessing children's development of scientific ideas and in applying this information to decide the kinds of science activities appropriate for their children. The materials will be for teachers of children aged between five and thirteen. The project is attempting to provide help with both facets of the process of matching children's activities to their abilities to learn from them."

Center for UFO Studies News Bulletin, edited by Margo Metegrano, is published by The Center at P.O. Box 11, Northfield, Illinois 60093. The Bulletin is not intended to be a technical report. It is solely to keep contributors and investigators current on the scope of Center activities. The director of the Center for UFO Studies is Dr. J. Allen Hynek, Chairman, Department of Astronomy, Northwestern University. Subscription to the *News Bulletin* is by a contribution of $10 (overseas minimum $15), which supports the work of the Center. Donors receive *News Bulletins* and summaries of technical reports during a 12-month period.

USMES News is published by Education Development Center, 55 Chapel Street, Newton, Massachusetts 02160. This newsletter, available free upon request, reports on developments in an NSF-supported program for elementary school children, integrating natural science, social science, mathematics, and language arts. Unified Science and Mathematics for Elementary Schools (USMES) currently has 30 experimental schools and 61 resource teams in 20 states and the District of Columbia.

essentia sheet is published at the Evergreen State College and reports on projects funded by the National Science Foundation (such as the Environmental Studies Project). Subscription to the newsletter is free upon request. Write to Dr. Robert C. Samples, Room 2116 Essentia, the Evergreen State College, Olympia, Washington 98505.

The Grantsmanship Center News, edited by Thomas T. Whitney, is published by the Grantsmanship Center, P.O. Box 44759, 7815 So. Vermont Ave., Los Angeles, California 90044; Norton Kiritz, Executive Director. This publication is issued eight times per year. Annual subscription rate is $10 for one year. Request a sample copy of Issue No. 6, June-July 1974. See also *Foundation News* published by the Council on Foundations, 888 Seventh Avenue, New York, New York 10019.

Newsletter of the Program on Public Conceptions of Science is published at 358 Jefferson Physical Laboratory, Harvard University, Cambridge, Massachusetts 02138, with supporting funds from the NSF and the Commonwealth Fund. The quarterly publication includes news items, communications from readers, and bibliographies of articles and books on the public conceptions of science, including conceptions of the ethical and human impact of science. Single copies may be obtained without charge by writing to the Program on Public Conceptions of Science at the above address. Back copies of certain issues of the *Newsletter* may still be available.

Plans are reported also for a *Project Physics Newsletter*, which will be sent free of charge to those requesting it. Write to the Harvard address given above.

REFERENCES

1. For one of the most comprehensive surveys of this unprecedented period of curriculum activity see Willard J. Jacobson, "U.S.A.: Post-Sputnik Science Curricula," in *Strategies for Curriculum Change: Cases From Thirteen Nations*. Edited by R. Murray Thomas, Lester B. Sands, and Dale L. Brubaker (Scranton, Pennsylvania: International Textbook Co., 1968), pp. 116-35; see also

Joseph D. Novak, "A Case Study of Curriculum Change—Science Since PSSC," *School Science and Mathematics* 69: 374-84; May 1969.

2. Thomas D. Fontaine, Deputy Assistant Director for Education at the National Science Foundation, Washington, D.C. 20550; as reported at a Symposium on School Science: Past and Future. Meeting of the American Association for the Advancement of Science (AAAS), Boston, Massachusetts, December 30, 1969.

Utilizing Community Resources

Charlotte Purnell, *Director, Del-Mod System, Dover, Del.*

A course in community resources is included in most teacher preparation programs. Generally, these programs are teacher-oriented and serve only to make the teacher aware that the classroom extends beyond the immediate confines of the school. Most science teachers must then catalogue the natural and man-made resources which can be used for field trips and compile a list of resource people who can be called upon to augment classroom activities.

For science supervisors, the underlying premise of marshalling support outside the school community is unchanged. The difference for the science supervisor is in the degree of effort, breadth of the community, and extent of the contacts.

In the usual school/community courses, the community is generally defined as the school district or nearby areas where access is easy and familiar to the students. For science supervisors to limit their effort to such an immediate area is a mistake. The community for the science supervisor should include the entire state, local and federal governments, statewide and local industries, and private foundations. In short, the main concern of the science supervisor is to secure funds, either direct or in kind, to carry out the programs which will result in better teaching, no matter where the source is located.

