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ABSTRACT

It is noted that much of what is known about middle and junior high schools is extrapolated from data on elementary or secondary schools. This study is designed as a systematic review of the current status of science teaching at these levels in the United States as a foundation from which curriculum modifications can be reasonably undertaken. The document contains the following sections: (1) The Middle School, Its Philosophy and Rationale; (2) Analysis of Major Committee Reports with Respect to Middle and Junior High School Science; (3) Analysis of Middle and Junior High School Science Programs; (4) Research Studies of Science Instruction in Middle and Junior High Schools; (5) Innovative and Exemplary Science Programs; and (6) A Context for Science Education: A Conceptual Framework for the English and Beyond. (MP)

THE STATUS OF MIDDLE SCHOOL AND JUNIOR HIGH SCHOOL SCIENCE

Volume II Technical Report

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INTRODUCTION

Social and cultural changes over the past decade or so have resulted in a widespread concern about the direction of public education in America. Questions about what knowledge is important to teach, and for what reasons, are asked in a variety of ways. Included in recent social changes is the extent to which science, technology, and society have become interactive in influencing life and living in the United States. Public attitudes toward schooling and toward science and technology have implications for the teaching of science. During this recent period of rapid social change and shifts in perspectives about science and technology, an awareness of educational deficiency in the early adolescent has also emerged. The early adolescent is in the school age group where a reformulation of science education is most likely to be immediately effective. Essential to the revitalization of the curriculum is the need to consider shifts in social conditions, emerging cultural values, and the impact of achievement in science and technology on personal and social living.

The middle school and the junior high school are two specially organized administrative units for educating early adolescents. These units are considered as secondary schools by some, as elementary by others, and as schools-in-between by still others. In general, there is no unique preparation for educators in these schools; some were trained to be elementary educators, and some, scondary. Few programs exist for the education of professionals in these schools. Data collected by the National Center for Educational Statistics do not treat these schools as separate educational levels. Much of what is known about middle and junior high schools has been extrapolated from data on elementary or secondary schools.

Rationale

Before modifications in the science curriculum can reasonably be undertaken, there is need for a systematic study of the current status of science teaching in the middle and junior high schools of the United States. We assumed at the onset of the study that most status surveys are too limited in scope to be useful in making policy decisions in education. Therefore, we planned a comprehensive study to include demographic information on students, teachers, teaching conditions, school facilities, learning resources, and related topics; the nature of the school science curriculum as revealed in an analysis of widely used

textbooks; philosophical assumptions including middle school education; and empirical studies on early adolescent development and learning. We also felt it was necessary to investigate the perceptions people hold of conditions that have fostered the notion of a "crisis in science education." It was apparent that part of the crisis in science education had its roots in the emerging science/technology/society paradigm of the scientific enterprise in the United States. This led us, within the limits of time available, to study the implication of these new perspectives for the teaching of science.

At every phase of the study and for every recommendation emerging from our endeavors, we assumed there must be some empirical basis or consensus for each derived statment, whether quantitative or qualitative.

Purpose of the Study

The purpose of this study was to determine the status of science teaching in middle and junior high schools in the United States. For most of the study (the exceptions are discussed), two periods, 1965-1970 and 1975-1980, were used as time boundaries for the literature to be reviewed. Analyses and syntheses of publications from several data bases were prepared. The resulting report describes the history and current status of science teaching in middle and junior high schools and includes recommendations for the eighties and beyond.

In the preparation of this Volume Two, Technical Report, all relevant data from all sources were analyzed. These anlyses form the basis for the various sections of the report. Each section is supported by a Reference List and a Bibliography. The statements in Volume One, Summary Report (1) are a qualitative representation of the data for each major category of information in Volume Two. The summaries are intended to be a description of a situation that exists, not an interpretation of that situation.

Organization of the Study

The data base for the section on The Middle School included textbooks and general writings about the goals, rationales, programs, and instructional strategies of middle and junior high schools. It also included papers from general educational journals for the time periods 1965-1970 and 1975-1980, as well as journals of professional educational organizations, such as the National Association of Secondary School Principals and the National Middle School Association. Common descriptions of goals, functions, criticisms, advantages, and characteristics were identified. Summary statements based on these common descriptions were made. Many more references were used than those noted specifically

in the text. The additional resources are listed in the Bibliography of this section.

The next section covers the status of science education in middle and junior high schools, 1965-1970 and 1975-1980, and considers reports prepared by committees, professional groups, and major studies. The principal information sources for the earlier period were the USOE survey of junior high school science and the ERIC/SMEAC survey of science teaching in public schools. For the 1975-1980 period, the primary sources of information were the three NSF-funded status studies of precollege science education and the results of the 1978 National Assessment of Educational Progress in science for 13-year-olds.

Each report was analyzed, topic by topic, and the information was coded. Where possible, quantitative information was recorded. Qualitative statements were briefed and coded, preserving as far as possible the wording found in the source. Categories of information, such as teacher characteristics, laboratory procedures, or course offerings, presented in this study are products of the availble data and were not preconceived. The amount of information in each category reflected the available data. The researchers responsible for the primary investigations had different purposes for obtaining the information found in their studies; any overlaps were fortuitous.

The next section reports analyses of texts and text programs used in middle and junior high schools. The <u>Reports of the 1977 National Survey of Science, Mathematics, and Social Science Education</u> (2) served as the major source of data on the most widely used classroom materials during the 1975-1980 time period. From the Weiss study, the 12 most widely used programs for these categories were selected for analysis.

The 12 programs were purchased and the actual published materials were examined during the analysis phase. They were analyzed for eight variables: science content; goals, objectives, and intents; teaching-and-learning styles; evaluation devices; career emphasis; science/technology/society emphasis; nature of student activities; and any changes in the programs since the 1965-1970 time period. The specific methodologies for evaluating the eight variables are described in the section, "Analysis of Middle and Junior High School Science Programs."

The empirical base for the analysis of research in science education in middle and junior high schools appears to be voluminous. Unfortunately, many studies conducted with sixth, seventh, eighth, and ninth graders do not include a school context. Initial bibliographies were developed by searches through DIALOG, using the ERIC and PSYCINFO data bases. Further searches used bibliographies prepared by the ERIC Clearinghouse for Science, Mathematics, and Environmental Education on research studies of science education in middle and junior high schools and in grades five through nine.

A bibliography of doctoral dissertations in science education (3) was used to develop categories for grouping research studies for analysis. These categories were then ordered in terms of priority for analysis and synthesis. Two topics were selected: analysis of texts and inquiry. These topics were selected because of the predominance of the use of texts as the curriculum in middle and junior high schools and because of the lack of inquiry used in classrooms.

Additional computer searches, through DIALOG with the ERIC and PSYCINFO data bases, were conducted to produce the final bibliographies from which the reviews were prepared. Complete documents were used when they could be obtained in paper, microfilm, or microfiche format.

The projective synthesis was developed from a data base of reports by presidential commissions, government agencies, professional organizations, and special task forces. All of the publications used for this synthesis were the work of groups, usually widely representative, who were concerned with schooling in general or with science education in particular. The reports were generally the product of deliberation and consensus. They are all reports judged by the investigators to have raised significant issues that provide a basis for planning precollege science education, particularly science education in middle and junior high schools.

This study also considered several papers (4,5,6) on methodological issues relevant to the task of analyzing the synthesizing research studies. The investigators applied many suggestions made in these papers, but take full responsibility for the application of the procedures in this work.

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SECTION I THE MIDDLE SCHOOL, ITS PHILOSOPHY AND RATIONALE

CHAPTER 1

THE MIDDLE SCHOOL

Origins

School organization and its effect on students and the learning process have been discussed for almost a hundred years. At the end of the nineteenth century, educators sought to eliminate the 8-4 program in favor of the six-year secondary program (6-6). They believed that the secondary school program should begin in the seventh grade and continue through the twelfth grade without a break in continuity. Such thinking among the educators of the late nineteenth century originated with President Charles W. Eliot of Harvard University who was concerned about the rising age of admission to Harvard. In 1892, while addressing the meeting of the National Education Association, he recommended shortening the program of the elementary school. His address resulted in the appointment of the Committee of Ten on Secondary School Studies by the National Education Association.

In 1893, this group recommended an introduction to secondary school subjects prior to grade nine. The Committee of Ten was followed by several other committees who looked at the the organization of elementary and secondary education. For three decades, leading educators expressed the need for a unified program of elementary and secondary education, the improvement of teaching methods, and the question of when certain secondary school subjects should be introduced. Speaking at a conference in 1902, John Dewey also supported the six-year elementary/six-year secondary school program.

The 6-3-3 plan came into being in 1909-10 when schools including only grades 7, 8, and 9 were initiated in Columbus, Ohio and Berkeley, California. G. Stanley Hall's volumes on the psychology of adolescence in 1905 and several "drop-out" studies carried out from 1907 to 1911 (1,2) helped bring about this change in educational organization. Following this beginning, the reorganization of elementary and secondary education into the 6-3-3 structure proceeded rapidly in many other cities.

How was a junior high school defined during this period of time? A 1919 <u>Bulletin</u> of the North Central Association defined a junior high school as one in which grades 7, 8, and 9 were segregated in a building by themselves. The junior high school had an organization and administration distinct from the grades above and below it, and classes

were taught by a separate group of teachers. The recommended characteristics of such schools were (3):

1. A program of studies decidedly greater in scope and richness of content than that of the traditional elementary school
2. Some pupil choice of studies, elected under supervision
3. Departmental teaching
4. Promotion by subject
5. Provision for testing out individual aptitudes in academic, prevocational, and vocational work
6. Some recognition of the peculiar needs of the retarded pupil of adolescent age, as well as special consideration of the supernormal
7. Some recognition of the plan of supervised study

Two aspects of the early junior high school became pillars of the movement. These were the concept of the junior high school as an integral part of secondary education, and the concept that the unique needs of early adolescents create a need for a special transitional school (4,5,6). Along with this growing stress on the centrality of needs of the early adolescent was an emerging emphasis on guidance as a necessary aspect of education at this level (7,8).

The term "junior high school" was first used to designate the Indianola Junior High School in Columbus, Ohio, in 1909. By 1916, this term was being used more than any other with the term "intermediate school" second in popularity (9). Douglass concluded that the terms meant the same thing.

By the 1920s, the purposes and functions of the junior high school included the following (4,10,11):

1. To provide a gradual transition from the elementary school to the secondary school
2. To exercise a holding power function and reduce the number of drop-outs
3. To help youth understand the nature of the society of which they are a part
4. To provide an exploration period for youth so they can discover their capacities, interests, and aptitudes
5. To assist pupils to make the fullest adjustment for self-realization and service to society
6. To provide vocational career preparation
7. To provide a unique school that can provide for the needs of early adolescence

In 1920, Briggs estimated that there were more than 800 junior high schools in the United States. At the same time, he reported considerable confusion among professional educators as to what an intermediate or junior high school is or ought to be (10).

A national survey of secondary education in 1930 found 1,787 separately housed junior high schools in the country. Yet, in spite of the rapid numerical increase, attacks on the intermediate unit of

schooling came from different sectors of professional education. Educational journals of the 1920s and 1930s were filled with discussions about the legitimacy of this type of organizational structure (12,13,14).

In 1940, William Gruhn and Harl Douglas developed a statement of functions for the junior high school based on statements of various study committees during the reorganization movement and statements of functions formulated by educational leaders in secondary education from 1910 to 1940. Their statement was then modified by 12 leaders in junior high school education. The Gruhn and Douglas statement has become a classical definition of the rationale for the junior high school. It is cited in most junior high school and some middle school textbooks still in use as a widely accepted statement of functions (15,16,17,18,19). The 1940 statement was modified in 1970 to include further developments in the thinking of educators about the philosophy of junior high school education. The six functions, however, were the same in 1970 as they were in 1940. This 1970 version is as follows (20:75,76):

Functions of the Junior High School

<u>Function I: Integration</u>. To provide learning experiences in which pupils may use the skills, attitudes, interests, ideals, and understandings previously acquired in such a way that they will become coordinated and integrated into effective and wholesome pupil behavior.

To provide for all pupils a broad, general, and common education in the basic knowledges and skills which will lead to wholesome well-integrated behavior, attitudes, interests, ideals, and understandings.

To provide for effective correlation among the studies, learning activities, and extra class activities of the total program of education.

<u>Function II: Exploration</u>. To lead pupils to discover and explore their specialized interests, aptitudes, and abilities as a basis for decisions regarding educational opportunities.

To lead pupils to discover and explore their specialized interests, aptitudes, and abilities as a basis for present and future vocational decisions.

To stimulate pupils and provide opportunities for them to develop a continually widening range of cultural, social, civic, avocational, and recreational interests.

To help pupils identify interests in school which will provide motivation for them to continue their formal education and to participate in educational activities that are appropriate for their individual growth and development.

Function III: Guidance. To assist pupils to make intelligent decisions regarding present educational activities and opportunities and to prepare them to make future educational decisions.

To assist pupils to make intelligent decisions regarding present vocational opportunities and to prepare them to make future vocational decisions.

To assist pupils to make satisfactory mental, emotional, and social adjustments in their growth toward wholesome, well-adjusted personalities.

To stimulate and prepare pupils to participate as effectively as possible in learning activities so that they may reach the fullest development of their individual interests and talents.

Function IV: Differentiation. To provide differentiated educational facilities and opportunities suited to the varying backgrounds, interests, aptitudes, abilities, personalities, and needs of pupils, in order that each pupil may realize most economically and completely the ultimate aims of education.

To provide learning activities in all areas of the educational program which will be challenging, satisfying, and at a level of achievement appropriate for pupils of different backgrounds, interest, abilities, and needs.

Function V: Socialization. To provide increasingly for learning experiences which will prepare pupils to participate in and contribute to our present complex society and help them adjust to future developments in that society.

To provide learning experiences which will prepare pupils for effective and satisfying participation as responsible citizens in our democratic society, both at their present level of maturity and, later, as adult citizens.

To provide learning experiences which will prepare pupils for participation in an effective and mature manner in the activities of young adolescents and, later, as older adolescents and adults. To help pupils appreciate, understand, and function effectively in a society in which there are individuals with different interests, abilities, backgrounds, and educational and vocational goals.

Function VI: Articulation. To provide a gradual transition from preadolescent education to an educational program suited to the needs and interests of adolescent boys and girls.

To help pupils acquire backgrounds and skills which will prepare them to participate effectively in the educational activities and program at their present school level and, later, in the upper secondary school, post-secondary schools, and adult life.

During the period between World War I and World War II, junior high schools became the answer to space problems, relieving the overcrowded conditions of elementary and high school buildings. Because many junior high school teachers were trained to teach in senior high schools and desired to become senior high school teachers, the junior high school began to live up to its name of being a "junior" edition of the senior high school. Many of its original goals and functions, although stated well in textbooks, were ignored or forgotten in actual practice.

Criticisms of the Junior High School

Growth in the number of junior high schools continued to 1960. In that year, the Educational Research Council of Greater Cleveland marked the Golden Anniversary of the first junior high school. In reporting that conference, the New York Times states, "The fiftieth anniversary of the junior high school in America has found considerable criticism focused on the 'stepchild' of public education. William T. Gruhn, one of the principals on the program of that conference, enumerated the following critical problems and needs (21):

1. There is serious shortage of qualified talent for positions of professional leadership in the junior high school...
2. There is a serious shortage of teachers prepared for teaching in the junior high school....
3. The curriculum must be reexamined and priorities must be established concerning what should be taught.
4. The influence of college entrance requirements, merit scholarship examinations, and similar programs must be examined.
5. There must be more agreement on the "essential purpose" that the junior high is to serve.

Why was the junior high school in such trouble as an educational institution by 1960? According to many educational experts, the problem was not with the "junior high school dream" or its goals but with the implementing organization (18,19,22,23). The name, "junior" high school, which implied a scaled-down version of a "senior" counterpart, had come under attack (15,24). The junior high school had become a mimic of the senior high school, complete with varsity athletic teams, marching bands, proms, graduation exercises--all deemed inappropriate for seventh-, eighth-, and ninth-graders (25,26,27). Other limitations cited by critics of the junior high school were:

1. The junior high school often fails to meet the special needs of many students and consequently drives them away from school rather than easing their transition from elementary to senior high (15,16,28,29).

2. The junior high school often offers its students a program of studies that parallels that of the high school and limits students

to a few choices when it comes to exploring various areas of interest. Little relationship between subjects is found (24).

3. The junior high often places too much emphasis on competitive participation in athletics and social activities. It pressures students to measure up to an ideal, which at their age may be emotionally dangerous (16,25).

4. The junior high school often fails to provide students with educational challenges equivalent to their present level of creative and intellectual development. There is little opportunity to develop individual responsibility. Students are essentially passive recipients of knowledge dispensed by teachers (29).

5. The junior high school often has many discipline problems, some of which relate to the fact that it houses ninth along with seventh and eighth grade students under the same roof (26,30,31).

6. The junior high school alienates students from successful educational achievement (15). There is a tendency in some junior high schools to make a program hard for the sake of being hard (32).

7. The granting of Carnegie unit credits in grade 9 is a problem. The high school must either accept the Carnegie credits of the junior high school or attempt to control the granting of these credits in grade 9 (15,24). In effect, the high school principal has a decision-making control over a school unit for which another administrator is responsible (17).

8. The teacher assigned to teach in junior high school often contributes to the problems of the school. Few teacher education programs differentiate the preparation for junior high teachers from that designed specifically for elementary or high school teachers. Many junior high school teachers lack understanding of the age group and its needs. Sometimes junior high staff are recruited from dissatisfied or unsuccessful teachers. Dissatisfaction among teachers is higher at this level than any other (18,24,33). In some areas, high school teachers are paid on a higher scale than elementary or intermediate school teachers, thus creating a status problem. Junior high school teaching is seen as a stepping stone to a higher salaried and/or more prestigious senior high school teaching position (19,32).

9. A similar problem exists with administrators. In many school districts, high school principals are paid at a better rate than junior high school principals. Commitment to intermediate level education as a lifetime career position is hard to come by when differential salary schedules exist (19).

The rationale for the junior high school as initially conceived was generally believed to be appropriate by professional educators; the failure was one of practice (15). The middle school movement erupted as

a protest against the program, not against the concept of the junior high school (34).

The Emergence of the Middle School

Although the junior high school continued to be under fire, no specific alternative structure was proposed until the early 1960s. At that time, Dr. William Alexander revived the term "middle school," which was being used in some private American schools and had been long used in European schools. He and other educators began to give the term a set of educational attributes (35). Conant (36) in his "recommendations for education in the junior high school years" made a number of suggestions to school boards for improving junior high school education. They included:

1. No matter what the particular organizational pattern, grades 7 and 8 should reflect the transitional nature of pupils in this age group.
2. English, social studies, math, and science should be required courses for all pupils in grades 7 and 8.
3. English and social studies should be taught in a block time program in grade 7.
4. Instruction should be intellectually challenging to all pupils.
5. The junior high school should have a strong guidance and testing program.
6. The junior high school should not be a replica of the senior high school; there should be no marching bands, scholastic athletics, or graduation ceremonies.

What led to the emergence of the American middle school? Several factors have been identified. First, the late 1950s and early 1960s were filled with many criticisms of American schools. A variety of books about education in general triggered new concerns about the quality of schooling (37,38,39,40,41,42). The successful launching of Sputnik in 1957 led to certain types of criticism about school curricula. Academic achievement, particularly in mathematics, science, and foreign languages became an obsession. Renewed interest in college preparation led to a call for a four-year high school where specialized courses in mathematics and science could occur. Interest grew in including grades 5 and 6 in an intermediate program that promised to strengthen instruction by allowing subject specialists to work with younger students. Many of the first middle schools were organized to include both grades 5 and 6.

The work of Jean Piaget (43) in cognitive development and of J. M. Tanner (44) in physical development, among others, gave rise to renewed interest on the part of educators in the developmental characteristics of 10- to 14-year-olds. One of the major philosophical foundations of the emerging middle school movement came to be the recognized need to develop a unique educational program for both the

preadolescent and the early adolescent, based on the many physical, cognitive, social, and emotional changes that occur in this age span.

Another factor leading to middle school formation was the desire to help eliminate racial segregation (45,46,47). In the larger cities such as New York, elimination of de-facto segregation was a real force behind the early middle school movement (25,48,49).

Increased enrollment of school-aged children was another contributing factor (45,46). A shortage of buildings resulted in double and sometimes triple sessions in some school districts. Because it was believed that older students were better able to cope with overcrowding than younger students, the ninth grade was moved to the high school to relieve the overcrowded junior high school. The same rationale was used to relieve the crowded elementary school by moving the fifth and sixth grade to the junior high school.

Another factor was the "bandwagon effect" (45,46). When middle schools received favorable publicity in periodicals and conferences, some administrators decided that the middle school was an educational innovation worth pursuing.

The desire to facilitate educational change and improve educational practices was another factor. More rapid and comprehensive change can often be effected by creating a new institution rather than by attempting to redo an existing one. Teachers and administrators in a new school free from the constraints and traditions of an existing school often are more receptive to new ideas (45,50). A new middle school can provide a catalyst for change and a means to better articulate the total K-12 program (36).

Philosophy and Rationale for Junior High/Middle Schools in the 1960s and 1970s

In 1965, Alexander and Williams proposed eight guidelines for a model middle school (51). In brief, these guidelines are as follows:

1. A "real" or model middle school should be designed to meet the needs of older children, preadolescents, and early adolescents.
2. Such a school should make a reality of individualized instruction.
3. A high priority should be given to the intellectual components of the curriculum.
4. Primary emphasis should be given to the skills of continued learning, inquiry and the discovery methods, and learning how to learn.
5. Many exploratory experiences should be provided.
6. The health and physical education program should be specifically designed for the age group.
7. A values emphasis should underlie all aspects of the program.

8. Teachers in the middle school need special competencies to work effectively with this group of students.

These guidelines are in many ways quite similar to the functions of a junior high school articulated by Gruhn and Douglas (20,52). The junior high statement does, however, include a much stronger statement about vocational preparation and has a "preparing for the future" thread throughout it that is not present in Williams and Alexander's guidelines.

In the 1960s an educational philosophy for junior high/middle schools was articulated by Bossing and Cramer as well as other educational experts. It included these components:

1. Belief in the dignity and worth of each student as a person with inherent rights to the fulfillment of her or his intellectual, social, and physical capacities (53). It was becoming widely recognized that the differences in any age group of 10- to 14-year-olds were tremendous (20,34,54).

2. Belief that students should be able to complete successfully the work of the school (53). In order to make that possible, the curriculum requires flexibility in content, methods, and instructional materials (20,54).

3. Belief that the growth patterns of the early adolescent are predictive and different from those of older and younger students, and that, because of this, a separate school environment and instructional techniques are essential (53).

4. Belief that children and youth require intensive guidance and nurturance during this phase of growth (20,53).

5. Belief that educators have a responsibility to attempt to understand student responses to learning experiences. This involves recognition of the multiple influences of out-of-school life situations that may be potentially stressful (53).

6. Belief that staff members should have an understanding of early adolescent growth and development and its impact on learning and that they also should have a genuine liking and concern for their students (53).

7. Belief that development of the fundamental skills and knowledge begun in elementary school should be continued in a functional way (20).

8. Belief that the curriculum should offer many ways for students to develop new interests and explore new areas of knowledge (20).

9. Belief that the curriculum should include general education for all, but also provide opportunities for some students to begin specialized study that may relate to future educational, vocational, and avocational interests (20).

10. Belief that students should have opportunities to develop skills of effective citizenship through study and experience (20).

Advantages of the Middle School

Proponents of middle schools have identified a variety of advantages of middle schools as compared to junior high schools. These advantages have been used as part of the rationale for initiating middle school units. These perceived advantages are:

1. The middle school unit has a status of its own rather than a "junior" classification. It is not a preparation for something else. In it, learning is for here and now, for personal need, not for "someday" (30,35,55).

2. The middle school facilitates the introduction of some subject specialization into grades 5 and 6 (24,30,35,56).

3. The middle school facilitates the reorganization of teacher education, which is sorely needed to provide competent teachers for the middle schools. Since existing patterns of elementary and secondary teacher education would not suffice, a new pattern had to be developed (30,35,56,57).

4. Developmentally, children and early adolescents in grades 6 to 8 are more alike than children and early adolescents in grades 7 to 9 (30,34). Because of earlier physical maturation, ninth-graders are now more like tenth- to twelfth-graders than they were several decades ago (34). Since they are undergoing a common experience of moving from childhood into adolescence, sixth- to eighth-graders should have special attention. They should have special teachers and special programs, which middle school reorganization helps facilitate (30,58,59).

5. Middle schools provide an opportunity for gradual change from the self-contained classroom of the elementary school to the complete departmentalization of the high school (30,58,60,61).

6. Middle schools permit the organization of a program that has an emphasis on continuation and enrichment of basic education in the fundamentals (30,62).

7. Middle school organization facilitates extending guidance services to younger students (30). A close relationship with one or more teachers, as well as the provision of professional counselors, will aid students in weathering the changes and conflicts typical of early adolescence (63).

8. Middle school organization helps to slow down the process of "growing up" by the removal of the older students typically found in a junior high school (30,59).

9. Middle school organization can be structured to bring together children and youth from differing neighborhoods, aiding their sociological development earlier than in a junior high school organization (30,57,59).

10. The physical unification of grades 9 to 12 permits better coordination of courses for the senior high school (30,63). It also facilitates more curricular experimentation for the middle school (57). It eliminates the possibility that some students and parents may not be aware of the importance of the ninth grade as part of the senior high school record in terms of college admission (30). It eliminates the need for special programs and equipment for one grade (ninth) (30).

11. Fewer discipline problems are present when eighth- and ninth-graders are not together (30,31).

12. Reorganization of the grade structure enhances the possibility that innovation may take place more readily (65). It makes possible more educational innovation (59).

Bondi makes the following comparison between the emphases of the middle school and of the junior high school (46:13):

Middle School Emphasizes:	Junior High School Emphasizes:
A child-centered program	A subject-centered program
Learning how to learn	Learning a body of information
Creative exploration	Mastery of concepts and skills
Belief in oneself	Competition with others
Student self-direction under expert guidance	Adherence to the teacher-made lesson plan
Student responsibility for learning	Teacher responsibility for student learning
Student independence	Teacher control
Flexible scheduling	The six-period day
Student planning in scheduling	The principal-made school
Variable group sizes	Standard classrooms
Team teaching	One teacher for a class
A self-pacing approach	A textbook approach, with all students on the same page at the same time (44:13)

Characteristics of a Middle School

Many different types of middle schools have developed over the past 20 years. Today, many middle school experts suggest that this diversity, individuality, and uniqueness is part of the strength of the middle school movement (34,66,67). There are, however, some commonly agreed upon characteristics possessed by "real middle schools"—i.e., those that are more than a name. A middle school is one that has:

1. A program that has been specifically designed to meet the physical, intellectual, social, and emotional needs of the pre- and early adolescent (35,46,60,68,69) and to cope with the problems of pre- and early adolescence (66). The mission of this kind of school is neither remedial nor preparatory (17); it is a school that promotes learning for the "here and now," not for some future time (55).

2. A wide range of exploratory intellectual, social, and physical experiences (49,70,71). Exploration should characterize the whole program (72). The school should provide optimum individualization of curriculum and instruction for a population characterized by great variability (73). There should be many electives available to all students to help them discover more about themselves, their interests, and the world around them (74). Exploratory programs should give students opportunities to develop interests in aesthetic, leisure, career, and other aspects of life (62,75,76,77).

3. An atmosphere of basic respect for the individual that can make a reality of individualized instruction (51,66,78). This may occur best in a nongraded, continuous-progress form of instructional organization (46,54,79,80).

4. An environment in which the student and not the program is most important and where the opportunity to succeed is ensured for all students. Development and enhancement of self-concept is recognized as an important educational goal (67,74,81). Students should be known, respected, able to experiment, and able to find success (82). There should be the absence of a "star system" in which a few special students dominate everything; in contrast to this, enhancement of feelings of worth in all students should be encouraged (83). It is recognized that self-esteem appears to have a stronger relationship to school achievement than either ability or motivation (84).

5. A positive and active learning environment (74,82,85). An active learning environment should be promoted since this is an important means of relating learner characteristics such as variable attention spans, physical restlessness, and concrete cognitive capabilities to subject matter (73,86,87). Restlessness and wide swings in energy level of students suggest the need for scheduled time to unwind, perhaps in the form of morning and afternoon breaks (88).

6. Facilities and scheduling that are flexible enough to allow for a variety of grouping patterns and activities (71,74,87).

7. A setting in which every student is well known by at least one staff member. A teacher-counselor in a home base or advisory group setting may be that staff member (24,60,89,90). In order to accomplish this, teachers will need to expand their perception of their role to include the whole child in a wide context. This strong teacher-counselor role is necessary in order to cope with the emotional and psychological crises that occur with this age group (66,79). Students also have a strong need to know and relate to an adult other than a parent (82).

8. A program that specifically helps pre- and early adolescents to grow in self-understanding and the understanding of others and includes the special concerns of this age group (18,34). Commitment to both the physical and mental health of each child is a middle school emphasis (74).

9. Multiple opportunities to develop social and human relations skills in activities appropriate for the age group. Learning to work well in a peer group is a developmental task for pre- and early adolescents (91). Schools need to find ways to deal positively with the importance of peer approval and the norm of conformity to peer behavior that can result in an intolerance of other's apparent differences (88). Learning often can be promoted best in an interactive context that includes working in dyads and small groups (69,92,93). Middle schools should deemphasize sophisticated social activities that mimic high school social life, such as competitive interscholastic athletics, early dating, night dances, and other "grownup" activities. Interest groups and low-keyed intramural and social activities should be programmed (74,79).

10. A concern with affective, as well as cognitive and psychomotor, development (94,95,96). The importance of affective factors as motivators--friendship, good grades, positive feedback--is acknowledged (97). Opportunities for values clarification and development should be a part of the school program (51,88).

11. A concern with creativity and divergent thinking as well as convergent thinking (79,98). There should be many opportunities for expression of creative talents through musical and dramatic programs, student newspapers, art, and other means of expression. Students should be able to do much of the planning and carrying out of such activities on their own (74).

12. A way to facilitate a smooth educational transition between elementary and high school while allowing for the physical and emotional changes taking place during this stage of development. It should provide a way to mediate between the onset of adolescence and the pressures of culture--a way to continue general education applied in a psychosocial environment that is functional at this stage of socialization (19,24,99). At the sixth grade level, the security and recognition found in a self-contained classroom needs

to be programmed in some way (31,72). Means must be found to promote continuous progress through and smooth articulation among the several phases and levels of the total educational program (73).

13. A program that provides a means to acquire essential learning skills in a sequential and individual manner. These skills would include reading, listening, asking questions, using library resources, and organizing information, among other things (45,80,100). A nongraded approach that will accommodate differentiated rates of growth is a suggested way to do this (46). The teaching of reading in the content areas and an emphasis on developmental, as well as recreational and remedial, reading should be a part of middle school programs (66). Multimaterials, rather than basic textbooks, should be used since maturity levels, interests, and backgrounds of students vary widely (79).

14. An educational climate that emphasizes learning how to learn. Developing abilities to solve problems, determine values, and be receptive to new facts should be a part of the educational process (70,71,74,78). The emphasis should be on inquiry rather than memorization (54). Every subject should be taught to reveal opportunities for further study and to appraise interests and values (72). Students should have some opportunities to direct their own learning; there should be an emphasis on self-direction and self-responsibility through a choice of activities (74,101).

15. A physical education program designed to develop conditioning and coordination (51,92). A strong intramural program should replace the traditional highly competitive athletic program. Stress should be placed on large muscle development, team sports, and helping students to understand and use their bodies (74,88).

16. A health program geared to promote positive physical and mental health and to provide sex education appropriate for this age (51,102). Since students this age are self-conscious in terms of rapid or slow development of secondary sex characteristics, health units should include self-image, physical development, and sex role identification (88).

17. Guidance in the development of mental processes, attitudes, and values needed for constructive citizenship (71,72,103). Students should have opportunities to be of service to others (101,104). Students with ethnic backgrounds need opportunities for conscious confrontation with their ethnic identity and for content about ethnic life styles; there is also need for learning skills of conflict resolution (105).

18. Staff members who recognize and understand the students' needs, interests, backgrounds, motivations, and goals as well as fears, stresses, and frustrations, and who are competent to deal with them (24,51,71). Since the students' attitudes toward school and school work are so affected by their relationships with teachers, skillful teachers are the main ingredient in a successful middle school

(106). Teachers need to be secure persons (107) who are effective in the area of human relationships (108). Teachers must understand the students' unpredictability in response to adult affection and their tendency to show rejection or ambivalence (109). A continuous teacher inservice program that stresses the personality development of students and the implications for education is necessary (74).

19. Varied instructional methods appropriate for this age group. These would include individualized instruction, variable group size, independent study programs, use of multiple materials, instructional media centers, and computer-assisted instruction (45,74,92,99,110).

20. Concern for the matching of teaching and learning styles. Each middle school staff needs to develop a range of teaching styles and approaches that provide specific learning environments for students who show a need for them (67).

21. An emphasis on diagnostic teaching. Teachers need to become diagnosticians of learning needs and resource persons who guide instruction (113). They also need to be able to assess the effectiveness of learning experiences in the achievement of special purposes for students (66).

22. Some cooperative planning and team teaching to provide interdisciplinary programs are provided (24,74,92,114,115). Subject matter areas should be reassessed with a view to a more effective synthesis of content and the development of interdisciplinary approaches (94). Teams of teachers from a variety of academic pursuits should provide opportunities for students to see how areas of knowledge fit together (46,54,116). Interdisciplinary learning is often cited as an appropriate way to make subject matter relevant to the interests and concerns of students (83,114,117,118,119).

23. Effective leadership from its principal. More than anyone else, the principal determines the atmosphere, direction, and effectiveness of a school. The principal should view herself or himself as an educational leader who maintains close touch with the school program and curriculum and who involves the staff in the decision-making process (54,66).

24. Evaluation of student progress carried out in a manner that is not counterproductive to major middle school goals nor destructive to student self-esteem insofar as possible. The marking and reporting system should focus on individual growth and include some self-evaluation features (24,120,121). Growth is measurable; evaluation should reflect student personal growth (54). Student conferences, as well as parent conferences should be part of the evaluation process (122).

25. Participation by parents and other community resource people in order to broaden the context for education (75,123,124,125). A planned program of community relations should not only involve parents and other community leaders in school programs and activities, it also should involve parents and community leaders in the decision-making process (74).

CHAPTER 2

THE MIDDLE SCHOOL CONCEPT

The middle school movement, as recently characterized by the President of the National Middle School Association (NMSA), John Swaim, is "entering a new era." The number of middle schools has grown constantly throughout the seventies, increasing during the past four or five years by 500 to 600 schools per year (126). A sharp increase in the number of middle schools is predicted for the first half of the eighties, followed by a leveling off during the last half of the decade. This increase will be due, in part, to the several large metropolitan districts presently converting to middle school organization.

However, when consideration is given to the number of middle schools truly trying to work within a middle school philosophy--"the middle school concept"--Swaim notes a decreasing trend. Many are middle schools in name only, despite the efforts of organizations like the NMSA and the Association for Supervision and Curriculum Development (ASCD) to provide guidance and direction to schools making changes in organizational structure. In facing the eighties, Swaim suggests it is increasingly important for the NMSA to keep the middle school movement focused on "creating an educational environment attuned to the needs of the emerging adolescent."

What is "the middle school concept"? While no rigidly prescribed formula for a "real" middle school is suggested, leaders of the middle school movement identify a variety of characteristics, which together comprise a middle school philosophy and rationale. Some of these characteristics are:

1. Middle school programs should be planned to meet the physical, cognitive, affective, and social needs of the early adolescents they serve. The diversity found in 10- to 14-year-olds is tremendous, and educational programs should attend to this diversity.

2. The change from concrete to formal reasoning is a natural part of human development often occurring during early adolescence. Middle school curricula should provide learning experiences appropriate for this transition.

3. An "active learning environment" should be promoted, since this is an important means of relating learner characteristics--such as variable attention spans, physical restlessness, and concrete cognitive capabilities--to subject matter.

4. Students should have opportunities for a wide variety of learning experiences and should have some opportunities to direct their own learning. Decision-making and problem-solving skills should be emphasized.

5. Interdisciplinary learning and team teaching often are suggested as being appropriate ways to make subject matter relevant to the interests and concerns of students.

6. The psychomotor and affective domains of learning should receive more attention than is usually the case in departmentalized junior high schools (94).

7. Participation of parents and other community resource people is encouraged (123). Middle schools should find ways to get youngsters into the community and to bring the community into the school.

8. Professional staff should be well trained in working with early adolescents. They should also be committed to students in this age group and enjoy working with them. The role of the teacher as one who is sensitive to the needs of early adolescents is emphasized.

9. The curriculum should excite students' natural curiosity. Creativity and divergent thinking should be as actively encouraged as convergent thinking (98). Exploratory programs should give students opportunities to explore and develop interests in aesthetic, leisure, career, and other aspects of life (89).

10. Each student should be recognized as a unique individual. Guidance and/or home-base programs should be carefully designed; "every student should be well known by at least one adult in the school who accepts responsibility for her or his guidance" (89). Development of a positive self-concept and the opportunity for successful learning experiences are sought for each individual student.

11. Developing appropriate interpersonal skills and socially responsible behavior are cited often as middle school goals (127). Learning can be promoted best in an interactive context that includes working in dyads and small groups, as well as in whole classes. Peer group formation is a major aspect of the early adolescent experience. Schools need to establish ways to make it a positive aspect of the educational experience.

12. Evaluation of student progress should be done in a manner that is not counterproductive to major middle school goals. In the struggle to establish adolescent identity, students are extremely vulnerable to assaults on their self-esteem. A marking and reporting system should focus on individual growth and include some self-evaluation features (121).

13. The lack of uniformity presently found in the middle school structure and program is viewed positively: "By resisting institutional

rigidity, the middle school has remained a dynamic concept" (98). Most middle school staffs work at developing their own curricula to meet the perceived needs of their particular student body.

14. "Back-to-basics" pressures have affected middle schools as well as other schools. Additional time allotments for reading and mathematics have been added. This practice frequently conflicts with other policies and programs characteristic of middle schools.

15. The essentials of education, including "the ability to use language, to think and to communicate effectively, to use mathematical knowledge and methods to solve problems, to reason logically, to use abstractions and symbols with power and ease, to apply and understand scientific knowledge and methods, to make use of technology and understand its limitations..." are endorsed by the Publications Committee of the NMSA (May 1980) as well as by many other educational groups.

16. In instructional processes, good middle school education is often closely related to good elementary school education (73).

17. An overall goal of the middle school concept has been to provide a smooth educational transition from elementary to high school by developing an educational institution with a uniqueness and an identity of its own. That identity should be based on the uniqueness and identity of the 10- to 14-year-old students it serves.

CHAPTER 3

SCIENCE INSTRUCTION, 1965-1970 and 1975-1980

Rationale and Goals, 1965-1970

In writings about middle and junior high schools between 1965 and 1970, discussions of the rationale and goals of science instruction generally were brief. Sometimes general goal statements were made; often, however, the section dealing with science merely presented examples of what specific schools were offering in terms of course structure or organization. In some instances, only course titles were presented.

When general goals and objectives for science instruction were presented, there was some agreement about them. There was, however, recognition that a lack of understanding of the purposes of science education contributed to the variation in science instruction found in junior high schools and middle schools during this time period (17). Some identified objectives were:

1. To develop a better understanding of the natural and physical forces of the environment and how human beings interact with the environment to their betterment or detriment (20,51).

2. To develop a clearer and more accurate comprehension of the processes of human growth and development in order to cope better with growth changes occurring in self and peers (51).