Government funding

Most science supervisors are aware of funds available to them from the federal government and in particular those which are allotted on a formula basis or administered through the state education agency. What is generally not known are those federal funds which are administered directly by the various federal agencies and for which open competition is the selection mechanism. Almost all federal cabinet offices have an educational component which is compatible with the particular cabinet responsibility and may fit the particular requirements of your district or school. Sometimes state departments of education circulate program announcements; more often they don't. Therefore, a good starting place is a copy of the Federal Register which contains a listing of the programs, the amount of the appropriation, and how to submit proposals. Although one can be placed directly on the mailing list (only to find after the effort is made to submit a proposal that there may be hidden requirements) a better source of the current listings and their restrictive clauses is the office of the local congressman. All congressmen maintain offices in their home districts, usually county seats, and have staffs paid to assist people in procuring funds. It seems that few supervisors use the offices of their congressional delegation as a resource to keep themselves up-to-date on federal programs and for assistance in developing and submitting proposals. Congressional staffs are often willing to help but they are rarely utilized by the local supervisor. If you do write federal proposals, don't expect the various agencies to supply all the funds necessary. Proposals are generally looked upon more favorably if there is local effort evident in the form of matched funds or in-kind contributions (e.g., time of director, secretarial services, supplies and materials, etc.).

All state money for education is not funneled directly through the state education agencies. Frequently, various state agencies run their own education programs, with information officers, when they are compatible with the agency's purpose. Science supervisors should investigate the departments of natural resources, environmental control, consumer affairs, social services, Indian affairs, agriculture, and archaeology. Sometimes these programs are published and circulated; but visiting the information officer is often more effective. These agencies are good sources of material for teachers since they prefer to work through one person in the district rather than answer the requests of a number of individual teachers. In addition, these agencies usually have money for printing and dissemination but lack the expertise to develop materials which may be useful to teachers. Frequently, these agencies will also supply personnel for programs organized and operated by science supervisors in outdoor education, environmental education, anthropology, career education, consumer education programs, and many others depending on the goals and composition of the district.

Industry sources

Major corporate industry is often willing and anxious to help with school programs. Direct program support, guest lecturers, and equipment are the kinds of services industry provides. If there is a major industrial plant in your area, the best place to start for grants-in-aid is the personnel manager. If the plant is small, speak to the plant manager. Most plants have small amounts of money which they can utilize for educational purposes without submitting the request to the corporate home office. If the request is large, it is usually submitted in writing and forwarded to the home office for action. Most major companies maintain company foundations which act on these requests, but endorsement by the local plant manager is essential if the request is to be considered seriously.

Several points should be considered in working with corporate officials and corporate foundations. First, brevity is the watchword. A proposal over five pages is too long. Educational jargon must be kept to a minimum. A succinct statement of the purpose of the project, data to support the purpose, how the project is going to be carried out, personnel involved, and expected outcome is sufficient material for the narrative. Second, the budget should be realistic and stated in precise terms. Matched funds or in-kind services are good for showing the local effort, but are not always essential. A ratio of three corporate dollars to one district dollar is a good rule of thumb. Third, a personal visit with the executive making the final decision is a must if the proposal is to be favorably received. Last, and perhaps most important, is that all requests should be made on a first and final basis. Industry does not want to be obligated over a long period of time but prefers to treat each request separately. Unlike the federal government, industry does not usually negotiate on budgets or programs; therefore, it is easier to come back for a new request rather than the same thing year after year. Moreover, corporate giving is determined by profits. Judicious reading of financial pages of a newspaper can make it understood why first and final requests are preferred over support of a select few clients.

Requests to smaller companies located in the district are not to be overlooked. The same ground rules apply for approach to small local companies as to large ones, except that requests should be smaller and for specific purposes. The request is particularly palatable if the company is a science-based one. Small companies are good prospects for support of field trips, special equipment, career education, residence camping, printing, or other specific requests. In the case of small companies, the decision is made by the owner or general manager and the decision is usually unilateral. One value of using small companies as a resource is that requests are handled quickly and input from the grantor is often given as a bonus. Follow-up is easier, and if the decision maker's interest is captured a valuable ally can be enlisted for future support.

Clubs, foundations, and trusts

Every community has service clubs, most of which are anxious to assist with worthwhile projects. Service clubs in some communities have built outdoor laboratories, served as leaders for overnight trips in residence camping, sponsored students in various science activities such as science fairs and conferences, and provided teacher support for summer activities. Moreover, most service clubs have established foundations which are willing to consider larger requests. However, these requests, like those to industrial plants, must have the approval of the local club.

Local private foundations and community trusts are other sources of support. The most difficult piece of information to acquire is from where the foundation is operated and who the chief administrator is. One starting place is a check with the *Foundation Directory* (this book can be found in most large public and college libraries). It lists the foundations by state, assets, purpose, and chief contact person. If a foundation is located nearby, it is wise to make a personal visit to the operating official—unless the information given in the *Directory* specifies otherwise (some foundations want no personal contact and will only accept letters). Many foundations are not listed in the *Foundation Directory*; they may be managed by banks or law firms. The best way to locate one of these foundations is by calling the trust officer at the local bank branch, or home office of a local bank. Foundations managed by law firms are more difficult to locate. Perhaps the most efficient method would be a request to the Internal

Revenue Service or the state tax office. All foundations are required to file income tax returns in May and list the name and address of the chief foundation officer. Often foundations are set up to support specific purposes and frequently education in general is one of the main recipients.

Community trusts are usually maintained by banks. These trusts generally consist of money bequeathed by individuals for good purposes in a given community. If funds are not specified for a particular purpose, the board of directors usually decides what the purpose is and acts accordingly on requests. Often, these purposes change with the times and an inquiry does no harm.

Another category of foundations is the large private ones of national stature. Although they tend to be more interested in large districts with district problems, or in identifying a problem and then seeking grantees who may attempt various solutions, a reading of their annual reports for necessary information on possible assistance. Their names and addresses can also be found in the *Foundation Directory.* When working with foundations, remember that their income depends on investments and fluctuates from year to year. Therefore, except in the case of large national foundations, a grant is rarely made for more than one year. The "first and final" principle favored by industry is much stronger with foundations. Brevity and clear succinct writing are essential to any foundation proposal. Contact by science supervisors with private foundations and community trusts is often neglected. This valuable resource can be tapped if properly approached and if the request is purposeful and will have lasting impact. Moreover, funds gained from private sources can be used to match federal funds and are indicative to federal proposal readers of the degree and extent of the local commitment.

The science supervisor has many tasks to perform. The main charge is obviously improvement of the science program. To do this, additional funds are often required. Therefore, it is imperative that the science supervisor have readily available sources which may be drawn upon to enable the supervisor to carry out his or her charge. The above-mentioned areas by no means exhaust all the possibilities but rather serve to point out some places which may have been overlooked. To the enterprising science supervisor, they represent a guide for healthy exploration.

Organizing a Science Materiel Center

Gerald Garner, *Specialist, Science Materiel Center, Los Angeles Public Schools, Van Nuys, Calif.*

In past years, the search for perishable materials needed for science classes led teachers on time-consuming collection excursions before and after school. For example, trips to meat packing plants were necessary to collect animal tissue. Teachers visited rivers and ponds to obtain specimens of protozoa, algae, or marsh plants. Journeys to hatcheries yielded fertile eggs, while ice cream manufacturing plants were a source of dry ice.

Increasingly, however, such excursions became impractical, and then impossible. As cities grew and expanded, quiet ponds were replaced by freeways. The natural environments of estuaries and rivers disappeared with the construction of marinas and concrete channels. Even egg hatcheries ceased operation or were moved elsewhere because of the construction of new housing tracts.

Other developments intensified the need for more diverse materials, as well as for inservice education. Teachers coming from other places, who were employed by expanding districts in considerable numbers during the 50's and 60's, were unfamiliar with the types of items required, and also with their local sources. Meanwhile, advances in science and technology were creating demands for new scientific materials and more extensive classroom laboratory work.

One effective solution to this dilemma has been developed by the Los Angeles City Schools.

Organization of the Science Materiel Center

To alleviate this situation, the Los Angeles City Schools established a Science Materiel Center in 1961, when federal funds became available through the National Defense Education Act, Title I. Policies and procedures for the operation of the Center were formulated jointly by science supervisors from the Division of Instructional Planning and Services and the Division of Secondary Education. This mutual cooperation has been one of the key factors in the success of the facility. Headed by a science specialist, the staff includes a secretary, a senior clerk typist, two truck drivers, a life science laboratory technician, life science stock clerk, and two chemistry clerks.