3. To become familiar with orderly methods of scientific investigation (17,51); to develop skills in critical thinking and experimentation (17); to seek answers to questions by scientific reasoning and interpretation of evidence collected by scientific design (20)

4. To develop a familiarity with the practical aspects of science (51) and an understanding of science as a human enterprise (20)

5. To acquire some knowledge of the world of science with an emphasis on concepts and principles (17,20)

6. To explore opportunities for careers in science (20)

7. To find through a study of science a means of enriching life through recreational and avocational pursuits (20)

8. To make science interesting and exciting to all students (17)

Changes in the Teaching of Science, 1965-1970

Writings about the middle or junior high school reflected perceived changes and trends in the teaching of science. Commonly reported changes were as follows:

1. A transfer of science content from high school to junior high or middle school and from junior high or middle school to elementary school (20)

2. Longer, more intensive study of fewer science topics, with longer periods of time elapsing between study of similar topics (16,17,20)

3. Reduction in the amount of science information presented in order to permit greater emphasis on principles and procedures basic to the study of science and how scientific knowledge is obtained (16,20,99); use of new programs grounded in concepts and structures of the various science disciplines (99)

4. Less emphasis on the accumulation of facts; more emphasis on developing inquiry skills; experimentation when conclusions are not predetermined (16,99); more "doing" of science appropriate to developmental level (53); more use of projects, small group activities, and experimentation to develop skills of inquiry (20); change from the teaching of one problem-solving method to many relatively unstructured methods (16)

5. Increased use of mathematics as a tool in the study of science (16,20)

6. Making science classrooms more like laboratories so that student experimentation could occur (17,20)

7. An increased amount of time given to science in the curriculum (17,20)

8. Recognition of the importance of science instruction for all students coupled with recognition of individual differences in students (17,20), resulting in the development of a track program in science (18) or some other means of instructional individualization (20,54,70)

9. Less reliance on a single textbook; greater use of audiovisual materials, supplementary materials, and multi-textbooks (16,17); greater use of flexible scheduling and facilities (17)

10. Greater use of community resources (53)

11. Exploratory opportunities to encourage students to understand and appreciate materials representing physical, life, and earth sciences to the limits of their abilities (53)

12. More emphasis on the study of science itself and less on the application of science (16,17,20)

13. Movement of science out of the core program to make it more laboratory-oriented (16)

14. Agreement that science should be required but little agreement on exactly how much should be required or in what form it should be presented. Writings about middle schools and junior high schools did not present a unified picture of a "common" science program. Some authors suggested that general science was the most usual offering (16,18,19,53,99). Others reported a program that presented life sciences in the seventh grade and physical science in the eighth and ninth grades (17,20). Many middle schools developed local science programs that were thematic (15,46). In some instances, science was combined with mathematics or health in a double-period, block-time program (53). Some use of curriculum projects such as Introductory Physical Science (IPS), Earth Science Curriculum Study (ESCP), and Biological Sciences Curriculum Study (BSCS) was reported (16,17,18). In some cases, honors programs at the ninth grade level were offered (18,20).

15. Many middle schools and some junior high schools had science-related clubs and science-related exploratory mini-courses (15,20,46).

Issues and Problems, 1965-1970

Articles about middle and junior high schools in this period rarely discussed issues and problems specifically related to science instruction. However, Howard and Stoumbis identified the following "old problems...and new issues" (17:127,128):

1. Textbooks. In these times, textbooks soon became obsolete, and perhaps that's a good thing, since many are full of errors and inconsistencies.

2. Teachers are still too often inadequately prepared. Even worse, it is not uncommon in junior high school to find a teacher saddled with a science class he didn't want and can't really teach, but has it because of "scheduling problems."

3. There is still too much teaching from the text and not enough pupil lab work.

4. Many schools attempt to teach too much content. It is impossible to teach or learn everything.

5. We still tend to underestimate the ability of interested students.

6. There is still too much repetition of content.

7. Too many junior high schools are still plagued by a lack of facilities, lack of materials, and a shortage of time to teach.

8. Science changes so rapidly that there is a need for a continuing inservice teacher-training program.

9. There is a conflict of opinion between those who believe that all science should be integrated and those who think that each subject should be distinct. General science is often criticized for just that—it is too general.

10. There is some feeling that there is a gap in the new programs, since there has been an omission of any real attention to applied science, engineering, and technology.

11. Unquestionably, the substantial majority of the new programs are aimed at the college-bound student.

12. There is a need for a correlation of instruction in mathematics and science.

Teaching and Learning Practices, 1965-1970

During this period, writings about middle and junior high schools often included general discussions about teaching and learning that had some application to science instruction, although the discussions presented usually did not relate specifically to science. The point was made often that good middle school or junior high school teachers need to be skillful in a variety of teaching techniques and that they should know by training, experience, and insight when to apply each particular method (15,20). Discussions of teaching and learning methods were organized in various ways. For example, Gruhn and Douglas (20) grouped teaching methods into four general approaches:

1. Assign-study-recite approach. This is the traditional teacher-dominated method of using a textbook or other materials where reading text material, discussing it, and being tested over its content are the major teaching/learning activities.

2. Subject-centered approach. Curriculum content is organized into a unit of content for all to use.

3. Activity-centered approach. Various kinds of pupil activities, often problem-oriented, are preplanned and prearranged by the teacher and carried out by the students.

4. Experience-centered approach. Learning experiences grow out of a pupil's expressed needs, interests, and abilities. They result as an outcome of cooperative teacher/student planning carried out in a cooperative, informal, and democratic manner. A variety of instructional materials and strategies are incorporated into the learning experience. Fundamental skills are taught as they are needed. The experience-centered approach is advocated as being the approach most appropriate for the attainment of the oft-stated goals of junior high and middle school education.

Within these approaches, a variety of teaching methods were suggested as being effective. Some of these approaches were traditional, having been the backbone of educational practice for decades. The lecture method, if not overused, was recommended to present specific information and provide key questions for student consideration (15). Short lectures could lead to discussion. If effective discussion was to take place, however, the teacher had to establish a classroom climate that encouraged acceptance of divergent ideas and open-minded problem solving (15).

Role-playing also was suggested as ideally suited to junior high and middle school learners, since it allows students to learn from one another and to put themselves in different situations (15). Programmed instruction, which is student rather than teacher centered, could free teachers to work with individual students and individual learning problems. Self-paced learning packets frequently were advocated as effective ways to individualize instruction (16,46). Many middle schools developed their own teacher-constructed learning packets for science classrooms. Bondi (46) presented some of the topics developed in this manner by the St. Cloud, Florida Middle School; for example, "Weather and You" and "Light--The Human Eye."

Team teaching was recommended often as a way to organize instruction in middle and junior high schools. The ways to organize teaching teams were virtually unlimited--either within or across grades or within or across subjects. In intradisciplinary teams, teachers concentrated on using their areas of special preparation, knowledge, and skill to help each other to plan effectively and to provide large- and small-group instruction. In interdisciplinary teaming, English and social studies often were combined; in some instances, English, social studies, and science were combined for cooperative teaching of interdisciplinary units of study or experiential education (15,20).

Flexible scheduling often was advocated to improve educational practice (16,158). Availability of different time blocks and sizes of instructional groups was recommended as being particularly valuable for the teaching of science. For example, longer laboratory periods and shorter large-group, lecture-demonstration periods became possible when a flexible schedule was implemented (16).

Many authors recommended independent study opportunities for middle school and junior high school students to facilitate the frequently mentioned objectives of increasing responsibility for learning and enabling students to pursue elective interests on their own. However, few schools appeared to have independent study programs that involved a high percentage of students (16). When independent study programs were coupled with team teaching efforts, it did become possible for teachers to work with smaller groups of students and to encourage independent study (16,159).

Supervision and Administration, 1965-1970

In junior high and middle schools, as compared to high schools, the role of department chairperson was deemphasized during this period, thus avoiding a narrow specialized focus (53). Administrative staff and counselors were encouraged to help teachers understand students and work effectively with them (53). In some large junior high schools, a school-within-a-school organizational pattern was useful in encouraging flexible scheduling, an atmosphere in which students were well known by staff, and a program more likely to result in attainment of typical educational goals for the junior high school (53).

Curriculum coordinators were useful in helping new teachers solve instructional problems, in bringing teachers together for curriculum planning and evaluation, and in introducing educational innovation (20). The principal was responsible primarily for the planning, organizing, and controlling functions of the school (54). However, planning activities sometimes were delegated to the staff. Decision activities were carried out on a full continuum from principal-centered leadership to staff-centered leadership (54). Evaluation was done by a review team including administrative staff and teachers (54).

The role of inservice education in relation to teacher attitude and student achievement was recognized (15). Effective teachers had to understand the pre- and early adolescent; they needed "how to do it" education for new content and methodology; they needed encouragement to develop positive professional attitudes toward educational change and innovation (15). It was known that supervisory style in different contexts affects attitudes toward change. Autocratic supervisory climates could be expected to result in hostility and aggressive behavior, disruption of group cohesiveness, and a lack of initiative and originality. Enhancement of positive self-concepts for teachers was an important goal of inservice education (15).

A team teaching organization encouraged supervision of junior team members by team leaders. The less experienced team members observed outstanding teachers. Cooperative planning was carried out; professional growth and development of all team members was encouraged (15).

Rationale and Goals, 1975-1980

Writings about middle and junior high schools during the past decade do not provide a separate rationale and goals for science instruction. Characteristics that define an effective general educational program are discussed widely, but the content areas usually are not addressed separately in much detail, although some sample units of study, learning packets, or individual school programs are scientific in nature (73,74). Interdisciplinary units may include scientific components, for example, "technology" (74).

Science is viewed as part of the course of studies designed to prepare students for social competence. It is one of the four content areas that comprise the basic studies program (the other three being mathematics, language arts, and social studies). In the middle school, these subjects often are taught in an academic block of time by an interdisciplinary team of teachers (74). Books about the middle school may include examples of general goals, portions of which are science-related. For example, the Hastings Public Schools include as a goal:

> Knowledge of the humanities, social sciences, natural sciences and environment, and the relationship between one's own acts and the quality of the environment at a level required to participate in an ever more complex world. As indicators of this goal, the students will demonstrate (74:310):
>
> a. Knowledge of the basic methods of inquiry in each field
> b. Interdisciplinary efforts to focus knowledge on contemporary and future problems
> c. Awareness of one's relationship to the environment
> d. An attitude towards preservation and wise use of natural and human resources
> e. Understanding the effects on the environment of human activities and values, lifestyles, technologies, population growth, energy use, etc.

The following sample of suggested themes for science in the middle school is suggested by Wiles and Bondi (74:98-101):

MAN AND THE WORLD

FIRST LEVEL

Man and His World

How man learns about his world:

Five senses: Observational skills, bias, recurrence, discrepancy, sense extensions, i.e., microscope

Graphics and quantifying: probability, development of patterns, science attitudes--news, UFO, ESP...

How man behaves toward his world:

Categorizing...
Measurement...
Model building...
Communication of data...

How man expects his world to behave:

Consistency and uniformity...
Cause and effect...

SECOND LEVEL

The Kind of World Man Thinks He Has Found

Man assumes the existence of variation and change

Normal curves...
Directional variation...
Extrapolation and interpolation...
Time--gradient--natural selection
Repeating sequences...
Interacting changes that result in balance...

Man thinks in terms of relationships rather than absolutes

Measurements express relationships...
Patterns govern relationships...
Frames of reference determine relationships...
Interdependence consists of relationships...
Heredity and environment are related...
Changes and rates are related...
Man and his tools are related...

THIRD LEVEL

Man Finds That His World Has Limits

Science is limited by how we feel about the world

We can look at our world two ways:

Problems of conflict, poetry and real world, painting and pictures, music and sound

Complementarity--Structure and function, nature of light, science and religion

Continuous discovery:

Prognosis of science inquiry
Limitations
Moral obligations
Social limitations--political and cultural

Teaching and Learning Practices, 1975-1980

Writings about middle and junior high schools in the period from 1975 to 1980 include discussions about teaching and learning. These writings emphasize a variety of themes, which are summarized below:

The Importance of the Learning Climate. An effective educational environment for 10- to 14-year-old learners should provide a sense of security while permitting socialization and exploratory learning activities (34). Since early adolescents are seeking greater independence, the learning environment should permit students to accept challenge. Variables affecting climate include structure, responsibility, reward, risk, warmth, support, standards, conflict, and identity (74). Teacher leadership style determines classroom climate. Once created, learning climate has a significant effect on student motivation and performance. Swick and Gatewood (82:11) identified ten conditions needed to promote a learning climate that is both affective and accountable. These conditions, stated in terms of students' needs, are:

To be known
To be respected
To be able to learn
To be able to find success
To be able to experiment
To be able to find structure
To be able to be alone
To know and relate to peers
To know and relate to an adult
To be able to become...

The Importance of the Teacher in Determining Educational Outcomes. Much has been written about personal characteristics important to teaching successfully in the middle school or junior high school. McMasters (107) identifies the need for resilience, personal security, and commitment to the democratic process and to giving students choices. Liking students; displaying enthusiasm; being alive intellectually, physically, and socially; having an open mind; possessing a wide variety of skills; being compassionate, tolerant, and flexible are listed as important personal characteristics by Wiles and Bondi (74), who also present several lists of "key competencies" for teachers as identified by several sources. One list suggests 61 needed skills that range from planning 'multidisciplinary lessons' to functioning calmly in a high-activity environment.

The Importance of the Relationship Between Various Aspects of Self-Perception and a Wide Variety of School-Related Variables (128,129). Bean, Lipka, and Ludewig (130), in synthesizing research on the self-concept, suggest that these variables include school achievement, perceived social status among peers, participation in discussions, completion of school, perceptions of the individual held by peers and teachers, pro-social behavior, and self-direction in learning. They also suggest that schools have many opportunities to enhance the development of individuals by moving (130:85,86):

From a custodial climate to a humanistic climate
From accepting failure to expecting and ensuring success
From attribute grouping to variable grouping
From age-isolation to multi-age interactions
From avoiding parents to working with parents
From institutionally imposed rules to cooperatively made rules
From subject approaches to life-centered approaches
From adult-exclusive evaluation to more self-evaluation

Since its inception, the middle school movement has emphasized the importance of developing educational practices that enhance rather than destroy a positive self-concept.

The Importance of Grouping Practices. Grouping practices in relation to organizational structure, teaching strategies, and student characteristics receive much attention in the literature. Wiles and Bondi (72) recommend that flexible grouping patterns be employed. Such patterns should include large groups, medium- or class-size groups, small groups, one-to-one learning situations, and independent study. Both heterogeneous and homogeneous groupings should be used, depending on interests, tasks to be accomplished, and skill levels.

Multi-age or "family" grouping is suggested by Milburn (131) to promote positive attitudes toward school and learning skills of cooperation. Eichhorn (34) recommends developmental grouping as a means of minimizing the effects of growth factors in order to maximize learning. He reports on the developmental grouping program used by the Upper St. Clair school system over the past decade and suggests that developmental age grouping enhances continuous progress educational organization,

improved climate for instruction, and the overall effectiveness of middle school education.

The Importance of Varied and Active Instructional Strategies. A need exists for a wide range of active instructional strategies, including learning centers, games and simulations, instructional packages and other forms of individualized instruction, and independent study (73, 74,86,127). The use of concrete learning materials and varied and appropriate questioning strategies are emphasized (132). Meeting the learning needs of individual students is a continued emphasis.

Along with the recognition of the need for varied and active learning strategies is the recognition that learning is best facilitated when the learners themselves have a share in developing and managing their own learning experiences. The school curriculum should not consist entirely of a "canned" curriculum (133).

The Importance of Teaching Reading Within the Content Areas. Within the past decade, educators have been challenged to improve the teaching of reading skills. The question of how best to do this has raised a variety of responses (66,134,135,136,137). In spite of a variety of approaches, there is agreement that all teachers should be trained to teach reading in their respective subject areas. Drawing from the field of psycholinguistics, Tovey (136) suggests that readers perceive and remember ideas that are of personal relevance. Readers interpret written discourse in the light of their immediate interests, questions, and understandings. Therefore, student interest is not only desirable, but an essential ingredient in instruction. Tovey urges teachers to evaluate the assumptions that underlie their teaching practices and their views of the relationship between reading and learning. If reading is not motivated by personally significant questions, even the most simply written books can be difficult to read. On the other hand, for the student who really wants to know about something, very complex text can carry much meaning.

The Importance of Interdisciplinary Team Teaching. Interdisciplinary team teaching is a recommended way to organize curricula, instruction, and staffing in middle or junior high schools. Interdisciplinary teaming promotes communication, coordination, and cooperation among subject-matter specialists. Students benefit from such instruction, escaping the fragmentation that characterizes much education (74). Such organization also facilitates the use of large- and small-group instruction and the implementation of independent study opportunities. Some middle school educators advocate a return to the core curriculum concept of the 1930s and 1940s as part of their interdisciplinary approach (73,80).

Interdisciplinary team teaching correlates content and skills and supports a personal development program focusing on the needs of students (115). Middle school educators have proposed various ways for planning interdisciplinary units of study; for example, "webbing" (138), "lesson plan trees," and "interdisciplinary planning wheels" (139).

The Importance of Recognizing Individual Differences in Learning and Teaching Styles. One of the current educational topics generating much interest and debate is the attempt to identify individual learning and teaching styles and to mix and match these styles. Gregorc (140) defines learning style as distinctive behaviors that indicate how a person learns from and adapts to her or his environment and give clues as to how a person's mind operates. In the past few years, educators have been trying to align learning and teaching styles (112,141,142, 143). Such attempts are now being appraised critically (144,145). Questions are being raised about the value of matching teaching and learning styles that relate to one's beliefs about education, teaching and learning, and how much students and teachers can and should change. Arth (111) suggests that a mismatch of student-preferred learning modality and teacher instructional methodology may result in discipline problems in young adolescents. He suggests the use of a learning style assessment instrument that will make possible students' assessment of their own preferred learning style.

The Importance of Brain Growth Periodization Findings as They Relate to Teaching and Learning. Since Herman Epstein's article on brain growth periodization appeared in Transescence in 1977, middle school educators have been interested in relating his findings to possible implications for education (146). Epstein reported a slow brain growth period in the 12- to 14-year age span. He predicted that it would be relatively more difficult to initiate novel intellectual processes during this time than in the periods both preceding and following it. He recommended that the curriculum should be altered to avoid novelties and to include a larger component of experience as well as practice of skills already acquired.

Toepfer (147,148) believes that many school programs "over challenge" 12- to 14-year-olds and that youngsters give up trying to learn things they cannot comprehend. He believes that it would be helpful to be able to identify when youngsters enter and leave the age-12-14-plateau period. He also suggests that further research into this period may be useful in understanding differences between boys and girls in learning experiences and timing from ages 11 to 15. Preliminary data suggest that girls experience more brain growth prior to the age-12-14 plateau than boys do and that the condition is reversed in favor of boys between ages 14 and 15.

Epstein and Toepfer (104) suggest that the middle school educational program should have a greater emphasis on students' interests. They suggest that much education should take place outside the school. They recommend community service programs, such as students working with the elderly in nursing homes and with children in day care centers. Teaching cognitive information should emphasize skills already learned.

Supervision and Administration, 1975-1980

Educators involved in supervision and staff development should be aware of what is known about adult learning. Adults come to any learning experience with a wide range of previous experiences, knowledge, interests, and competence. Individualization, therefore, is appropriate for adults as well as for children and youth. Many adults operate at the concrete level of cognitive operations; therefore, concrete and direct learning experiences are appropriate for them as well as for youth. Adults prefer to learn in informal situations where social interaction can take place among learners. Inservice educators and supervisors should (149):

- Include more participant control over the "what" and "how" of learning
- Focus on job-related tasks perceived as important by the learner
- Provide choices and alternatives
- Include opportunities to practice what is to be learned in real-life or simulated work settings
- Encourage learners to learn from each other
- Encourage participants to give one another feedback concerning performance and areas of needed improvement

Middle school team organization helps teachers function as professionals with freedom and responsibility to see that students learn, progress, and find excitement and joy in learning. It encourages initiative in team members and can help teachers and students alike to become excited about learning (150).

Teacher performance is the key to effective middle and junior high schools. Improving teacher performance is a complex task, but it can be accomplished by school administrators who demonstrate a supportive attitude, exemplified by verbal encouragement and moral support; real support in the form of planning time, supplies, instructional materials, fresh ideas, and inservice programs; and shared decision making. Kron (151) recommends a "broken-front" approach that sees inservice education as systematic, small-group, and developed as needs arise. If teachers articulate a need for an inservice program, that need should be met as soon as possible.

Haschak (152) reports the use of a daily "huddle" involving an interdisciplinary teaching team, a counselor, and other staff, including principal and assistant principal, as deemed appropriate. The "huddle" facilitates planning, administrative communication, professional development of staff, and communication with parents, as well as interdisciplinary planning.

Just as middle schools use peer pressure to their advantage in designing instructional strategies for students, middle school practitioners can learn from one another. Bourgeois (153) reports on interschool visits taking place under the auspices of the New England League of Middle Schools. Teacher exchanges of up to a week's time and

school-site conferences are a popular way of broadening teachers' experiences.

McGee and Eaker (154) report the findings of the practice of Supervision in Tennessee (155) that relate to the perceptions of junior high and middle school teachers and principals. The findings included the following:

> Almost 60% of the teachers in the study perceived their supervisory classroom observations as not being helpful. Of the principals included in the study, 93% believed that their observations were helpful to teachers.
>
> Psychological support to try new ideas usually was not provided for 77.8% of the teachers, although 86.7% reported that they needed this support.

Ritz and Cashell (156) report a recent study of the supervisory effectiveness of 143 science supervisors and 258 of their teachers in which teachers were asked to express their views about 26 informal and formal supervisory activities. Four factors influencing effectiveness emerged: instructional/intervening, interpersonal/supporting, management/planning, and socializing. Two additional factors also were identified: attraction (how much the supervisor is attracted to membership with the faculty) and acceptance (how much the faculty accepts the supervisor as a member). The views of teachers and supervisors differed significantly on four factors: instruction/intervening, interpersonal/supporting, socializing, and acceptance.

With regard to instructional/intervening activities (such as inservice workshops and co-teaching), supervisors rated themselves more successful than teachers rated them. On the interpersonal/supporting factor (such as helping teachers with personal problems, informal communication, and mediating conflict), teachers again rated supervisors as less effective than the supervisors rated themselves. However, regarding the socializing factors, the supervisors rated themselves much less effective than the teachers rated them. On the fourth factor, acceptance in the faculty group (in terms of how truthful, argumentative, or friendly supervisors could be), the teachers gave the supervisors significantly lower ratings than the supervisors gave themselves.

A second part of the study focused on trying to improve understanding of the dynamics of effective supervision: What are the elements that make supervision in science effective? Ritz and Cashell hypothesized that supervisors who develop a relationship of "psychological membership" (having a high degree of attraction and acceptance) with their teachers are seen by teachers as more effective supervisors than those whose faculty relationships are less positive. Analysis showed that group membership accounted for some 39% of the variance in supervisory effectiveness. The survey items that best explain this relationship suggest that general interpersonal/communication behaviors are the source of this correlation. The authors conclude that it is essential for supervisors to improve the interpersonal/communication aspects of their supervision.

To improve instruction, most types of supervision--management-by-objectives, clinical, human relations, and peer supervision--focus on teacher behavior. They stress what the teacher says and does in the classroom. This focus on teacher behavior is based on several assumptions (157):

- Teacher behavior will influence student behavior.
- Teachers can control their behavior to influence student behavior.
- Knowledge about the ways various teacher behaviors influence student behavior exists.

Zahorik (157) questions the acceptability of these assumptions. He notes the role that values play in the three assumptions concerning teacher behavior and suggests that supervisors should stress the development of values rather than the performance of certain behaviors. He suggests that supervision of values development should focus on the basic, fundamental elements of education; for example, the student, the subject matter, the teacher, and others. The supervisor should help teachers clarify their beliefs or convictions about these elements. To do this, supervisors need to clarify their own values and to make their values position known to teachers. They could develop their own values prior to attempting values development supervision, or they could develop their values along with the teachers through dialogue and mutual clarification. In this form of supervision, behavior is seen as an outgrowth of values development. The supervisor would be concerned with the relationship of values to behavior and would try to help teachers achieve consistency between values and behavior.

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SECTION II ANALYSIS OF MAJOR COMMITTEE REPORTS WITH RESPECT TO MIDDLE AND JUNIOR HIGH SCHOOL SCIENCE INSTRUCTION

CHAPTER 1

GOALS FOR SCIENCE TEACHING IN MIDDLE AND JUNIOR HIGH SCHOOLS

Goals and objectives represent the direction and foci of educational efforts in science, the expected changes in the potentialities, proficiencies, and attitudes of students who enter the process. In this sense, goals represent the commitment and role of science teachers. Goals presumably provide criteria for selecting and organizing subject matter as well as for assessing educational benefits from schooling. They are the conditions needed to maximize the desired returns from instruction. Under the best circumstances, all policy and practical decisions are made in terms of the conceptual framework that harbors the array of science educational goals.

In examining the information from the three NSF status studies relative to goals, we found it necessary to consider implicit as well as explicit information. This attests to the difficulty of identifying the goals of science teaching as they are expressed in educational literature and reflected in teacher practices and the curriculum. In addition, teachers sometimes state they are supportive of a goal, such as inquiry, but fail to use learning activities that provide students a reasonable expectation of attaining the goal. Thus, we have teaching goals that exist more in theory than in practice.

Socializing Goals

Teachers and educational specialists often do not interpret the use of goals in the same way. Most teachers tend to think of goals and objectives in terms of "socializing" the students (lg:24). Socialization is the process of bringing students into an acceptance of the customs, standards, and traditions of schooling. Socialization includes active cooperation with the system, not rebelliousness (Ig:26.3). The subject matter of science frequently is used to create order in the class and maintain teacher control (lj:5). The teacher's goal is to help students accommodate "the educational system as it is for their own benefit, and for the teacher's benefit" (lg:26.3). Teachers are mostly concerned with the circumstances of their own classrooms (lg:12) and the emphasis is on working hard, keeping busy, being polite, competing, aspiring to improve, working independently, and preparing for things to come (lh:25). Essentially, the goal is to produce the "good" student (lj:4), to encourage "poor" students to work harder (lg:15,16). Good

students get good grades (1c:18). "Good grades" mean that the student is being prepared for the next rung in the educational ladder (1j:4, 1g:21,24,35) and, for the very best students, entrance to college (1c:18). A major complaint of middle and junior high school science teachers is that students come to them from the elementary schools poorly prepared and lacking motivation (2:182).

Subject matter is determined by how it sustains and protects the teacher in the social system of the class (1g:23), more so than by its validity in academic terms (1b:18). The goal of learning is the development of skills for acquiring information from the textbook (1j:6), and students learn best by successfully carrying out assignments (1g:12). Science teachers apparently are more oriented toward socializing functions than toward subject matter or students (1g:3). Though the emphasis in the science curriculum reform movement of the 1960s and 1970s was "to know the structure of a discipline" (2:182), this goal is not commonly accepted by teachers.

Knowledge Goals

The science curriculum of the schools is regarded as a set of knowledge and skills rooted in the academic disciplines (1j:4, 2:182). Of the 23 states that have established science goals, 17 list the major goal to be acquiring "facts, concepts, and principles" of science (2:173). The selection and conceptual organization of the subject matter are functions of the textbook or worksheets rather than of teachers or students (1g:21). "Teachers argue there should be a significant body of learning at every grade level which is difficult, which may not make much sense at the time, but which has to be learned by every student" (1g:16). The primary responsibility of schools is academic, and teachers feel it should continue to be so (1b:18). In this vein, cognitive achievement is viewed as increasing one's factual knowledge and, ultimately, one's ability to make better scores on achievement tests (1h:26).

The validity of the subject matter or the facts to be learned is a function of the instructional materials. There is a strong philosophical bias toward the authority of book learning (1f:61). Over 90% of a sample of 12,000 science teachers stated their instructional materials were the heart of their teaching curriculum 90% to 95% of the time (1d:66). The textbook is accepted by teachers; they seldom criticize the book they are using, and most teachers state they are not concerned about the "philosophy" of their subject. Teachers often appear to use subject matter to demonstrate their personal competence and to control and impress students (1g:7).

Inquiry Goals

In spite of the efforts of some science educators to keep alive the idea of inquiry as a goal of science teaching, there is very little inquiry to be observed in schools (lc:1,5); inquiry as a goal has a low priority (lc:11); most of what passes for inquiry occurs in the elementary and junior high schools (lg:31). Principals of grades 7 through 9 were surveyed. It was the judgment of 73% of them that less than 25% of instruction time in science is spent on inquiry (li:68); the median time was about 10% (lg:31). A majority of teachers stated they do not use "inquiry teaching" because students are unable to carry out inquiries, or inquiry is too difficult (li;68). Teachers were not confident they could make systematic inquirers of students (lc:4,li:68). They stated that inquiry teaching does not seem to work but for the very brightest (lc:7). A fourth of the teachers stated they do not have the materials or supplies to carry on inquiry/discovery teaching (lg:31,li:68). Others feel that "it is too hard to ask students enough of the right questions" to make inquiry teaching effective, or that students "are too likely to 'goof-off'" (li:68).

For whatever reason, there is very little inquiry teaching to be observed in schools (lg:30). A basic problem seems to be that teachers do not know how to implement a discovery/inquiry approach to teaching (3:144); they also find inquiry teaching threatening (lc:10). Though inquiry teaching is little evidenced in schools, most teachers are of the opinion there has been too much emphasis on discovery-learning, hands-on activities and field studies, and that the time spent on these activities did not serve the learner sufficiently well as he or she moved into another grade (lf:4). Understanding subject matter and being able to read intelligently, not inquiry, are viewed as the best preparation for the next learning experience (lc:3). Knowledge is interpreted as knowing the meanings of words, relationships among concepts, and steps to go through to solve problems (lc:3). Independence of thought (lg:23.3) and qualities of good thinking (lc:1) were regarded as more the student's business then the school's. Student inquiry and independence of thought were often seen as things one wishes for but which teachers should not allow to happen without pupils "first knuckling down to the dull, intricate lessons, first earning the right to express an opinion" (lg:26.3). Teachers neglect inquiry teaching for another reason--inquiry as a process is not included on standardized tests (2:158,lc:3).

There are other problems that have served to influence the lack of inquiry teaching as conceived by the curriculum developers of the 1960s and 1970s and by science education specialists. Teachers follow a nineteenth century view of the "scientific method" as defining a problem, forming a hypothesis, deducing observable consequences, and listing conclusions. The "messing about," "scuffle with nature," "hands-on," or an aesthetic appreciation of scientific inquiry is not prevalent (lg:7,8;lc:6,3). Science teaching in schools does not aim to develop an appetite for submitting beliefs to an empirical test (lc:9). Students react to scientific inquiry as being too abstract, too irrelevant to life's problems (lc:9). Furthermore, the diffuse nature of the

inquiry goal has failed to gain public support (lc:1). While inquiry remains a frequently stated aim of most science curricula, it is seldom found as a teaching practice (lc:5).

Science/Social Goals in General Education

These goals broadly include those that represent "general education" or "scientific literacy," in contrast to career goals or preparation for the next level of schooling. Science/social goals are sometimes described in terms of "science for the citizen." These are goals directed toward closing the gap between scientific progress and social adjustment and indicate something of the value people attach to the learning of science. Increasingly since the early 1970s, the literature on the teaching of science has referred to goals related to the impact of science and technology on society (2:185). Over 75% of parents, school superintendents, and science teachers state they believe science education can influence the growth of technology in our society, as well as the economy and quality of life, and they suggest the schools should try to do something along these lines (lj:8). A questionnaire sent to 150 school superintendents asked whether they though a lack of emphasis on science teaching might influence the growth of technology in our society, the economy, military preparedness, and the "quality of life" in this country, and 75% of the respondents replied "yes" (57% "yes" for military preparedness) (lh:20). However, 50% of the superintendents avoided answering this section of the questionnaire (lh:20). When teachers and school counselors were asked whether there should be a major effort to increase "scientific literacy," nearly all the teachers and 87% of the counselors responded positively (li:85). Over half of the students queried were in agreement; a third stated they did not know what "scientific literacy" meant (li:85).

If the question of science/society and "scientific literacy" goals are explored from the context of general education, we find a confusing picture. There is a broad commitment to science as a part of general education in the schools (lc:41). It is most likely to be interpreted as "minimal competency" or "functional literacy," but not in the sense of a person who understands, interprets, and can make critical judgments on science/social issues (lc:41). Nor is general education interpreted in the sense of understanding the world and oneself, or in terms of the meaning of science for human life and living (lc:41). The general education goal, while held to be important in schooling, is not observed to be achieved (lc:43). What is found is a discipline-centered curriculum taught in an authoritarian manner (lg:6), although some environmental education programs do endeavor to present science in the context of "the life worth living" (lc:43).

The apparent contradiction in school policy of affirming the importance of general education in science on the one hand and neglecting to implement the policy on the other, requires more extensive analysis. Of the 23 states that have identified goals for science teaching, only three list "science-society interaction" as a goal

(2:173). Six states list goals related to appreciation and attitudes toward science, and six list self-and-environment objectives as purposes of general education (2:173). Many elementary school teachers were encouraging the observation of natural and social environments, but few were developing conceptualizations (1c:1). General education goals for science teaching in the junior high school were not felt to be vital by teachers or parents (1j:24). In fact, general education in the sciences is downgraded by teachers (1g:17). They claim that deeper understanding of science for mature thought is a provocative idea, but one that lacks empirical substantiation (1j:24). "Scientific literacy" is something that depends on local circumstances and value patterns (1j:24). Furthermore, "scientific literacy" is not something testable with a single standard on a universal scale (1j:24). In other schools, general education courses in science are interpreted as those elective courses designed to "popularize" science, such as oceanography, ecology, environmental or ecological studies, and space science (1c:43).

General education in the sciences as preparation for future citizenship is most often thought of by school personnel as dealing with career preparation, not the future of the social order (1h:21). Overall, in the sites at which classes were observed, science was seen as having a rather limited value or importance in the education of <u>all</u> students (1j:24,1c:20). For most students, the goal of "understanding the world in which we live" is viewed as remote and impractical (1h:19). This may be one of the reasons students do not enroll in science courses unless they are required (1h:19). Teachers are inclined to avoid science topics that are likely to cause them "social discomfort" (1g:23) or may upset expectations of the community (1g:25).

During the middle or junior high school years, students are progressively segregated into "fast" and "slow" learner groups in science, and only occasionally is a voice raised to state that science is of benefit for everyone (1c:1). For each of these subgroups, specific rather than general educational goals are set (1c:1). Under this condition, a general education concept of science is conceived as something for students not in a college preparatory or a vocational track (1c:41). General education in science is for the "less able and/or unwilling" (1c:42). In other schools, an opposite position is taken; science courses that deal with the total environment and the world of ideas are reserved for an elite group of students who have done well with the "basics" and the acquisition of subject matter (1g:16,17). The core value of science in many schools is excellence in specialized knowledge; the relationship of this knowledge to the larger society is minimized (1f:4).

The general education curriculum in science is conceived as courses in general science, life science, physical or earth science, and sometimes general biology (1c:42). General science courses are promoted as courses with an "emphasis upon things useful in everyday life" (1c:45): a potpourri of things that are nice to know (1c:42) and contain few or no abstractions. One-semester and mini-courses (6 to 8 weeks in length) are sometimes designed to simulate general education courses such as horticulture, ecoscience, space science, or environmental studies (1c:43,44).

It is apparent that "science for the citizen" or "scientific literacy" has many different meanings in the schools (1c:46). Whatever these perspectives might mean as a goal of general education, it is not evident that the goal is achieved (1c.43).

Values as Goals

There is a trend in the rhetoric on science education to emphasize values as they relate to a positive self-image, self-fulfillment, and personal values (2:164). Some attention also is given to teaching the values of science as a contribution to thinking, problem solving, and preparing for the tasks of life (1c:26). Some teachers do transmit values (1c:33), and others have the impression that an emotional involvement with a topic is about the same as an ethical value (1g:30). These are not the value concepts idealized by science education specialists (1c:33). Most teachers reject the idea of linking science and social values, preferring the postivistic, value-free research ideology taught in most university science courses (1g:19). Teachers recognize the potentiality of trouble in dealing with value-laden questions and steer away from them (1j:14). There is not much discussion of social values, and any debate that might arise is curtailed by a reluctance "to get off the subject" 1h:23). One exception to this practice is found in considering "life worth living" issues found in environmental education courses (1c:43).

Career Education as a Goal of Science Teaching

Career education as a goal of instruction from the elementary through the secondary school was brought to a focus by a series of Congressional Acts and federal funding beginning in 1972. Prior to this time, a number of career-oriented educational activities and the development of instructional materials took place in the U. S. Office of Education. In 1972, the responsibility for research on career education was transferred to the National Institute of Education. To strengthen career education in schools, Congress passed and the President signed into law the National Career Education Incentive Act of 1977. The intent of these federal activities was to make career education an integral part of schooling at all educational levels (4).

The 1979 public school Gallup survey of parents of teenage students found that only 20% of these parents felt their children were receiving adequate career guidance (5). Parents speak highly of the vocational aim in schools; however, they are not convinced the aim is achieved (1c:24) and they want schools to do better (1c:25). This implies that science teaching must reflect concern for, and awareness of, science-related careers to be consistent with parental desires (2:160). Nearly two-thirds of parents and 59% of school superintendents feel that science courses should be aimed more than they are toward vocational

goals, but only 31% of science supervisors (grades 7 through 12) agree (1i:43). A number of states identify career education among the top ten educational goals or priorities (2:159,160).

Providing a strong program for those students who will become the nation's future scientists is not a high priority in school systems (1c:1). Only occasionally are students counseled into careers in science (1c:25a). For the most part, counselors see as their primary responsibility the placing of students in tracks, and they find that heavy counseling demands leave little time for long-range career planning (1c:25a). With the practice of identifying and guiding students into separate courses for "better achievers" and "slow learners," and with the "better" track oriented toward college, one may presume that the "better" students will have a more favorable opportunity to enter a science career (1c:11,22).

Career awareness as an educational goal should begin in the lower grades and be a collaborative effort of the total instructional staff (4,6). While science teaching should not be tied solely to careers, the science teacher has a vital responsibility in career guidance (7). However, teachers have not had the special preparation they need to carry out a career awareness program (2:71).

The 1980 "report to the President of the United States" (8) states "there is persuasive evidence that many students today are simply not aware of the career opportunities which exist in scientific and technological fields." The available data on science career education as a goal of science teaching in middle and junior high schools indicate strongly that the goal does not exist in practice. Career information is seldom found in science textbooks; science teachers, for various reasons, do not accept responsibility for career education; and school counselors seem not to have time for career guidance. Although there has been a decade of intensive effort by the Department of Education to popularize career education, supported by a budget of tens of millions of dollars per year, plus an extensive research program carried out by the National Institute of Education on career education, and the development of a wealth of instructional resource materials for teachers, little progress has been made in the schools toward effective career education in the sciences. Two-thirds of the science supervisors still do not accept career education as a goal for science teaching (1i:43).

"Basics" as Goals of Science Teaching

The question of "basics" in schooling is tied to the issues of behavioral objective and competency measures. "Basics" and "behavioral objectives" do not rest on a theory of knowledge for the teaching of science such as Herbert Spencer's <u>What Knowledge Is of Most Worth?</u> or Polanyi's concept of "tacit knowledge" where the focus is on the importance of knowledge. Rather, both "basics" and "behavioral objectives" appear to be based on assumptions about how specific information is acquired, retrieved, and quantitatively measured. Basics as goals

are considered here because they are so commonly interpreted as learning goals for science teaching. The confusion about basics in education will be evident from the data presented herein.

The consensus among teacher (55%) and parents (64%) is that schools give too little emphasis to the basic knowledge and skills that every student should have (1f:34). For all the school sites studied, the "back to basics" movement was apparent at every grade level (1d:45). Teachers perceive basics as skill in the Three Rs (1d:48) and rate reading as the "most basic of the basics" (1d:38,39). Science teachers tend to perceive basics in science to be a set of knowledge and skills rooted in the academic disciplines (1d:17) or knowledge about traditional subject matter (1d:35). To traditional teachers, teaching the basics often means raising the student's quality of performance; it is not a matter related to the curriculum (1d:37). These teachers tend to veiw the "basics problem" as one of instruction rather than of experiential learning (1f:3). Teachers in general are convinced that too little attention has been placed on basic skills (reading and computation) in schools, and have a "grand belief" that if science courses were better taught, cognitive achievement and basic skills would be improved at the same time (1f:3).

The movement to set specific (behavioral) objectives for science courses is well integrated with the movement to a fundamentalist (basic) curriculum (1e:23). "Back to basics" narrows educational goals to specifics (1b:18). Teachers are about equally divided on the issue of whether more specific instrumental goals will lead to an overemphasis on simplistic skills and the memorization of isolated facts (1i:97,1e:23). Parents have the same concerns. In districts where instructional objectives have been specified and tests constructed to measure them, no evidence was found that the procedure changed the achievement level of youngsters (1j:11).