Located in Van Nuys, the Science Materiel Center serves teachers in regular junior and senior high schools, and adult schools. Although separate budgetary funds are not provided, the Center has been able to provide materials for advanced placement, physically handicapped, and continuation schools on a restricted basis. Materials have also been provided to the Youth Services Outdoor Education Program.

In the past, the Science Materiel Center provided services to the life science departments of the Los Angeles Community College District on a contract basis. Project APEX, a federally funded educational-opportunity program (now terminated), was supplied with complete kits for every biology experiment. During 1968, the Programs for Educable Mentally Retarded Section of the Division of Special Education initiated plans to supply science kits for EMR classes. Currently, 72 different basic, single-concept, self-contained kits for elementary, junior high, and senior high school EMR classes are maintained and delivered by the Center. These kits are designed to provide all equipment and supplies needed for the EMR science program. Printed materials are included to aid the teachers, and individual student exercise sheets are furnished with secondary kits.

Phases of development

Services of the Science Materiel Center were initiated in these developmental phases:

Phase 1 Establishment of a perishable-materials supply center, with provision for bi-weekly deliveries to schools.

Phase 2 Purchase of specialized equipment, not available in schools, for use by teachers on a loan basis.

Phase 3 Development of a demonstration laboratory-classroom and other facilities for inservice training programs, including institutes, special demonstrations, and teacher workshops. These facilities also are utilized by outstanding science students.

Phase 4 Provision of workshop equipment, including power and hand tools, for use by teachers in the construction of "home-made" teaching aids.

Types of materials

During its first year and a half, the emphasis at the Science Materiel Center was on implementation of Phase 1. With the cooperation of science department chairpersons, the staff developed a comprehensive list of perishable items required by teachers. In each subsequent year, this list has been evaluated and modified to enrich laboratory activities in science classes. The Center now makes available more than two hundred items, including:

Animal Tissues Beef brains, beef eyes, beef bile, lamb heads, lamb hearts, lamb shanks, lamb plucks, lamb tongues, lamb tracheae, oxalated beef blood.

Aquarium Items Duckweed, elodea, foxtail, hygrophilia, vallisneria, axolotl, brine srimp, brine shrimp eggs, clams, comets, fantails, guppies, newts or salamanders, ghost shrimp, shubunkins, snails, tadpoles.

Cultures Amoeba, Daphnia, drosophila, euglena, plankton (preserved), pond mat, pond water, protozoa, and spirogyra.

Dry Items Blood slides, bran, drosophila medium kit, rat and mouse food, dry baker's yeast, brewer's yeast, planter mix, and sterile plastic petri dishes.

Animals Ascaris, crayfish, fetal pigs, frogs, mice and rats, earthworms, mealworms, crickets, and fertilized eggs.

Plants Cobra lily, coleus, geraniums, and mimosa.

Seeds, Bulbs, and Spores 28 varieties, including genetic corn and tobacco seeds.

Inorganic Items Dry ice, spring water, radioactive iodine, and phosphorus in solution.

Marine Items Live clams, mussels, and sea urchins.

Hormones Thyroid tablets and indoleacetic acid.

Antibiotic Sensitivity Discs Aureomycin and penicillin.

Prepared Sterile Culture Media Crones, potato dextrose agar, and tryptic soy agar and broth.

Prepared Stains and Indicators 27 items.

Consumable and Loan Kits Bacteriology kit, sea urchin development kit, drosophila medium kit, nine BSCS kits, two mineral kits, and three bottled gases.

Economic considerations

After being received by the Science Materiel Center, fresh animal tissues are washed, packaged in freezer wrap, and quick frozen. For easy inspection, the lamb heads are cut along the mid-saggittal line to expose the brain, pituitary body, nasal cavities, sinuses, teeth, and tongue. Cranial nerves may be removed, meninges demonstrated, and the cranial oavity exposed. Each half of the lamb head serves a dissection material for two students. The entire processed head costs 70 cents, which means that the cost per student is about 20 cents for material that can be utilized in several units in physiology or biology. Beef eyes cost 25 cents each, frozen and packaged. Most invertebrate cultures cost an average of 50 cents per classroom set. Savings such as these have reduced the per-pupil cost for laboratory work to such an extent that today student participation in activities is almost as economical as teacher demonstrations were in the past.