There is another side to the "back to basics" emphasis in schools. "Back to basics" seems to be the most promising option in the light of decaying conditions in schools and the public outcry against funds spent for well-intended but failing program innovations (1b:12). Basics provide a goal for which teachers can identify their efforts (1b:18) and that they feel is more focused and articulated than are goals associated with the innovative curricula (1e:32). Teachers, more than the critics of education, are advocates of "back to basics" perhaps because they want to be accountable for assignments in which they can succeed; whatever else is taught is considered a student bonus (1b:18). This position is supported by parents. "Back to basics" appears to be a reaction against the science curriculum improvement program of the 1960s (1d:37). Teachers who tried some of the newer curricula are changing back to traditional curricula where there is a focus on performance skills and away from conceptualized experience (1f:5). Currently, it is the language of the behavioral psychometrician psychologists "who speak of the tasks to be accomplished, traits to develop, and things to measure and test" that dominates curriculum thinking (1e:33).

Goals and Student Diversity

Although teachers recognize the heterogeneity of students, the demands for equity in schooling have not led to a personalizing of objectives (le:23). Schools use goals to encourage a uniformity of instruction in the direction of least diversity (le:24). Teachers prefer to work toward common specific aims, for good or ill, for all students (le:23). While uniformity of instruction is seemingly opposed by principals and teachers, more uniform standards are sought (le:24, 26). Parents are equally divided on the question of whether schooling should be more or less uniform (le:26). Parents have a concern that when students from different junior high schools feed into the same high school, one group may be at a disadvantage if there is not a uniformity of goals and curricula (le:27). Teachers, curriculum supervisors, administrators, and parents wholeheartedly support the notion that a commitment to specified objective and firm curricular arrangements for each grade level would improve the sequencing of courses and better articulate educational efforts (le:28,29). There is a consensus that too much or too little uniformity could be harmful (le:27). Almost everyone, however, feels teachers should be free in the way they go about obtaining these goals (le:30).

Qualitative goals are not stated for gifted and talented students in the sciences. Two-thirds of the science teachers respond to the achievements of talented students by providing an opportunity for extra-curricular activities or by granting special incentives and privileges (li:33), such as appointment as a laboratory assistant or encouragement to enter a Westinghouse science talent competition (le:18). One-third of the teachers ignore the talented student with the comment "all students are treated alike" (le:33). Brighter students headed for college are provided with special courses in science, presumably with goals suited for college preparation (lc:17). There is an obvious conflict in schools between those who want to preserve a pluralistic society and those who would reduce heterogeneity (le:4).

Goals: Summary and Interpretations

Parents, students, teachers, administrators, and curriculum supervisors were asked to order the importance of science education goals under three headings:

1. Human experience: aesthetic, emotional, intellectual experiences
2. Knowledge: basic facts, concepts, nature of science and technology
3. Career: preparation for life work, foundation for work, preparatory skills

Disagreements were found in how and whether these goals were achieved (le:3). Parents and students rate the importance of the career goal

first, knowledge second, and human experience third; school administrators are in general agreement (li:103,104). Teachers and supervisors rate knowledge the highest priority, but disagree on the importance of the other two goals. Teachers rate human experience second and careers third, while supervisors rank careers second and human experience third (li:103,104). In terms of the emphasis placed on specific goals by schools, a larger proportion of administrators, supervisors, and teachers place knowledge first, while parents believe that career goals are receiving the most emphasis (li:104). Human experience is recognized by all respondents as receiving the least emphasis in schools (li:104).

Purposiveness in schools does not seem to be simple, well focused, or well coordinated (lc:16). Teachers are more inclined and are more successful in discussing conditions in which teaching is occurring than they are in describing a "sufficiently complex and trustworthy conceptual system to encompass both the dynamics of the curriculum arrangements and the dynamics of student comprehension" (lf:2). When opportunities are available to teachers in summer institutes or inservice programs, they are seen as opportunities to talk with other teachers and collect "gimmicks" that can be incorporated into existing practices, rather than opportunities to overhaul their conceptual systems (lg:5).

Teachers base their goals for teaching science on their classroom experiences, their own personal values, and the widely held beliefs of the community (lg:26). They are more inclined to accept social norms (the way students are expected to behave) than they are the instructional goals espoused in their teacher education courses (lg.5). Teachers have their own ideas about basic goals, and though they usually are not articulate about them, the goals appear to be different from those that curriculum authorities and instructional technologists consider primary (lg:1). In part, the acceptance or approval of a set of goals by teachers is an expression of personal preference more than of commitment (le:3).

Developers of new curricula often regard teachers and school administrators as obstructionists to change and innovation. What is more likely the case is that school people do not agree with the educational goals of the innovators, any more than science teachers agree among themselves on many goals (lg:26.1). Teachers set goals consistent with their own values and those they believe to be widely held in the community (lg:26.1). They also have an internalized concept of what the constraints are in the classroom, and any different pedagogical framework for teaching science is likely to fail (lg:5). Inservice programs provide little help in adapting subject matter to objectives for which it was not originally prepared (lj:2). It is not surprising that career awareness, inquiry, scientific literacy, and science as social process, widely heralded goals of science teaching, are not considered important by the rank and file of teachers.

People generally have different ideas about proper and improper goals for public education (lh:1). Many advocacy groups are found in and out of schools (lh:1). One way teachers have of protecting

themselves selves from these many pressures is to stay with global and noncontroversial aims (le:23).

The notion that the goals of science teaching should reflect the current condition of the scientific enterprise, progress in scientific disciplines, shifts in the social and cultural scene, and the interaction of science, technology, and society are not considered by the majority of teachers to be important factors in setting the goals of science teaching. The causal events that lead to goals guiding the teaching of science arise from the social norms of students, teacher preferences, and community values. One result is that objectives remain relatively stable and appear to have changed little over the past 20 years (1955-1975) (2:170). In 1974, the National Association for Research in Science Teaching listed "goals of science education" as the highest priority in needed research (2:184). In 1980, two surveys, one of major university faculty specialists in science education and the other a survey of schools and support agencies, both found the highest ranking problem in science education to be "uncertainty about goals" and a pressing need for a new rationale (9).

CHAPTER 2

SCIENCE TEACHING

Characteristics of Science Teachers

The typical science teacher in a middle or junior high school has taught for 11.5 years (3:135), and 50% have a degree beyond the Bachelor's (3:139,2:95). At the time of the survey (1976-1977), 44% of the teachers were carrying college work for credit (3:40). Of science teachers for grades 7 through 9, 62% are males (3:141). The schools in which they teach are departmentalized (2:14), and teachers are regarded as specialists in science (1d:6). Of the designated science teachers, 76% teach only science (3:142), while 24% teach other subjects such as mathematics (3%) (1i:20).

Although the majority of these science teachers teach only science, this does not necessarily mean science in all of these grades. Although 35% of them teach courses in general science, some also teach biology (13%), physics (10%), or chemistry (7%) at higher grade levels. In addition, 58% teach courses other than science (1i:20).

The most common preparation of general science teachers in grades 7 through 9 is biology, although 33% have less than 9 credits in biology (2:82). On the whole, general science teachers lack depth in more than one area of science (2:71,100). A recent survey of junior high school science teachers in Pennsylvania (10) shows that 77% of the teachers surveyed had no intention of becoming junior high school science teachers; only 35% had done their student teaching in a junior high school, and 87% stated they would have benefited from a program that specifically prepared one to teach science at this level.

There appears to be a consensus among school administrators that anyone can teach general science (2:63). Junior high school science teachers are less satisfied with their teaching load than are high school teachers (2:95). Nationally, 13% of these teachers state they do not feel qualified to teach one or more of their courses (3:222). The number is close to 20% in small schools, urban and suburban communities, and in the north central part of the United States (3:222).

The Teacher in the Classroom

The typical science class in middle and junior high schools consists of 30 or 31 students, a higher number than is found in the average elementary or secondary school classroom (3:67). Classes in social studies and mathematics at grades 7 through 9 are smaller than those for science (3:67). Science-class periods average 51 minutes (3:68). Eighty-six percent of the science courses are one year in length (3:65).

The predominant method of teaching science in these schools is lecture-and-recitation (1j:6,3:B-62). A survey of 535 teachers asked how they had taught their most recent science class. The survey revealed that 75% had used a combination of lecture and discussion (3:106). Fifty-nine percent stated they also used some manipulative materials (3:106). Few teachers attempt to engage students in learning by experience (1f:7). Teachers justify lecturing on the basis that students can't read, admitting they don't know why students can't read and won't study (1f:10). Teachers in grades 7 through 9 use a highly routinized instructional procedure: strict time allotments and activities that are designed to keep students busy and productive in covering the subject matter (1g:56). The concept of teaching is essentially an "industrial" or "management" one (1g:54,55). The teaching tends to be specific, focused on behavioral objectives and criterion-referenced tests (1d:44). The combining of the informational components into complex responses for problem solving is either deemphasized or omitted (1d:44). Answer-giving is expected of students and it is for this they are rewarded (1g:11,12). Much of the instructional time is used for socializing students (getting order in the classroom and suitable conditions for teaching) (1g:11). Two-thirds of the principals are of the opinion that many teachers are most concerned with "getting instruction to happen," and these teachers like packaged, individualized, instructional program (1i:68). Teachers more concerned with subject matter tend not to like packaged instruction (1i:68).

Teachers divide their time equally between instructing a class as a whole and working with small groups or individual students (3:111). Working with small groups of students appears to be limited by a lack of accommodations, according to 56% of the teachers surveyed (3:135).

The teaching procedures most frequently used (daily or once a week) by teachers in these science classes are (3:B-62):

1. Discussion, 90%
2. Lecture, 78%
3. Tests and quizzes, 66%
4. Individual assignments, 57%

The common practice is assign, recite, discuss, and test (1j:6). Games and puzzles are frequently used by 22% of the teachers, while 29% never used them (3:B-86). Eighty-five percent or more rarely (less than once a month) or never make use of such techniques as televised, computer-assisted, or programmed instruction; neither do they use contracts, simulations, field trips, or guest speakers (1b:62). Sixty-nine percent

of the teachers do not have student library work and 51% do not utilize student reports or projects (1b:62). The most frequently used audio-visual materials in these science classes are films, filmstrips, and overhead projections; however, these materials are not used as frequently as once a week by 20% of the teachers (3:B-74). Sound recorders (records, tapes) are seldom used by teachers (3:B-74). The predominant instructional materials are those to be read or written upon (1d:60). Educational technology is viewed by teachers as a means for focusing on the basics (1d:44) and as a means for reducing forgetting (1e:12).

Laboratory ("hands-on," or manipulative) materials are used daily by a fourth of these teachers, and another third have laboratory-type activities at least once a week (3:B-62). A fifth of the teachers rarely or never use laboratory work in teaching science (3:B-62). Teachers who have attended institutes sponsored by the National Science Foundation are nearly twice as likely to make more and frequent use of manipulatory materials than teachers who have not attended an institute (3:108). When teachers were queried about their most recent science lesson, 59% stated they made use of manipulatives (3:106). In most of the science classes observed, students had increasingly fewer materials to manipulate as they progressed from grade 3 through grade 12 (1c:60). Student-created materials are rare in science classes, even for science fairs (1d:62).

In the survey of 12,000 science teachers, instructional materials were desribed as the heart of their teaching and the determinants of their instructional methods (1d:66). Instructional materials virtually dictate the curriculum and become both the medium and the message (1d:66). Central to instruction is the textbook; it is the authority in the class; the teacher is the arbiter (1d:66).

A number of educational problems interfere with the instructional process in science teaching. Administrators and students are bothered by the testing program; curriculum supervisors feel the major problems are fiscal; and teachers rate discipline as the number one problem (1e:9). Time spent on discipline problems and administrative activities in the classroom reduce instructional time as much as 50% (1e:10,11). Teachers consider students who are not busy and working to be an instructional problem, even though they are not bothering anyone (1i:65). Eighty-two percent of principals of grades 7 through 9 feel that student behavior is of equal or greater importance than the learning of subject matter (1i:65). Twenty-four percent of science teachers feel that students' inability to read is their most serious instructional problem (3:160). Sixty percent find there are few opportunities for them to learn ways of dealing with instructional problems (1i:70). There is some evidence that middle schools are better organized to deal with instructional problems than are junior high schools (1i:70). Teachers feel there is little time available to them to think about instructional problems and that inservice programs are not of much help (1i:71). They see as one of their greatest needs the learning of new instructional procedures, such as using "hands-on" materials effectively and implementing a discovery-inquiry approach to learning (3:144).

Inservice Programs

About half of the sciences teachers have participated in inservice programs; 48% have attended an average of 5.3 inservice courses during the past three years (before 1976-1977), and 41% have participated in at least three National Science Foundation institutes (li:23). A majority (63%) feel they take good advantage of the experiences of other teachers for solving their own problems (li:72). They would like to share ideas more with other teachers, engage in joint teaching, and visit other classrooms; however, there are few opportunities to do these things (la:5). Although teachers want more professional contact with other teachers, they do not favor inservice programs run by experienced teachers (li:73). Among teachers who have not profited from the experiences of other teachers, the most frequent reasons given were (li:72):

1. No time to work on these things
2. Little reward to teachers for helping each other
3. Teaching problems are idiosyncratic

Teachers are frequently critical of pre- and inservice education as they struggle with teaching problems (lg:7). Supervisors recognize the need to provide inservice courses oriented to teacher needs (li:74). In 15% of the school districts, the results of standard tests given students are used to discover topics to include in inservice program (3:29). Only 18% of the teachers found inservice programs to be useful as a source of information about new curricular materials (3:B-15). Most feel that inservice programs do not really help with learning problems (li:20).

Half of the teachers list conditions as "good" in their school for solving pedagogic problems. Of the remaining half, 29% are of the opinion conditions are not "good" and that "nobody cares" (li:71). However, 77% of the science supervisors are of the opinion conditions are "good" (li:71).

In addition to inservice programs, teachers can expect to find information for resolving their pedagogic problems in professional reading. Compared with teachers of other subjects in middle and junior high schools, science teachers tend to read widely (li:23), averaging 5.5 education articles per month and 12.1 science articles (li:24). In addition, they read 5.1 books on education and 4.4 science books per year (li:24). Only 37% of the science teachers find journal articles particularly helpful (3:156). At the time of the survey (1976-1977), 44% were taking college courses for credit, and prior to this, 56% had been taking courses (3:140).

No teachers mentioned the possibility of using the results of educational research for resolving instructional problems. Decisions about teaching and learning are made mostly on the basis of "folk knowledge" derived from the experiences of other teachers. When teachers were asked to identify their source of information about a set of curricular materials, 66% stated they obtained their information from other teachers and 53% listed college courses; 37% cited publishers' sales

representatives. A fourth of the teachers also listed federally sponsored workshops and professional journals as a source of curricular information (3:B-15). Face-to-face contacts with other people is by far the predominant way information on science teaching is transferred.

Federally Funded Programs

Nationwide, 32% of science teachers in grade 7 through 9 and 39% of the principals have attended one or more NSF institutes (3:87). In the southern states, 41% of the teachers attended one or more NSF institutes--the highest attendance in the nation (3:87). Forty percent of the teachers participated in summer institutes and 18% in inservice institutes. None of the other NSF activities such as academic-year institutes, administrators' conferences, cooperative college-school programs, resource personal workshops, leadership development projects, school system projects, or teacher-centered projects attracted more than 8% of the teachers (3:B-9). They had a favorable reaction to the full-time NSF summer institutes: 53% stated the institutes provided ideas and contacts and increased their confidence; 51% felt the number of institutes should be increased so that all needing them could attend; 15% of the teachers felt the institutes were good for good teachers but not really of benefit for those needing help (1g:51). Sixty-one percent of curriculum coordinators and 46% of school administrators would like to have the federal government support more institutes (1g:52). Of school superintendents, 77% feel that NSF should continue to sponsor programs to help teachers implement the federally funded curricula (3:77).

The NSF programs attracted 48% of the principals to one or more programs (3:125). The summer institutes attracted the largest number, 10%; inservice workshops, 5%; all the NSF programs had some attendance by principals (3:B-10). State supervisors of science made the widest use of NSF-sponsored activities: 69% attended summer institutes, 48% inservice institutes, 30% academic-year institutes, administrator conferences, and leadership development projects (3:B-8).

Overall, the continuing professional education of science teachers is meager for various reasons (1g:48):

1. There are fewer inexperienced teachers.
2. Incentives for earning credits and degrees have diminished.
3. Money available to support resource persons is down.

Perceived Needs of Science Teachers

The majority of these science teachers feel they need assistance to do the best job of teaching science; only 19% state they do not need help (3:146). The need for assistance is about the same whether the

teacher is from a large or a small school, a well-to-do or a poor community, or a rural or a city school (3:146). In response to an open-ended question on needs, teachers identified the following categories as major areas of concern (li:75):

1. More time for planning, preparation, and sharing of ideas with other teachers
2. Constructive supervision by master-teachers
3. Opportunities to consult master-teachers and to attend planned workshops
4. Longer internships for teacher certification
5. Better communication with administrators and other teachers and with parents

Opportunities to learn new teaching methods ranks high on the list of teacher needs (3:B-112,2:95). Obtaining subject matter information bothers two-thirds of the teachers (3:B-112), as well as understanding the relevancy of science topics for students (2:96). The diagnosing of learning problems (2:177,178) and the implementing of discovery/inquiry approaches (3:B-112) also are serious concerns. Nearly half of the teachers feel they have difficulty using "hands-on" materials (3:B-112). About 75% do <u>not</u> feel they have problems with establishing objectives, planning and teaching lessons, or maintaining discipline (3:B-112). Laboratory management concerns a third of the teachers (3:B-112). When they were asked what universities might do to be of most help, 43% said develop curricula appropriate to the times; 16% wanted workshops or institutes; 12% suggested college courses oriented to teacher needs; and some 20 other suggestions were less frequently mentioned (lg:19).

More than half of the teachers felt university people would not be of much help to them because the faculty is more interested in theory than practice and also because the university faculty is not interested in school people (li:74). These teachers felt the federal government might help meet their needs in the following ways (lg:19).

1. Hire resource people to help teachers develop teaching skills
2. Offer more institutes on the improvement of teaching skills
3. Provide films and laboratory materials to schools at low cost.

These teachers did not think a public campaign to promote "scientific literacy" would be of much help (lg:19).

Supervision of Science Teaching

Science teachers in middle and junior high and secondary schools were asked to rate the adequacy of their knowledge of science subject matter and effective teaching practices. The ratings of middle and junior high school teachers were lower than those of secondary school teachers (11,12). Only a few states have certification requirements for middle and junior high school science teachers; one survey of 80 of these teachers showed only 4% certified for teaching in these schools

(2:63). Teachers certified to teach in elementary schools are approved to teach subjects in the middle school, grades 6, 7, and 8. Teachers certified to teach in secondary schools are deemed qualified to teach science subjects in junior high schools (13). The shortcomings of appropriate teacher education for middle and junior high schools are recognized by practicing teachers. The need for supervisory and support systems is apparent. The status of these services as they existed during the the 1976-77 school year are summarized.

<u>Supervisory Personnel for Science</u>. Persons with the title of supervisor or curriculum coordinator are found in 20% of the schools. Teachers and department chairpersons have supervisory responsibilities in 46% of the schools. Administrators, principals or superintendents are the science supervisors in 30% of the schools (3:38). Thirty-seven of the schools have district supervisors. Typically (60% to 70%), those responsible for science also supervise social studies, reading/English, and other subjects (3:36). Of those school districts that have supervisors for science,, 37% spend no time and only 20% spend as much as 75% of their time in the schools (3:39). A sample of 340 school districts revealed that 63% had no science supervisors (3:37). Rural areas, small districts, and the north central states had the fewest number of supervisors (3:37). Fifty-two percent do not have a science department chairperson and, where they do, the person is not given released time and is not compensated for supervisory activities (3:48).

About 25% of the science supervisors have curriculum supervision as their primary assignment (lg:40). A large amount of time is spent on locating and evaluating instructional materials, disseminating information about curricula, and developing curricula (3:B-4). In addition, there are administrative duties, and lesser amounts of time are devoted to hiring and evaluating teachers and coordinating inservice programs (3:B-4). Nationwide, only 20% of the science supervisors spend as much as 75% of their time on supervision-coordination activities.

We can only conclude that supervisory services for science teaching are, at best, minimal in the middle and junior high schools, and for a majority of schools essentially no services are provided.

<u>Teaching Qualifications of Supervisory Personnel</u>. In schools where principals supervise science, 11% have an undergraduate major in science. They are three times as likely to have majored in social studies (3:46). However, only 26% of the principals feel they are not well qualified to supervise science (3:47). A fourth of the persons responsible for supervising science are likely to belong to a national science teachers association of some type, but only 6% belong to the National Association of Science Supervisors (3:45); a larger number (40%) belong to a state science teachers organization (3:44). Fifty-three percent of science supervisors have not attended a professional meeting on the subject they supervise (3:42). Eighty-seven percent of the school districts, when hiring supervisors, require that they have relevant teaching experience; 80% require a supervisor's credential; and 65% require a Master's degree in the relevant field. Where supervisory

services are provided, a majority of those responsible for the services are either not trained specifically for supervising science or do not assume the professional responsibilities expected of a science supervisor.

State Science Supervisors. There are 61 state science supervisors (3:B-8); 40% are located in the southern states (3:A-11). These supervisors spend time on a variety of activities, such as curriculum development, 72%; working with district supervisors, 70%; helping to evaluate district programs, 68%; evaluating curricular materials, coordinating inservice programs, and working with college personnel, approximately 50% (3:B-1). Nationwide, 69% of state science supervisors spend more than half of their time in coordinating science teaching activities (3:34).

Supervision and the Teacher. Science supervisors have the responsibility for helping teachers with pedagogic problems and for improving the curriculum (1g:40). However, only 33% spend a moderate or large amount of time working with individual teachers (3:B-4). Forty-two percent state they do observe in classrooms (3:B-4). Fifth-six percent of science supervisors for grades 7 through 12 state they spend 10% or less of their time supervising, coordinating, or consulting with teachers on instruction (1g:42).

Less than 60% of science teachers feel they have the help from supervisors or coordinators that they want (2:89). Teachers tend to work alone without help from supervisors, other teachers, administrators, or department heads (1g:27). When science coordinators for grades 7 through 12 were asked to indicate the number of teachers to whom they were expected to provide consultative help, the median number was 219 (1g:43). To meet these expectations, coordinators use bulletins and committee meetings, but very little personal contact with individual teachers (1g:43). Teachers seem to be receptive to "good" help but question whether district supervisors, colleges of education, or any other agency could provide much help (1g:44). When asked what they expected of a science supervisor, 50% or more of the teachers listed the following (1g:45):

1. Knowledge of sources of curricular materials, 89%
2. Skill in diagnosing individual student learning difficulties, 76%
3. Ability to "speak out" to protect curriculum, 73%
4. Recent, full-time teaching experience, 59%
5. Administrative experience, 58%
6. Skill in interpreting test scores for whole classes or schools, 53%

When teachers were asked to identify their sources of information about curricular materials, only 26% named local subject matter coordinators (3:B-15). Many teachers feel that better progress in science teaching would be made if more cooperative efforts took place within the school; the problem is not simply the lack of supervisory services (2:3). There is a consensus among science teachers that they are not

obtaining the services they wish to have from the supervisory or coordinating staff. Supervisors feel inservice programs could help with teacher problems, but teachers do not request such help (11:70).

Summary

The present state of supervision in the middle and junior high schools is viewed as inadequate and incompetent in terms of teacher expectations. Teachers expect more personal help with their teaching problems than school systems are currently providing. The school systems either lack supervisory staff or have a staff that is poorly qualified for science supervision.

CHAPTER 3

SCIENCE STUDENTS

How Students Perceive Their Science Classes

Thirteen-year-old students do not view science as their favorite subject in school; only 11% place science first and 18% rank it a second choice (C01E01) (Reference Note). About a third of the students (31%) do not find science boring and 21% state it is boring, but the majority (48%) are ambivalent (C01E02). However, 40% of the students state science classes are fun, and 44% do not mind going to class (C01E02). A population of 264 high school seniors, looking back to their ninth-grade biology course, saw the lessons as boring (31%) and the subject matter as irrelevant to student lives (21%); however, 19% of the students responded that their own immaturity at the time of the course may account for some of their reaction. No other items of dissatisfaction (teachers, textbooks, facilities, etc.) received more than a 6% expression of inadequacy (1d:13).

What is studied in science classes is viewed by 13-year-old students as interesting (48%), not too difficult (46%), or too easy (60%) (C01E03). Students feel that what they are taught was not learned in previous courses (40%) or outside of school (50%) (C01E03). While a majority (80%) of early adolescents feel that the things they learn in science are related to the real world and are useful (76%), they view them as likely to be more useful in the future (74%) than currently (57%) (C01U01). Whatever their reactions to science courses, 70% of the students are of the opinion that science should be required in schools (C01U01).

When students were asked how they personally felt about science classes, they described them as happy (67%) and comfortable (56%) places, where their curiosity was stimulated (46%) (C01E04), and where they were not afraid to ask questions (C01E02). While students did not feel stuipid (72%) in science classes, only 38% felt successful, and even fewer felt confident (31%) (C01E04). Nearly half of the students (49%) felt they had to memorize too many facts; 18% of their classmates strongly disagreed (C01E03).

Teaching in middle and junior high schools tends to be highly structured (1g:55), textbook bound (3:88), and information oriented (1j:16). Students are grouped homogeneously for instruction and there are few special efforts to consider the needs of either the more able or

less able students (1j:15). Individualization in most schools means to the teacher "a student proceeding at his own pace" (1b:26) in contrast to teaching practices that consider the diverse individualities of youngsters (1b:27). Keeping students busy and productive seems to be the principal concern of the majority of teachers (64%) (1i:65). How do the students perceive these teaching practices? Less than 20% of the students feel they can choose topics or projects (17%), select the order of topics (14%), decide when they are ready to hand in assignments or take tests (17%), or choose what they want to learn (11%) (C01I01). In nearly half (47%) of the science classes, the exact order of the textbook is followed, but for 45% of the students there are opportunities to work at their own speed (C01I01).

Over two-thirds (68%) of the students feel they are encouraged to think for themselves; but only 38% feel they are encouraged to be creative (C01T01). They feel some teachers (41%) recognize their right to have an opinion and that 42% of the teachers encourage them to state their opinions (C01T01). Students (62%) see their science teachers as willing to share their opinions on questions about things like overpopulation or pollution (C01T02); most teacher, however, tend to ignore controversial issues (1c:29).

Students believe that only one teacher in five (20%) is willing to admit to not knowing something (C01T01). Principals (95%) think it is good for pupils to see teachers make mistakes (1i:66), but 66% are inclined to let students discover mistakes made either by the teacher or themselves; only 13% of the principals feel a correction should be made immediately (1i:67). Most students (63%) feel their science teacher wants them to point out mistakes he or she makes (C01T02).

In commenting on their most recent science teacher, 13-year-old students felt their teachers really like science (76%), try to make science exciting (58%), and that more than half (52%) of the teachers are enthusiastic (C01T02). Only 18%, however, feel that their science teacher takes a personal interest in them (C01T01).

An Interpretation

Thirteen-year-old students, on the whole, do not react unfavorably to their science classes but neither are they wholeheartedly supportive. Whatever efforts are made to individualize science instruction are at best minimal, and what is practiced is philosophically weak. Students do not actively dislike science, though it is not their favorite subject; they feel it is rather dull and authoritatively presented. In reviewing the information on student attitudes toward science instruction, one suspects the subject matter of the curriculum is inappropriate (1d:7) and that instruction is more routine than inspired (1j:6).

Students' Views About Science

For a decade or more in the United States, a profusion of legal, political, and educational efforts have been made to provide women and minorities equal access to careers in science and engineering. Differences in attitudes toward science and in cognitive achievement have been observed between boys and girls and between blacks and whites (14). These differences may influence career choices. Information from the 1976-77 National Assessment of Educational Progress: Science (15) has been used to identify the nature of sex and racial differences among 13-year-old students regarding science. It has long been recognized that early experiences with science influence the career choices students make (16).

Sex Differences in Attitudes Toward Science

The information abstracted from the 1979 NAEP report is from a national sample of 2,500 13-year-old students questioned during the 1976-77 school year. Expressions reflecting differences between student responses are typically at the .05 level of significance. The organization of findings parallels the NAEP publication and are as follows:

Attitudes Toward Science

- o Boys display a slightly more favorable attitude toward science classes than girls and find classes less boring (pp. 6, 9).
- o Boys participate in science activities outside of school more frequently than girls (p. 9).

Vocational and Educational Intentions

- o Boys and girls express similar feelings about the benefits of an education in the sciences whether career directed or not (p. 15).
- o More boys than girls display a favorable attitude toward a career in science (p. 15).

Experiences with Science-Related Activities

- o More boys than girls have visited a planetarium, factory, science laboratory, electric-generating plant, and sewage-treatment plant (p. 18).
- o Boys, more than girls, have done experiments with electricity, such as making a magnet or wiring a circuit (p. 18).
- o Girls, more than boys, have made collections of leaves, flowers, and insects (p. 18).

Personal Use of the Tools and Attributes of Science in Problem Solving

- o Only a small difference exists in the use of problem-solving techniques between boys and girls; the difference favors boys (p. 24).

Science and Society

Confidence in science:

- o Boys are more likely than girls to regard science with a sense of wonder (p. 29).
- o More girls than boys regard science with indifference or show a lack of interest (p. 29).

Support for research:

- o Boys are more supportive of research than girls (p. 32).

Awareness of the Methods, Assumptions, and Values of Science

- o Boys score higher than girls on measures of science knowledge, comprehension, application, and analysis/synthesis (p. 49).
- o On the content areas of science, boys score significantly above girls in their knowledge of biology, physical science, earth science, and integrated topics. The least difference between the sexes is in the knowledge of biology and integrated topics (p. 49).
- o On questions involving a knowledge of the processes of science, societal problems, applied science, and technology, boys do significantly better than girls (p. 49).
- o Girls are significantly better than boys in their understanding of decision making (p. 49).
- o Boys and girls are not significantly different in their ability to relate science to self, although boys score slightly higher on these questions than girls (p. 49).

Summary (p. 53)

Patterns of performance for 13-year-old boys and girls on the total number of attitude items on the 1976-77 NAEP Science Assessment are:

Personal Experiences

- o Attitude toward science classes (39 items): favors boys
- o Vocational aspirations in science (23 items): favors boys
- o Using tools and attributes of science (35 items): favors boys
- o Experiences with science (90 items): favors boys

Science and Society

- o Support of research in science (35 items): no significant differences
- o Personal involvement (24 items): favors girls

Awareness of the Nature of Science (16 items): no significant sex differences

Typically, boys outscore girls on all cognitive measures; on attitudinal measures there are fewer differences between boys and girls.

Racial Differences in Attitudes Toward Science

By the age of 13, blacks and whites display differing attitudes toward science. The NAEP report on Attitudes Toward Science provides information on aspects of these differences for 13-year-old students. The organization and classification of student responses illustrating racial differences follows that of the NAEP report.

Attitude Toward Science Courses and Science Teachers

- Blacks and whites are interested in science courses to the same extent at age 13 (p. 6).
- Whites, more than blacks, perceive their science teacher as a person who likes and is enthusiastic about science and tries to make it interesting for students (p. 85).

Vocational and Educational Interests

- Blacks are more inclined toward a career in science and have higher educational aspirations in science than whites (p. 12).

Experiences with Science-Related Activities

- Blacks have visited science-related facilities, such as planetariums, museums, or zoos, less often than whites. To an even greater extent, fewer blacks than whites have visited outdoor places, such as oceans, mountains, or forests (p. 18).
- Blacks, as a group, report significantly fewer science-related experiences, such as viewing the moon and north star through a telescope, observing a fossil or an animal skeleton, watching an egg hatch or a seed sprout, than do whites (pp. 20, 80).
- Blacks engage in extracurricular activities, such as going to science lectures, reading books and articles on science, talking about science, and doing science projects, on their own more frequently than do whites (p. 86).

Personal Use of the Tools or Attributes of Science for Problem Solving

- Whites average slightly above blacks in the use of science tools or attributes for problem solving (p. 24).

Science and Society

- Blacks are less confident than whites in their feeling that science could solve some of our societal problems (p. 29).
- Fewer blacks than whites are involved with societal problems, such as cleaning up litter, walking or riding a bicycle to conserve fuel, or using less heat in the winter (p. 38).
- Blacks are less supportive of research in the sciences than whites (p. 32).

Awareness of the Methods, Assumptions, and Values of Science

- Blacks score significantly lower than whites on items related to the methods, assumptions, and values of science (p. 44).

Cognitive Characteristics

- Blacks are significantly (10 to 12 percentage points) below the national average in their knowledge, comprehension, application, and analysis/synthesis (p. 49).
- Blacks are significantly (12 to 15 percentage points) below whites in their knowledge of biology, physical science, earth science, and integrated topics (p. 49).
- On questions related to process methods in science, societal problems, science and self, applied science and technology, and decision making, blacks average signifcantly (10 to 13 percentage points) below whites in correct responses (p. 49).

Focus of Control Orientation

- Whites are significantly more likely to believe that there are logical explanations to things one sees happening than are blacks (p. 91).
- Blacks are significantly less likely to keep on working on a task if they run into problems they didn't expect (p. 91).

Summary

Patterns of performance for 13-year-old, black and white students on the <u>total</u> number of attitude and cognitive items on the NAEP Science Assessment show signifcant differences from the national average in each category of items (pp. 53, 77).

All Cognitive Items (248 items): favors whites

<u>Attitude items:</u>

Personal experiences

- Science classes (39 items): no significant differences
- Vocational aspirations (23 items): favors blacks
- Science and self (23 items): favors whites
- Tools and attributes (35 items): favors whites
- Experiences with science (90 items): favors whites

Science and Society

- Supportive of research (35 items): favors whites
- Personal involvement (24 items): no significant differences
- Persistent societal problems (49 items): favors whites
- Applied science and technology (14 items): favors whites

Awareness of Science (16 items): favors whites

It is almost impossible to interpret attitudinal data. Sometimes students check questions in ways they believe they should be answering, and the investigator cannot be certain when this is the case. Overall, the information comparing 13-year-old blacks and whites appears to indicate that blacks are equal to or exceed whites in having a positive attitude toward science classes, desiring to pursue science as a career, and desiring to engage in science-related activities. The data also show that blacks, compared to either the national average or whites, have a weaker knowledge background in the sciences, do not understand science processes or methods, and are less inclined to be aware of possible applications of science and technology to the resolution of science/social issues. While blacks would apparently enjoy a career in science, they see little likelihood they will become scientists.

By the age of 13 years, upon entering the seventh grade, boys and girls show distinct differences in their attitudes toward science as well as in their knowledge of science. The same situation is true for blacks and whites. These differences in the perceptions and cognitive understanding of science were formed during childhood or the years of elementary school education, but one cannot necessarily attribute these differences to the conditions of schooling. It is somewhat more likely that social forces operating outside of the school and different cultural expectations for boys and girls, as well as for blacks and whites, contribute substantially to these differences. Correctives for these differences during the middle and junior high school years in science courses are not observed to take place.

Students' Understandings of Science and Support for Scientific Research

As science has increasingly become a basic part of the intellectual and social traditions of the twentieth century, scientific literacy has grown in importance as a goal of science teaching. Not only is an understanding of science important as an intellectual achievement, but it also has widespread importance for effective participation in our society. All citizens today are faced with problems and issues requiring scientific and technological literacy for responsible decision making.

What is the image of science held by 13-year-old students in middle and junior high schools? When asked which of a selected list of problems they think scientists should be given money to study, these students responded as follows (C06B01):

1. 93% would give money for something useful, such as efficient, lightweight ways of storing electrical energy (92%).
2. 73% would not give money for things that probably would never be useful.

3. 70% or more of the students would support research on how X rays change living cells, 80%; small parts of the atom, 79%; chemicals in sea water, 81%; how animals communicate, 71%; and distant stars, 73%.
4. A majority of students would give money to study how continents move around, 64%; storms on the surface of the sea, 61%; how genes control plant characteristics, 64%; how gases condense around crystals, 66%; how bacteria and green plants live together, 67%; habits of fish in the ocean, 58%; and how monkeys learn, 52%.
5. Of least interest to these students is how mice react to drugs at different times of the day, 45%.
6. While students indicate a preference for applied research, the majority would not negate any study having the characteristics of basic research.

A second series of questions, focusing on financial support for applied science, was asked of 2,500 13-year-old students. Their reactions were as follows (C06A01):

1. Over 90% of the students would approve of giving money to study cures for cancer, 97%; earthquake prediction, 94%; methods of reducing air pollution, 95%; ways to produce more food, 92%, ways to solve the energy problem, 96%; ways to use solar energy, 94%; how to develop low pollution, electric transportation systems, 90%; and fire safety problems, 91%.
2. Their next order of priority for research was transportation problems, 80%; ways to cure a very rare disease, 81%; ways to solve population problems, 75%; ways to control insects, 72%; how to prevent droughts, 71%; methods of birth control, 70%; ways to maintain a steady and plentiful supply of fish for food, 70%; how to make rain fall on farmland, 70%; and methods of farming the ocean.
3. Two problems that do not appeal to students are how people behave when they live in very crowded cities, 34%; and new ways to build smokestacks, 20%.

When students were asked whether they had confidence that an application of science could help solve certain science/society problems, their responses were (C05A01) that science could do nothing to prevent wars, 58%; control the weather, 53%; or reduce world population, 50%. They were more confident that science could in some measure help find cures for diseases, 97%; save us from an energy shortage, 94%; save our natural resources, 94%; reduce air and water pollution, 89%; prevent worldwide starvation, 91%; and prevent birth defects, 76%.

To further explore their confidence in science endeavors, students were asked to respond to several questions (C05A02). When asked whether, for the most part, they felt that science and technology will eventually solve most problems such as pollution, disease, drug abuse, and crime, some of these problems, or few, if any, of these problems, 78% of the students felt there was a good chance science and technology would solve many of these problems. When asked about their general reaction to science and technology, 40% of the students replied "excitement and wonder," and another 21% replied "satisfaction and

hope." Only 2% view science and technology with fear or alarm and 21% are indifferent. In responding to the question as to whether science and technology are changing too fast, too slowly, or just about right, most students (60%) said "just about right." The others who had an opinion were about equally divided between "too fast" and "too slowly." Responses to whether science and technology have changed life for the better or for the worse showed 36% opting for "better" and 4% for "worse," with 47% ambivalent.

Students feel that science and technology have caused some of our science/society problems (39%), and an equal percentage think only a few of our problems have their origin in science/technology. A few students (7%) believe none of our problems are caused by science and technology, and 7% believe most of our problems result from these forces. When asked about the degree of control society should have over science and technology, 42% would leave things as they are, but 26% would increase controls, and 11% would decrease controls; 21% of the students had no opinion.

The results of this survey of 13-year-old students is remarkably close to the ratings indicated by adults on the same questions (17). More adults (70%) are of the opinion science and technology have changed life for the better compared to 36% for 13-year-old students. Students react to science and technology in terms of excitement and wonder (40%), whereas adults (56%) choose satisfaction or hope on the same question. There are no major differences in ratings on the same sequence of questions between 13- and 17-year-old students.

Issues and programs of basic and applied research in science are only minimally dealt with in the most widely used science textbooks for grades 7, 8, and 9, and not at all in some textbooks. Very little attempt is made to articulate science courses with the understandings students have about science when they enter these grades (1d:7).

To what extent are 13-year-old students aware of methods, assumptions, and values in science? These attribues provide some notion of the extent to which students are attaining a degree of scientific literacy. Students are aware that:

1. Unexpected observations have played an important role in increasing scientific knowledge, 68%.
2. Scientists do not always find answers to their questions, 77%.
3. Observations of natural events are very important sources of scientific information, 73%.
4. There may be different methods of solving a single scientific problem, 78%.
5. Scientists do not assume that some events have mysterious causes, 47%.

For Items 1, 3, and 5, one student in five had no opinion (C08A01).

To obtain some notion of whether these students are aware of ethical and value assumptions inherent in scientific endeavors, they were

asked to indicate their feeling on statements about scientists and their work (C08A03). They agree with the following statements:

1. One very important job of a scientist is to report exactly what he or she observes, 88%.
2. Different scientists may give different explanations about the same observations, 87%.
3. Scientists must be willing to change their ideas when new information becomes known, 79%.

Students disagree with such statements as:

1. If a researcher accurately reports his or her experimental results, other researchers should accept the results without question, 61%
2. Once scientists develop a good theory, they should stick together to prevent others from saying it is wrong, 45%.
3. Scientists should not criticize each other's work, 25%.

At a somewhat higher level of cognition, the students were asked to react to statements about scientific theories (C08A02). Their reactions to statements about theory are:

1. 81% feel scientific theories are important products of science.
2. 79% believe scientists are interested in improving their explanations of natural events.
3. 69% believe that some theories that scientists use today will be shown to be inadequate some day.
4. 64% recognize that theories are useful even though they may be incomplete.
5. 59% are aware that one important use of a scientific theory is to predict future events.

Do 13-year-old students attempt to carry the attributes and intellectual tools of science into their daily lives? Students were asked to respond to questions involving an aspect of scientific inquiry and to indicate a frequency of use. Their responses are summarized in Table 1 (C04A01). The information in Table 1 reveals that most students (78%) feel it is important to look at all sides of a question (Item 5) before making a decision, but are less inclined (45%) to gather a variety of information (Item 12). For 64% of the students, a book on science represents an authority (Item 2). A majority of students (69%) would prefer to figure out how something works on their own (Item 8) rather than be told (Item 7).

Table 1. Personal Use of the Intellectual Tools and Attributes of Science by 13-Year-Old Students

QUESTIONS	% ALWAYS	% OFTEN	% SOME-TIMES	% SELDOM	% NEVER
1. How often do you try ideas to see if they work?	8	32	50	9	1
2. How often do you believe what you read in books?	23	41	27	7	0
3. How often do you check your school work to see if it is accurate?	23	27	30	15	4
4. How often do you read labels when you are trying to decide whether or not to buy a product?	37	25	16	15	5
5. Do you think it is important to look at all sides of a question before you make a decision?	55	23	18	3	1
6. Do you believe there are logical explanations for things you see happen?	24	36	35	4	1
7. How often do you prefer being told an answer rather than having to find out the answer on your own?	10	19	40	25	7
8. How often do you like to figure out how things work?	27	42	23	7	1
9. When you find out your ideas don't fit the facts, do you change your mind?	17	28	45	7	2
10. How often do you keep working on a task even if you run into problems that you didn't expect?	15	37	32	13	2
11. When you try out a new idea and find it does not work, do you feel you have wasted your time?	8	12	38	23	19
12. How often do you gather a variety of information before you make a decision?	10	35	35	16	3

Thirteen-year-old students were asked about the extent to which they engage in problem-solving activities outside of science classes (C04A04). A majority of students have:

1. Done an experiment, 62%
2. Taken measurements, 76%
3. Made careful observations, 68%
4. Worked on a part of a problem at a time, 80%
5. Tried to find out more facts about a problem, 77%
6. Thought of several ways to solve a problem, 83%

These students had attempted to work on the following types of problems at least once (C04A02):

1. Fix something electrical, 83%
2. Fix something mechanical, 86%
3. Figure out what to do with an unhealthy plant, 79%
4. Figure out what is wrong with an unhealthy animal, 94%

These students believe that what is learned in science classes could be helpful in (C04A03):

1. Driving a car, 42%
2. Cooking, 60%
3. Shopping, 45%

They also feel that they and their families make use of science information in (C04A06):

1. Deciding what food to eat, 60%
2. Keeping healthy, 83%
3. Deciding how many vitamins to take, 47%
4. Choosing a toothpaste, 41%
5. Deciding whether to smoke cigarettes, 60%
6. (C04A05) Understanding how their own bodies work, 81%

These students believe that science is useful outside of class (67%) and that laboratory procedures have a wider use than in the laboratory (77%) (C04A05).

By the time students are 13 years old, 54% feel they make frequent use of science outside of class, and 56% state that they have frequently used scientific methods to help plan some part of their lives (C04A07).

A goal of science teaching is to acquaint students with career opportunities at an early stage of their schooling, so they may know the options open to them and the special obligations and requirements for entering careers that interest them. The sciences offer a range of career opportunities, from skilled technicians to researchers, in a variety of subject fields. How do 13-year-old students perceive their interests and their potentials for a career in science? When asked about their personal interest in a selected list of "science-related" tasks, they would like (C02A02):

1. Working in a laboratory, 46%
2. Making field studies, 34%
3. Reading science articles, 32%
4. Sharing ideas with others, 77%
5. Writing reports about their findings, 46%
6. Designing and building things, 66%

To further learn the interest these students might have in science careers, they were asked about science-related activities they would like to do (C02A01):

1. 48% would like a job that lets you use what you know about science.
2. 43% want to work with scientists in an effort to solve problems.
3. 81% would like to visit a scientist at work.
4. 49% would like to know more about jobs in science or engineering.

Most students (76%) feel there are science-related jobs they could do, but only a third (33%) plan to take more science beyond the school

requirement, 32% are not sure, and 35% are sure they do not want to take more science (C02A01).

When these students were asked what working in a science field would mean for them personally (C02A01), their responses were: It would

1. be fun, 49%.
2. be too much work, 50%.
3. be something I could do, 66%.
4. be boring, 52%.
5. make me important, 42%
6. take too much education, 42%.
7. be lonely, 59%.

When asked for their personal reaction to the education and training needed to work in a scientific field, their feelings were (C02A04): It would

1. cost too much money, 37%. (Only 26% stated it would not.)
2. be worth it in the long run, 57%.
3. open many job opportunities for me, 63%.
4. be worthwhile, even if I didn't go into a scientific field, 55%.

An Interpretation

Thirteen-year-old students in middle and junior high schools demonstrate a surprisingly well-informed image of science. As a group, they know what science means as an enterprise and as a procedure for generating new knowledge and insights. They see ways in which science can serve them personally and can resolve science-based social problems. Furthermore, by the age of 13, they have formed preferences among problems they would like to have scientists work on. As might be expected, most of these problems are in the category of applied science, but basic research is not overlooked. We would have to conclude from the data that they have, by one means or another, acquired a respectable degree of scientific literacy. Most of what they appear to know about science as an intellectual endeavor is not found in the textbooks they have used. Growing up in a science-oriented, technological society in itself can account for part of what they know, but not all.

Educational Equity

The question of equal educational opportunity was a prominent issue during the 1970s, and it continues to be important. The problem arises from attempts to recognize student differences on one hand and, on the other hand, to treat all students as equal. "Mainstreaming," for

example, represents this conflict. Mainstreaming attempts to provide equality of education and, at the same time, seeks to accommodate diversity (lj:20). "Tracking" is a practice of assigning students into groups with different long-term objectives in mind and with lessons that differ in complexity and comprehensibility (le:14). "Grouping" is a temporary assignment of students to groups to facilitate study toward common objectives, with students returning to regular classes on the next assignment (le:14). Eighty-nine percent of junior high school principals in the sample do not use tracking; 50% prefer groups only when there is a likelihood of improving instruction (le:15).

Only 50% of the principals feel either grouping or tracking generally improves instruction (le:15). Seventy percent believe that sustained and heavy emphasis on homogeneous grouping is unfair to students (le:15), and 69% of the parents agree. (li:32). Fifty-three percent of parents would favor grouping if it would improve instruction (li:32). Principals are somewhat more inclined to think of tracking in terms of the learning ability of students than in terms of improving instruction (li:32).

About half of the grade-7-to-9 schools group students for science instruction (2:34), usually homogeneously (lj:15). In 69% of these classes, students are of mixed ability, although 13% of the schools have some high-ability classes, and 17% have special low-ability classes (3:B-7, le:6). It is at the junior high school level that schools begin to classify students as fast or slow learners (lc:1), and students with special talents are likely to be accommodated through extracurricular activities, special incentives, or privileges (li:33). Special education people are not involved with science subject matter but focus on instruction (le:7).

Teachers are looking for ways to make classes less heterogenous (le:6); nearly half (47%) make use of individual assignments for doing so (3:B-62). Others use teacher aids to work with individuals or small groups (le:7). Dividing a class into small groups based on ability (le:7) or attitude toward school work (lf:26) or using self-pacing instruction (2:35) are other means of dealing with the problem of heterogeneity. Absenteeism in schools automatically works to reduce heterogeneity (le:6), as do efforts to isolate or expel misbehaving students (le:12). However, about half the time, it is the misbehaving student who gets first attention in class (li:66). It has been suggested that some degree of homogeneity could be attained by <u>not</u> requiring slow learners to take science, but 93% of the science supervisors are opposed to this position (lc:2). Educators and most parents want students to take science, yet most are not supportive of changing the course to fit those not bound for college (lc:2). The elitist aim of science teaching begins in the junior high school (lc:20).

Individualization of instruction in schools is overshadowed by the importance of meeting minimal requirements in courses and achieving common terminal objectives. The schools respond by operating expeditiously in terms of simply getting the curriculum job done (le:13). There are doubts that individualized teaching would contribute much to equal opportunity of education (le:21). Another concern is that ability

grouping of students results in poorer students getting the poorest teachers (1e:16,1c:21). While the majority of teachers work with classes in a group setting, 35% of the science teachers seek to work with students as individuals (3:111).

Reference Note

Numbers such as C01E01 refer to NAEP science items, released and unreleased. Released items are from The Third Assessment of Science, 1976-77, Released Exercise Set. Report No. 08-S-00, May, 1978. NAEP, Education Commission of the States, 1860 Lincoln Street, Denver, Colorado 80295.

CHAPTER 4

SCIENCE CURRICULA AND INSTRUCTION

The early adolescent is enrolled in schools that have more variation in administrative organizational patterns than is found for other age groups of students. There are middle schools (grades 6, 7, 8 or 5, 6, 7, 8), junior high schools (grades 7, 8, 9), and intermediate schools (grades 7, 8). Each of these typically is housed in a separate building and considered an administrative unit (2:13,14). Grades 7 and 8 are sometimes part of a K-8 elementary school and are administered as part of the elementary school. In other instances, grades 7, 8, and 9 form part of a six-year secondary school, with all grades in the same building and administered as a secondary school. This arrangement provides an opportunity for ninth-graders to take science courses at a higher grade level (3:63). In general, these schools have specialized science teachers serving all grade levels.

General science is the commonly taught science in junior high schools; 95% offer the subject (2:88). While general science textbooks typically are written as a balanced series of topics for a three-year, sequential program, this is not the way schools use them; for example, a text series in general science is used in 76% of the seventh grades, 66% of the eighth grades, but only 6% of the ninth grades (3:53). During the science curriculum improvement drive of the 1960s and early 1970s, discipline-centered courses such as life, earth, and physical science began to replace general science (2:100,182). By 1977, 20% of the science offerings in grades 7 through 9 were in earth science, 21% were in life science, 13% in physical science, and 5% in biology I (3:53). Environmental education courses were about the only interdisciplinary teaching found in the science curriculum (1d:18).

In junior high schools (grades 7, 8, 9), the enrollment in general science courses was 5,212,318 in 1977; in the discipline-organized courses, 2,807,315 students, or about one million students each, were enrolled in life science, earth science, and physical science (3:58,61). General science is the only science program offered in 50% of these schools (3:56). Most of the diversity in science course offerings is found in grade 9, where general science, physical science, biology I, and earth science frequently are taught. However, junior high school science teachers feel there are fewer programs available to them, and those that are available are not appropriate to the needs of their students (2:95).

There is little consistency in the pattern of offerings of discipline-centered courses in junior high schools. Two common patterns are (2:100):

1. Life science, grade 7; physical science, grade 8; and earth science, grade 9
2. Physical science, grade 7; earth science, grade 8; and life science, grade 9

There is little agreement on the vertical organization of the science curriculum or the value of a hierarchical approach (1e:37), although teachers assume that their primary responsibility is getting students ready for the next grade level (1e:31).

Another way of viewing the character of the science taught in these grades is to look at the textbooks being used. Forty percent of the classes in junior high schools are taught from a general science textbook, 31% from a life science or biology text, 21% from an earth science text, and 8% from a physical science text (3:B-45,1d:18,2:88).

At least one of the federally supported, innovative science curriculum projects designed for use in junior high schools was being used in 39% of the school districts during the 1976-77 school year (3:80). The Earth Science Curriculum Project (ESCP) was used by 12% of the schools, the Intermediate Science Curriculum Study (ISCS) by 11%, Introductory Physical Science (IPS) by 8.6%, and Outdoor Biology Instructional Strategies (OBIS) by 3% (3:B-23). The Human Sciences Program (HSP), available only in an experimental form, was used in 2% of the junior high schools surveyed (3:B-23).

There is a positive correlation between the extent an innovative curriculum is known and its use in schools; for example, 89% of science teachers in middle and junior high schools have never heard of the University of Illinois Astronomy Program, 1% have used the materials (3:B-39), and none of the schools surveyed are presently using the program (3:B-19). Of the school personnel who are expected to know about new science curricula, such as science supervisors, principals, and curriculum directors, only 16% know about OBIS, 22% about HSP, 33% about ISCS, and 43% about ESCP (3:B-29). Less than 50% of the teachers have seen any of the new federally sponsored curricula (3:79). Forty-one percent of the district representatives state their schools are using innovative materials, but 16% do not know whether they are or not (3:125). The average number of new programs being used in grades 7, 8, 9 in a district is 1.6 (3:124). This number was slightly larger in the previous school year (3:99).

Schools in the northeastern United States, small cities, surburban schools, and those with high pupil expectations have the highest frequency of use in innovative science curricula (3:81). Thirty-nine percent of the teachers were using a federally sponsored science program in the 1976-77 school year (3:80), a drop in number from previous years (3:B-23). The greatest drop in the use of these programs, by teachers and by school districts, involves the BSCS biology versions (Blue, Green, Yellow, and Interaction of Experiments and Ideas) (3:B-33,

B-39,85); these courses, however, were not developed for use in grades 7, 8, and 9. There also is a drop in the use of all federally sponsored science programs since they were first introduced into middle and junior high schools (3:B-39). Administrators and teachers turned against the federally supported curricula when they found these programs at odds with their own purposes and difficult to manage (1h:22).

Another factor restricting the use of the curriculum reform materials was a failure of the developers to consider local schools, local goals, and the practicing teacher (1h:27). Furthermore, the dedication of teachers to the socialization of students, as well as their own efforts to conform to the social norms of the community, provide plausible explanations of why teachers react negatively to curricular and pedagogic innovations (1g:11,26). Principals feel the federally supported programs improved curricular alternatives (58%) and the quality of instruction (27%), and 66% believed the federal government should continue to support curriculum development projects (3:76).

A single textbook is the curriculum in 50% of science courses in these schools; 25% of the teachers use two textbooks and 21% use three or more (3:89). Six percent state they do not use a textbook (3:94). Of the junior high school science classes, 38% are taught from a general science textbook, 30% from a biology or life science text, and the remaining are taught from a physical or earth science book (3:B-45). The science textbooks most often used by teachers in 1976-77 were copyrighted before 1971 in 22% of the schools, between 1971-73 in 31% of the classes, and 25% had copyright dates between 1974-1977, with 16% of the teachers stating they did not know the copyright dates of the books they were using (3:96). School districts with the highest per pupil expenditures use the oldest textbooks (3:95). Survey results suggest science textbooks were not being replaced as rapidly in 1977 as they were in the late 1960s (2:123). The typical junior high school textbook was two to four years old; the most recently published books in use were those on earth science (2:88).

For grades 7, 8, and 9, thirteen science textbooks account for nearly 50% of the adoptions and, of these, three account for 21% of the adoptions (3:B-45). The variety of science textbooks used in the remaining 50% of science courses is not known, except that no single textbook is used by more than 1% of the schools (3:B-45). Of the 13 most widely used textbooks, six are in the life sciences without one text dominating the field (3:B-45).

More than 40% of the teachers use the teacher's manual that accompanies the textbook. A third use the publishers' tests; 26% use the "hands-on" material accompanying the text; and less than a third make use of audiovisual materials related to the textbook (3:97). However, in approximately half of the school districts none of these materials are available.

The control of textbook adoptions by state agencies has become less restrictive in many states during the past two decades (2:123). Teachers are increasingly involved in selecting textbooks; in only 2% of the schools teachers are not heavily involved (3:98). Students, parents,

and school board members are only minimally involved (5%) and superintendents only slightly more (15%) (3:98). The selection of science textbooks is done by teacher committees 70% of the time. Other school personnel are involved as follows (3:B-48,B-49): individual teachers, 62%; principals, 56%; and district supervisors, 31%. Teachers generally are satisfied with the textbook they use, and 63% would choose the same book again if given the chance; for 11% of the teachers, their present textbook is one they have used before; another 17% of the teachers have no preference among textbooks (3:100).

Teachers view the textbook as the heart of the instructional program (1d:65,66), as the subject matter that must be covered in a course (1g:56), and as the authority for the subject matter (1d:59). There is little agreement among teachers on what should be taught in junior high schools (1d:5,6). Typically, it is the "old science," a passing along of the lore studied by the present adult population when they were in school (1d:7). The selection of course materials does not seem like an important topic to teachers and administrators (1d:65).

Twelve percent of the grades 7 through 9 schools surveyed are using textbooks or curriculum materials developed primarily for use in elementary schools, such as COPES, ESS, SCIS and IS (3:B-19,B-33). Twenty-two percent are using textbooks written for use in high school, such as BSCS biology texts, PSSC physics, Project Physics, and CHEM study chemistry (3:B-19,B-34). We can presume most of these high school textbooks are used at the ninth-grade level and are more often found in a four-year high school than in a middle school organization.

There is a general criticism of the textbooks used in schools expressed by administrators, supervisors, teachers, students, and parents but little agreement as to the major weaknesses. For example, administrators (59%), supervisors (43%), and teachers (55%) think the reading level is too high, but only 26% of the students and 16% of the parents agree (1i:91,92). Forty-two percent of the students feel textbooks are out of date, but only 17% of the teachers, 13% of the supervisors, 10% of the administrators, and 3% of the parents agree (1i:91, 92). Students (20%) and parents (17%) think science concepts are too difficult, but only 11% of the teachers feel this way. Students are more convinced (27%) than their teachers (14%) that there is too much frivolous material in textbooks. Teachers (22%) and students (16%) are in closer agreement that the subject matter of textbooks is poorly related to course tests (1i:91,92). In a sample of 894 school administrators, supervisors, teachers, students, and parents, only 13 persons considered the school science curriculum as worthy of praise, and none of these was an administrator or teacher (1i:95).

Instructional arrangements for the teaching of science are year-long courses in 86% of the schools (3:65). In grades 6, 7, and 8, between 110 and 140 minutes per week are devoted to science instruction (2:32). More time is allotted to science courses where the NSF innovative curricula are used (2:32). The typical class enrollment in science is 31 students, slightly higher than for either mathematics or social studies classes at the same grade level (3:67). The average class load for a science teacher is 4.6 classes; 38% of the teachers teach four or

fewer classes, while 57% have teaching loads of five or six classes, and 5% have seven or more classes (li:20).

Dissemination of Information About New Science Programs

The lack of a national, centralized, educational system in the United States makes the dissemination of information about new instructional programs and materials to thousands of schools a difficult task. One way teachers and principals have learned about new programs is by attending NSF institutes. Typically, programs for staffs of middle and junior high schools have not been widely available; thus we find only 23% of the principals and 21% of the teachers have attended one or more institutes (3:71). The number of teachers who have attended an institute varies throughout the United States, those in the western region having a higher (32%) attendance (3:70). Two-thirds of the state supervisors of science have attended one or more NSF programs such as summer institutes (69%), inservice (18%), academic-year (30%), administrator (30%), and leadership development (30%) (3:70,B-8). Of those persons generally responsible for local curriculum development, 40% have attended an NSF summer institute, 18% have attended an inservice program, and a smaller percentage (less than 10%) have attended other types of informational programs (3:B-9). One in four school principals has attended an NSF program--summer institutes (10%) and inservice programs (5%) account for half of their involvement; these figures do not necessarily mean that the NSF program was oriented to science (3:B-10). Among the many NSF programs available, the summer institutes have been most widely attended by administrators, supervisors, and teachers from middle and junior high schools (3:B-11).

Teachers, state supervisors, and district curriculum respondents were asked to select the one set of materials with which they are most familiar and to indicate where they learned about it. An additional criterion for the state supervisors included the program they had put forth the most effort to disseminate (3:72). The major sources of information for state supervisors are publishers and sales representatives (84%), journals and other professional publications (76%), meetings of professional organizations (67%), federally sponsored workshops (65%), and teachers (54%); all other categories of information are less than 50% each (3:73,B-13).

The local curriculum respondents for grades 7 through 12 receive their information about new science programs from publishers (63%), teachers (62%), journals and professional publications (61%), college courses (49%), and professional meetings (44%); other sources are of less significance, under 30% (3:B-14). Teachers learn about new science programs mostly from other teachers (66%) and from college courses (53%), followed by publishers (37%) (3:B-15). Approximately a fourth of these teachers get information on a new curriculum from a subject specialist (26%), federally sponsored workshop (23%), or professional publication (28%). Inservice programs are not a frequent source of information (18%) (3:B-15).

Half of the states have a means, through the state science supervisor, to disseminate information on new curricula. The new science programs disseminated by some of these states include (3:B-17):

<u>Intermediate Science Curriculum Study</u>, 85%
<u>Earth Science Curriculum Project</u>, 76%
<u>Introductory Physical Science</u>, 74%
<u>Outdoor Biology Instuctional Strategies</u>, 62%
<u>Time, Space, and Matter</u>, 49%
<u>University of Illinois Astronomy Program</u>, 10%

Information about the two BSCS programs for special education students, <u>Me Now</u> (35%) and <u>Me and My Environment</u> (39%), also is distributed by state departments of education, as well as the BSCS <u>Human Sciences Program</u> (37%) (3:B-17). Typically, state supervisors use a variety of activities to disseminate curricular materials, with inservice meetings and discussion sessions ranking highest (3:B-19). Such activities have resulted in the adoption of at least one federally sponsored curriculum program by 39% of the schools (3:80), but 17% of the local school district respondents report they have not heard about any of the federally supported science curriculum studies (3:79). Information about new science programs has been more widely distributed than information about new programs in mathematics and social studies (3:76).

How do state science supervisors go about disseminating information about a specific science program? The most common method (95%) used to inform teachers about new materials is simply a discussion of the materials with the staff. Between 80% and 90% of the supervisors also conduct workshops, arrange for consultants or sales people to meet with teachers, or send out written descriptions of the new materials. Approximately 75% of the supervisors send out sample materials, arrange for teachers to see a new program in action, or directly assist teachers in trying out the materials. To a lesser extent (65%), supervisors arrange for teachers to attend a meeting or institute to learn about new materials (3:B-19).

To see or learn about a new science program is important, but is the information of much value or use? Teachers perceive the information they obtain from other teachers to be very useful (52%), as well as that from professional journals (49%), and college courses (44%) (3:B-118). While 49% rate professional journals their most useful source of information, only 63% read such journals (li:24). Of those who do read professional journals, the average number of education articles read per month is 5.5, and the number of articles on science or science teaching is 12.1 per year (li:24). These teachers read an average of 5.1 books on education per year and 4.4 books about science (li:24).

Federally sponsored workshops are seen as very useful for obtaining information by 26% of the teachers (3:B-118); however, only 32% have attended an NSF institute (3:69). One teacher in five feels the information obtained at professional meetings and from inservice programs is very useful (3:B-118). Information about new programs obtained from the following sources is rated very useful by relatively few teachers:

principals, 13%; local subject specialists, 17%; state department personnel, 7%; teacher union meetings, 4%; and publishers, 9% (3:B-118). A survey of 535 science teachers revealed that two-thirds of the teachers do not find professional journals particularly useful as a source of new curricular information; while three-fourths of the state science supervisors do (3:156).

School superintendents (55%) feel that the federal government should give more attention to the dissemination of information about new science curricula (3:77). At the same time, about half of the superintendents are concerned that federally supported curricular and dissemination efforts might foster a national curriculum (3:77).

Principals feel their most useful sources of information about new instructional materials are professional journals (71%) and meetings of professional organizations (47%) (3:121). Approximately a third of the principals feel the information they obtain from other principals (39%), local subject specialists (36%), college courses (34%), teachers (31%), and local inservice programs (30%), to be very useful (3:B-121). Less useful is information obtained from federally sponsored workshops (19%), publishers (10%), and teacher union meetings (0%) (3:151,B-121).

District curriculum respondents rate professional publications (55%) and meetings of professional organizations (42%) as the two most useful sources of information, with teachers third (33%) (3:B-123). Not more than one respondent in four rates other sources of information to be of high utility; for example, college courses (26%), local inservice programs (25%), federally sponsored workshops (24%), other specialists (19%), principals (18%), publishers (14%), state department personnel (13%), and teacher unions (2%) (3:B-123,151). Knowledge about sources of curricular materials is seen as the major responsibility (89%) of the science supervisors for grades 7 through 12 (1g:45).

State science supervisors find their most useful sources of information on science to be professional publications (72%), professional meetings (66%), state department personnel (61%), and local subject specialists (51%) (3:B-124,151). The following also are listed as very useful sources of information, but less frequently (3:B-124,151): local inservice programs (31%), publishers (28%), teachers (25%), college courses (10%), principals (6%), and union meetings (2%).

Implications

The network of communication about new curricula and instructional materials is centered in professional publications and meetings, where the source of information is described, along with the usefulness of the information. Teachers are a major link in the communication chain as a source of information not only for each other but for curriculum coordinators, supervisors, and principals. What is not clear is the teachers' original source of information about new programs. One suspects it is from a variety of sources. This results in a chain reaction of seeking

information among teachers. NSF summer institutes and college courses also are important parts of the communication chain. While commercial organizations appear to be an important source of information, they are not judged to be the most useful to school personnel.

Deterrents to Effective Teaching and Curriculum Implementation

Science teachers perceive a number of factors that act as deterrents to their very best science teaching. These teachers also suggest how some of these conditions might be alleviated. The most serious problem, stated by 87% of the science teachers, is the inability of students to read as well as they should, and two-thirds of the teachers feel students are not interested in science (3:B-128). Students also are considered less well behaved (2:100). Somewhat more than half of these same teachers state that each of the following factors acts as a deterrent to effective teaching in their schools (2:100,3:B-128):

1. Inadequate facilities
2. Insufficient funds for supplies and equipment
3. Lack of materials for individualizing instruction
4. Classes too large
5. Inadequate articulation of instruction across grade levels
6. Not enough diversity in elective courses

Thirteen percent of grades 7 through 9 science teachers feel they are not adequately qualified to teach science (3:144,2:99).

Factors not considered a serious deterrent to science teaching by 60% to 80% of the teachers were (3:B-128):

1. Low enrollment in courses
2. Compliance with federal regulations
3. Their own interest in science teaching
4. Insufficient number of textbooks
5. Their own inadequacy for teaching science
6. Not enough time for instruction
7. Difficulties in maintaining discipline
8. A belief that science is less important than other subjects
9. Lack of planning time for classes
10. Out-of-date teaching materials

A majority (80%) of grades 7 through 9 teachers state they need help in some aspect of teaching science. The most serious needs identified by nearly half of the teachers were (2:101,3:B-112):

1. Motivating students
2. Obtaining information about instructional materials
3. Learning about new teaching methods, especially implementing a discovery/inquiry approach

A third of the science teachers feel they need assistance in one or more of the following areas (2:101,3:B-112).

1. Teaching both fast and slow learners
2. Using manipulative materials
3. Working with small groups of students
4. Maintaining equipment
5. Articulating instruction across grade levels
6. Maintaining live plants and animals

Forty-three percent of the teachers desire assistance in one to four of these areas, and 37% in five areas or more (3:145). Teachers in schools where there are science supervisors feel a need for assistance as much as teachers in schools where there are no science supervisors (3:146).

Principals of grades 7 through 9 schools perceive the two most serious deterrents to effective science teaching to be inadequate facilities (41%) and the poor reading ability of students (40%) (3:B-131). However, principals see these problems to be less significant than do teachers (3:B-128). Other deterrents to effective teaching stated by principals are (3:B-131):

1. Insufficient funds, 32%
2. Lack of instructional materials adapted for individualizing instruction, 21%
3. Low student interest in science, 19%
4. Inadequate articulation of instruction across grade levels, 15%
5. Class sizes too large, 12%

In general, school principals do not rate corresponding deterrents to effective teaching to be as serious as do teachers.

Eighty-seven percent of school curriculum respondents agree with classroom teachers that a serious deterrent to effective science teaching is the poor reading ability of students (3:B-133). The science reading problem in schools appears to be a condition that is not dealt with in the cause of schooling. Forty-seven percent of the science teachers in grades K-3 rate poor reading ability as a deterrent to effective science teaching; in grades 4 through 6 this increases to 71%, and to 87% in grades 7 through 9 (3:B-128). District curriculum respondents identified the following deterrents to effective science teaching (3:B-133):

1. Low student interest, 65%
2. Lack of materials for individual instruction, 59%
3. Insufficient funds for purchasing equipment and supplies, 57%
4. Inadequate facilities, 47%
5. Large classes, 38%
6. Not enough teacher planning time, 36%
7. Out-of-date teaching materials, 32%
8. Science not considered as important as other subjects, 32%
9. Student discipline problems, 29%

State supervisors of science typically do not view the deterrents to effective science teaching to be as serious as do teachers, principals, and district supervisors. The major problems of science teaching as seen by state supervisors are (3:B-136):

1. Low enrollments in science, 40%
2. Inadequate diversity of electives, 33%
3. Lack of student interest in science, 24%
4. Discipline problems, 15%
5. Inadequate reading skills, 14%

Surveys of science teacher needs have been done to formulate relevant programs of inservice education for junior high school science teachers. The results of these studies reveal that teachers consider their most serious teaching problems to be (2:99-102):

1. Motivating students and building their self-esteem
2. Using information processing strategies, such as problem solving, inquiring, and decision making
3. Individualizing instruction, especially for slow and fast learners
4. Maintaining discipline

Adequate teaching facilities and appropriate curricula for these students are also considered serious needs by teachers.

Teachers feel that problems of facilities and equipment could be solved if the federal government would provide schools with laboratory materials at low or no cost (1g:49). Teachers stated that they were not using the new federally supported science materials because of a lack of funds, and they think that the demand for innovativeness has ebbed (1g:53). Teachers did not see that educational research and theory would be helpful with their problem because research and theory have little practical value (1g:24).

Summary

The major obstacles to effective science teaching center on:

1. Student variables such as motivation, interest, and learning skills
2. The teachers' inability to utilize, or inadequate knowledge of, instructional strategies for processing information in the contexts of inquiry/discovery, decision making, and problem solving
3. Science curricula inappropriate for the early adolescent
4. Inadequate teaching facilities, equipment, and supplies

Controversial Issues and the Teaching of Science

As science has grown to be increasingly involved in social affairs, the problems and issues it deals with have become nearly always controversial. Should early adolescents study and analyze societal issues such as health care, abortion, and race? More than 50% of school professionals believe they should, but only a third of the students and parents take this position (li:89). The public does not put a high priority on attempts to teach these topics, using a "scientific approach" in social studies classes (li:97). The use of federal funds for developing teaching materials on controversial topics is supported by more students (68%) than by their parents (41%) (li:79). Sixty percent of school superintendents are of the opinion that federally funded curricular programs should not include controversial topics (3:77).

By the age of 13, students have formed rather definite and seemingly consistent opinions about many controversial topics. On the question of growing a baby organism from an egg in a test tube, 40% of the students believe it is all right for scientists to try this with a frog, 20% with a dog, but only 10% would approve of such an experiment for a human being (C07A01) (Reference Note). More than half (53%) of the students would approve the efforts of scientists to make a robot that thinks and acts like a person, a larger percentage (63%) would encourage research to make mechanical parts for people, and they are divided (43% yes, 40% no) on the question of efforts to create life (C07A01). Students would oppose efforts to clone a human being (71%) (C07A01), to control the way people act (77%) and to experiment on people without their approval (86%) (C07A02). There is extensive support (86%) for seeking other forms of life in outer space (C07A01).

Students at this age have reservations (63%) about scientists working on secret projects, 29% favor, and 8% would never approve (C07A02). Students are also hesitant about allowing scientists to do any kind of research they want to do (42%), 30% would approve, and 28% definitely would not approve (C07A01). There is strong opposition to efforts to create diseases for germ warfare (82%) (C07A02) but less opposition for attempts to make bigger bombs (63%) (C07A01). While students recognize such issues as DNA research, evolution, and control of atomic energy as scientific controversies, they are not able to see the "bit of pure knowledge" as separate from that same knowledge in a social context (lc:27); students tend to associate science with scholarship, not with social, political, and economic issues (lc:27).

The most commonly used science textbooks (3:91) do not emphasize controversial science/social issues in any substantive way nor do the stated goals of the texts reflect these concerns as a focus of instruction. Teachers on their own may deal with certain controversial topics, but tend to do so only if they feel they have community support (lc:28); the result is that controverisal issues are largely ignored in teaching (lc:29). However, teachers report there is no real problem in their community on teaching biological evolution or about human sexuality (lc:28), but they are more hesitant on questions of eugenics and overpopulation (lc:29). Science teachers feel there must be community

support for the teaching of controversial issues and that there is need for better instructional programs for dealing with such issues (1c:29). There is also substantial community support for developing better programs in controversial areas (1c:30); parents are no more conservative than teachers.

Thirteen-year-old students feel they can do something personally about resolving many science/society problems. Around 50% feel they could help solve problems of pollution (67%), energy waste (60%), accidents (58%), and food shortages (47%). Only a comparatively few students feel they could do something about such problems as overpopulation (23%), disease (31%), and the depletion of natural resources (C03A01).

Early adolescents express a willingness to work on societal issues, even if it is inconvenient, by using less electricity (87%), walking or taking bikes more often (87%), using returnable bottles (88%), riding in a small economy car (78%), spending a day helping to clean up street litter (69%), separating trash for recycling (65%), staying home from a party when they have a bad cold (60%), and using less heat in the winter to save fuel (56%) (C03A02).

When asked how frequently (always or often) they personally got involved in doing something about societal problems and issues, their positive responses tended to be lower than their willingness to be involved. For example, around 40% or fewer of the students regularly use seat belts (22%), pick up litter (26%), reuse paper or plastic bags (34%), separate trash for recycling (29%), or become involved in a litter clean up project (42%) (C03A04). More than 50% of the students feel they are involved in solving representative societal problems to the extent of turning off unneeded lights (58%), making sure they turn off water faucets (81%) when through using the water, and obeying traffic laws (75%) (C03A03). Only 37% of the students feel they are not personally guilty of causing pollution more than they should (C03A04).

An Interpretation

Over the past decade, there has been a shift in the scientific enterprise toward an increasing emphasis on science applied to societal needs. The professional literature on goals for the teaching of science reflects the science/society interaction (2:164,168,183). Students, by the age of 13, recognize the importance of science/society issues in their lives and wish to be involved in resolving them. There is little in the science curriculum of middle and junior high schools that reflects the current status of the scientific enterprise as it relates to social issues. Teachers claim it is the pressures emanating from a "back to basics" movement that limits their response to personal and social needs (1b:12), but it must not be overlooked that only 41% of all parents have heard of the "basics" movement in education (1i:51) and that teachers were found to be "the advocates" of "basics" more than anyone else (1b:18).

Furthermore, most teachers are wary of linking science and human values (1g:19), an issue that is difficult to avoid in studying science/society issues. It is simpler to use a disciplinary approach and teach authoritatively (1g:6). Teachers respond to the social system in ways that relate to their teaching situation (1g:26.1) but do not respond easily to new teaching goals that arise from transitions in society nor in the discipline they teach. They tend to fear that new goals and curricular topics will bring about a confrontation with the public and therefore react negatively toward them (1g:25,26), although they have substantial community support for developing better programs on controversial topics (1c:30).

The extent to which science/society topics are not in the textbooks being used is the extent to which the topics are not taught, although teachers state they would consider teaching the topics if they had appropriate materials (1c:29). It seems evident that the various efforts, as they are reflected in scholarly writings, to expand the social and value dimensions of science teaching have not appreciably influenced school practices (1c:27). There is little information in middle and junior high school science courses that would help students develop an awareness of or comprehend connections between science and related social issues. The work of Roshal, Frieze, and Wood (18) reveals that sixth-grade students have a somewhat (better than neutral) favorable attitude toward technology, its values, and uses. Scientific/technological enlightenment as an aspect of effective citizenship in modern American does not exist in any real sense as a goal of science teaching in the middle and junior high school grades.

Testing, Evaluation and Assessment

Throughout the past decade (1970-1980), there has been much public concern about what students were or were not learning in schools. These concerns have stimulated a "back-to-basics" movement in schooling. Although the rhetoric on what should be basic is extensive and controversial, there has been little support for knowing science as one of the basics. There has been a wave of public pressure to hold schools "accountable" for what they claim to teach. By 1978, "33 states had taken some kind of action to mandate the setting of minimum competency standards for elementary and secondary school students" (19). To determine the nation's progress in science achievement, the National Assessment of Educational Progress (NAEP) was initiated in 1969 to gather relevant information. The first assessment of science took place during 1969 and 1970, the second during the 1972-73 school year, and the most recent one during the 1976-77 school year. The total impact of these various efforts to assess student achievement represents a questioning of the purposes of schooling by the public and a general loss of credibility in the education enterprise.

Testing students in science is a natural part of teaching (1f:12) and is done to satisfy teacher concerns (1f:13). A third of the science teachers give a test at least once a week, and another 30% at least once

a month (3:27). Most teachers make up their own tests (1f:15). Students are expected to learn assignments and are tested accordingly (1f:14,1g:22). Records are kept on how well students perform (1f:16). Most tests do not tell teachers anything they don't already know (1f:17). Testing essentially represents maintaining a proper classroom (1f:14). The results of tests are used to assign grades, and students see the need for getting good grades (1f:19). A third of the students, as well as a third of the teachers, believe it is more difficult to get good grades in science than in other subjects (1c:18). Measurement specialists continue to talk about the technical inadequacy of grades; teachers do not (1f:19). Testing is also used to help maintain control over students and to socialize them (1f:18). Most science teachers, school administrators, curriculum coordinators, and parents agree that the present mode of testing is adequate (1f:21). There is essentially no reference in the case studies of schools about using tests to evaluate teachers or curricula (1f:17). While there is evidence that schools are doing more testing in science classes, there is little evidence the results are being used to improve the educational system (1e:35).

Standardized tests are used in 33% of science classes in grades 7 through 12 (3:27). However, standardized tests are used by more than 50% of urban schools and large districts. By far, the greatest use of test results was to inform teachers, followed by informing parents (3:29). About half of the schools use test results to assign students to remedial programs and as diagnosis/prescription for individual students (3:29). Schools rarely use test results to assign students to programs for the gifted, to determine topics for inservice education programs, or to revise curricula (3:29). Teachers see little need for a wider interpretation of test results in terms of district or classroom use (1g:45). Supervisors see their job to be fitting curricula to the testing (1g:45). Overall, evaluation is seen as a process of rewarding sincere efforts on the part of a student and avoiding overrewarding students for modest accomplishments (1g:11).

The accountability and competency movements in education during the 1970s have had some influence on science teaching in middle and junior high schools, although there is little direct evidence of what these effects have been. Nearly all school districts report some form of "evaluation officer" whose function is to monitor student achievement (1h:10). When talking about science teaching, the topic of accountability rarely comes up in the conversation (1h:12). A survey of 49 states revealed that only 2% required specific competencies in science for graduation in 1977 (3:32). Thirteen percent plan to implement a science competency program in the future, but 63% of the states have no such plans (3:32). The remaining states either did not respond to the questionnaire or were unclear in their plans (3:32). Nearly three times (35%) as many states plan to have competency measures in mathematics as in science (3:31). In response to a question as to whether schools should require that all students attain some minimum competency level in science in order to graduate from high school, parents are the group in highest agreement and school administrators the most opposed (1i:91). About half the students support the idea of a competency level in science for graduation as do two-thirds of the teachers (1i:91). A major

criticism of the tests used for accountability measures in schools is that they only indicate achievement and have little validity as an indicator of science competency (1h:11).

Public concern about student achievement in the sciences came into prominence in the early part of the 1970s. Press reports of declining scores on the College Board Examinations and the Scholastic Aptitude Test indicated that students were going into colleges and universities less well prepared than in past decades (2:114). Both these tests are used with college-bound students and are, therefore, limited in providing information on science achievement at various age levels. With the founding of the National Assessment of Educational Progess in 1969, measures of school science achievement have been made at ages 9, 13, 17, and in some years, at adult levels. The major results of the 1976-77 science assessment of 13-year-old students, enrolled in either grade 7 or 8, are reported here (16):

There is a small but not significant decline in achievement from the 1972-73 level to 1976-77.

Student achievement in biology has increased since 1972-73.
Student achievement in the physical sciences continues to lessen.
13-year-old students know more science than 9-year-olds and less than 17-year-olds; 8th-grade students know more than 7th-graders.