Arrangements for collection of materials are carefully coordinated for maximum effectiveness. A single excursion, for example, can yield spirogyra, pond culture, and spring water; and, since the meat-packing companies with which the Center deals are located in the same general area, a week's supply of animal tissues can be picked up at the same time. An itinerary is planned which includes the various suppliers, such as hatcheries, nurseries, and the University of California at Los Angeles, so that the least possible time is spent in gathering items.

Other economies also are achieved in a variety of ways. For example, biological supply houses have cooperated with the Science Materiel Center by offering special rates for wholesale orders. Special delivery of live materials, such as cultures, makes it possible for shipments to reach the Center overnight from almost any part of the United States. Live frogs can be purchased in other areas and transported here by air freight more economically than they can be obtained from local sources.

Emphasis on service

By far, the most important aspect of the Science Materiel Center's operation is the service it provides. A lump sum is budgeted to the Center so that the specialist can allocate supplies on the basis of the science enrollment in each school. In addition, schools are permitted to transfer their own funds to their Center account. To perform its service role effectively, the Science Materiel Center staff assures that perishable materials are delivered to the "right place at the right time." High standards of quality are scrupulously maintained. With advance notice, the Center can supply any number of 10 different strains of Drosophila for use in genetic experiments. Within 24 hours, 10 μc of Iodine 131 and Phosphorus 32 can be delivered. These are safe quantities for the teacher to use, or to place in storage, inasmuch as the chemicals are short-lived isotopes. One of the major contributions of the Science Materiel Center is its conservation of teacher time. For example, a considerable period is needed to culture Drosophila. A student can be employed to measure and pack the ingredients of the culture media in a small container, ready for use. The teacher then needs only to add water, to cook the solution, and to pour the medium into a container for classroom use. Collection of chemicals and equipment also can be time-consuming. Teachers themselves have provided invaluable assistance to the Center in the supplying of perishable materials. Working with university personnel, the Center staff has developed "Sea Urchin Egg Fertilization and Development" Kits.

Special equipment and inservice education

Progress in initiating Phase 2 in the operation of the Science Materiel Center—that of establishing a special equipment loan service —led to the introduction of Phase 3 (Inservice Education) as well. The first items of equipment placed at the Center and made available on a two-week-loan basis to schools included kymographs, atomic scalers, Zeromatic pH meters, wave motion machines, oscilloscopes, and microtomes. Recently lasers, marine sampling devices, absorption spectra demonstrators, and other equipment has been added to the loan list. Since some science teachers needed training in the use of these types of equipment, institutes have been held for this purpose. After each inservice session, the volume of requests increased for the loan of the particular equipment that was involved. (Since elimination of the institutes, due to recent district economy measures, the specialist at the Center now provides training for individual schools.)

Instructional aids workshop

Just as Phase 2 stimulated the initiation of Phase 3 of the Science Materiel Center program, the latter phase has led to Phase 4—that of establishing facilities where science teachers can prepare their own classroom aids. Although Phase 4 has not been fully completed, a large workroom equipped with benches and electrical outlets already has been made available. Equipment includes a drill press, circular saw, jigsaw, metal brake, and lathe. It has been proposed that the workroom be open during several evenings each week and on Saturdays. Presently, the Center is open from 8:00 a.m. to 4:30 p.m., Monday through Friday, for workshop use.

Responses from schools

Since the Science Materiel Center has been in operation, the responses of teachers to its services and facilities have been enthusiastic. For example, after distribution of the sea urchin kits, one science department chairman wrote: "Probably our most outstanding experiment of the semester. . . . We all (students as well) thank the Science Center staff for this fine effort."

A number of conclusions can be made regarding the value of this facility. For example, it is evident that the Science Materiel Center has helped to resolve a number of serious problems relating to science instruction. From the number of inquiries received from other school systems, it is also apparent that a similar center could be invaluable to many urban school districts, or to a number of small districts working cooperatively.

Other science centers

In addition to the Science Materiel Center, there are eight Regional Science Centers located throughout the Los Angeles Unified School District. They are served by one Technical Support Center.

The primary goal of the Regional Science Centers is to assist teachers in improving the quality of science instruction and learning. This is implemented through a teaching program at the centers with classes transported from schools, an instructional program material resource loan service, purchase of consumable instructional program material resource loan service, purchase of consumable "center developed" kits by schools, and staff development. Staff at each center includes a teacher, a science aide, and a clerk.