Certain student groups at age 13 tend to perform <u>above</u> the national level in science achievement. These are:

Males, whites, and students in the northeastern United States
Students who have at least one parent with a post-high-school education score significantly higher in every category of questions on the NAEP tests
Students who live in advantaged, urban communities or in suburbs of large cities

Certain groups of students at age 13 tend to perform <u>below</u> the national level in science achievement. These are:

Females, blacks, and those students whose parents did not graduate from high school
Students who live in the southeastern region of the United States and those who live in disadvantaged, urban communities and in big cities

Some student groups show little deviation from the national level of achievement. These are:

Students in the western region of the United States and those who attend school in medium-sized cities or in smaller places

Students who come from homes where a newspaper and magazines are received regularly and there are 25 or more books plus a set of encyclopedias score higher on science achievement than students from homes

lacking one or more of these characteristics, regardless of whether the student is black or white.

At age 13, boys have a significant achievement advantage over girls in biology, physical science, and earth science. Boys have an advantage over girls on integrated topics, process methods of science, and science related to self. Boys are significantly better in their understanding of applied science and technology. Girls show significantly better command of decision-making skills than boys.

At age 13, boys have a relevant and significant advantage over girls at each taxonomic level of science: knowledge, comprehension, application, and analysis/synthesis.

The results of the NAEP tests for 13-year-old students indicate that by this age the social, economic, and cultural environments of students have created differences in science achievement beyond those that can be attributed to schooling. These cultural factors also account for differences in science achievement by sexes and by racial background.

The NAEP tests indicate that, in 1976-77, the test scores of 13-year-old students were lower than those for 1972-73, and were much lower than in 1969-70 when the first test was given. There is a smaller drop in average achievement between the last two test periods because of a large rise in biological knowledge, stimulated perhaps by the popularization of the environmental movement at this time (1970-75). There is speculation that the student achievement scores for the 1969-70 period may be abnormally high as a result of the attention given science instruction during the 1960s and the many efforts made to stimulate teachers and students to "do better." But the fact remains that science achievement for 13-year-old students has declined throughout the period from 1969 to 1978.

Facilities and Equipment

About 20% of the science teachers feel they have very good science facilities (3:B-99), but 25% have no laboratory facilities (2:39). Seven out of ten schools have a combination laboratory-classroom; one school in ten has a separate laboratory and classroom arrangement (2:39). Nationwide, 51% of grade 7 through 9 schools have resource centers for individualized instruction (3:B-92). In addition, small-group meeting rooms are available in 56% of the schools (3:127). Forty-four percent of the teachers are of the opinion that the science facilities need improvement (3:135).

The following science equipment is used at least ten days in a school year (3:B-86): (1) meter sticks and rulers, 61% of the teachers; (2) balances and scales, 49%; (3) models, 45%; (4) microscopes, magnifying glasses, batteries, and bulbs, rocks, and living plants by about 35%. The teachers feel the following equipment is not needed; hand

calculators, 69%; cameras, 62%; living animals, 49%; living plants, 39%; rocks, 38%; and magnets, 31% (3:B-86). There is not much agreement about what equipment should be "standard" in science rooms. While 95% of the teachers have microscopes, 74% have models, and 51% have cameras (3:127), some do not feel a need for microscopes (30%), cameras (62%), or models (17%) (3:131). Fifteen percent of the schools have greenhouses; 40% of the science teachers would like to have one, but 50% see no need, and only 8% state they ever made use of one (3:127,131). The situation is about the same for the existence and use of weather stations, telescopes, and darkrooms (3:131). Between 50% and 60% of the teachers feel they have adequate facilities, equipment, supplies, and storage and preparation space (3:B-99). What the teachers would most like to have are laboratory assistants (72%), money for incidental supplies (52%), and space to accommodate small student groups (56%) (3:135,B-99;2:95). Overall, facilities and equipment are deemed by teachers to be somewhat less than satisfactory. Teachers also are more concerned by the lack of physical materials than with the organizational problems of science teaching (1g:46).

Only a few programs (21%) have a budget for science equipment. In 1977, the amount set aside per year for equipment averaged about $5 per pupil, plus $3.75 per pupil for supplies (3:126,200). The total expenditure for the education of a middle or junior high school student was $936 (weighted average) for the 1976-77 school year, an amount about 9% less than for pupils in either grades K-6 or 10-12 (1h:19). More than half (55%) of pupils believe the reason more instrument technology is not used in middle and junior high schools is cost rather than opposition by teachers (1i:69). The funding for schooling and science teaching is being seriously reduced (2:168,169). Approximately 55% of school administrators, supervisors, teachers, and parents believe that budget cuts are lowering the quality of instruction (1i:97). The extent to which cost is a factor in reducing the availability of instructional materials is questionable, because less than 2% of the average school district's budget is so spent (1d:66). A solution to the problem may not depend on increasing monies for total school programs, but rather on categorically funding in terms of instructional objectives and priorities (2:170).

The extent to which information technology and related equipment are used in science teaching has not been fully explored, and only limited information is available. Nationwide, 16% of the grades 7 through 9 schools have access to computers or computer terminals (3:127). Large districts and suburban schools have somewhat more access to computers (20%) than do smaller units (3:B-92). Hand-held calculators are found in 49% of the schools (3:117). A majority of teachers (69%) feel that hand-held calculators are not needed for instruction, and only 10% ever make any use of them (3:B-86). There are no significant differences throughout the United States in terms of school size, location, pupil expenditures, or type of community in the availability of computers and hand-held calculators in schools (3:B-92).

Reference Note

Numbers such as C07A01 refer to NAEP science items, released and unreleased. Released items are from The Third Assessment of Science, 1976-77, Released Exercise Set. Report No. 08-S-00, May 1978. NAEP, Education Commission of the States, 1860 Lincoln Street, Denver, Colorado 80295.

CHAPTER 5

MIDDLE AND JUNIOR HIGH SCHOOLS, 1965-1970

A comprehensive survey of the status of organizational patterns of science teaching in middle and junior high schools does not exist for the period 1965-1970. The United States Office of Education (20) surveyed the teaching of science only in schools that had grades 7, 8, and 9 during the period 1963-1965. Kealy (21) has summarized the results of surveys carried out between 1960 and 1970 as part of studies made to determine the extent of reorganizational patterns in "the middle portion of the educational ladder" that differed from the typical grades 7, 8, and 9, or junior high school, organization. The majority of surveys, including those done by the federal government, lump informamation about grades 7, 8, and 9 under secondary school programs (grades 7 through 12) or, in some instances, with data on elementary schools (grades K through 8). In this section, our purpose is to identify changes in school organizational patterns that emerged during the 1960s for the education of the early adolescent.

The extent to which school districts have modified traditional organizational arrangements (8 and 4 grades, 6, 3, and 3 grades, and 6 and 6 grades) into grade combinations considered more educationally suitable for the early adolescent has been documented by Kealy (21). A USOE report on junior high schools by Wright and Greer (22) revealed that 12% of the principals of these schools were considering a reorganization of grade combinations. A survey by Cuff (23), with replies from 44 state representatives or state publications, revealed that 29 states had a total of 499 middle schools. These schools included grades 6 and 7 and did not extend below grade 4 or above grade 8. The most common organization (55%) consisted of grades 6, 7, and 8; 30% of the schools included grades 5, 6, 7, and 8; and in 9% of the schools, grades 4, 5, 6, 7, and 8 formed the middle school unit. Cuff's criterion for a middle school excluded a seventh and eighth grade organization sometimes referred to as an "intermediate school."

Alexander (24), using the criterion of a middle school as one "having not less than three or more than five grades including grades 6 and 7," identified 1,101 middle schools in the United States. A 10% random sample of these schools, stratified by USOE geographical regions, showed that 60% were organized on a grades 6 through 8 basis; 27% included grades 5 through 8; and 7%, grades 4 through 8. Among other combinations of grades for middle schools, only 1.8% of the total sample included a grade 9. Alexander's definition of a middle school, like Cuff's, excluded the combination of grades 7 and 8 as an emerging school

organization replacing the junior high school plan. The ERIC (25:10) survey showed that 3% of the school districts of the United States had a grades 7 and 8 organization. Alexander (24) interprets "the expansion of middle school organizations" as "a phenomenon of the current period" (1967-68).

A USOE survey (20) of public junior high schools organized exclusively on a grades 7, 8, and 9 basis identified a total of 3,133 such schools. Alexander, Cuff, and Rogers did not gather information on the seventh and eighth grade, two-year intermediate school.

Kealy (21) surveyed the number of middle schools in the United States for the school year 1969-1970. Using data in reports obtained from state departments of education, he identified 2,298 middle schools, a number double that found in the 1967-68 survey, which listed 1,101 middle schools. Schools with grades 6 through 8 represented 58.2% of those surveyed; 25.4% of the schools used a grades 5 through 8 organization; and 6.1% a grades 4 through 8 grouping. Other groupings, comprising 10.4% of the schools were organized in such grade combinations as 6 through 9, 4 through 7, 5 through 7, 5 through 9, or 3 through 7. A national survey by ERIC (25:10) indicated that the "middle school" concept was not widespread.

The movement away from more traditional school organizational patterns (6, 3, and 3; 8 and 4; or 6 and 6) was based on the assumption that a "better" type of education could be provided to early adolescents in a middle school framework. In Alexander's (24) detailed study of 110 middle schools, he asked school personnel to identify reasons for changing their school organizations from a traditional pattern to one of a middle school. Multiple reasons were given by the respondents:

1. 58% sought to eliminate crowded conditions in other schools.
2. 45% wanted to provide a program specifically designed for early adolescents.
3. 40% thought the new organization was a better bridge between elementary and high schools.
4. 30% wanted to provide for more specialization in grades 5 and/or 6.
5. 25% wanted to move grade 9 into high schools.
6. 25% considered the move a way to remedy the weaknesses of the junior high school.
7. 24% wanted to try out various innovations.
8. 21% thought it was a way to utilize a new school building.
9. 13% chose the option because it had been successful in other school systems.
10. 6% felt it was an aid to desegregation.
11. 12% had other reasons.

The majority of reasons given for establishing a middle school pattern of education reflect administrative expediencies rather than an inherent philosophical concept of education perceived to improve learning opportunities for early adolescents.

The school day (20:4) in 92.5% of junior high schools in the United States was organized into separate class periods with a six- or seven-period day. The ERIC (25:15) survey showed that 41% of the schools had a six-period day, 35% had seven periods, and 14% had eight periods per day. Alexander (24:116) found that middle schools were departmentalized to the same extent as junior high schools. He noted, however, that 30% of them were using variable and modular schedules differing from the conventional, uniform, daily schedule of equal periods.

For about 98% of the schools, the school year was between 165 and 195 days (20:5); for 75% of the schools, the range was between 176 and 185 days. The ERIC (25:16) survey found the length of the school year to be 180 to 184 days for 69% of the schools and 175 to 179 days in 21% of the schools.

The length of science class periods was found to range from 38 to 62 minutes (20:5) with 53 to 57 minutes most common. These figures are similar to secondary schools in general, where the range is from 40 to 70 minutes (25:15) with 40% of the schools using a 50- to 59-minute period, and 25% a 50- to 54-minute class period. The Committee on Junior High School Education of the National Association of Secondary School Principals (26:5) recommended that a block-time or core program "may be an effective means of bridging the gap between the elementary and junior high schools." This could mean teaching science and social studies, or science and another subject, as a core program extending over several class periods. A Cornell University Project on the Junior High School (27:9), supported by the Ford Foundation, carried the recommendation that one-sixth of the instructional time in grades 7, 8, an 9 be devoted to studying science.

The decade from 1960 to 1970 was a period in which there was much concern about appropriate education for the early adolescent. Questions were raised about the junior high school (grades 7, 8, and 9) as to whether it was the best school organizational pattern for students in the age range of 11 to 15 years. A variety of new organizational patterns were developed and rationalized in terms of student maturity, interests, needs, developmental and learning characteristics, curricular goals, and in terms of effective use of school facilities, size of school, enrollment, and school management. With few exceptions, the new organizational patterns did not include the ninth grade as a part of the new "middle school" or "intermediate school" framework.

Course Offerings and Enrollments

In the 1960s, a number of federally supported science curricula were developed for elementary and secondary schools in the United States. Innovative courses specifically designed for use in middle or junior high schools did not appear until late in the 1960s and were not reflected in the school science surveys done between 1965 and 1970.

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General science was the most commonly taught science subject in the 1965-1970 period (20:6) in all sections of the United States (25:29,30), with 94% of the schools scheduling the course. Life science courses were offered in almost one-fourth of the schools (20:6). The survey (25:32), done five years after that of the USOE, showed 47% of the junior high schools offering a life science course. Of the total junior and senior high school enrollment in biology courses in 1970, grades 7 through 12, 18% of the enrollment was found to be in the junior high schools, usually at the ninth grade level (25:30). Earth and physical science were taught in about one-fifth of the junior high schools (20:6,7) in 1965. By 1970, nearly 50% of the middle and junior high schools had a course in physical science (25:35) and 52% a course in earth science (25:42). There was a tendency for physical, life science, and earth science to be offered at the ninth grade level. Nine percent (25:37) of the junior high schools offered a course in health science, usually at the eighth grade level (20:6) in 1965, with the number increasing to 26% by 1970 (25:38).

In 1965, environmental science was not identified as a course offering in middle and junior high schools but was found in 4% of the junior high schools in 1970 (25:78). In addition to course offerings, environmental science topics were incorporated into other science course offerings as follows: seventh grade, 15%; eighth grade, 16%; and ninth grade, 27% (25:79). Environmental science topics were also found in social studies classes (25:80): seventh grade, 4.6%; eighth grade, 5%; and ninth grade, 8.6%.

Space science, health science, and environmental science offerings were not distributed equally as courses throughout the junior high schools of the United States; space science was strongest in the middle eastern and far western states; health science in the southwestern and the Great Lakes areas (20:8) and in the plains states (25:37). Environmental science courses were offered more frequently in the New England, far western, and Rocky Mountain areas (25:78). These data, along with those on life and physical science offerings, indicated that the traditional general science pattern of science teaching in the junior high schools was beginning to change.

In 1965, 77% of the students in junior high schools were enrolled in science classes (20:6). In smaller schools, under 500 students, 90% of the students were taking a science course. The majority of students (67%) were taking a general science course at some grade level; enrollment in a life science course was 4%; and enrollment in both physical and earth sciences was less than 4% (20:6-8).

At the close of the 1960s and beginning of the 1970s, a number of innovative science curriculum programs were in either a planning or developmental phase. Some of these new programs were generated at the state or local level, and others were federally supported with the idea that a "good science" course was appropriate nationwide. Typical of the new science curriculum projects initiated in the 1965-1970 period were the following (28):

Human Sciences Curriculum Project (BSCS)
Life Science (Educational Research Council of America)
Quantitative Physical Science (Duke University)
Introductory Physical Science (Educational Services Incorporated)
Time, Space, and Matter (Princeton University)
Earth Sciences Curriculum Project (American Geological Society)
University of Illinois Astronomy Project
Stanford University Junior High School Science Project
Inquiry Development Program (University of Illinois)
Michigan State Curriculum Committee Junior High School Science Project
Mathematics Through Science (SMSG)
Science Teachers Adaptable Curriculum (Portland Public Schools)
Pennsylvania Curriculum Development Project (Harrisburg)
New York City Science Grades 7-8-9 Project
Project Plan (American Institutes for Research)
Nova School Science Plan (Florida)
Intermediate Science Curriculum Study (Florida State University)
Foundational Approaches in Science Teaching Project (Hawaii Curriculum Center)
American Association for the Advancement of Science, Junior High Science Proposal

In one way or another, all of these programs sought to provide a more suitable curriculum for the education of the early adolescent. The extent to which these programs become operational within schools can only be assessed at a period of time later than 1970.

Science Teacher Characteristics

All the information on the characteristics of science teachers in junior high schools during the period 1965-1970 is from a National Science Foundation survey conducted in 1969 (29). The survey included a total of 5,505 secondary school science teachers, of whom approximately 25% were teaching in grades 7, 8, or 9. The information reported here is only that which can be distinguished as pertaining to the sub-set of junior high school science teachers.

In addition to teaching science, 98% of the teachers had other duties related to science teaching, and 86% "other school activities" (29:107). Eleven percent of the teachers were also engaged in some type of teaching outside the junior high school, such as in a community college or a four-year college or university. Another 22% of the science teachers were employed in nonteaching positions.

A third of the teachers were carrying academic or professional work leading to an academic or professional degree, while an additional 19% were taking course work not leading to a degree. Two-thirds of these teachers were engaged in a variety of other professional activities (29:107).

Many teachers whose major assignments were in general science had serious inadequacies in their training. The percentages of these teachers with no course credits in various science fields were: biology, 17%; chemistry, 34%; earth sciences, 38%; physics, 46%; and mathematics, 27%. The percentages of teachers who had between 1 and 17 semester hours in the various sciences were: biology, 37%; chemistry, 42%; earth sciences, 38%; physics, 42%; and mathematics, 50% (29:131). The data base does not reveal the balance of science preparation for teachers of general science.

The teachers were asked to indicate the types of experience they felt contributed significantly to successful teaching. The experiences indicated to be of significant value by the 1,352 respondents were (29:147):

1. Courses in subject area, 77%
2. Courses in teaching methods, 47%
3. Student teaching, 47%
4. Inservice teaching experience, 46%
5. Courses in student behavioral problems, 38%
6. Related work experience, 34%
7. Courses in laboratory methodology, 27%
8. Other preparation, 11%

Junior high school teachers were inclined to designate courses in student behavioral problems as valuable, while senior high school teachers thought subject-area courses had greater value (29:50). Teachers who had student teaching experience, courses in professional education, and 30 or more semester hours of science in their teaching field rated the quality of their education for teaching science higher than did teachers with limited or no background in these areas (29:53).

More than half (57%) of the junior high school teachers had participated in an NSF or an industry-sponsored training program by 1969. The types of NSF inservice programs attended and the percentages of teachers attending were:

1. Summer institutes, 21%
2. Inservice institutes, 15%
3. Academic-year institutes, 4%
4. Any other type of NSF program, 5%

An additional 8% of the teachers attended a federally supported program other than one supported by NSF. State and local inservice programs were attended by 14%. Industrial or privately supported programs were attended by 7% of these teachers (29:171). More senior high school teachers reported participation in NSF programs than junior high school teachers (29:58). Of the junior high school teachers who did participate in an NSF program, the majority attended more than one program (1 to 6) (29:173).

The science teachers of 1968-69 were comparatively young, with a median age of 32 years (29:10,11). This is seven years below the median age of the total labor force and five years below the median age of

those in the labor force with a bachelor's degree. Sixty percent were below the age of 35 years and 18% were older than 45 years.

Sixty-seven percent of the science teachers were men, about the same ratio as a decade earlier. Sixty-three percent of the teachers between the ages of 25 and 44 were men; 45% were women. In younger (under 25) and older (45 or more) age groups the percentages of women were higher than those of men (29:13). In the southern states, there was a higher proportion of women than men, and the reverse was true in the north central and Pacific sections of the United States.

Junior high school science teachers were queried concerning their short-term (five years) aspirations and goals in several dimensions: level of employment, field, type of occupation, and type of employment (29:178). Seventy-eight percent expected to be teaching, and 13% planned to become full-time or part-time housewives. Eighty-one percent of the general science teachers expected to be teaching general science five years later. About half of the teachers (49%) stated their future goal to be that of a classroom teacher; 31% wanted to be in some other form of educational work, such as curriculum specialist, school administrator, or supervisor; 9% hoped to find employment in some field other than education. Relatively more participants in NSF programs than nonparticipants expected to: become departmental supervisors, 14% participants versus 7% nonparticipants; stay in a science occupation, 80% versus 65%; and remain in junior hgh school education, 71% versus 66% (29:63). Two-thirds of the science teachers wanted to continue at the grade levels they were teaching, 12% wanted to move to a higher grade level, and 2% wanted to teach at the elementary school level. The majority of teachers (70%) aspired to a master's degree and 16% to a specialist in education or a doctorate degree (29:64).

The survey information indicates that at least two-thirds of the science teachers in junior high schools were young (under 35 years), liked what they were doing, expected to stay in education, and sought to improve their professional backgrounds to the level of a master's degree.

Early Adolescents' Understanding of Science

The first National Assessment of Science was carried out during the 1969-70 school year. The assessment included exercises appropriate for four age groups--9, 13, 17, and young adults from 26 to 35. Our examination of the results of the assessment is confined to the age 13 group, or the early adolescent.

The first assessment of science was designed to provide a "benchmark" study of science achievement for different age groups throughout the United States. A broad purpose of the program was to begin to provide responsible information on how well teaching was working in the United States or, in other terms, to find out what pupils were learning in science classes. This position was in contrast to testing programs

of which the purpose was to learn where pupils stood in comparison with other school children. The design of the assessment package was to provide a bank of censuslike data for a given population of students.

The central question of what students should know about science was determined by "more than 3,000 scholars, teachers subject matter experts, curriculum specialists, laymen, including members of school boards, and test specialists" (30:28). From the deliberations of these people, four primary objectives of science education were evolved. These statements encompassed the objectives of science education both within and outside of the schools. The four primary objectives were interdependent and should be regarded as different facets of the same entity--an integrated pattern.

The assumption was that these objectives were common for each age group, and that educational progress was cumulative from one age group to the next. Thus, it was expected that 13-year-old students would understand more science than 9-year-olds and less than 17-year-olds. "The delineations are, in general, written in terms of what approximately half of the people at a given age level might be expected to know or to be able to do" (30:9). The primary objectives for science education as they were identified in 1969 were (30:9-25):

I. Know fundamental facts and principles of science

Examples: Characteristics of electricity and magnetism, heat and kinetic theory, chemical behavior, minerals and rocks, diversity of living things, organization of living matter, ecology, evolution, solar system, stars and galaxies, health and nutrition, etc.

II. Possess the abilities and skills needed to engage in the processes of science

Examples: Ability to identify and define a scientific problem; recognize a hypothesis; propose or select validating procedures (logical and empirical); obtain requisite data; interpret data and check for logical consistency; reason qualitatively and symbolically; read scientific materials critically; apply scientific laws and principles; distinguish among fact, hypothesis, and opinion; distinguish the relevant from the irrelevant; and distinguish the model from the observations the model was derived to describe.

III. Understand the investigative nature of science

Examples: Scientific knowledge develops from observations and experiments; observations are generalized in class; laws are generalized in terms of theories; not all questions are amenable to scientific inquiry; science is not, and probably never will be, a finished enterprise.

IV. Have attitudes about and appreciations of scientists, science, and the consequences of science that stem from adequate understandings

Examples: Recognize the distinction between science and its applications; have accurate attitudes about scientists; understand the relationship between science and misconceptions or superstitions; be ready and willing knowingly to apply and utilize basic scientific principles and approaches, where appropriate, in everyday living; be independently curious about and participate in scientific activities.

The results of the NAEP tests in terms of the four primary science objectives for 13-year-olds for the school year 1969-70 were as follows (31a:73-93).

OBJECTIVE I. KNOW THE FUNDAMENTAL FACTS AND PRINCIPLES OF SCIENCE

General Summary

All of the exercises for this objective were multiple-choice. Difficulty is influenced not only by the concept being assessed, but also by the difficulty and the potential for confusion induced by the alternatives offered. Most 13-year-olds answered correctly when asked about simple scientific facts, many of which are close to everyday experience (baby comes from its mother, brushing teeth prevents tooth decay, dark clouds bring rain, fanning a fire makes it burn faster, etc.).

Exercises answered correctly by a good many 13-year-olds tended to be farther removed from everyday experience. Some required knowledge of prehistoric humans, the formation of fossils, or the movement of air masses--all actions or things inaccessible to direct observation. Others required awareness of scientific principles of molecular movement, pasteurization, and the like. Other exercises of this difficulty, while drawing on observation, also called for application of theoretical ideas (e.g., refraction of light by water).

The most difficult exercises did not deal with any single type of content. Often the chosen single alternative required a precise discrimination. For example, one exercise asked the students to choose which of five parts of the central nervous system is the center of memory and intelligence. Exercises on molecular theory and chemical reactions were generally difficult.

Most 13-year-olds responded correctly that:

The human baby comes from its mother's body (98%).
You brush your teeth to keep them from decaying (98%).
Thick, dark-gray clouds are more likely than others to bring rain on a summer day (93%).
The best balanced meal (from among five alternatives given) includes steak, bread, carrots, and milk (89%).
The comfortable temperature for a schoolroom is 70^{o}F (86%).
Fanning a fire makes it burn better because fanning increases the supply of oxygen to the fire (79%).
Cancer is a disease that cannot, at present, be controlled by a vaccine (78%).

Even without atmosphere the launching of a rocket from the moon is possible (74%). (This result was obtained in the fall of 1969, after the lunar landing).

A good many 13-year-olds responded correctly that:

Sedimentary rock usually forms in layers (65%).
The earliest men on earth were probably small, hairy, and stooped (63%).
In hot water, the molecules are moving faster than in cold water (61%).
Predicting the movement of air masses is an important factor in predicting weather (59%).
A human action such as draining a swamp can upset the ecology of a small area (57%).
A second weight can be hung at an appropriate position to balance another weight (55%).
Flower seeds develop from the ovules rather than leaves, petals, roots, or stems (54%).
The apparent bending of a spoon in a glass of water is explained by refraction of light (51%).
Most of the chemical energy expended in the automobile engine is not used to move the car but is changed into heat (48%).
Mercury can be used in a glass thermometer because when heated it expands more than the glass (45%).
Pasteurization of milk kills bacteria harmful to humans (40%)
A block of wood is more buoyant in salt water than in fresh water (39%).
Most caves are formed by the action of underground water on limestone (38%).
Natural selection offers an explanation for why giraffes have long necks (38%).
A body covering of feathers is what distinguishes birds from all other animals (36%).
Our knowledge of atoms is based on observations of how matter behaves (34%).

Rather few children of this age level correctly responded to exercises on the following:

A good thing to do when someone faints is to lay the person down and keep him or her warm (32%).
As a candle burns, molecules of a different kind are formed (27%).
The cerebrum is the brain's center for memory and intelligence (26%).
The presence of an ocean fish fossil on a mountain outcrop is best explained by the hypothesis that the mountain was raised up after the fish had died (26%). About half (53%) thought the best explanation was that the fossil fish was carried to the mountain by a great flood.

OBJECTIVE II. POSSESS THE ABILITY AND SKILLS NEEDED TO ENGAGE IN THE PROCESSES OF SCIENCE

General Summary

Exercises causing students least difficulty were those requiring them to form a simple hypothesis employing elementary scientific knowledge (e.g., to suggest why paint on one side of a house had deteriorated more than paint on the remaining sides). Interpretation of tabular data was more complex. Most children of this age level were able to:

Select, from a chart listing weights of various common elements found in the human body, the element that is most abundant (oxygen) (92%).
Choose from among several possibilities the best hypothesis for why paint on one side of a house doesn't last as well as the paint on the remaining sides (83%).
Select, from a chart listing weights of various common elements found in the human body, the scarcest element (sodium) (81%).
From pictures showing how high three solids of the same size float, determine which is heaviest (75%).
Interpret a graph showing the effects of different diets on the weight of guinea pigs (71%).

Given the following exercises, a good many 13-year-olds could:

Balance a beam balance with a weight (64%).
Interpret tabular data to correctly determine which series of four weights best establishes that one object is heavier than another (62%).
Correctly use a graph and tabular data to determine the food needs of a dog (61%).
Perform a simple experiment by measuring the time it takes a pendulum to swing back and forth ten times (38%).
Select from a variety of laboratory apparatus the equipment necessary to determine the boiling point of water (36%).

Rather few 13-year-olds:

Chose from a variety of line graphs the one best showing average, normal height increases in children as a function of their ages (27%).
Found out the density of a wood block using the beam balance and a weight of a known mass (4%).

OBJECTIVE III. UNDERSTAND THE INVESTIGATIVE NATURE OF SCIENCE

General Summary

Most 13-year-olds were able correctly to:

- Select from a variety of skills (music, magic, marketing, mathematics, and manufacturing) the one (mathematics) that is most useful to scientific research (79%).
- Recognize that the statement, "My dog is better than your dog," is not a question amenable to scientific inquiry (73%).
- Recognize that repeated measures of the same thing will usually yield successive results that are close to each other but not all exactly the same (69%).

A good many 13-year-olds correctly responded on the following:

- The basic purpose of a scientific theory is to explain why things act as they do (56%).

OBJECTIVE IV. HAVE ATTITUDES ABOUT AND APPRECIATION OF SCIENTISTS, SCIENCE, AND THE CONSEQUENCES OF SCIENCE THAT STEM FROM ADEQUATE UNDERSTANDINGS

General Summary

The following exercises deal with having accurate attitudes about scientists and having scientific curiosity about things in everyday life. Most 13-year-olds expressed attitudes consistent with the objective.

- They indicated they believed that women can be successful scientists (94%).
- Most indicated they did not believe that scientists always work in laboratories (91%).
- Only a few indicated great curiosity about why things in nature are the way they are (8% said they had such curiosity "often," another 64% "sometimes").

Summary

In general, 13-year-olds answered correctly those items closely related to everyday experiences and personal observations. "Most of this age are able to make simple judgments based upon elementary scientific facts (31b:5-7). The 13-year-olds were aware of much of the common scientific phenomena around them; for example, items related to meteorology, astronomy, personal hygiene, food, and biological sciences. The group did well on exercises requiring them to form conclusions on the basis of information contained in tables and graphs. Thirteen-year-olds found it difficult to choose from alternatives and to use scientific apparatus. Nearly three-fourths of them were good at recognizing

questions amenable to scientific inquiry, and 56% knew the basic purposes of a scientific theory. About two-thirds of these students were "sometimes" curious about why things in nature are the way they are, although only 8% indicated they "often" had such curiosity. Most (94%) believed women could be successful scientists; 91% believed scientists did not always work in laboratories.

Influence of Social and Cultural Factors on Science Achievement

Parental Education

In the 1969-70 national assessment of science, each 13-year-old student was asked to fill in the "tail sheet" of the exercise book and indicate the highest year of schooling completed by his or her father and mother. Levels of parental education were coded as follows (32:27):

0: Education of parents not ascertained
1: Neither mother nor father educated beyond grade 8
2: Either mother or father had some high school, but neither completed high school
3: Either mother or father completed high school, but neither was trained beyond high school
4: Either mother or father was educated beyond high school

Disregarding all other variables (color, sex, region, etc.) that may exist in an examination of science test results compared with educational attainment of parents, a positive relationship was found. Students whose parents were in levels 0, 1, and 2 fell below the national median in science achievement; level 3 students were about at the national median, and students with a parent who had some education beyond high school scored above the national median (32:29).

The science performance of 13-year-old students in relation to the educational levels of their parents was:

Level 1: Neither parent attended high school.

The unadjusted, total science score was 11.8% below the national median. There were no atypical test items that might characterize students in this educational level of parents. The percentage difference between educational levels 4 and 1 was 17% (unadjusted and 11.2% (adjusted) (32:44).

Level 2: At least one parent attended high school.

In this category, students had a median 6.2% below the national median. Here, one finds that "exercises requiring reasoning from graphs or pictures tend to be exceptionally difficult for

respondents whose parents failed to complete high school, as do exercises that demand special vocabulary knowledge" (32:45).

Level 3: At least one parent graduated from high school.

At age 13, there was a slight tendency (1.3%) for respondents to perform below the average (32:32,34). The adjusted median was -1% (32:45). There were no closely related exercises where a deficit would indicate a general weakness in comparison with the national median.

Level 4: At least one parent educated beyond high school.

Students in this category had a median score 5.2% above the national median. The students performed especially well on exercises requiring an understanding of (1) testing hypotheses, (2) reading charts and graphs, and (3) a knowledge of particular facts and principles. The strengths of Level 4 students were the weaknesses of Level 1 students (32:32,35,48).

Students who did not identify the educational level of their parents had a median score of 7.7% below the national median of their age group.

When the exercises for 13-year-olds were sorted into biological, physical, or unclassified groups and were associated with parental educational levels, the patterns of student achievement were similar to all items combined (32:39). Whether biological or physical science topics were considered, student achievement was consistently and positively related to the educational level of their parents.

SCIENCE ITEMS	LEVEL OF PARENTAL EDUCATION				
	0	1	2	3	4
Physical science	-7.4%	-11.1%	-6.4%	-1.4%	+5.2%
Biological science	-7.8%	-12.2%	-6.2%	-1.9%	+5.4%
Unclassified exercises	-9.2%	-12.3%	-3.6%	-0.9%	+3.9%

The science achievement of 13-year-olds, in relation to the levels of parental education, was examined in terms of the four objectives of science education: (1) facts and principles, (2) abilities and skills, (3) investigative nature, and (4) attitudes and appreciations (32:38). Parental education had the least effect on student attitudes toward and the appreciation of science and the greatest effect on their science abilities and skills. Overall, effects associated with the four levels of parental education appeared to be almost identical, from one age to another (32:49).

OBJECTIVES	LEVEL OF PARENTAL EDUCATION				
	0	1	2	3	4
1	-7.1%	-11.5%	-6.2%	-1.5%	+5.4%
2	-10.4%	-12.5%	-7.5%	-1.4%	+5.7%
3	-11.0%	-13.5%	-3.3%	-1.3%	+4.9%
4	-4.4%	-2.0%	-2.6%	-0.2%	+1.4%

Region, Size and Type of Community

Science achievement scores for 13-year-old students were compared by geographical regions, and the size and type of community in which students lived. However, any interpretation of comparative achievements in terms of these variables did not imply causal factors, but only illustrated an existing situation.

Regional advantages or deficit for 13-year-olds in terms of national median on all exercises (32:10-20):

1. Northeast: 2% advantage
   a. Facts and principles: +1.5%
   b. Abilities and skills: +3.2%

2. Southeast: 4.8% deficit
   a. Facts and principles: -4.5%
   b. Abilities and skills: -7.7%

3. Central: 1.9% advantage
   a. Facts and principles: +2.1%
   b. Abilities and skills: +2.3%

4. West: 0.6% deficit
   a. Facts and principles: -0.6%
   b. Abilities and skills: -0.6%

When exercises were sorted according to physical versus biological science, the regional effects were not significant (32:18). At age 13, students in the northeastern and central regions performed a little higher on the assessment than did those in other parts of the country. In the southeast, students showed a deficit on 108 of 122 (89%) exercises. Compared to the national sample, 3% more of the southeastern students stated they often asked questions about science.

Size and type of community effects. Educational progress for 13-year-olds in the sciences was examined in terms of four community sizes (32:21-28):

1. Big cities (over 200,000 population)
   a. All exercises: -4.7%
   b. Facts and principles: -4.6%
   c. Abilities and skills: -4.8%

2. Urban fringe (areas surrounding big cities)
   a. All exercises: +3.4%
   b. Facts and principles: +3.3%
   c. Abilities and skills: +4.0%

3. Medium-size cities (20,000-200,000 population)
   a. All exercises: +1.1%
   b. Facts and principles: +1.2%
   c. Abilities and skills: +1.7%

4. Small places (under 20,000 and rural)
   a. All exercises: -1.1%
   b. Facts and principles: -0.9%
   c. Abilities and skills: -2.2%

The poor science performance of 13-year-old students in big cities was examined in some detail. Their poorest performance (-5.0%) was on exercises involving the investigative nature of science, and their best responses were on exercises concerning science attitudes, appreciations, and consequences (-1.9%) (32:57). Students in big cities were equally deficient in physical (-4.6%) and biological (-4.7%) information. Students living in the urban fringe did better than the national average on quantitative matters of genetics (+10%), setting up mechanical apparatus (+12%), and general knowledge about atoms (+11%) (32:59). Urban fringe students made their best showing on "understand the investigative nature of science" (+4.2%). There were no atypical exercises for 13-year-olds in medium-size cities and small places. However, students in medium-size cities did better on biological (+2.1%) than physical sci-ence (+0.8%) topics (32:63). In smaller places, the difference between the biological and physical science understanding was slightly (+0.7%) in favor of the physical sciences.

The differences in the performance of students, by regions and by size and type of community, raise questions about science education in the United States that deserve further study. It seems evident, however, that out-of-school experiences and social factors have an influence on a student's understanding and appreciation of science, regardless of what happens in school.

Sex and Racial Differences in Science Achievement

Sex Differences

The issue of whether boys and girls show differences in their understanding of science at age 13 can be explored from information obtained from the 1969-70 National Assessment of Educational Progress (31). When test results for all questions were combined, the median score for boys was 1.7% higher than that of girls. Of the 122 exercises on the science test, boys performed better than girls on 90, or 74% of the total number (33:23-35).

An analysis of male-female differences in terms of the objectives for science education revealed that the median was in favor of 13-year-old boys on Objective I, Know Fundamental Facts and Principles of Science, and Objective II, Possess the Abilities and Skills Needed to Engage in the Processes of Science (33:26). For Objective III, Investigative Nature of Science, and Objective IV, Attitudes and Appreciation of Sciences, the number of test items was too small (eight each) to allow a meaningful evaluation of sex differences. Exercises on which boys most clearly peformed better than girls were exercises that pertained to simple experiments in physics.

Sex differences on biological versus physical science exercises favored boys. The median for boys on the physical sciences was 2.4% in their favor and for the biological sciences it was 1.5%. The distribution of scores on physical and biological exercises was similar for males and females. The only exercises on which boys performed at least 9% better than girls were physical science topics (33:30).

While boys appeared to understand science better than girls at age 13, the sex differences on the four objectives of science education were small and probably were not significant. Adjusted or balanced medians between sexes were smaller than for unadjusted values.

Racial Differences

"In view of the widespread national concern with the educational disadvantage of blacks and other minority groups, National Assessment was designed so as to begin an evaluation of the details of such possible disadvantage. The color of each respondent was noted by the exercise administrator on the assessment package as answers were turned in" (32:5). The color classification was recorded as "black, "white," or "other."

The median for 13-year-old black respondents was 15% below that of whites and other racial groups on the science test as a whole (32:5,6). Median relative performance by blacks on each of the science objectives

showed blacks to have a disadvantage for each objective, as follows: (1) facts and principles, -15%; (2) abilities and skills, -18.7%; (3) understand investigative nature, -18.8%; and (4) attitudes and appreciations, -4.3% (32:7,8). Blacks did relatively better on science fact exercises than on science process items. There were no systematic differences in black performance on physical science exercises (-15%) versus biological exercises (-15.4%) (32:7,9).

"Blacks are subject to many adverse social, economic, and cultural conditions and it is extremely difficult to identify factors most responsible for their comparative disadvantage in science learning with other racial groups. Using a technique of balancing, which reduced "double counting" of individuals for any given factor, the performance of blacks was examined as a residual disadvantage after a consideration of type of community, parental education, sex, or regional representation (32:11). When the science scores for 13-year-old students were "balanced," the median for blacks showed a -11.0% disadvantage compared with the unadjusted median of -15% (32:11).

After balancing, scores on individual science exercises were examined in terms of being atypically high or low compared to the national median. This provided additional insights into performances by racial groups. For example, age 13 blacks did about as well as non-blacks on exercises that referred to direct experience, such as purpose of tooth brushing, kind of clouds that bring rain, and burning gasoline in a car creates heat (32:17,18). Blacks also did well on questions based on everyday experiences about human biology and about scientists (exercises not released) (32:17).

Exercises on which 13-year-old blacks did especially poorly in science were those that tended to be bookish (flower seeds develop from ovules) and have an abstract quality (making predictions from information about weather) (32:20). "Another set of exercises with poor black performance involves the plotting and interpretation of data graphs," for example, the use of physical apparatus to generate data that is to be graphed (32:20). Blacks had difficulty with items involving science principles such as the "balance of nature." "In general, black 13-year-olds do most poorly relative to the national sample on exercises involving either unfamiliar terms or remote content materials for which the correct approach involves a detached indirection characteristic of the 'scientific method'" (32:21).

Overall, "blacks perform best on those science exercises most dependent upon daily experience and common knowledge and poorest on those which involve a detached research attitude toward the objects and phenomena of science" (32:26).

Homogeneous Grouping

In the 1960s, educators assumed that, for purposes of instruction, students should be grouped on the basis of similarities in learning

characteristics. Homogeneous grouping in science was practiced in at least some grade by about 60% of the junior high schools (20:10). The practice of grouping was not equally common for all grade levels; in the junior high schools, for example, grouping was typical in 39% of the schools at grade 7, 42% at grade 8, and 45% at grade 9 (25:21). Less than 10% of the junior high schools used grouping at only one grade level (20:20). School enrollment also showed an influence on the practice of grouping students in junior high schools: with 1,500 pupils, three-fourths grouped; 500 to 1,499 pupils, two-thirds grouped; and fewer than 500 pupils, only 41% grouped.

Schools were asked whether they anticipated changes in emphasis in homogeneous grouping for science classes during an ensuing two-year period. Nearly one-fourth of the schools of all sizes stated they planned to give more emphasis to grouping, and 3% of the schools indicated less emphasis (20:12). Small schools (500 or fewer students) planned to increase student grouping more than did large schools during the next two years (20:12).

Criteria used for grouping students in junior high school science were roughly comparable regardless of school size. The percentage of schools using various criteria were: (1) intelligence tests, 90%; (2) teacher recommendations, 90%; (3) achievement tests, 87%; (4) previous marks, 86%; (5) pupil interest, 65%; (6) aptitude tests, 41%; (7) parent recommendation, 30%; and (8) other criteria, 10% (20:12).

Using multiple factors as the bases for grouping students was the common practice. Middle-size schools (500 to 1,499 pupils) made a greater use (45% compared with 27%) of aptitude tests and parent recommendations than did small or large schools (20:11). About 7% of the schools used reading test scores as a factor in grouping students for science instruction (25:25).

The extent and practice of homogeneous grouping in junior high school science during the 1960s was greatly reduced during the 1970s as the educational trend shifted to concepts of equity and the practice of "mainstreaming."

Supervisory and Administrative Services

The period 1960-1970, showed major efforts being made nationally to improve science teaching in the schools. These activities included new curricula, new programs for inservice teacher education, and federal funds for the purchase of science supplies and equipment. By 1963, nearly 28% of science teachers in junior high schools had attended a National Science Foundation program, and 66% of the schools indicated at least one teacher on their staff who had participated in an NSF program (20:25). The smallest percentages of teachers participating in these programs were from the southeastern and New England states. About one-quarter of the nation's schools provided funds for the development of instructional materials by teachers during the summer months (20:24).

This practice was most common in the far western states, involving 40% of the junior high schools. It was least common, 17%, in New England. Overall, about two-thirds of the nation's junior high schools provided some type of inservice training (20:24). This training was usually at the system level, except for small schools where the programs were organized at the school level.

Nearly 80% of the schools made use of specialists or consultants, ranging from 65% for small schools to 93% in the large schools (20:25). About 50% used science curriculum specialists from city or county school departments; nearly 40% used consultants from state departments of education and professional people from colleges or universities. Helping teachers serving several schools were used in 10% to 12% of the small and middle-size schools and in one-third of the large schools (20:25). The pattern of consultant help varied widely throughout the United States; for example, 90% of the schools in the far western states used consultants, in contrast to 60% in New England schools. All regions, except the plains states, made the greatest use of city-county consultants; the plains states made more use of state department specialists (20:26). Helping teachers were most widely used in the far western regions and consultants from colleges and universities in the southwestern areas. The tendency was for schools to seek out general curriculum specialists; although other unspecified types of consultants were used. Seventy-five percent of the schools in the far western states reported using science-trained specialists, in contrast to 42% of the New England schools and approximately 60% for the national average (20:26,30).

Whether the services of consultants made a difference in moving away from traditional curricula and practices in the junior high schools only time will tell. It can be said, however, that the majority of schools had the specialized assistance needed to provide new insights into school practices.

Support staff within the middle school grades consisted typically of administrators and counselors. For most middle school grade combinations there was one administrator for every 400 pupils or less (34:5). One function of the school administrator in 86% of the middle schools was the management of discipline (34:23).

Professional school counselors were found in 40% of the middle schools. Only 4% of the middle schools met the ideal ratio of one counselor for each 200 pupils. However, 41% of the schools had one counselor for each 400 to 600 students (34:21). Large enrollment schools (over 400) tended to offer more professional counselor services than did small schools. The apparent deficiency of counseling services may have resulted from teacher-counselors supplementing the work of professional counselors.

Teaching and Learning Resources

Science teaching and learning in schools are influenced by administrative arrangements and by instructional resources. Among the administrative factors are class size and the teaching load. Class size is of concern because of its relation to the feasability of carrying on laboratory activities. The mean class size, in the 1960s, for all junior high school science courses throughout the nation was 29 students (20:9). The mean class size for all sciences taught in grades 7 through 12 was 26 students, with 74% of the classes having 30 or fewer students (20:107). The smallest science classes were found in the southwestern states (mean 24 students). In all other areas of the United States, class size means ranged from 29 to 31 pupils (20:9). No one region of the United States was consistent in its rank of mean sizes for all science courses.

Teaching load is influenced by the number of class hours per week devoted to teaching science and the number of separate class preparations the teacher must make. In the 1960s, the largest number (36%) of junior high school science teachers had 21 to 25 class hours of teaching per week; however, 13% had between 26 and 40 hours (20:8,9). Another third of the science teachers spent ten or fewer hours per week teaching science and appeared to have more diverse teaching assignments. Assuming that 30 hours of science teaching per week would be a normal load, there was an overwhelming proportion of teachers assigned to part-time science instruction (20:9,29).

Textbooks were used in 80% of the science classes, although not at the same percentage level for all grades. Over 95% of the schools used texts in grades 8 and 9; fewer schools used textbooks in grade 7 (20:13). At all grade levels in 60% of the schools, a single text was the prevailing practice. Half of the schools used a coordinated text series for the three grades (20:13). At all grade levels in 60% of the schools, a single text was the prevailing practice. Half of the schools used a coordinated text series for the three grades (20:13). Fifty percent of the textbooks in use, for whatever science course taught, were copyrighted two to four years in the past (20:14). Earth science textbooks were the most recent and health science the oldest in terms of publication dates. Only about 2% of the schools were using textbooks ten or more years old, with the exception of life science texts where the number was 5% (20:14). Resource materials prepared by teachers to replace textbooks, or to adapt a course to local needs, were found in 10% of the schools (20:14). However, teacher-prepared worksheets were used in almost two-thirds of the schools (20:15).

A variety of reference materials on science were found in 94% of the junior high school libraries, with 70% of the schools rating their collections as good or excellent (20:15). Weekly science newsletters and science periodicals were available in 87% of the schools. Science reference collections were rated good or excellent, according to types of publications, as follows: (1) general reference books, 85%; (2) popular science magazines, 73%; (3) science reference books, 69%; (4) science books other than adopted textbooks, 64%; (5) weekly science

periodicals, 58%; (6) scientific journals, 47%; (7) professional science teaching materials, 47%; and (8) science paperback books 25% (38% of the libraries did not accept paperbacks) (20:40). Schools were asked to estimate the number of science-related titles in their libraries, and the mean number of titles was 452, the median 522 (20:41). Large schools rated the adequacy of their science library collections as poor ten times as frequently as did small schools (20:16).

Classroom collections of general reference and/or science textbooks other than adopted texts were found in 98% of the schools; however, only 10% of these collections were rated as excellent (20:16). Typically, 50% of the schools considered their classroom science book collection as good. In a majority of schools, teachers had access to reference materials that were housed outside their classrooms but could be brought into class (20:16).

Audiovisual aids as a resource for science teaching were surveyed as to whether they were readily available to science teachers. (It was assumed that "readily available" was a better measure of use than simply noting whether the school had a particular audiovisual aid.) The percentages of junior high schools in which audiovisual aids were readily available, and those in which they were not available, are shown below (20:42).

AUDIOVISUAL AIDS	% READILY AVAILABLE	% NOT AVAILABLE
1. Commercial charts	61%	7%
2. Homemade charts	48%	14%
3. Commercial pamphlets	58%	9%
4. Microprojector	70%	19%
5. Slide/filmstrip projector	94%	0.8%
6. Overhead projector	54%	32%
7. Opaque projector	67%	18%
8. Commercial models (ear, eye, torso, etc.)	61%	16%
9. Sound motion pictures	80%	3%
10. Silent motion pictures	45%	37%
11. Television, broadcast	28%	47%
12. Television, closed circuit	5%	92%
13. Filmstrips and slides	10%	23%
14. Flannelboard	24%	23%
15. Commercial displays	49%	6%

Forty-six percent of the teachers reported an inadequacy of self-instructional materials in their schools (29:112). Evidently, the most common piece of audiovisual equipment in junior high schools was the slide-filmstrip projector, but 23% of the schools owned no filmstrips or slides, and only 10% of the science teachers found them readily available. While 28% of the teachers found it convenient to use commercial television broadcasts, nearly half the schools did not own a television receiver. Items teachers might make, such as charts or a flannelboard, were not widely used.

Whether laboratory work was used in teaching science was influenced, in part, by facilities and equipment. In 70% of the junior high schools in the United States, science was taught in a combination class-laboratory room (20:17). A fourth did not have laboratory facilities for teaching science, and this was truer (40%) for the large schools (20:17). Facilities designed for teaching the more specialized science subjects, such as life, health, physical, and earth sciences, in contrast with general science were not common (20:18). More than 90% had water, gas, and electricity available in the room for teacher demonstrations, but less than 30% of the schools had these utilities available at pupil tables (20:43). Small schools were more likely to have fully equipped laboratory tables than large schools. Three-fourths of the schools had a separate storage room for science equipment, and 90% of the schools had cupboard space, a storeroom, or both (20:44). Large schools were more likely (90%) to have a separate storeroom than small schools (56%). Special facilities and equipment for science teaching were present in many schools; for example, (1) weather equipment, 56%; (2) planetarium within reasonable travel distance, 43%; (3) housing for small animals, 34%; (4) school planetarium, 12%; and (5) a greenhouse, 6% (20:18). Less than 10% of the schools indicated they had any special facilities other than those listed. A few schools had nature trails and land laboratories (25:81).

During the 1960s, the National Defense Education Act made federal money available to local schools for improving their science teaching resources. Thirty percent of the junior high schools used these funds to improve their science teaching facilities, and 82% of the schools reported equipment purchases (20:19). Only 15% stated they made no use of federal funds to improve teaching resources. NDEA money to purchase equipment was spent for overhead projectors; microprojectors; commercial models; and, to the greatest extent, filmstrips and slides (20:20). In almost three-fourths of the schools, an annual budget provided for new science equipment. This is true for 90% of the large schools (1,500 students), but only for about 50% of the small schools (500 students or less) (20:20). About 75% had a budget for consumable materials, and 70% had budgets for both consumable materials and new equipment and supplies (20:20). Small schools were less likely to have any kind of budget for supplies and equipment. Less than 25% of the schools made funds directly available to teachers to buy supplies as needed. With the availability of NDEA funds, 75% had increased their equipment purchases over the past two years (20:44).

Science learning resources that were not necessarily curriculum bound were represented by club activities and interschool science fairs.

Sixty percent of the schools had one or more science clubs, 30% had only one, and 10% had five or more clubs (20:45). Nearly three-fourths of the schools participated in interschool science fairs at some grade level: (1) 3% at grade 7, (2) 59% at grade 8, (3) 66% at grade 9, and (4) 30% at all grade levels (20:45). About two times as many projects were completed by students in the eighth and ninth grades as were completed by seventh graders (20:46).

Teaching and learning resources for science instruction in the junior high schools of the United States during the latter part of the 1960s were improving. On a statistical basis, it would appear that three-fourths of them had suitable rooms and the equipment for teaching science. However, there was great disparity among schools located in different sections of the nation and between large and small schools. In the southwestern part of the United States, schools were typically below the national average in facilities and equipment. Large schools were less likely to have adequate laboratory facilities than small schools but did have more adequate libraries. It seems quite evident that school administrators could benefit from a well-developed set of guidelines and standards for instructional resources that reflects the demands of modern science curricula in terms of intellectual goals and supporting instructional practices.

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   i. Chapter 18, Survey findings and corroborations
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SECTION III ANALYSIS OF MIDDLE AND JUNIOR HIGH SCHOOL SCIENCE PROGRAMS

INTRODUCTION

"The quality of science instruction offered in the junior high school may well be a determining factor in the student's life-long attitudes toward science and scientists".(1:1). This statement, though written sometime ago, is very apropos today. No one can deny at least two of the important variables that influence the quality of science instruction in a classroom: the teacher and the materials being used.

These two variables are very complexly interwoven and difficult to separate when analyzing a specific class. All combinations and permutations of teaching styles and types of materials are possible and probable. No one scheme of analyzing the currently used materials will reveal the true state of the art. A multifaceted approach is necessary, and only then can the broadest trends be gleaned with any confidence. Program materials are analyzed in this section with the full realization that the teacher is a very significant force in determining the effect the materials will really have on the students using them. No curricular materials are teacher-free; all are highly teacher-dependent. These facts complicate the prospect of analyzing classroom materials outside the classroom environment.

Certain assumptions must be made in order that each set of materials gets its "fair shake" in a nonclassroom analysis. Simply stated, for this study, materials are analyzed at face value. When examining each set of materials it is assumed that the materials will be used as the developers intended (for the right grade level, setting, etc.). Further, it is assumed that the teacher will teach the materials as described by the developers, i.e., teach the labs if labs are provided, etc. For purposes of consistency, it is important to make these assumptions and not to make any inferences about other possible uses of the materials.

All statements that are made about the materials analyzed in this section are based on personal examination of the materials. All materials reported herewith were secured first-hand and analyzed by the people writing this report. This first-hand approach seems important, since results of these materials analyses will be compared and contrasted with dimensions reported in other parts of this report.

Sales figures for science education programs are not kept in any systematic form on a national basis. Therefore, knowing what science materials are currently being widely used in our schools is not easily nor accurately determined. Nor is such determination inexpensive and without potential disagreement. <u>Report of the 1977 Nation 1 Survey of</u>

Science, Mathematics, and Social Science Education (2) served as the major source of data on the most widely used materials for the 1975-80 time period. This study was the most comprehensive and exhaustive study of this type completed during 1975-80. Thus, this data source represents the "best" data for the time period studied.

Several problems were encountered in using the Weiss data for this study. One problem resulted because the grade classifications used in the Weiss study were not congruent with this study. This study considered grades 6 through 9 as encompassing the bulk of middle and junior high school students. The Weiss data were reported in the grade categories 4 through 6 and 7 through 9. Thus, for purposes of this study we had to extrapolate the data for the sixth grade from the 4-6 Weiss category. This extrapolation led to our decision to analyze the top two most widely used sixth-grade programs as a part of this study. Two were selected because of the large percentage of usage represented by the two programs (25%). The many other sixth-grade programs that were reported fragment the remainder of the market into very small pieces, each of which captures only a very small percentage of the market. Thus, the decision was made to examine only the two largest sellers at the sixth-grade level.

In the 7-9 Weiss grade period, the decision was made initially to analyze the top four programs since they represented about 25% of the usage. After reflecting on this decision and analyzing how the Weiss data were collected, it was noted that no life science programs were contained in the four top-selling programs. Therefore, the analysis would be void of life science programs. This omission resulted from our straight linear use of the Weiss data. The life science market at this level doesn't have one "big winner." The market is very evenly divided among four or five life science programs. Thus, in the Weiss data no life science program made it into the top four programs when only grades 7 through 9 were considered even though the total market for life science materials is very large. Hence, the decision was made to analyze the next five programs (all of equal usage) reported on the 7-9 list. The net result of this decision was the need to analyze nine programs instead of the intial four. Totally, for the 6-9 category, the result of this decision was to analyze eleven major programs instead of six as originally planned.

The next key issue that emerged was the important idea of reviewing all the materials in those programs that were designed to be used as a three-year series. In the analysis of the major series, one book in one of the series Focus on Physical Science (FOPS) did not appear in the Weiss data. This title was added to the analysis group, bringing the total of programs to be analyzed to 12.

The next problem encountered was the availability of multiple editions of the same materials. Because of the time lag that is known to occur from the release date of a program until it is in place in schools, the following scheme was employed for final selection of the materials when several copyright dates were available. A 1977 copyright was considered to be first priority, with a several year delay such a copyright date would most likely represent the materials currently in

use in schools. When a 1977 copyright was not available, the date closest to 1977 was selected, with an earlier date having priority over a later date (for example, a 1976 date would be selected over a 1978 if both were available, but a 1978 would be selected over a 1974 copyright date.) The exact materials that were analyzed and their copyright dates are shown in Table 1. Note the abbreviations in parentheses after each citation in the table. These abbreviations will be used throughout the rest of this report. A similar set of criteria was employed for the 1965-70 time period, with 1967 serving as the comparable reference point for the time period.

Table 1. Specific Program Materials Analyzed (Classified for Ease of Description and Comparison)

LIFE SCIENCE	PHYSICAL SCIENCE	EARTH SCIENCE	GENERAL SCIENCE	OTHER
Living Things, Fitzpatrick, Teter, and Bain, Holt, Rinehart & Winston, Inc., 1970. (LT)*	Focus on Physical Science, Heimler and Price, Charles Merrill, 1974. (FOPS)*	Focus on Earth Science, Bishop, and Sutherland, Charles Merrill, 1976. (FOES)*	Science: Understanding Your Environment, Mallinson, Mallinson, and Smallwood, Silver Burdett, 1976 (UYE)*	Probing the Natural World, ISCS, Silver Burdett, 1970.
Focus on Life Science, Heimler and Lockard, Charles Merrill, 1974. (FOLS)*	Introductory Physical Science, IPS Group, Prentice-Hall, 1967. (IPS)*		Concepts in Science, Brandwein, et al., Harcourt Brace Jovanovich, 1975. (CIS)*	
Life: Its Forms and Changes, Brandwein, et al., Harcourt, Brace & World, 1968. (LFAC)*			Principles of Science, Heimler and Neal, Charles Merrill, 1975. (POS)*	
			**Modern Science Series, Blanc, Holt, Rinehart, & Winston, 1971. (MSS)*	
			**Study Lessons in General Science, Gross, et al., Follett Educational Corp., 1975. (SLGS)*	

*The abbreviations in parentheses after each citation will be used throughout the rest of this report.
**Not available for purchase from publisher.

CHAPTER 1

SCIENCE CONTENT

An examination of the commonly offered courses (2:53) and the most commonly used materials (2:44-45) reveals the overall science content being offered at the middle/junior high school level. Science content at this level seems to be organized into three major patterns:

1. A three-year sequence of life, physical, and earth science
2. A one-, two-, or three-year offering called general science
3. A one-, two-, or three-year sequence of integrated or thematically organized materials

In addition to these major patterns, other patterns are found. Often a major pattern is interrupted with the insertion of a health package or other specific content area deemed important in a specific locale. The content of the 12 programs analyzed in this study will be discussed only within the major classification scheme; unique patterns will not be considered. Comparisons will be made within and across the three broad categories suggested above. The categories of life, physical, and earth science are also useful in dividing the content of course materials into more manageable units.

Life Science

The content in the three life science books studied can best be characterized as encyclopedic. Table 2 (on page 150) shows the topics covered in one of the books (FOLS) as taken from its table of contents. The numbers in parentheses show how many of the three life science programs included each topic. This "covering" thrust in these programs allows each topic to be covered only superficially. The net result is that the materials are overwhelming and more difficult to read (even though the reading level claims are low) than some more advanced texts that provide more information on each topic. The conceptual load in all of these texts is inappropriate for the developmental level of middle and junior high school students. There are more major content areas covered in these programs than there are days in a school year.

Analysis of the vocabulary in the texts further amplifies the encyclopedic nature of the programs. A sampling of one of the life science texts (FOLS) reveals that, on the average, each chapter contains

over 100 new and/or unfamiliar technical terms. This 100 does not include words that are not on a standard vocabulary reading list for this age level. Since the book contains 25 chapters it means that students are exposed to minimally 2,500 new and/or unfamiliar technical terms in the course. Since the student activities or other materials in the course might also contain new vocabulary words the 2,500 number can be interpreted as a minimum.

Table 2. Content Coverage--Life Science Books

The number in parentheses indicates the number of programs from a total of three that contained each topic

- Scientific methods (3)
- Scientific problems (3)
- Experiments (3)
- Scientific tools (3)
- Measurement (3)
- Metric system (2)
- Life characteristics and activities (3)
- Classification (3)
- Scientific names (3)
- Species (3)
- Spontaneous generation (1)
- Origins of life (2)
- Extraterrestrial life (1)
- Classification of matter (3)
- Physical change and chemical change (3)
- Symbols and formulas (3)
- Chemical equations (3)
- Atoms (3)
- Isotopes (1)
- Digestive system (3)
- Circulatory system (3)
- Spiracles, gills, and lungs (3)
- Nervous system (3)
- Endocrine system (3)
- Skeleton (3)
- Kinds of tissues (3)
- Cell theory (3)
- Cell structure (3)
- RNA and protein (3)
- DNA (3)
- Diffusion and osmosis (2)
- Turgor and plasmolysis (2)
- Cell energy (3)
- Cell division (3)
- Requirements for growth (3)
- Chlorophyll (3)
- Chemistry of photosynthesis (3)
- Rate of photosynthesis (3)
- Flowers (3)
- Pollination and fertilization (3)
- Seeds (3)
- Germination (3)
- Seed dispersal (3)
- Selective breeding and cross breeding (2)
- Polyploidy (1)
- Characteristics of bacteria (3)
- Kinds of bacteria (3)
- Cultures (3)
- Staining (1)
- Budding and regeneration (3)
- Fission (3)
- Sexual reproduction (3)
- Earthworms, grasshoppers, and frogs (3)
- Mammals (3)
- Embryology (3)
- Age (1)
- Dominant and recessive traits (3)
- Hybrids (3)
- Mendel's laws (3)
- Blending (3)
- Gene theory (3)
- Reduction division (3)
- Gene chemistry (3)
- Sex determination (3)
- Mutations (3)
- Animal breeding (3)
- Behavior (3)
- Tropism (2)
- Reflex act (3)
- Training (3)
- Instinct (3)
- Chemical senses (2)
- Sense of sound (2)
- Vision (3)
- Color vision (2)
- Biological clocks (1)
- Mosses and liverworts (3)
- Ferns (3)
- Seed plants (3)
- Roots (3)
- Stems (3)
- Leaves (3)
- Plant cells (3)
- The heart (3)
- Coronary circulation (3)
- Arteries and veins (3)
- Capillaries (3)
- Circulation of the blood (3)
- Blood (3)
- Red blood cells (3)
- White blood cells (3)
- Lymph (3)
- Blood clotting (2)
- Blood types (1)
- Respiration (3)
- Excretion (3)
- Digestion (3)
- Digestive system (3)
- Nutrition (3)
- Filterable viruses (1)
- Structure of a virus (3)
- Are viruses alive? (3)
- Classification of protozoa (3)
- Amoebas (3)
- Flagellates (3)
- Ciliates (3)
- Sporozoa (3)
- Algae (3)
- Yeasts (3)
- Molds (3)
- Slime molds (2)
- Human anatomy (3)
- The skeleton (3)
- Bones (3)
- Muscles (3)
- Tissues (3)
- Cells (3)
- DNA and RNA (3)
- Causes of diseases (3)
- Koch's postulate (2)
- Polio (2)
- Vaccinations (2)
- Disease defenses (3)
- Interferon (1)
- Antibiotics (3)
- Disinfectants and chemotherapy (1)
- Cancer (1)
- Disease carriers (3)
- Classification of drugs (2)
- Tobacco (2)
- Alcohol (2)
- Narcotics (2)
- Narcotics addiction (2)
- Barbiturates (1)
- Amphetamines (1)
- Hallucinatory drugs (2)
- Marijuana (2)
- Fossils (3)
- Life in the past (3)
- Theory of evolution (3)
- Natural selection (3)
- Descent and change (3)
- Mutations and theory of evolution (3)
- Food absorption (3)
- Central and peripheral nervous system (3)
- Brain and spinal cord (3)
- Neurons and stimuli (3)
- Taste, smell, and touch (3)
- The eye (3)
- The ear (3)
- The autonomic nervous system (3)
- Loewi's experiment (1)
- The endocrine system (3)
- Reproduction (3)
- Pedigrees (1)
- Carriers (3)
- Sex-linked traits (3)
- Multiple-gene inheritance (3)
- Heredity and environment (3)
- Biological relationships (3)
- Biosphere (3)
- Community (3)
- Succession and climax community (1)
- Community boundaries (1)
- Forest (3)
- Desert (3)
- Grassland (3)
- Tropical savannah (3)
- Tundra (3)
- Life zones (3)
- Ocean (3)
- Soil conservation (1)
- Forest conservation (1)
- Wildlife conservation (1)
- Water conservation (2)
- Water pollution (2)
- Air pollution (2)
- Nutrition (3)
- Foods and nutrients (3)
- Water (3)
- Minerals (3)
- Carbohydrates (3)
- Fats and oils (3)
- Proteins (3)
- Vitamins (3)
- Energy from food (3)

Mastery of a foreign language after four years of high school work is usually estimated to be about 10,000 words or about 2,500 words for each one-year course. Middle and junior high school foreign language courses usually have a goal of accomplishing one-half as much, or about 1,250 words. (A one-year high school foreign language course is usually done in two years in the middle or junior high school.) Considering the conceptual load of the science course, coupled with the "foreign" language load equal to or worse than a real foreign language course, is it any wonder that students have the view of science they often possess?

Physical Science

The homogeneity of content coverage found in life science programs does not seem to be as prominent a characteristic with the physical science programs. The major content of the two programs analyzed (Table 3) reveals this lack of homogeneity as well as other characteristics of the two programs.

Table 3. Content Topics of Two Physical Science Programs

PROGRAM 1 (FOPS)	PROGRAM 2 (IPS)
Introduction to Physical Science	Introduction
Classification of Matter	Quantity of Matter: Mass
Atoms and Compounds	Characteristic Properties
Periodic Table	Solubility and Solvents
Families of Elements	The Separation of Substances
Carbon and Its Compounds	Compounds and Elements
Solids and Fluids	Radioactivity
Solutions	The Atomic Model of Matter
Conservation of Mass	Sizes and Masses of Atoms and Molecules
Acids, Bases, and Salts	Molecular Motion
Force and Work	Heat
Moving Bodies	
Laws of Motion	
Heat Energy	
Heat and Its Uses	
Waves	
Optics	
Electricity	
Electronics	
Radiation	
Nuclear Reactions	
Nuclear Technology	

Program 1, which is part of a series that includes one of the life science books, follows the "covering" philosophy. The physical science field has not been narrowed for the young reader, as evidenced by the comprehensive content coverage of physical science topics. Program 2, on the other hand, has a thematic, experiential approach, and "coverage" is sacrificed for an in-depth probe into one aspect of the physical world (atomic model of matter).

Arguments can be made for each approach, and different educational settings might dictate one over the other. Perhaps the more interesting thing to note is that the choice of different content coverage does exist. (The choice is probably more one of methodology than content. This will be discussed later.) Terms and concepts such as adiabatic cooling, allotrope, diffraction grating, endothermic reactions, Frasch process, Snell's law, isobutane, mass spectrographics, pentadiene, rarefaction, rubidium, three-dimensional strong bands, tetrafluoroethylene, and thermionic emission found in Program 1 should be evaluated in terms of the nature of the intended audience. The physical sciences

with their heavy reliance on mathematics and equational logic for understanding of concepts, would seem to make the selection of content coverage in physical science programs at this level a very important priority.

Earth Science

The single most widely used program at this age level (2:B44-45) is an earth science program (FOES). This program's content coverage can be described, as were some earlier programs, as encyclopedic and all-encompassing of the earth science field. The program is divided into 22 major units as follows:

The Universe
The Solar System
The Earth-Moon System
Science of the Earth
Minerals
High Temperature and Pressure Rocks
Sedimentary Rocks
Erosion in Humid Regions
Erosion in Arid Regions
Glaciers
Topographic Maps
Earthquakes and the Interior of the Earth
The changing Crust
Dating Geologic Time
Geologic Time Scale
The Atmosphere
Weather and Climate
The Hydrosphere
Circulation of Ocean Waters
Air and Water Resources
Natural Resource
Energy Resources

Each unit is subdivided into major topics. The program contains 138 major topics, with many embedded in each topic area. For example, "High Temperature and Pressure Rocks" is divided into the following sections:

The Rock Cycle
Origin of Igneous Rock
Igneous Rock Textures
Igneous Rock Composition
Igneous Rock Classification
Origin of Metamorphic Rock
Metamorphic Textures
Metamorphic Composition
Metamorphic Classification

Within this one chapter, student must deal with the following terms and concepts:

dust cloud theory
centers of condensation
Kuiper's theory
gravitational attraction
barycenter
center of gravity
ellipse
month
eclipse
inner core
seismograms
Jupiter
Neptune
Saturn
7.35×10^{22}kg
-173^{o}C
Mare Tranquillatis
maria
Mare Nubium
craters
zenith
geodetic
mean diameter
synodic month
axial rotation
spherical
Pythagoras
stadium
Eratosthenes
Alexandria
Syene

lunar
eclipse
solar eclipse
perihelion
kilometers
aphelion
revolution
solar year
tropical year
rotation
earth day
sidereal time
Polaris
perpendicular
vernal equinox
autumnal equinox
precession
mean distance
orbital velocity
full moon
waxing gibbous
waning gibbous
waxing crescent
waning crescent
relative position
new moon
dark of the moon
first quarter
last quarter
satellites
semicircle

Straight Wall
volcanic vent
walled plains
explosion craters
chain craters
rills
rays
Crater Tycho
basalts
Hawaiian lavas
Fra Mauro
Magnetometer
astronomy
meteorology
geology
oceanography
physics
Nansen bottle
nuclear reactor
plagioclase feldspars
olivine
pyroxene
iron sulfide
orbit
Newton,s law of
physics
principle of rocketry
mothership
escape velocity
gravity
inertia

circumference
Magellan
oblate spheroid
pendulum clock
period
polar circumference
equatorial
circumference
density
surface area
mass
atmospheric pressure
polar radius
equatorial radius
equatorial bulge
centrifugal force
lattitude
equator
longitudes
meridians
Prime meridian
international date
line
$V=4\pi r^3$
$A=4\pi r^2$
$C=2\pi r$
$(M_1XM_2)/d^2=(MXm)/r^2$
crust
mantle
g/cm^3
outer core

This chapter in the student's materials is by no means atypical, nor is the nature of the content unique within the whole program. The conceptual load for a young eager mind is overwhelming. The content of the program can be summarized--all of earth science.

General Science

Perhaps when an author or publisher attempts to create a program for "general science" and not for a disipline (such as life, physical, or earth science) there is, subconsciously, more of a concern for what should be included. The reasons for this are probably not as important as the net result; that is, the content is not nearly as encyclopedic. Although many of the broad content areas found in the general science programs are congruent with those in the discipline-bound programs, there certainly are drastic content and organizational differences in the general science programs. Teachers no doubt recognize these distinctions, and perhaps this explains the tenacity with which the general science courses have survived over the years, withstanding the pressures to change to a life, physical, and earth science series.

The general science programs appear to be written at a more appropriate level for sixth- to ninth-grade students. There seems to be much more attention given to providing a set of student materials that is readable (with a story line or thematic presentation) than to presenting encyclopedic, discipline-bound materials. Content seems to be selected to move or illustrate ideas and themes and is not written just to "cover" the entire discipline. The content seems to come closer to the cognitive level of the students. The content in each program can still be characterized as being approximately one-third life science, one-third physical science, and one-third earth science. The ability of the author or publisher to interrelate this content is quite varied across the programs examined. Topics such as motion, matter, energy, force, work, and machines from the physical sciences; rocks, minerals, earthquakes, geologic history, weather, climate, and oceanography from the earth sciences; and classification of living things, survey of plants, survey of animals, genetics, cell energetics, and conservation from the life sciences seem to be the typical content included.

The content coverage in the two-year program, compared to the programs designed for one year, are obviously different. The two-year program (POS) is much less thematic, and little attempt is made to hide the fact that there are abrupt shifts from one content area to another. For example, the Machine Unit (machines, levers, mechanical advantage, pulleys, wheels and axles, inclined plane, wedge, screw, efficiency, and power) is followed by the Geology Unit (structure of the earth, weathering and erosion, rocks, minerals, igneous rock, sedimentary rock, metamorphic rock, changes in earth's crust, plate tectonics, earthquakes, and volcanos). In many ways, general science programs designed for more than one year are no different in their content than the coverage in the life, physical, and earth science courses combined. There is really a cosmetic reshuffling of much of the content of the three separate courses combined in the general science courses designed to be used in a multiple-year series.

Other

Other available programs provide alternatives to the content typically covered in the best-selling science series at this level. At the time of the Iris Weiss, RTI study (2), only one program of this type made it into the 12 top-selling programs. Therefore, only that program will be analyzed in this section. Other alternative programs will be described in other sections of this report (Innovative Programs).

The content of the one program briefly described here (ISCS) represents a real alternative to the typical content coverage found in all the other materials. The three-year program is very thematically organized, with experiential learning being of equal content with the other subject matter. From the outside, the student book looks like any other book, but when opened, it is obviously different from others. Pictures and illustrations are abundant, but for the purpose of assisting students in their experimental work, not to give factual information or to

be decorative. There are no italicized words and no long narratives devoted to information dispensing. The entire focus and educational philosophy of the program is very different from all the other programs. The authors describe the subject matter of the program, but the processes of scientific inquiry are such an integral part of the total program that describing the subject matter alone describes only half the content. The authors outline the subject matter of the program as follows:

LEVEL I Organizing Themes
- Content--Energy, its forms and characteristics
- Process--Measurement and operational definition

Student Progress
- Observe work being done
- Measure force
- Measure distance
- Measure work
- Measure energy
- Identify forms of energy
- Observe energy conversion
- Measure heat--infer conservation of energy
- Infer moving particle model for matter

LEVEL II Organizing Themes
- Content--Matter, its composition and behavior
- Process--Model building

Student Progress
- Particle model for matter
- Expand model
- Infer limited number of particles--atoms
- Observe matter combinations
- Infer rearrangement of atoms
- Expand model to include differentially charged particles
- Test expanded model
- Apply expanded model to biological systems

LEVEL III Organizing Themes
- Content--Independent units
- Process--Experiment and investigation

Student Progress
- Apply LEVEL I and II principles to study from units on:
  - Astronomy
  - Environmental biology
  - Geology
  - Human variation
  - Genetics
  - Space science
  - Meteorology
  - Other units available

As is quite obvious from the content descriptors, the program is more concerned with "uncovering" science and its nature than it is with covering all earth, physical, and life science subject matter. The program has sacrificed coverage for an experiential learning model and an in-depth pursuit of fewer subject areas. The program, from a content point of view, represents an alternative to the other most often used programs.

CHAPTER 2

METHODOLOGY

Goals, Objectives, Intents

Examination of the program materials as they actually arrive from the publishers is perhaps a more realistic view of a program than the one described by its authors. Problems seem to emerge in the commercial marketplace that often give programs an undesirable reputation. All of the usual snafus occurred in our purchase of materials for this study. Some components for programs never did arrive after six months of waiting and reordering. It is no wonder that a teacher might get discouraged about a very excellent program if certain key components never arrive for use. A six-month delay is nearly an entire academic year. Programs that have these kinds of delivery problems will not survive no matter how well conceived they might be or how good the goals might sound.

How clearly do the goals and intents of a program emerge from the materials that arrive in the boxes from the distributor? Before trying to analyze the quality of the program's goals and objectives it is probably revealing just to tally the trends of various inclusions in the rationale components of the various programs in this study. Table 4 shows the results of analyzing nine of the programs for 29 potential components. (One program, LFAC, was not included in this table because of missing components that were not delivered by the publisher.) Note that this analysis does not consider the quality of each component but merely considers the question of whether or not the component was included. For example, one should not conclude that the presence of the nine discussions of evaluation (Number 2 of Table 4) was adequate nor of reasonable quality. An attempt to make reasonable comments on the quality aspect will follow.

Analysis of Table 4 reveals that publishers and authors have made the judgment that evaluation materials, behavioral objectives, teacher's editions, teaching planning guides, background information, and safety are priority items in explaining and defending a program to its purchasers. On the other hand, parental involvement, out-of-class work, teacher inservice, field testing materials, rationale statements, psychology of students and of learning, philosophy statements, and goal statements for students do not seem to be priority items. It is interesting to contemplate explanations for these apparent priorities. Does the publisher provide what teachers want and demand? Does the teacher

have any power to demand any more or anything different? Does the teacher want only the "practical" items? Are the programs, in reality, void of substantive rationale and goals? These and other questions raised by results like those in Table 4 are not answered easily.

Table 4. Pedagogical Components Found in Nine Commonly Used Science Programs

COMPONENT	PROGRAMS CONTAINING COMPONENT
1. A special Teacher's Edition	9
2. Discussion of how to evaluate student's work	9
3. Teaching tips of individual lessons	9
4. Equipment lists for the programs	9
5. Explicitly stated behavioral or other objectives	8
6. Planning guides for implementing programs	8
7. Background information for teacher	8
8. Testing and evaluation are described and discussed.	7
9. Evaluation materials are available.	7
10. Classroom safety is discussed and warnings provided.	7
11. A goal statement for educators	6
12. Goal statement includes an information component.	6
13. Goal statement includes a science process component.	6
14. Teaching tips are provided for the overall program.	5
15. Classroom management schemes are described.	5
16. Grading procedures are discussed.	5
17. A goal statement(s) for the student	4
18. A philosophy of education is included as part of the goal statement.	4
19. Process skills are identified for the program.	4
20. A philosophy of science is provided.	4
21. The philosophical assumptions underpinning the program are stated.	3
22. Scope and sequence charts are shown for the program.	3
23. Skill development is outlined for the program.	3
24. Psychology of the learner is discussed in the context of the program.	3
25. A rationale is provided justifying the program.	3
26. Field test results are included along with tips from such trials.	3
27. Teacher in-service materials are available	2
28. Out-of-class suggestions are outlined for supplementing the program.	2
29. Tips and/or materials for parental involvement	0

After examination of the rationales provided with the programs for this study, the somewhat ageless philosophical issue of the balance between content and process seemed to emerge as significant. The programs probably can be categorized into three classifications based on their goal and rationale statements as follows:

1. Those that are factually oriented and defend that students must develop a background of information before they can understand science concepts or experiment on their own. These programs are characterized by an encyclopedic student book, a vocabulary-oriented workbook, and a teacher's guide with the answers to the many factual questions in the student book and workbook.

2. Those that attempt to "walk the line" and provide everything for everybody. These programs typically have an encyclopedic student book (divided into many units so that things can be omitted easily), a separate laboratory guide (usually just a pencil-and-paper workbook), a separate book of optional exercises for the "inquiry type" teacher to add to the program, and a Teacher's Guide with the answers filled in.

3. Those programs that present science as an involving process and allow students to become involved in their own learning. The materials for programs of this type often are different in their appearance (paperback versus hardback, etc.), but more significantly, they have student exercises and prose woven together so that doing exercises is necessary if the program is going to make sense to the learner. This categorization, though perhaps a gross oversimplification, is nonetheless useful in discussing trends in goals and objectives as stated in the programs.

The first thing to note is that programs that can be classified in Category 2 are the most popular in sales. This fact is perhaps not surprising, since the obvious goal for these programs seems to be to appeal to all markets and philosophies. Teachers may not be risk takers (or may not feel that they are in a position to take risks), and programs in Category 2 are thus quite appealing. These programs contain a little bit of everything, and the teacher or supervisor can find whatever is needed when discussing the program with her or his constituency. If their clientele wants to hear about "basics" then the encyclopedic text can be displayed. If laboratory work is a concern, the supplementary lab exercises can be dusted off. If drill is of concern, the student workbook can become dominant. On the surface at least, programs in this category look well "balanced." That is why analysis of materials alone can be deceptive. The real, pertinent question is: What is the balance that is actually used in the classroom situation? These programs make the exclusion of the student activities very easy, and in actual practice many Category 2 programs quickly become Category 1 programs.

The second trend worth noting from the goal sections of these programs is that the educational system obviously demands that the "new" programs defend themselves and prove they are better than the "old" programs. This is evidenced by the significantly more lengthy and defensive-sounding rationale and goal statements in the newer programs. The established programs have very terse and short statements of their intents. The rationale statement, if even present, is usually about two to three paragraphs in length. New programs, on the other hand, have five to ten pages of rationale and take great care in defining goals, assumptions, and testing results. More established programs simply do

not provide comparable information. From a quality point of view the newer programs are much more thoughtful in explaining, defending, justifying, and helping the teacher to implement the program. Perhaps, to administrators and other decision makers, they sound too defensive. Perhaps teachers do not want all the explanation. Perhaps there is no incentive to change. Whatever the reasons, the newer, more thoughtfully justified programs are not as popular and are being rejected.