Each Regional Science Center includes a classroom, animal facilities, outdoor planting areas, greenhouses, nature trails, teacher workshop areas, and resource display rooms.

Most Centers have developed an individual and unique feature or facility. These include one with a planetarium, another emphasizing California native plants, one with an oceanography program, and one specializing in conservation units.

Centers are often used as a focal point for after-school and community activities, particularly in the utilization of community volunteers to develop and maintain materials.

The Technical Support Center serves the eight Regional Science Centers by providing animals, animal food, materials for kit development, technical assistance, and wild animals for mobile units. It also supports the Regional Science Centers by selection, assignment, and staff development of Science Center personnel. The Science Materiel Center and Technical Support Center make materials available to one another to increase the variety and improve the implementation of kit development.

Appendix:
A Checklist for Science Supervisors

This less than profound set of questions is designed to help you to look at your performance as a supervisor. The questions are more important for the implications they suggest than for their answers. Consistently low evaluations may lead you to explore the professional opportunities to be found in beachcombing. Rate yourself on each question by placing a circle around the number in the 10-0 line under each question that you honestly feel is appropriate. Connect the dots with a line and estimate your Z.Z. Score. (Zig-zaggedness)

The format for this evaluation scale was borrowed with permission from the Cornell Evaluation Scale for Teachers (1963 edition) developed under the direction of Philip G. Johnson, Professor of Science Education, Cornell University, Ithaca, New York.

CHECKLIST

1. *Does your administrator depend on you for advice about needed changes in the science program?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

we plan changes together — I report changes, he applauds — he tells me what should be done

The supervisor needs to be knowledgeable. A record of good informed judgement will build the administrator's confidence in you.

2. *How does your administrator usually react to your projected budget?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

we agree on additions and cuts — I'm expected to fight for it — we don't discuss it

He should expect you to have clearly stated justification for each item. You should expect that adjustments will occur as the science budget is placed within the total budget. Defend vigorously and adjust gracefully.

3. *To what degree are your present facilities and equipment being used?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

lab work included, and equipment accessible	most teachers are using some equipment, others are learning	some labs not used; some equipment still packed

Unused equipment may reflect poor purchasing choices or a need for inservice programs. Unused equipment sitting on shelves is upsetting to administrators.

4. *Has there been a noticeable change in the amount or kind of science taught in the district during your tenure?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

yes, after study and deliberation	we're thinking and talking about changes	dramatic changes every year

The degree of desirable change is different in every case, but absence of change denotes apathy or complacency. Rapid fire change denotes irresponsibility.

5. *How many teachers attended the last general group meeting you scheduled?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

80 percent signed up; 70 percent came	less than 20 percent signed up. Some dropouts	attendance is required

Watch your objectivity when evaluating meetings with attendance required. Do teachers really drop out for dentist appointments?

6. *What has been your response to teachers' requests for discussions or inservice sessions?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

two or more requested; two held	haven't had time to schedule them	none requested

Only a really enthusiastic staff will ask for meetings. Even then requests are few. Don't fail to meet them.

7. *Can you show tangible evidence that the last meeting you held for science teachers was profitable?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

a 20 percent increase in individual requests for more information	when meeting is mentioned, teachers say, "what meeting?"	I think so, let's see. . . .

Constant follow up and careful evaluation should be made, at least mentally, after group and individual work with teachers.

8. *How many different science teachers have invited you to visit their classrooms this year?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
40 percent of total 20 percent of total none

You'll be invited if teachers feel you add something good to the instructional program or the classroom atmosphere and if they think you are interested in coming.

9. *Have you been asked to help interview and evaluate candidates for positions on the staff?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
yes sometimes no

If your administrator feels that you are a working, contributing, member of the school services team, you will be consulted in personnel matters.

10. *Do you like and respect most of the people on the staff in your school system?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
yes, we work hard and play hard together I like them, but not socially we have many weak, ineffective people

The amount of friendliness, support, and interest you give to others is often mirrored back to you.

11. *How many really enjoyable days did you have at work this week?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
4½ days 3 days forget it

We win some and lose some, but should be looking forward to going to work at least .... percent of the time.
(you decide)

12. *When was the last time you participated with other staff members in a facetious semantic duel or some other mutually enjoyable nonsense?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
yesterday six months ago what do you mean? I don't understand

If your score is low, is it because you don't enjoy oneupmanship? A sense of humor is an effective catalyst for rapport and cooperation.