A third item relative to the goal statements found in nearly all the programs is the heavy use of statements of assumption without justification and the heavy use of current educational jargon. Every program claims to be modern, modular, individualized, and easy to teach. Modern and easy to teach are certainly possibilities with an encyclopedic hardcover book, but modular and individualized seem more difficult to relate to such programs. Every program claims to have a conceptual, unified view of science, and yet the program materials, especially evaluation materials, do not match this goal statement. Clearly, there is a working assumption on the part of authors and publishers that teachers can implement a program's goals with ease, since there is little or no support for the teacher in most programs except for a highlighted version of the student book. The feeling one quickly develops is that publishers and authors do not want to take a stand on any educational issue for fear of irritating a potential purchaser. The result is rather dull, bland-looking teacher materials with weak goals and little or no rationale.

The fourth item relative to the goal statements at this level is that, as a group, these statements clearly are out of date. There is little recognition of recent trends in science education and the changes that occurred in elementary and secondary science during the 60s and 70s. The materials commonly used have goals that sound like materials found earlier in the century. This may be a reflection of the lack of comparable federal emphasis at this level. The programs seem clearly not to be designed with goals in mind for this unique population of students and teachers. Instead they convey a "watered down" version of secondary science programs typical of the 30s, 40s, and 50s. They look like the "old" junior high school approach--get them prepped for high school--without the recognition that science education at the high school level has changed since 1930. The goals of the middle school movement (discussed elsewhere) and the research on the 10- to 15-year old seem to be totally unrecognized in the goal statements of the vast majority of the programs.

In summary, the goal statements seem to be clearly out of step going into the 1980s. There is little written in the goals about the nature of science, science as a process, science as a way of knowing, science and its interaction with society, what scientists are like, and science for the future. The goals seem to emphasize vocabulary accumulation, factual information, exposure to the broad subject areas of science, the rigors of science, that science is tough, and that scientists are an elite group that only few can appreciate or hope to become a member of. The few programs that deviate from these goal trends have hardly dented the market and are not threatening alternatives. The goals and objective statements in most programs at this level are out-

dated in many ways and shallow in even more ways. They are all in great need of review and revision in order to reflect the current nature and role of science in a 1980s society and to stop the continued biased and outdated concept of science currently being conveyed by these programs.

It is difficult to quantify goal statements, because every author or publisher adopts an individual format and components. A few examples, taken from all of the analyzed programs, might illustrate the diversity of views expressed and give some basis of understanding for some of the above perceptions:

> In reading the text, students should pay close attention to scientific principles, new vocabulary terms, cause-and-effect relationships, and examples and illustrations of scientific principles.

> Placed throughout the text to aid the student are questions in the margins, scientific vocabulary in either boldface type or italic type, and phonetic pronunciations. Questions in the margins near the related text material assist the student by identifying the major principles and concepts, and by serving as a guide for reading and study. In assigning a section for study, you may wish to read these questions to the class or have students read them silently in order to clarify the nature and purpose of the assignment. Questions in the margins provide motivation as well as opportunity for the student to check his learning as he proceeds through the assignment. Questions and problems in a given section make excellent written assignments. Oral review of the questions following each assignment makes an excellent summary and helps you to identify points which may require additional explanation.

> Use the study questions at the end of the chapter for student self-study, review, or testing. Correction of wrong answers to the study questions is an effective learning technique.

> Science investigations which extend beyond the textbook presentations are provided at the end of each chapter. These investigations encourage the able student to develop his knowledge and interest in science. Some investigations are valuable as projects for science fairs.

> Photographs and drawings help the student to visualize science principles and concepts and show practical applications of science principles. You may wish to review and analyze a photograph and its caption as a means of introducing a new topic or stimulating class discussion. Graphs and tables show how data is organized in a meaningful way.

> ...lends itself to a variety of teaching methods--demonstration, group reading of text material, lecture, reporting on an experiment, class discussion of a science current event, reviewing a homework assignment, viewing a film or filmstrip. Different methods serve to reinforce each other and, thereby, increase student achievement.

Most young people are naturally interested in life science for every life depends upon the principles of biology.

Students will be able to list and define the steps involved in the scientific method.

Students will be able to list the four parts of an experiment; explain why experiments are conducted.

When you try to find out if students have learned anything, you probably give some form of written test. This might be a true-false, completion, matching, or essay type examination. All of these forms of evaluation are important in determining whether or not students have achieved their objectives.

...is designed for maximum flexibility in teaching. The text is divided into six units which are divided into 23 chapters. Each chapter is divided into numbered sections. The units organize the text into major areas of study; the chapters and sections subdivide the units into specific topics for study. These divisions and subdivisions aid the student in locating specific topics and assist the teacher in arranging class and homework assignments. In addition, these divisions and subdivisions provide for adaptation to individual classroom needs and make the text particularly useful in situations where individualized instruction and flexible scheduling are employed.

...is a readable, enjoyable text. The reading level is low and the interest level is high.

Diagnosing a student's abilities is another use of performance objectives.

First, it presents all the major concepts of biology. Only ideas can stimulate interest in other ideas. At the same time, as its second main feature, the book presents these concepts in the simplest, most nontechnical manner possible. Language is kept simple and technical terminology is cut to the bone.

It is important that the teacher not fall into the habit of simply drilling for facts. He should emphasize ideas and biological principles wherever possible.

Any teacher who finds that his class is capable of handling more technical vocabulary can easily give his class more terms. He can also add extra factual detail whenever a class is able to absorb it.

Even though the students are relatively lacking in biological background, many of them will still be willing and able to progress beyond the scope of the textbook itself. For these students, the teacher can upgrade the course by giving fuller explanations and by introducing a more technical vocabulary.

In the teaching of biology, just as in any other sort of teaching, one is justified in giving tests to students: (1) as a means of encouraging specific accomplishment; (2) as a means of informing students where there are deficiencies in their work; (3) as a means of letting the teacher know to what extent his teaching has been a success or failure; and (4) as a means of determining the merit of each student in comparison with the merits of others in the class.

Students possess a natural interest in heredity. This helps to offset the inherent difficulty of understanding some of its concepts. Considerable drill will be needed on mitosis, meiosis, genes, chromosomes, and diagrams. Avoid controversy on what is and what is not heredity in humans. Except in a few cases, such as color blindness and albinism, it is better to use plants or animals as genetic examples.

...aims primarily to give the student a valid understanding of the nature of science and of the way that knowledge in science has been accumulated. It arms him with skills and concepts that will help him interpret the natural phenomena and technology that confront him. Preparing the student for future science courses or for a specific vocation are secondary to these more general goals.

...materials have been designed to allow the rate of instruction and the scope and sequence of content to vary with the individual student background interest and ability. The project developers feel that the inability to provide this is the greatest deficiency in present-day education.

The activities the students are doing are mostly thing-centered....program calls for students to handle objects, to observe natural phenomena, and to try to explain what they have seen. To the degree possible, "reading about" has been reduced in favor of "doing."

Teaching-and-Learning Styles

The teaching-and-learning styles found in the programs can be classified into two basic groups:

1. Those in which student activities are basically the program, and without their completion the reading materials in the program make little or no sense.

2. Those in which student activities can easily be separated from student reading materials or are packaged in a separate student book.

Only two of the twelve programs are of the first type. These programs require equipment management and a teaching philosophy built around the

concept that the learner is going to share in the responsibility for learning along with the teacher. The teacher must assume the role of a counselor, co-learner, and thought-provoker. The teacher role shifts from the traditional dispenser of knowledge to one that allows a more personalized and individualized approach to development and learning. The management of equipment, a noisier classroom, an atmosphere of "doing," and individualized evaluation become the concerns of teachers in programs of this type. Students are involved in a "hands on" kind of science. The net result is less content coverage for the benefits that accrue from this student involvement approach.

On the other hand, the majority of programs (ten of twelve) can be characterized as teacher directed. The teaching-and-learning styles are in sharp contrast with the student activity-oriented programs in the sense that all students are doing basically the same thing, at the same time, at the direction of the teacher. Teacher lectures, class discussion, recitation sessions, and teacher-directed activities characterize classrooms using these program materials. The same program materials may be used in very different ways in different classrooms. The variable contributing most to this variation is the decision on how, or whether, to use the student activities included with the program. Some of the programs (about half) provide more suggested activities than could reasonably be done in a school year. The others clearly deemphasize classroom activities involving experimentation by providing few activities or few specific directions to conduct the activity. The final decision concerning the number of activities used with these programs is left to the teachers. What teaching style, what philosophy, what learning style is centered around their use is likewise highly teacher dependent.

One can imagine nearly all of the programs in the hands of a "dynamic" teacher as being very workable, with students receiving a very good science program. But the general unwritten message in the majority of these programs is--read, write answers to questions, memorize vocabulary lists, get ready for the tests on Friday, and science is boring and very serious work. Though the materials in total have the potentially "balanced" look, they are packaged and structured to allow the easy "unbalancing" of the program. The encyclopedic text that accompanies each of these programs quickly gives the student and teacher the feeling that "covering" science is much more important than "uncovering" science. The teaching style that is communicated in subtle ways is a lecture-test-lecture system, a system that can be deadly for adolescent students.

The "real" teaching-and-learning style of a program is probably communicated most clearly in the program's evaluation materials. The evaluation materials for the nonstudent, activity-oriented materials are highly vocabulary oriented with little or no process orientation. Students quickly learn from the evaluation scheme what the important learning style of a program should be. A more detailed description of the evaluation materials follows later in this section.

The two quick sample surveys that follow illustrate in a small way the nature of the two teaching-and-learning styles found in these pro-

gram materials. The flavor of each type is only partially captured by the two analyses.

"You's" and "Your's"

The style of writing in programs can be characterized and described in many coding systems. The purpose here is not to code the materials in an elaborate scheme but rather to illustrate the "flavor" differences in the two kinds of programs. The programs in each type (activity-oriented versus text-oriented) are very homogeneous within their subset. Thus, only one of each type was analyzed as representing the entire group of materials. A 1% sample of the pages in each program was completed as illustrated in Table 5. Interestingly, the programs were very similar in length, and a 1% sample resulted in the same number of pages analyzed. Very simply, the number of "you's" and "your's" were tallied for each of the evenly-spaced five pages in each set of materials (first page, halfway in first half, middle page, halfway in second half, last page). The results follow:

Table 5. Analysis of "You's" and "Your's" in Two Science Programs

PROGRAM 1 (FOES) (TEXT-ORIENTED) 503 PAGES		PROGRAM 2 (ISCS) (ACTIVITY-ORIENTED) 552 PAGES	
Page	Number of "you's" and "your's"	Page	Number of "you's" and "your's"
1(3)*	0	1	8
125	0	138	11
251	3	276(5)	7
376	0	414	7
503	3	552	3
Total	6	Total	36
Average per page	1.2	Average per page	7.2

*Numbers in parentheses show substitute pages used if a blank page resulted.

The number of "you's" and "your's" found on the pages in these two programs is significantly different. Although this analysis is hardly conclusive nor is it indicative of many other charateristics programs can possess, it does illustrate the "flavor" displayed by the two programs. Program 2 is talking to the students on a personal basis with the obvious implication that it is their program. Program 1 is very impersonal and is concerned with giving information to students in a formal way without any personal involvement or reflection required. This difference in style verifies the goals and objectives described by the program developers. The goal statements for Program 2 reflect

personal and process orientation for the student, while Program 1 goals are much more oriented toward the information nature of science.

Questions

Another analysis was done on the same pages of the same two programs. This analysis involved tallying the use of question marks in the materials.

Table 6. Question Marks on Selected Pages of Two Science Programs

PROGRAM 1 (FOES) (TEST-ORIENTED)		PROGRAM 2 (ISCS) (ACTIVITY-ORIENTED)	
Page	Number of Question Marks	Page	Number of Questions Marks
1(3)	4	1	1
125	3	138	0
251	4	276(5)	4
376	1	414	5
503	4	552	3
Total	16	Total	13
Average per page	3.2	Average per page	2.6

The interesting thing to note about this tallying scheme is that there is not a significant difference in the total use of questions. A more in-depth analysis of the sources of information the student is expected to use to answer the specific question does reveal another facet of the differences in the two programs. Each question was categorized based upon the following sources of information. Table 7 shows a summary of the results.

Table 7. Student Sources of Information for Answering Questions in Two Science Programs

	PROGRAM 1 (FOES) (TEXT-ORIENTED)	PROGRAM 2 (ISCS) (ACTIVITY-ORIENTED)
A. Reading-recall	12/16 = 75%	0/13 = 0%
B. Observation within experimental work	0/16 = 0%	5/13 = 38%
C. Inference from experimental work	0/16 = 0%	7/13 = 54%
D. Rhetorical question	4/16 = 25%	1/13 = 8%

The focus of each of the programs seems to be very clear when one looks at the nature of the use of questions. Program 1 uses questions as a guide for reading comprehension and factual recall. The nature of the teaching-and-learning styles thus seems quite clear. Program 2

likewise reveals its true nature by this simple questions analysis. Questions in this program are used to guide student's experimental work and to probe to determine levels of understanding from such work. The teaching-and-learning style seems equally revealed and verified for both program types by these simple tallying analyses.

Evaluation Devices

From a student's point of view, the "real" program in any course is the one represented by the materials the teacher uses to evaluate them. Students quickly decode courses. They get right to the core of the course (evaluation) and proceed to study accordingly. Teachers can state a variety of goals for their course (such as "Make students think"); but if their evaluation materials are not consistent with the stated goals, students will focus only on those that are actually used. Table 8 shows the evaluation components found in the analyzed programs. Following is a discussion of the nature of some of the various components.

Table 8. Evaluation Components Found in Nine Commonly Used Science Programs

COMPONENT	PROGRAMS CONTAINING COMPONENT
1. Study questions at end of chapters or units	9
2. Written chapter or unit tests	8
3. Self study check lists	7
4. Discussion on evaluating class work	7
5. Additional reading suggestions	6
6. Vocabulary lists for students	5
7. Tests basically of factual-recall type	5
8. Ditto masters for tests provided	4
9. Written exams for course available	3
10. Tests basically a mixture of recall and process items	3
11. Contains a philosophy of evaluation section	3
12. Contains suggestions for student notebooks or record books	3
13. Laboratory practical exam suggestions	0
14. Tests basically process or "thinking" type questions	0
15. Suggested grading schemes using the evaluation materials	0

From the developer's or publisher's point of view, it seems important to provide evaluation materials for teacher use. It looks as though regular evaluations are judged to be important, since all nine programs contained study questions at the end of each chapter or unit, and eight provided actual tests for chapters and units. None of the

programs told teachers how to use the materials to grade or how to give lab practicals or "thinking" type tests, and only three suggested how to view evaluation philosophically in their courses. The fact that seven of the nine included additional reading lists for students seems to imply that the 500-page book provided with each program is not enough reading for students in science during the course.

Perhaps the most significant point worth noting with respect to evaluation materials is that they are consistent with the goals and objectives communicated with the program's materials. Those programs that are information-oriented have information-oriented evaluation materials. Those programs that state an interest in the processes of science and in thinking scientifically have evaluation materials with those foci. There seems to be a definite lack of evaluation materials of the non-pencil-and-paper type. The appeal in all programs is to have evaluation materials that are easy for teachers to score. Within this constraint, however, the range of foci of evaluation items is quite wide and represents the same dichotomies found in the programs as described in other parts of this report. The following sets of four questions, taken from two "typical" chapter tests, illustrate the focus of each of these programs as well as the distinct difference in the philosophy of evaluation. Notice Program 1's obvious focus on vocabulary and recall of factual information. Programs 2's questions are clearly more thought-provoking and call upon student experience, developmental level, and thinking ability to answer. Just as program materials offer a diversity of choices of teaching styles, so do the evaluation materials available for the various programs.

<u>Program 1 (FOES)</u>

1. According to most astronomers' interpretations of the red shift, which of the following is the most distant from earth?
   a. pulsars c. galaxies
   b. cepheids d. quasars

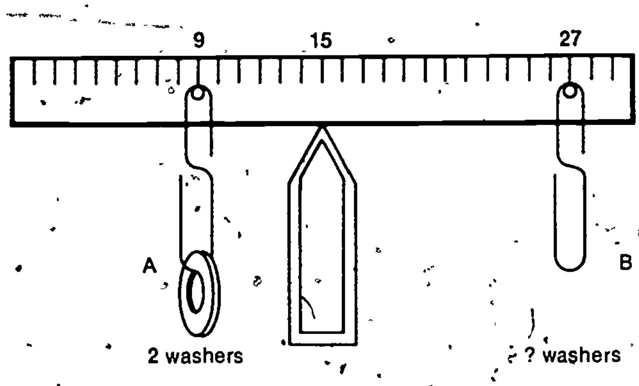
2. Name the three types of galaxies.

3. What is the Big Bang theory?

4. The direction of star movement is determined by a(n) ________. This instrument records the change, or the ________, in the visible spectrum of a group of stars as they move away from the earth. Distances to stars and other celestial bodies outside the solar system are measured in units called ________.

Program 2 (ISCS)

1. How many washers would have to be placed on hook B to balance 2 washers on hook A?



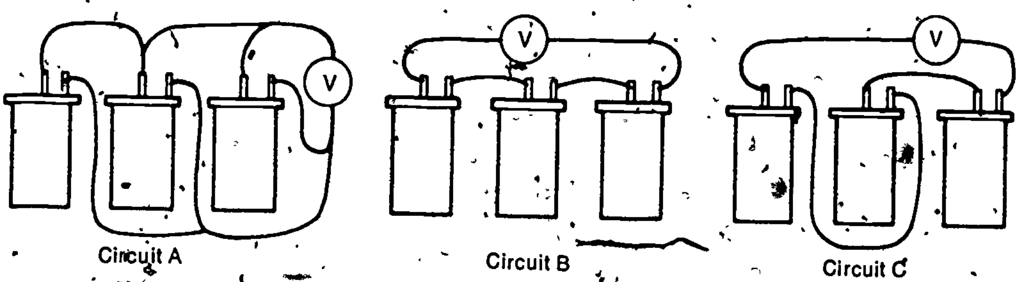
The following information and table are to be used to answer questions 2 and 3. Darrell does an experiment involving several balls he bought at the dime store. The data collected from the experiment are given in the table shown below.

Kind of Ball	Height Dropped From	Height of Bounce
2-inch solid rubber ball	10 feet	9 feet
2-inch hollow rubber ball	9 feet	6 feet
2-inch clay ball	8 feet	1 foot
2-inch steel ball	7 feet	2 feet
2-inch glass ball	6 feet	3 feet
2-inch plastic ball	5 feet	6 feet

2. Which of the following variables did Darrell keep constant?
   a. The material from which the balls were made
   b. The height that each ball bounced
   c. The diameter of the balls
   d. The height from which each ball was dropped

3. Darrell made several mistakes in setting up his experiment. Which of the following was his most serious mistake?
   a. There were no variables in the experiments.
   b. There were too many uncontrolled variables.
   c. He should not have tried the experiment because no practical information could be gotten from it.
   d. Darrell did not make measurements that were careful enough.

4. In which circuit would the voltmeter (V) reading be the highest?
   a. Circuit A
   b. Circuit B
   c. Circuit C
   d. The reading would be the same in all three circuits.



CHAPTER 3

ALTERNATIVE PROGRAMS

Career Emphasis

Dr. Trudy Banta in her article "Career Education: How Do Your Science Texts Stack Up?" (3) suggests a framework for analyzing texts, as well as a framework for a reasonable career education component in a science program. Dr. Banta writes:

> Career education should not be a "sometime thing"; instead it should be an instructional strategy that can be used by every teacher, in every course, at every grade level. Its goals should be to help each student: better understand self in relation to the world of work; acquire and use occupational information to make an informed career choice; and prepare for a chosen career before leaving school.
>
> Career education is not a new subject to be added to an already crowded curriculum. Rather, it is a way of using career-related examples to teach traditional academic content. Career education can have two primary emphases:
>
> 1. Career development, which helps students understand themselves; become aware of their own values, interests, and abilities; and learn how these qualities function as strengths or limitations in their pursuit of life roles; and
>
> 2. Career preparation, which relates subject matter to the way students can apply it in their life roles as family members, citizens, workers, and participants in leisure-time activities.
>
> Specifically, texts which provide learning experience in career development should do at least some of the following:
>
> - Help students to explore their own interests, attitudes, values, and abilities
> - Promote students' skill in making decisions that are personally relevant
> - Discuss worker characteristics (interests, aptitudes, abilities) needed for successful participation in a given occupation

- Discuss science-related occupations (how different kinds of work are performed)

A science text which provides learning experiences in <u>career preparation</u> should do one or both of the following:

- Discuss the academic preparation or specialized training needed for a specific science-related occupation
- Suggest ways in which science concepts may be <u>applied</u> in one or more of the student's life roles

Dr. Banta's checklist was used to analyze the ten programs in this study. However, it was not to compare programs, as described by Dr. Banta. Instead, the checklist was used as a tallying device to analyze the status of career education in all the programs as a group.

Table 9. Checklist for Evaluating Career Education Content of Science Texts

	PRESENT	PRESENT	VERY EFFECTIVELY PRESENTED
1. Exploration of students' own interests, values, abilities	10	0	0
2. Promotion of decision-making skills	10	0	0
3. Discussion of worker characteristics (interests, abilities, etc.) needed in a given occupation	9	1	0
4. General discussion of science-related occupations (how the work is being done)	7	3	0
5. Discussion of academic preparation or specialized training needed for work in a given science-related field	9	1	0
6. Suggestions for applying science concepts in one or more life roles	6	4	0

A quick examination of the results tallied in the checklist in Table 9 reveals that career emphasis in student materials is nearly void at this level. One could debate the nature of what good career education should be for 10- to 15-year-olds, but examination of these materials reveals that career education in any form is nearly nonexistent. The focus that does exist in a few of the programs consists of a one-page 'special' section concerning people and their careers. These

special one-pagers are, for the most part, very well done, with photographs and with special-interest writing styles replacing the textbook style. They are not integrated into the text material, the student activities, or any other part of the program. They are rather cosmetic and are inserted into the books as the career somewhat reasonably relates to the content of the chapter. How that content relates to the career, how the interests of the people relate to the content, and what the qualifications or requirements are for the job are basically missing. More than half of the programs are totally void of any career- or job-related components.

Science, Society, and Technology

Materials relating to science, society, and technology were analyzed together due to the overlapping of various topics. The results of the analysis are obvious and irrefutable. The interpretations or conclusions to be drawn from the results, however, can be varied and debated. Some will argue that the lack of materials on the science/society/technology trio for 10- to 15-year-olds is a good thing. Others will argue that this is a bad situation. The idea that different people can look at the same data and come to different conclusions is exactly the concept that is missing from the program materials, whether they deal with societal issues or not.

Programs that deal with issues of the relationships among science, society, and technology and truly examine the issues by definition must be interdisciplinary in nature. No science/society/technology issue can be addressed effectively with information from just one discipline. Since all of the analyzed programs are clearly not interdisciplinary one could quickly infer that the programs do not deal with science/society/technology issues to any great extent. This is exactly the state of science/society/technology issues in the examined programs. The programs are clearly hard core science programs. Some are fact-oriented and some are process-oriented, but no matter what the pedogogical focus they are about science and little else. The image they create is fairly clear--science operates insulated from society and has little interest in things outside the walls of the laboratory.

The publishers or authors certainly did not purposefully set out to create such an image. It just seemed to happen when other concerns apparently assumed priority. None of the programs makes reference to legislation for research; where funding for scientists comes from; who votes on science issues; or the roles of government, private industry, and universities in the scientific enterprise. The list of issues not mentioned or even hinted at in all the programs could be very long, much longer than the list of specific topics briefly mentioned in some of the programs.

The discussion of a specific, noncontroversial technology is apparently judged to be much more possible than any inclusions that would be viewed as having societal implications. The list of included specific

technologies is much longer than the list of included societal issues. Explanations of how these technologies developed or how they relate to scientific research, however, are nonexistent.

In the programs that contained any topics in these areas, the format for treatment is almost standard. Most of the topics are treated as one-page special inserts in the books. There is no attempt to integrate the topic or issue with the rest of the text material. The other standard way to treat these topics is via photographs and their captions. These likewise are usually inserts, and there is little integration with the other text material. (Maybe students only look at the pictures and read the captions, and therefore, this is a good design.)

Perhaps the most noteworthy point to make is that there are virtually no opportunities provided for students to become "involved" intellectually or otherwise with science/society or science/technology issues. The issues when present are discussed only as factual information, with no hints that there may be controversy or different interpretations of the same information. One of two images is clearly created from the materials:

1. Science will solve all of our problems
2. Science has no relationship with the problem(s)

Unless the teacher provides what the materials do not, students in these programs will be sheltered from the myriad of issues surrounding science/society/technology issues. It is debatable how much a 10- to 15-year-old should have to deal with controversy, politics, and global issues. Therefore, it is much safer for the author or publisher to include none. One could likewise, however, argue that information about the parts of a the leaf are equally inappropriate for a 10- to 15-year-old and eliminate it from the program, also.

The critical thing to note in the programs examined is that, even though the list of mentioned topics looks long in this science/ technology area, the treatments are inconsequential in the balance of the whole programs. When a topic in this area is included in the materials, it usually looks exactly like what it is--an insertion in one of the later editions of the program to make it look modern and up to date. The result, however, is a patchwork-looking job and a program with little integration or logic. The science/society/technology topics may be in one-page inserts throughout the book, or a last chapter (or more) may be tacked onto an earlier edition of the book with a chapter or unit title trying to capture an application or integration theme.

Typical science/society topics found in half or more of the programs included: drugs; thermal pollution; water pollution; air pollution; pesticides; water treatment; energy alternatives; nuclear energy; and conservation of wildlife, forests, soil, and water. Other topics that appeared in only one or two programs included: food additives and preservatives, sanitation and health, endangered species, genetic counseling, human genetic diseases, death, old age, mineral supplies,

farming and food supply, recycling, population pressures, earthquakes, acid rain, national parks, wildlife refuges, and sea farming.

Science/technology topics that occurred in half or more of the programs included: automobile engines, nuclear power generation, weather detection equipment, disease prevention and control, satellites, lasers, and space travel. Topics that appeared basically only once among the ten programs included: electric generators, food preservation, ocean-exploring vessels, selective breeding, telephone, radio waves, rockets, life detectors, artificial organs, chemotherapy, atomic bomb, electric motors, gasoline refinement, polymer chemistry, cryogenics, telescopes, vacuum tubes, rectifiers, transistors, CRT's, digital computer, analog computer, X rays, cyclotron, solar cells, ultrasonic devices, electric cars, prosthetic devices, amniocentesis, interferon, infrared photography, and microwave cooking.

In summary, if our society currently has any problems or concerns to which science and technology can contribute in meaningful ways, it is not reflected in the science materials currently used in our middle and junior high schools except in only peripheral ways. What is communicated by the materials is that science is a body of factual information and interesting things to do in the laboratory, with apparently little or no relationship to our everyday lives and problems.

Student Activities

What students do during the planned activities of a class period is probably the only thing that really matters in terms of what impact the course will have on the students. Goals, objectives, emphases, foci, and other things written about the course are not the course from the students' point of view. The only thing that matters to students is what they do and learn in the course that <u>in their view</u> is personally valuable. Thus, the analysis of student activities within a program is probably more important than any other analysis that could be done. It might also be the most difficult to do based on the materials alone. Given the same materials, two students might do two completely different things. Thus, assumptions need to be made about activities when they are analyzed. It must be assumed that they are done as described by the author or publisher, in the appropriate sequence, and that students actually have the opportunity to do the activity as written.

In order to analyze student activities, five programs (one each of life, physical, earth, general, and thematic science) were selected from the twelve programs and the student activities were coded using the activity coding scheme previously developed by Robinson and his colleagues (4). The coding scheme has four major areas of focus: major activity focus, type of knowledge, content, and what students do. The conventions and definitions required for this coding scheme are briefly described below with a detailed description in Appendix B (page 198). Only a sample of activities were coded from each of the five programs.

Every fifth activity was coded for a 20% sample of the activities provided with each program.

Coding Scheme Brief

A. Major Activity Focus

All coding of activities will be done in terms of the literal content of the totality of materials the student uses in the conduct of the activity. Activities may include only one major focus, all three foci, or various combinations of them. The major foci are:

Craftsmanship. A major part of the activity is craftsmanship, construction, building. Craftsmanship is part of an activity where students put things together, build apparatus, or otherwise assemble parts that could have been already assembled. The student cannot complete the activity satisfactorily without construction. Construction may be the product, or it may be a means to the end. Craftsmanship subsumes, but is more comprehensive than, the psychomotor domain described by Bloom and others (5).

Affect. A major part of the activity is affect. It calls upon the student to develop empathy, to reflect on how objects or events affect others, to be sensitive to other feelings, to examine one's own feelings about some object or event. Or a major part of the activity is an appeal to emotions or feelings rather than, or in addition to, acquisition of new knowledge or presentations of information. Aesthetic outcomes, appreciating form, design, beauty, etc., are further examples of an affective focus. Affect is synonymous with domain as described by Krathwohl and his colleagues (6).

Cognition. A major focus of the activity is knowledge. Knowledge acquisition may involve reasoning or it may be remembering, either exactly as presented, or with re-presentation, but without reasoning or performing cognitive operations. Cognition, as described here, is classified by Piagetian types of knowledge rather than the taxonomy developed by Bloom and others (5).

B. Types of Knowledge

Any activity may require some knowledge acquisition, even though its central focus may be craftsmanship or affect. The criterion used in deciding the single code for this category is to determine a single highest level predominant type of knowledge acquisition that a student must use if the activity is to be understood as the writers of the activity intended. If a single problem or small part of an activity requires a high level of knowledge acquisition, it should not be used in coding. The knowledge type must be predominant, not unique. If two knowledge types are equally predominant, the higher type (defined by the higher number in the coding values) will be coded. Each activity will be assigned a single "type of knowledge" code. The code will reflect

the predominant logical requirement of the activity. The above convention will be violated when a higher knowledge type is required to get the "gist" of the activity, even though a lower type is predominant. In this instance, the higher type is recorded.

The first determination will be to dichotomize the general knowledge type, that is, determine if the knowledge acquisition is essentially figurative or operative. If it is figurative, the task ends and the code of figurative knowledge is applied. If operative knowledge is required, we will want to code the kind of operative knowledge as precisely as possible.

Figurative knowledge is knowledge that has not resulted from reasoning. It depends on recognition of the configuration of the stimulus. Figurative knowledge emphasizes forms of representation: deferred imitation, symbolic play, drawing, mental imagery, language, and memory, especially rote memory.

Passive "reading" of data without having to mentally act on, reason about, or transform it is a good example of figurative knowledge acquisition. When students are asked "What did you see?" or when they are asked to describe or consider static states of objects at some point in time, figurative knowlege acquisition is the requirement.

When the emphasis is on symbolically representing information without requiring any logical transformation, figurative knowledge is being attained. In figurative knowledge, emphasis is on representation without consideration of the necessary logical relation between the knowledge represented and the representation itself; for example, words become an end in themselves and not a means to an end. Further examples are: asking for an accurate "reading" of the situation without asking for an understanding of what was "read," or the activity is developed in such a way that the student can easily go through the activity without reasoning.

Figurative knowledge includes all preoperational knowledge. The preoperational child tends to take the immediate appearance of things as the sole and ultimate reality. A single, isolated cognition with little or no potential is the hallmark of the preoperational child. When we ask for an isolated cognition without comparison or referent to other cognitions, we are asking for figurative knowledge.

Operative knowledge is knowledge that results from reasoning. In general, operations consider how things have changed from what they were to what they are now or how things might change. Operations ask for an inference, an induction, or a deduction. It is a representational act that is an integral part of an organized network of related acts. Cognitive operations are a holistic domain, presupposing a structured system that includes other related operations, "for the moment latent and inactive but always potentially actualizable by themselves and, above all, always a force governing the form and character of the operation which is momentarily on stage." (Please see Appendix A for the details of the logic in the subcategories under the operative category.)

C. Content of the Activity

Activities were to be categorized according to the following content categories:

Life sciences. The content or process(es) used is(are) derived from or directly related to one of the subdisciplines of the biological, medical, or health sciences.

Physical sciences. The content or process(es) used is(are) derived from or directly related to one of the subdisciplines of physics, chemistry, engineering, or materials science.

Earth sciences. The content or process(es) used is(are) derived from or directly related to one of the subdisciplines of geology, oceanography, astronomy, paleontology, astronomy, or meteorology.

Behavioral sciences. The content or process(es) used is(are) derived from or directly related to one of the sciences that deals with human action and arrives at the establishment of generalizations of human behavior in society, that is, psychology, sociology, anthropology, archeology.

Social science. The content or process(es) used is(are) derived from or directly related to one of the sciences that deal with the institutions and functioning of human society and with the interpersonal relationships of individuals as members of society, that is, economics, political science, geography.

Humanities. The content or process(es) used is(are) derived from or are directly related to history, languages, literature, and philosophy.

Fine arts. The content or process(es) used is(are) derived from or are directly related to subjects for which aesthetic purposes are primary or uppermost, such as painting, sculpture, drawing, architecture, music, ceramics, dance, drama, or landscape architecture.

Mathematics. The content or process(es) used is(are) mathematical.

Other. The content or process(es) used does(do) not fall into one of the above categories.

D. What Students Do in the Activity

This category is used to code the central "doing" that students engaged in as they used the activity. An activity may have more than one "doing."

Appreciating. A noncognitive act of positive awareness or positive recognition of some object or event.

Calculating/computing/graphing. A single category in which one or more of these operations is central to the conduct of the activity.

Constructing. The student must build, put togther, or in some other way construct something in order to carry out the intent of the activity.

Creating. The preparation of something novel, when the student is asked to produce a novel product and is not given criteria for judging whether the product is the "right" one.

Deciding. Includes decision making, coming to a choice among alternatives for a course of action, and arriving at a concensus by a group. A decision usually implies action or potential action.

Experimenting. The student must gather data systematically under specified conditions. Variables or controls need not be specified. It differs from information gathering (below) in being systematic and controlled.

Interviewing. Conducting one or more interviews is an essential part of the activity.

Listening/watching. When the student uses a sound-slide program, sound filmstrip, or sound film.

Nurturing. When students are caring for plants and/or animals over a period of days or weeks, where nurturance is an essential component of successfully meeting the activity focus.

Reading. When the student must read a booklet or book integral to the activity in order to do the activity successfully.

Listening. When the activity depends on the student listening to a tape recording, record, stethoscope, or other sound device.

Valuing. Includes the decision that A is of more worth or importance than B. It is comparative and more than two alternatives may be compared. The outcome of the comparison must result in a higher value on one of the alternatives.

Watching/viewing. Includes the use of silent films, film loops, flat pictures, overhead transparencies, slides, filmstrips with no sound, wall charts, and posters.

Information gathering. Measuring, counting, taking photos, making prints of objects, diagramming, sketching, describing, and recording observations in natural settings are examples of data gathering. Unlike experimenting, data gathering takes place in a naturalistic environment with no attempt to randomize, to sample, or to control variables.

Student Activity Analysis

The results of the coding of student activities are shown in Table 10 on page 181. The data can be analyzed within each program as well as across programs. The first pattern that emerges is the consistency that occurs within any given program itself. None of the programs looks "balanced" across all the variables. Whatever the emphasis of the program, it seems to permeate all the student activities in that program. Examples include the heavy emphasis on reading in the life science program, the large amount of craftsmanship and construction in the thematic program, the greater amount of logic in the thematic program, and the larger amount of experimentation in both the thematic and physical science programs.

Across programs there is some variation in the student activities in the amount of craftsmanship, the amounts and types of logics used, the content coverage, and the amount of experimentation. All programs are similar in their lack of activities focusing on affective dimensions and their heavy emphasis on cognitive outcomes. Additionally, there is a heavy emphasis on the figurative type of knowledge, that is, most things have been reduced to "nonlogic thinking situations" for the student. All programs are basically void in providing opportunities for decision making, creating things, interviewing, listening, valuing, and watching as defined by this coding scheme.

In terms of content, the physical sciences seem to be a predominant emphasis at this level. There is no emphasis within or across programs on the interdisciplinary nature of knowledge. The content of all programs at this level is strictly confined to the natural sciences. No attempt is made, in any of the programs, to relate the natural science content to any other content areas.

The high emphasis on information gathering and the low emphasis on construction and experimenting seem to go along with the goals stated for most of the programs--that science is knowledge and science is not a way of knowing. The thematic program is the one exception to this trend and brings the average up in these areas for all the programs together. The high dependence on reading for the completion of the labs is a reflection on the "dry lab" nature of most of the student activities provided.

Summary

Though the analysis of programs commonly used at this level reveals interesting patterns for the materials when taken as a group, it is worth reiterating the idea that there is a diversity of programs contained within this subset. Teachers and educators do have a choice of philosophies, content, learning styles, and student activities among the materials available to them. A careful analysis of the programs reveals that all the programs do not "look" or "act" alike. The authors and

Table 10. Results of Coding Student Activities in Five Major Science Programs

	L (%)	P (%)	E (%)	G (%)	T (%)	TOTAL (%)
A. MAJOR ACTIVITY FOCUS						
Craftsmanship	0	0	0	0	0	0
Affect	0	0	0	0	0	0
Cognition	82	76	53	85	0	71
Craftsmanship and affect	0	0	0	0	0	0
Craftsmanship and cognition	18	12	26	0	80	16
Affect and cognition	0	12	21	15	0	12
Craftsmanship, affect, and cognition	0	0	0	0	20	1
Not codable into the above categories	0	0	0	0	0	0
B. TYPES OF KNOWLEDGE						
Figurative	88	70	68	58	40	68
Operative						
I. Addition of classes	0	6	10	0	0	4
III-IV. Multiplication of classes						
A. Intersection	0	0	0	0	20	1
B. Correspondence	12	12	10	31	0	16
V. Seriation	0	0	0	0	0	0
VII-VIII. Multiplication of relations						
A. Intersection	0	0	5	0	40	3
B. Correspondence	0	0	0	8	0	2
Formal	0	12	5	3	0	6
Not codable into the above categories	0	0	0	0	0	0
C. CONTENT OF THE ACTIVITY						
Biology	89	0	0	30	0	23
Physical sciences	5	100	11	30	71	47
Earth sciences	5	0	89	27	0	24
Behavioral sciences	0	0	0	0	0	0
Social sciences	0	0	0	0	0	0
Humanities	0	0	0	0	0	0
Fine arts	0	0	0	0	0	0
Mathematics	0	0	0	13	28	6
Not codable into the above categories	0	0	0	0	0	0
D. WHAT STUDENTS DO						
Appreciating	0	6	6	2	9	4
Calculating	0	4	6	17	13	8
Constructing	9	13	17	4	23	12
Creating	0	2	0	2	0	1
Deciding	0	0	0	0	0	0
Experimenting	3	17	8	12	23	12
Interviewing	0	0	0	0	0	0
Listening/watching	0	0	0	0	0	0
Nurturing	6	0	0	10	0	3
Reading	39	11	17	10	23	19
Listening	0	0	0	0	0	0
Valuing	0	0	0	0	0	0
Watching/viewing	0	0	0	2	0	1
Information gathering	45	45	46	40	9	40
Not codable into the above categories	0	2	0	0	0	0

publishers, as of 1977, did not see science appropriate for students at this level the same way.

There are two ideas that dampen this diversity and the prospects for the immediate future for even more diverse materials. First, it is unfortunate that the diversity in the materials in 1977 was not greater than it was. The innovative nature of elementary and secondary materials of the sixties and seventies seems to have had little penetration into the middle and junior high school materials. Second, and even more depressing, is the apparent forthcoming removal of the more "innovative" programs from the pool of choices available. The economics of publishing seems to be working against the programs requiring equipment or other manufactured supplies. Only hardcover books seem to be surviving, and the innovative packaging of materials seems to be on an indefinite holding pattern. The choice that was available (though somewhat limited) is rapidly being reduced as programs with materials are no longer being sold. The net result will be a sense of programs that do all "look alike" and "act alike."

The checklist created by Harry Milgrom in 1964 (7) provides a series of thoughtful questions that should be answered when evaluating a science program. This checklist of questions is very judgmental and less systematic than other schemes used in analyzing programs in this study. Even though these questions are very difficult to answer precisely, the answers as suggested by these authors do seem to reflect the state of the art of science programs at the middle school and junior high school level.