13. *Do you think your work is usually more efficient and effective than the work done by other staff members?*

10 ... 9 ... 8 ... 7 ... 6 ... 5 ... 4 ... 3 ... 2 ... 1 ... 0
we have a good staff — I have strengths and weaknesses — yes

A low score here should make you re-examine yourself for the presence of cockiness and the danger of self-tripupmanship.

14. *When you lack needed information or don't know how to do something, what course of action do you take?*

10 ... 9 ... 8 ... 7 ... 6 ... 5 ... 4 ... 3 ... 2 ... 1 ... 0
hunt something or someone to help — act blasé and bluff it through — abandon the project

Leave the omnipotence to God.

15. *When you commit a blunder in judgment or action, what do you do?*

10 ... 9 ... 8 ... 7 ... 6 ... 5 ... 4 ... 3 ... 2 ... 1 ... 0
announce it and ask forgiveness — proceed cautiously to cover up — blame someone else

Teachers and administrators will generally forgive a humble soul when they know he has good intentions. Just don't let careless thinking cause you to outlive their forbearance.

16. *How many of the teachers under your direction have had a good or novel idea for teaching science this year?*

10 ... 9 ... 8 ... 7 ... 6 ... 5 ... 4 ... 3 ... 2 ... 1 ... 0
several — few — none

Be sure that the teachers with good ideas have a chance to share them and get some recognition for them. If you had all the good ideas, where did you get them?

17. *How recently have you tried to work directly with students on a regularly scheduled basis?*

10 ... 9 ... 8 ... 7 ... 6 ... 5 ... 4 ... 3 ... 2 ... 1 ... 0
this semester — haven't thought of doing it — have forgotten how to do it

It's important that teachers know that you can teach and that you know how it feels to take classroom responsibilities.

18. *When was the last time you took a science content course, either credit or non-credit?*

10 ... 9 ... 8 ... 7 ... 6 ... 5 ... 4 ... 3 ... 2 ... 1 ... 0
this semester — less than three years ago — more than five years ago

Informal reading and study is some help in keeping up with new findings in science, but will not suffice indefinitely.

19. *How recent is your training in statistics, theory of learning, and educational research?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
this semester — less than three years ago — more than five years ago

Again, informal reading and study help but are not guaranteed to give you the new skills needed to practice new techniques.

20. *How often do you read abstracts of research being done in the area of your scientific interest or in education?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
weekly — seldom — don't know where to find them

Membership in AAAS, AIBS, and other such organizations will give you access to journals. AERA and NARST report research findings. Check the journals available in local libraries.

21. *When was the last time you checked in your school libraries for the science books students could use?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
last week — last year — never get to it

The librarian will welcome your help in book selection. You need to know what is available for students and teachers.

22. *When do you preview science films, filmstrips, programed learning, tapes, and new products?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
before selection is made by A-V director — after selection is made by A-V director — only on request by a teacher

The supervisor needs to exert some leadership and responsibility in the acquisition of these products. Poor selection can seriously compromise the purposes of the science program.

23. *When was the last time you submitted an article for publication in a professional journal or the public press?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0
this year — two years ago — never thought of doing it

Journals need your viewpoints and experiences. Writing about your program forces clarification of thought. Authorship brings professional status.

24. *When was the last time you coordinated a joint school-community learning situation for students or staff?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

10	7	3
last semester	we don't interrupt the teaching schedule	I'm not acquainted with resources here

Science programs that have no room for current events in science or programs devoted to special interests are not likely to sustain student interest. Most schools need resource people to fill gaps in content or knowhow.

25. *To what degree do you participate in the activities of professional associations?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

10	7	3
seek opportunities for committee and program participation	attend state and national meetings	no time or money for this activity

Professional isolationism and good supervision are inconsistent.

26. *Are you planning and carrying out a program for personal professional advancement?*

10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . 0

10	7	3
looking for advancement as qualifications increase	expect to be advanced as competence increases	seniority will provide advancement

Advancement comes to those who know how to identify opportunities or to make the opportunities themselves. For example, as the use of the systems approach in education continues to grow, the prepared and imaginative supervisor can advance in many directions. He has the choice.

RATING YOURSELF

For your score, total the numbers you have circled.

250-230 .... See question 13
220-190 .... Survival and improvement can be expected
75-59 .... Have you tried beachcombing?