1. Does the book portray science as an exciting adventure of the human mind? 4 yes, 1 no, 5 questionable

2. Is the book provocative and challenging? 2 yes, 8 no Does it inspire more questions than it answers? 2 yes, 8 questionable

3. Does the book further understanding of the basic principles of science? 9 yes, 1 no

4. Does the book give insight into the methods of science? 2 yes, 8 not particularly

5. Does the book stimulate new interest and stir new wonder? 2 yes, 8 no

6. Does the book promote independent inquiry and thought? 2 yes, 8 no

7. Does the book provide leads for experiments? 9 yes, 1 no

8. Is the book based on some foundation of previous knowledge and experience? 2 yes, 8 unknown

9. Does the book reveal the role of the imagination in the progress of science? 3 yes, 7 no

10. Is the content of the book within the comprehension of children in the age group for which it is written? 3 yes, 7 no or questionable

11. Is the style of writing appropriate to the subject, clear, interesting, and meaningful to the reader? 5 yes, 5 questionable

12. Has the book been checked for accuracy of scientific vocabulary and expression? 10 yes

13. Are the illustrations in the book clear, meaningful to the text, and scientifically correct? 10 yes

14. Does the author give careful attention to details given in the book? Basically all yes

15. Is the book more than a "cut and dried" collection of assorted facts? 4 yes, 6 no

16. Does the book introduce the reader to such tools of scientific exploration as observation, measurement, and reasoning from data? 4 yes, 6 no

17. Does the book increase, in some measure, children's awareness and understanding of the science in the world around them? Basically all yes

18. Does the book help the reader gain greater insight into the "chains of events" in the history of science? Basically none

19. Does the book try to involve the reader in action and thought or does it relegate him to the role of a bystander? 4 action or thought, 6 bystander

20. Does the book provide ideas for the reader to ponder and mull over? Most do

21. Does the book distinguish fact from fancy? Most do

22. Does the book try to show what motivates scientists and makes them tick? 2 yes, 8 questionable

23. Does the book portray science as an endless quest or does it close the door to further exploration by describing "all there is to know"? 5 endless quest, 5 closes the door

24. Does the book show how scientists establish order out of apparent chaos by bringing to light the big, unifying ideas? 2 yes, 8 questionable

25. Is the emphasis of the book on learning by rote or on learning by reason? 6 rote, 4 reason

26. Does the author show that he understands the needs and aspirations of children? Most do not

27. Does the author respect the dignity and intelligence of the young reader? 5 yes, 5 no

28. Does the author try to cover everything in a science area, or does he deal only with selected aspects of the area for greater depth of treatment? 4 yes, 6 no

29. Does the book merely enumerate discoveries of the past, or does it illuminate the approaches and probings that lead to discovery? 7 enumerate discoveries, 3 illuminate

30. Does the book present a great deal of information without indicating how scientists go about unearthing information? 6 yes, 2 no

31. Is the book written to conform to a preset pattern for a series? 8 yes, 2 no

32. Does the book contain any original or unusual features that set it apart from other books about the same subject? 3 yes, 7 no

33. Does the book introduce the reader to the nature and spirit of "The Scientific Enterprise"? 4 yes, 6 no

CHAPTER 4

ROOTS: 1965-1970

Earlier editions for each of the programs were analyzed to determine what changes had occurred in these materials in the decade from 1965-70 to 1975-80. This analysis, of course, reveals only changes that occurred in materials that ended up being best sellers in 1977. It does not describe what the best-selling programs of 1967 that didn't continue to be best-sellers. This analysis is thus not a reflection on all the possible trends in science education from 1965-70 to 1975-80 but rather just the changes in the programs that survived as best sellers to 1977. Comparable data to the Weiss 1977 data (2) are not available for 1967. This is why a "roots approach" design has been employed for this part of the analysis.

It is fairly easy to describe the changes in the programs from 1965-70 to 1975-80. In a word, the majority of the changes can be described as minimal. This is a fairly predictable trend in the educational publishing industry; that is, when you happen on a winner, don't mess with it. Publishers change programs only as sales start to slip, and even then there is a general tendency to come out with a whole new program and not revise the old one. Therefore, one could predict that the best sellers of 1977, which had their roots ten years or more earlier, hadn't changed much since their earlier editions.

The changes that were made from edition to edition were basically cosmetic. Greater use of four-color art and color photographs was a universal trend across the programs over the decade. The quality of both the art and the photographs improved with each new edition. The educational value of these components (better placement and related to text materials, etc.) also improved with each edition. Those programs that contained the special one-page career briefs did change, and these pages were updated across editions. This, of course, was easy to do and was a flexible design component to continually make the materials look current without changing the organization of the program.

Any major change in any of the programs in terms of content refocusing, teaching style changes, etc., is difficult to find in any of the programs. A few specific improvements and changes can be found in a few of the programs, but none comes close to being considered a major change. The "stay with a winner until it dies" philosophy seems obvious with all of these programs.

For each of the programs, the following questions were considered as a starting point for comparing across the decade:

1. Were there major shifts in content emphasis in the program from 1965-70 to 1975-80?

2. If new content was added to the program, was some content dropped?

3. Were the written goals for the program changed in later editions of the program?

4. Was a new teaching style suggested in later editions?

5. Were new sections for the teacher added in later editions?

6. Were the evaluation devices updated from 1965-70 to 1975-80?

7. Did the philosophy of evaluation change from 1965-70 to 1975-80?

8. Did the amount of career emphasis in the program change from 1965-70 to 1975-80?

9. Was there any change in the educational philosophy of the program over the decade?

10. Was there any change in the educational psychology the program discussed?

11. Did the science/society emphasis change over the ten years?

12. Did the science/technology emphasis change over the ten years?

13. Did the nature of the student activities change over the ten years?

14. Were there any major design changes in the program?

The answer to all of these questions for all of the programs is, basically, no. There were no major changes in any of the programs over the decade, except for changes in appearance (new covers, art, photos, etc.)

In 1967, Dr. S. S. Blanc conducted a study entitled "Distribution of Physical Science Principles in Junior High School Textbooks" (8). Dr. Blanc found 122 principles, which he grouped into ten major science topics as follows:

Matter and Energy (19 principles)
Electricity and Magnetism (13)
Liquids and Gases (13)
Weather and Climate (11)
Astronomy (10)
Light and Sound (20)
Force and Motion (11)
Properties of Air (5)
Fire and Heat (8)
Geology (12)

The principles were found in varying degrees in all five programs that he analyzed. Dr. Blanc randomly selected five programs for his analysis. Each was a three-year science program designed for seventh, eighth, and ninth graders.

One of the three-year programs from the 1977 group was selected and analyzed for the 122 physical science principles from Dr. Blanc's study. The physical science and the earth science texts were analyzed in detail to determine which of the 122 principles were included in the materials. Just as Dr. Blanc did in 1967, this study made no attempt to determine if the principle was adequately covered or properly described. It was concerned only with whether the principle was present in the student materials. The following principles from Dr. Blanc's list were found to be present in the 1977 series:

Matter and Energy

Matter is any substance that has weight and occupies space.
All matter is composed of single elements or groups of elements.
An element is the simplest form of matter and is composed of tiny particles called atoms.
All substances are made up of small units called molecules, which are alike in the same substance.
Elements combine physically to form mixtures and chemically to form compounds.
Matter can be changed from one form to another but cannot be created or destroyed.
Inertia is a property of matter which resists changes in movement of the substance.
Matter can be transformed into energy and energy can be transformed into matter.
Matter exists in three states as solids, liquids, and gases.
The main difference among a solid, a liquid, and a gas is in the movement of the molecules in the substance.
Atoms of all elements are made up of invisible protons, electrons, and neutrons.
Atoms of radioactive elements are constantly disintegrating and giving off various rays.
A nuclear reaction takes place when one element changes into another element.
Energy is the ability to produce motion or exert force.
Energy can be changed from one form to another but cannot be created or destroyed.
Energy that a body possesses because of motion is called kinetic energy.
Energy that a body possesses because of position is called potential energy.
Light and heat are forms of radiant energy.
Radiant energy travels in waves in straight lines in all directions from the source.

Light and Sound

Light waves travel in straight lines while passing through a uniform medium.

Light waves striking an object may be absorbed, transmitted, or reflected.

When light falls on an opaque object, a shadow is formed behind the object.

When a beam of light falls on an irregular surface, the light rays are scattered in all directions.

Light rays passing at an angle from a rare to a denser medium are bent or refracted towards the normal.

Light rays passing at an angle from a dense to a rarer medium are bent or refracted away from the normal.

Light rays may be brought closer together, or converged, by using a convex lens.

Light rays may be spread apart, or diverged, by means of a concave lens.

An image appears to be as far back of a plane mirror as the object is in front of the mirror.

Ordinary white light is made up of waves of many different wave lengths, or colors.

The color of an object depends on what light rays it transmits, reflects, and absorbs.

Sound is produced and transmitted by vibrating materials.

The loudness of a sound depends on the energy of the sound waves.

Sound waves spread out in all directions from the object producing the sound.

Sound waves travel through different substances at different speeds.

Musical tones are produced when a vibrating object sends out regular sound waves.

Noises are produced when a vibrating object sends out irregular sound waves.

The pitch of a musical sound depends on the rate of vibration of the vibrating object.

The quality of a musical sound depends on the pitch and the harmonics of the tones.

Sound waves are reflected from smooth, hard materials and absorbed by soft, rough materials.

Electricity and Magnetism

Magnets always have two poles and are surrounded by fields of force.

Like magnetic poles repel each other and unlike magnetic poles attract each other.

An electric current may be produced by friction, chemical action, or magnetism.

A substance that gains or loses electrons becomes electrically charged.

An electric current is a flow of electrons from a negative to a positive pole.

An electric current flows when there is a difference in electrical pressure between two points.

An electric current flowing through a wire sets up a magnetic field of force.
An induced current may be produced by a wire moving through a magnetic field.
An alternating current flowing through a coil can induce a current in an adjacent coil.
Electrical energy used in overcoming resistance to flow is changed into heat or light.
Chemical changes are produced when an electric current passes through an electrolyte.
Transformations of energy are made possible by vacuum tubes and resonating circuits.
Electromagnetic waves go out in a straight line in all directions from a transmitter.

Force and Motion

All motion is produced by force, but not all force produces motion.
When force overcomes resistance and moves an object, work is performed.
To every action there is an equal and opposite reaction.
A body at rest will continue at rest until some outside force moves it.
A body in motion will continue in motion until stopped by an outside force.
The force that holds molecules of a substance together is cohesion.
Machines multiply the force exerted in order to make it easier to do work.
When there is a gain in mechanical advantage, there is a loss of speed.
Whenever one surface is moved over another, resistance or friction is produced.
Work done by a machine plus the work lost because of friction equals work put into the machine.
A body in rotation tends to fly out in a straight line from the circumference of the circle.

Liquids and Gases

A dissolved substance is equally scattered throughout the liquid in which it is dissolved.
A body floating in a liquid is buoyed up by a force equal to the weightof the displaced liquid.
Any body of free liquid will seek a level in which all surfaces are at the same height.
The pressure at any point in a fluid is the same in all directions.
Pressure exerted on a confined liquid is transmitted unchanged through the liquid.
The pressure in a fluid increases directly as the depth.
A gas always tends to expand throughout the whole space it occupies.
The pressure of a confined gas is increased if the temperature is raised.
The pressure of a confined gas is increased if the volume is decreased.

Heat is released when a gas is compressed and is absorbed when a gas expands.

Gases, and most liquids and solids, expand with heat and contract with cold.

The average speed of molecules in a gas is increased with a rise in temperature.

Heat is released when a gas is changed into a liquid and absorbed when the liquid is changed into a gas.

Properties of Air

Air is matter that occupies space and has weight.

Differences in pressure can be used to make air do work.

Air pressure is increased by increasing the number of molecules that strike a surface.

Atmospheric pressure decreases with an increase of water vapor or a rise in altitude.

Air that is moving exerts less pressure than air not in motion.

Weather and Climate

Weather is the result of changing conditions in the atmosphere due to movements of air masses.

Climate is the average of weather conditions in a certain place over a period of time.

The main cause of weather change is the unequal heating of different parts of the earth by the sun.

Winds are air movements caused by the unequal heating of the earth's surface by the sun.

Air masses move from regions of high atmospheric pressure to regions oflow atmospheric pressure.

Air masses revolve in a counterclockwise direction in the northern hemisphere and in a clockwise direction in the southern hemisphere.

Bodies of land heat up and cool off more rapidly than bodies of water.

The more nearly vertical the rays of the sun, the greater the heat and energy received by the earth.

The atmosphere surrounding the earth prevents most of the heat from leaving the earth.

The higher the temperature of the air, the more moisture is needed to saturate it.

Rain will occur when centers of condensation form in vapor-saturated clouds that are cooled.

Fire and Heat

A fuel is a substance that will burn and give off heat.
Each combustible substance has a kindling temperature that varies with its condition.
Heat travels through space and is carried by solids, liquids, and gases.
Heat tends to diffuse and equalize temperatures of all places and objects it reaches.
There is a continuous transfer of heat between two bodies of different temperatures.
Most objects expand on heating and contract on cooling.
Heat is conducted by the kinetic energy transfer from molecule to molecule.
Most of our heat energy comes originally from the sun.

Astronomy

The solar system is composed of planets and other bodies revolving in orbits around the sun.
The sun is a hot, gaseous star in the center of our solar system.
The movement of bodies in our solar system is controlled by the gravityof the sun.
The planets revolve in huge ellipses around the sun in nearly the same plane.
Movements of air and water on the earth are due to the pull of gravity and the rotation of the earth.
The sky is filled with many millions of stars each giving off its own light.
The universe is composed of great clusters of stars called galaxies.
The conditions of temperature and atmosphere on most planets will not support life.
The pull of gravity and the inertia of the object must be overcome to place an object in space.
The change of seasons is the result of varying amounts of heat receivedby the earth's surface.

Geology

Rocks may be formed by cooling and solidifying of magma or by the compacting of sediments.
Rocks and minerals may be changed from their original form by heat and pressure.
The succession of fossils shows a progressive development of life from simple to complex.
The earth is a huge sphere made up of the atmosphere, hydrosphere, and lithosphere.

Two groups of forces are constantly acting on the earth's surface, building it up and tearing it down.

Erosion takes place in proportion to the resistance of the rocks to decomposition and disintegration.

The earth's surface may be elevated or lowered by internal pressures and forces.

Forces within the earth may cause breaks and faults to appear in the earth's surface.

Earthquakes are produced by the sudden slipping of the earth's surface along faults.

Every stream is a part of a large drainage system that is wearing down the earth's surface.

Glacial conditions are found where there is an increase in latitude or an increase in altitude.

Plants and animals, along with weather and climate, help to form and change the soil.

All 122 physical science principles were found in the series (FOPS) that was analyzed. Not only were the principles present but they were easily found, since the major topics of the physical science book were very parallel to Dr. Blanc's principles list.

The more interesting thing to contemplate is: What are the principles in the 1977 series that are <u>not</u> on Dr. Blanc's list from 1967? No attempt was made here to formulate the principles statements nor to be inclusive of all the possible additions. What follows is a sample list of topics not covered by Dr. Blanc's list that have principles inherent in their coverage: science and technology are interrelated, the metric system is universal, density = mass/volume, substances have physical and chemical properties, atomic models, atoms combine chemically several ways to form molecules, polyatomic ions and valence, atomic mass and valence tables, families of elements, catalysts, allotropes, law of multiple proportions, chemical isomers, fractionation and distillation, polymer chemistry, ionic and covalent bonding, solution chemistry, chemical reactions and equations, endothermic and exothermic, molecular mass and formula mass, molar solutions, acids, bases, salts, relative motion, conservation of momentum, thermal pollution, cryogenics, Doppler effect, vacuum tubes, rectifiers, transistors, computers, transmutation, fission-fusion, cyclotrons, and plate tectonics.

What this analysis reveals is the "addition principle" of educational publishing. The continual addition of content occurs over time with no removal of any old content. The net result is the encyclopedic nature of most programs. The other interesting thing to note is that the books do not get longer with the additional content, but rather more is jammed onto a page and each topic is covered less thoroughly. Therefore, not only are the books encyclopedic, but they are also difficult to read, as they jump from one major principle to another with little attempt to connect them with a story line.

It is no wonder students view science as a mass of difficult information (like a foreign language) and not as an exciting, dynamic, intellectual process!

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APPENDIX A

Sample Vocabulary Analysis

FOLS--CHAPTER 1

Boldface and/or Italicized Words

science
product of science
process of science
defining problem
collecting information
forming a hypothesis
testing a hypothesis
communicating results
theory
glacial hypothesis
experiments
problem
procedure
observation
conclusion
control group
experimental group
variable
microorganisms
electron microscope
pH meter
pH scale
neutral
qualitative observation
quantitative observation
standard unit
English system
metric system
meter
liter
gram
kilogram
milli-
centi-
kilo-

New and/or Unfamiliar Words

scientific inquiry
atoms
molecules
germs
scientific method
electronic recordings
proposed solution
prediction
magnetic tape
coral islands
Darwin
limestone
calcium carbonate
sea level
extinct
scientific journal
volcanic rock
controlled
beef broth
beef bouillon
Pyrex
beaker
sterile
Leeuwenhoek
image
magnification
eyepiece
coarse adjustment
arm
stage
fine adjustment
base
tube
revolving nosepiece
high power objective
diaphragm
lenses
cover slip
slide
specimen
rotate
electron beam
electron rays
fluorescent screen
measurement
fixed quantity

litmus paper
acid
microscope
Vorticella
drug
medicine
electron microscope
pH meter
basic
saliva

length
mass
volume
standard mass
milligrams
milliliters
millimeters
centimeters
kilometers

FOLS--CHAPTER 5

Boldface and/or Italicized Words

specialized cell
striated muscle
voluntary muscle
cardiac muscle
involuntary muscle
smooth muscle
secretions
plasma
antibodies
cell theory
unicellular
multicellular
virus
cells
cytoplasm
cell membrane
endoplasmic reticulum
mitochondrion
nucleus
ribosome
vacuole

nuclear membrane
RNA
ribonucleic acid
protein
code
DNA
deoxyribonucleic acid
enzyme
diffusion
osmosis
concentration
active transport
osmotic pressure
turgor
plasmolysis
ATP
ADP
mitosis
chromosomes
centriole
spindle

New and/or Unfamiliar Words

tissue
cells
organisms
life systems
organs
dissolved chemicals
solutions
compounds
elements
red blood cells
white blood cells
hemoglobin
transport

oxygen
carbon dioxide
network
grainlike particles
rod-shaped bodies
enzymes
carbon atoms
carbon
hydrogen
nitrogen
sulfur
amino acids
species

cartilage
epithelial
striations
digestive tract
windpipe
dissolved food
minerals
optic nerve
cell theory
Hooke
atom
iodine
stain
Schleiden
Schwann
amoeba
paramecium
organic compounds
"alive"
large molecules
protein
fat
starch molecules

chemical reaction
chemical unit
composition
potassium permanganate
membranes
dialysis tubing
concentrated
glucose
high energy phosphate
$C_6H_{12}O_6$
O_2
CO_2
released energy
adenosine triphosphate
adenosine diphosphate
"power houses"
cell division
prophase
metaphase
anaphase
telophase
replicas

APPENDIX B

Coding Human Sciences Activities
by
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March 1, 1981

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A Continuing Program of the BSCS
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In order to utilize Human Sciences activities in research studies the activities need to be categorized on a variety of descripta. These descripta will be used as dependent variables with student characteristics such as sex, age, etc., used as independent variables. Activities with the same descripta will be pooled together mechanically for some studies and will be factor analyzed to see if they pool together in other studies. There will be basic data coded for every activity. These basic data consist of: module in which the activity was tested, activity identifier, year tested, and grade level of the test group. Data in the data bank will enable us to determine how many students chose the activity, as well as provide information about what these students were like.

The purpose of this paper is to describe new descripta that need to be generated for each field-tested activity. This version of the coding criteria was used to code all Human Sciences activities by two coders. The next task will be to find any ambiguities or limitations in the descripta and to calculate both interrater and intrarater reliabilities.

There are four major coding categories that are described on the following page. Each category has subdivisions that were used in the coding process. The codings were marked on optically scanned sheets for data processing. The categories and coding protocols will be described next, followed by the details of the optically scanned coding sheet layout.

Conventions

Coders will use the student activity as the object for coding. They will not read the teacher's guide to the activity. The literal content of the activity plus media, worksheets, evaluation problems, and other materials students use as they do the activity are to be the data sources for activity coding.

This convention is adopted because activity guides were not provided for some activities and because of differences in activity guides for different levels. Descripta coding must reflect the activity from the student's perspective. The key points made in the activity guides should be reflected in the student materials. If they are not, then they should not influence activity coding.

A. Major activity focus. There were three principle foci proposed for Human Science activities: cognitive, affective, and craftsmanship.

All coding of activities will be done in terms of the literal content of the totality of materials the student uses in the conduct of the activity. Activities may include only one major focus, all three foci, or various combinations of them. The major foci are:

I. Craftsmanship. A major part of the activity is craftsmanship, constructing, building. Craftsmanship is part of an activity where students put things together, build apparatus, or otherwise

assemble parts that could have been already assembled. The student cannot complete the activity satisfactorily without construction. Construction may be the product or it may be a means to the ends. Craftsmanship subsumes, but is more comprehensive than the psychomotor domain described in Bloom, et al (1956).

II. Affect. A major part of the activity is affect. It calls upon the student to develop empathy, to reflect on how objects or events affect others, to be sensitive to others' feelings, or to examine one's own feelings about some object or event. Or, a major part of the activity is an appeal to emotions or feelings rather than, or in addition to, acquisition of new knowledge or representations by means of presenting information. Aesthetic outcomes, appreciating form, design, beauty, etc., are further examples of an affective focus. Affect is synonymous with the affective domain described by Krathwohl and his colleagues (1964).

III. Cognition. A major focus of the activity is knowledge. Knowledge acquisition may involve reasoning or it may be remembering, either exactly as presented or with re-presentation, but without reasoning or performing cognitive operations. Cognition as described here is classified by Piagetian types of knowledge rather than the taxonomy developed by Bloom, et al (1956).

Each activity will be assigned a single code number to describe the major focus. The major focus may be coded for one or for any combination of the three categories described above. Specific codes and values for each code are provided at the end of this paper. The major focus will be coded in column 69.

B. Types of knowledge. Any activity may require some knowledge acquisition, even though its central focus may be craftsmanship or affect. The criterion used in deciding the single code for this category is to determine a single highest level predominant type of knowledge acquisition that a study must use if the activity were to be understood as the writers of the activity intended. If a single problem or small part of an activity requires a high level of knowledge acquisition, it should not be used in coding. The knowledge type must be predominant, not unique. If two knowledge types are equally predominant, the higher type (defined by the higher number in the coding values described below) will be coded. This code will be made in column 70 of the optical scan sheet. Each activity will be assigned a single "type of knowledge" code. The code will reflect the predominant logical requirements of the activity. The above convention will be violated when a higher knowledge type is required to get the "gist" of the activity even though a lower type is predominant. In this instance the higher type is recorded.

The first determination will be to dichotomize the general knowledge type, that is, to determine if the knowledge acquisition is essentially figurative or operative. If figurative, the task ends and the code of figurative knowledge is applied. If operative knowledge is required, we will want to code the kind of operative knowledge as precisely as possible.

I. Figurative knowledge is knowledge that has not resulted from reasoning. It depends on recognition of the configuration of the stimulus. Figurative knowledge emphasizes forms of representation: deferred imitation, symbolic play, drawing, mental imagery, language, and memory, especially rote memory.

Passive "reading" of data without having to act on it mentally, reason about it, or transform it is a good example of figurative knowledge acquisition. When students are asked "What did you see?" or when they are asked to describe or consider static states of objects at some point in time, figurative knowledge acquisition is the requirement.

When the emphasis is on symbolically representing information without requiring any logical transformation, figurative knowledge is being attained. In figurative knowledge, emphasis is on representation without consideration of the necessary logical relation between the knowledge represented and the representation itself; for example, words become an end in themselves and not a means to an end. Further examples are: asking for an accurate "reading" of the situation without asking for an understanding of what was "read," or, the activity is developed in such a way that the student can easily go through the activity without reasoning.

Figurative knowledge includes all preoperational knowledge. The preoperational child tends to take the immediate appearance of things as the sole and ultimate reality. A single, isolated cognition with little or no potential is the hallmark of the preoperational child (Flavell, p. 167). When we ask for an isolated cognition without comparison or referent to other cognitions we are asking for figurative knowledge.

II. Operative knowledge is knowledge that results from reasoning. In general, operations consider how things have changed from what they were to what they are now or how things might change. Operations ask for an inference, an induction or a deduction. It is a representational act which is an integral part of an organized network of related acts. Cognitive operations are a holistic domain, presupposing a structured system that includes other related operations, "for the moment latent and inactive but always potentially actualizable by themselves and, above all, always a force governing the form and character of the operation which is momentarily on stage." (Flavell, p. 167).

1. Concrete operations are inductions, inferences, and deductions from or about concrete witnessed events. The content of deductions is real objects. The focus is on the properties of objects, classification and relations, or facts and contradictions of facts. Concrete operations include inductive summative processes of accumulating instances (examples) and correspondences. They are "concrete" rule oriented, rules being fixed and immutable. Formal operational problems, such as the pendulum problem, can be reduced to concrete operational problems by providing concrete referents in all aspects of the problem and eliminating many alternatives for the student. The concrete thinking may, nevertheless, be very sophisticated, and, therefore, difficult.

Concrete operational requirements in an activity will be elaborated into subtypes for coding purposes. These types will be explained following the discussion of formal operations.

2. Formal operations are operations on the potential and hypothetical rather than on the real. Formal operations require the delineation of all possible (logical) eventualities at the outset and then an effort to discover which of these possibilities really do occur in the present data. The real becomes the special case of the possible, not the other way around (Flavell, 1963, p. 204). When proportional reasoning, logically manipulating contrary-to-fact propositions, hypothetical-deductive thinking, and systematic combinatorial thinking are required in an activity, the coding is for formal operations.

This category will not be further elaborated. It will not be used when one question in an activity reflects formal requirements. In distinguishing the concrete from formal dichotomy we are concerned with the most frequent operations required, rather than the highest mode required in the activity.

C. Coding categories within concrete operations. The Roman numeral designations provided in this section follow the conventions used in Flavell (1963) and Inhelder and Piaget (1958) for convenience in referring to those sources for further specifications of each type of thinking. The Roman numerals correspond to Flavell, but some categories are combined. The coder is to select the single most appropriate category, a subcategory within concrete operations, when the decision is that the activity requires concrete operational thought as its predominant knowledge acquisition mode.

I. Primary addition of classes (class inclusions, class hierarchy). "Class" refers to concrete, real, physical entities. The student is required to make subclasses, make a superordinate class, or make a set of superordinate classes. The student is required to take a superordinate class and make two or more subordinate classes.

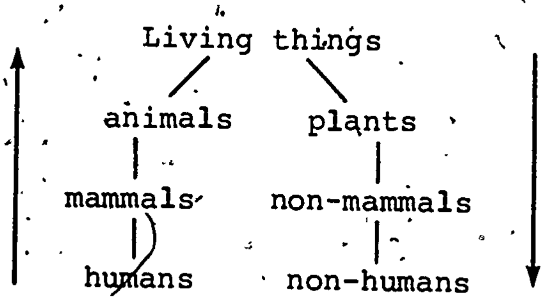


Figure 1.

II. Secondary addition of classes (reclassification). The student is required to reclassify classes. For example, a class group of teachers (one class group) and students (one class group) are to be

reclassified as male (one class group) and female (one class group). This knowledge type will not be coded. It will be included in the "not codeable" category.

III-IV. Multiplication of classes (or bi-univocal multiplication of classes). Class, as before, refers to concrete, real, physical entities. Students may be asked to relate one class to another (one-to-one), or many classes to one class (many-to-one), or vice versa (one-to-many.) Both cognitive tasks will be coded in this category.

A. Intersection of Classes

1. The logic required is to generate the intersection of two or more variables (classes), creating a new entity (class) at the intersection. The initial entities lose their identity as the new class is developed. For example, "A Swingin' Rule" from the HSP module RULES provides a 3X3 table for the number of swings that occur when each elements of one set (size or

Number of Swings in 30 Seconds

String Length	Small Weight	Medium Weight	Heavy Weight
6 in.			
12 in.			
18 in.			

Figure 2.

weight) intersects with each element of a second set (string length). Notice that the entries within the table (frequencies) are different from the entries that define the intersecting classes. Also notice that the entries within the table define a single entity whereas the entries within a correspondence table (Figure 3) essentially involve two, or

Hair Color	Eye Color: Brown	Blue	Hazel
Brown			
Black			
Blond			
Red			

Types of people

Figure 3.

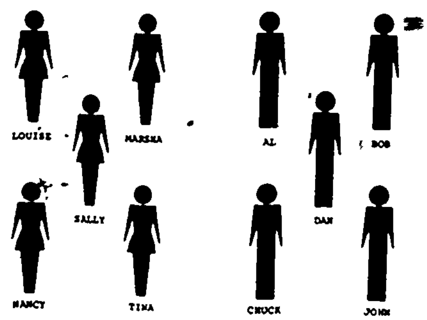
more, entities. In intersection the elements that define the classes that are intersected define a "new entity." For example, in completing the matrix the intersection of three

eye-color classes with four hair-color classes requires the student to generate new classes--types of people.

B. <u>Correspondence</u>

1. Item 7 from Form A of the 1976 version of <u>How Is Your Logic?</u> and also, Item 2 from Form B of the 1976 version of <u>How Is Your Logic?</u> Both of these questions ask the student to set in correspondence each element from one class with each element from another class. For example, in Item 7 of Form A (Figure 4) the student is asked to set in correspondence each

A 7.1976



A GROUP OF FRIENDS DECIDE TO GO DANCING. THERE ARE FIVE MEN AL (A), BOB (B), CHUCK (C), DAN (D), AND JOHN (J), AND FIVE WOMEN, LOUISE (L), MARSHA (M), NANCY (N), SALLY (S), AND TINA (T). EACH MAN WANTS TO DANCE WITH EACH WOMAN.

WRITE ALL OF THE POSSIBLE MAN-WOMAN COUPLES OF DANCERS THERE WOULD BE IF EACH MAN DANCED WITH EACH WOMAN. USE THE FIRST LETTER OF EACH PERSON'S NAME IN YOUR ANSWER.

ANSWER:

Figure 4.

of the elements from the class of men with each of the elements from the class of women. <u>Notice that when each element of one class is set in correspondence with each element of another class, a complete matrix is produced</u>. Also, notice that the elements that make up the body of the table still retain their original identities, that is, there are two elements that "make up" each cell of the body of the table.

2. "Where Do They Live?" from the HSP module on BEHAVIOR.

This activity requires the same logic as the items described above. However, the results are different because <u>one element of a class is set in correspondence with one element of a second class</u> (that is, the picture of the middle-class American family is to be set in correspondence with the white frame middle-class American family house; no other correspondence of the middle-class American family with any other house is correct).

Pictures of Houses

Pictures of People	A	B	C	D	E	F	G	H	K
1									
2									
3									
4									
5									
6									
7									
8									
9									

Figure 5.

Notice that the form of the result is similar to the table in "A Swingin' Rule," the logic is identical, but the entries in the table are different--there is one and only one correct entry for each class. Thus, the result of this type of correspondence is a single line of correspondence in contrast to a complete matrix as described for the items from How Is Your Logic? It is still coded as III B, correspondence of classes.

V. Seriation (ordering, sequencing, addition of asymmetrical relations). Item 1 on Form A (Figure 6) of the 1976 version of How Is Your Logic? requires the construction of an ascending (increasing) series. Item 4 on Form A of the 1976 version of How Is Your Logic? requires the construction of a descending (decreasing) series (Figure 7).

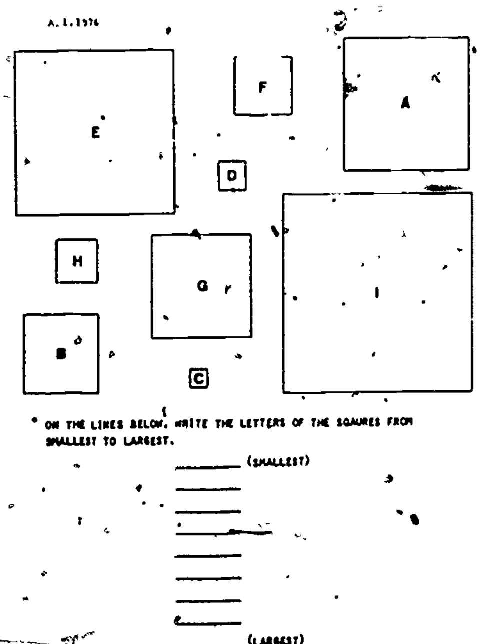


Figure 6.

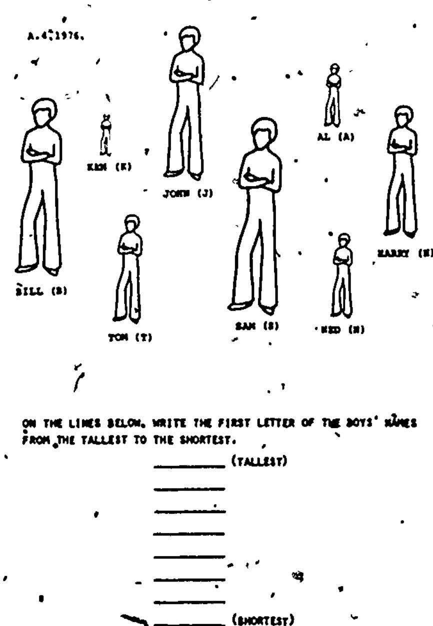


Figure 7.

VI. Addition of Symmetrical Relations. Sibling relations are the best example of this type of knowledge. This category will not be coded. Examples fall in the "not codeable" category.

VII-VIII. Multiplication of Relations. This topic includes the intersection of relations; correspondence of relations from one series with relations of another series; one-to-one or bi-univocal multiplication of relations, and many-to-one multiplication of relations.

A. Intersection of Relations

1. Intersection of relations is analogous to intersection of classes. The student is required to creating a new series jointly defined by the original series. In intersection the relations that define the two series that are intersected define a "new entity." For example, Item 8 of Form A of the 1976 version of How Is Your Logic? requires a student to take one series (increasing lines) and intersect that series with another series (decreasing size) to complete the matrix (Figure 8). Note also that the entries in the table are

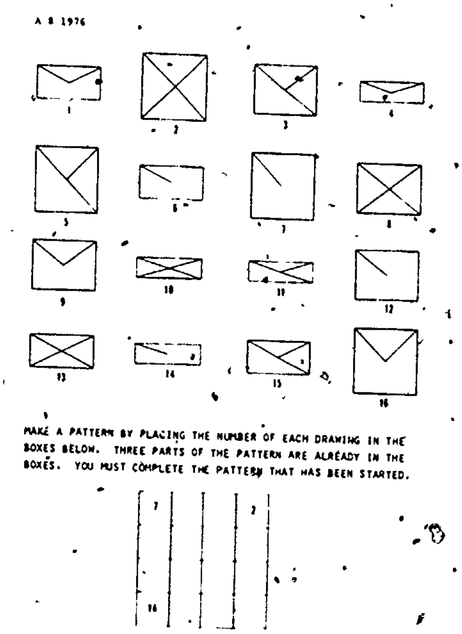


Figure 8.

defined by the joint position when both series are simultaneously taken into consideration. Also, in multiplication of relations the position (sequence) of the elements in each individual original series and the resultant matrix are of prime importance, whereas in multiplications of classes the position (sequence) of elements is irrelevant. In Item A8 there is one and only one correct positioning of each element, whereas in A7 (Figure 7) any ordering that accounts for all of the pairs is acceptable.

B. Correspondence of Relations

Items 6 and 7 of Form A and Items 3 and 7 of Form B of the 1974 version of How Is Your Logic? illustrate these operations. All of these questions require the student to set in correspondence one element from one series with one, and only one, element from another series. For example, in Item 6 of Form A of the 1974 version of How Is Your Logic? the student is asked to set in correspondence one of the elements from the series of boys of different height with one of the elements of the series of fishing poles of different height (Figure 9). (The second shortest boy should coincide with the second shortest pole and the third shortest boy--Guy--should coincide with the third shortest pole.) Note that the correspondence established is between two increasing series (that is, as the boys get taller, the poles they are using get taller).

A 6.1974

DON IS THE SHORTEST OF FOUR BOYS: JIM, THE NEXT SHORTEST, GUY, THE NEXT SHORTEST, AND RAY, THE NEXT SHORTEST. EACH BOY OWNS A FISHING POLE, WITH THE SHORTEST BOY OWNING THE SHORTEST POLE, THE NEXT SHORTEST BOY, THE NEXT SHORTEST POLE, AND SO ON.

WHICH BOY IS THE SECOND SHORTEST AND OWNS THE SECOND SHORTEST FISHING POLE?

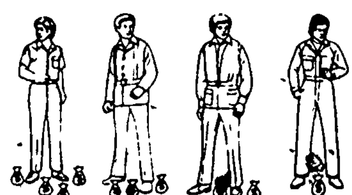
- JIM
- GUY
- RAY
- DON
- NONE OF THE ABOVE ANSWERS IS CORRECT.

MARK AN X ON YOUR CHOICE.

Figure 9.

A 7.1974

BOB IS THE RICHEST OF FOUR MEN, TIM, THE NEXT RICHEST, FRED, THE NEXT RICHEST, AND JACK, THE NEXT RICHEST. THE RICHEST MAN OWNS THE SMALLEST CAR, THE NEXT RICHEST MAN, THE NEXT SMALLEST CAR, AND SO ON.



WHICH MAN OWNS THE SMALLEST CAR AND IS THE RICHEST MAN?

- FRED
- BOB
- JACK
- TIM
- NONE OF THE ABOVE ANSWERS IS CORRECT.

MARK AN X ON YOUR CHOICE.

Figure 10.

Item 7 of Form A of the 1974 version of How Is Your Logic? uses the same logic (Figure 10). However, the correspondence is between an increasing series (richness of men) and a decreasing series (car size). Note also that the results of this type of correspondence is a single line of correspondences in contrast to a complete matrix.

Activities requiring concrete operational thought are to be coded for one of the six categories (I, III-IV A, III-IV B, V, VII-VIII A, VII-VIII B) of concrete operational thought described here. The code will be placed in column 70 on the optical scan sheet.

D. Content of the activity. Activities are to be categorized as to the following content categories. First, the major content focus is to be coded. Then, a second and third code must be given, if needed to describe the activity content. Three content codes will be assigned to each activity.

Code in the following manner. Select the major content descriptor, code in column 71. If there is no other content source in the activity, repeat the code in columns 72 and 73. If there is only one additional content descriptor for the activity, code the major content source in both columns 71 and 72, and the second content source in column 73. If there are three or more content sources, select the three that best describe the content of the activity. Then select the major content descriptor and code it in column 71. Do not try to code the remaining two content codes hierarchically; code the lowest numbered content source in column 72, and the highest in column 73. Note that every activity must have a content code number in columns 71, 72, and 73. (See Instructions for Coding Activity Descripta Onto Pink Optical Scan Sheets at the end of this memo.)

1. Life Sciences. The content or process(es) used is(are) derived from or directly related to one of the subdisciplines of the biological, medical, or health sciences.

2. Physical Sciences. The content or process(es) used is(are) derived from or directly related to one of the subdisciplines of physics, chemistry, engineering, or materials sciences.

3. Earth Sciences. The content or process(es) used is(are) derived from or directly related to one of the subdisciplines of geology, oceanography, astronomy, paleontology, astronomy, or meteorology.

4. Behavioral Sciences. The content or process(es) used is(are) derived from or directly related to one of the sciences that deals with human action and arriving at the establishment of generalizations of human behavior in society, i.e., psychology, sociology, anthropology, archeology.

5. Social Science. The content of process(es) used is(are) derived from or directly related to one of the sciences that deals with the institutions and functioning of human society and with the interpersonal relationship of individuals as members of society, i.e., economics, political science.

6. Humanities. The content or process(es) used is(are) derived from or is(are) directly related to history, languages, literature, and philosophy.

7. Fine Arts. The content or process(es) used is(are) derived from or is(are) directly related to subjects for which aesthetic purposes are primary or uppermost, such as painting, sculpture, drawing, architecture, music, ceramics, dance, drama, or landscape architecture.

8. Mathematics. The content or process(es) used is(are) mathematical.

9. Other. The content or process(es) used does(do) not fall into one of the above categories.

E. What students do in the activity. This category is used to code the central "doing" that students engaged in as they used the activity. An activity may have more than one "doing." Three, two-digit codes will be used to describe what students do. Each "doing" must be critical to the achievement of the activity goals. In some activities there are several of these "doings." For example, in "Strange Fossil" (KNOWING), constructing is the most necessary "doing." It is one thing the student must do to get the "gist" of the activity. Note that we are not coding for outcomes, but for what the student does. Creating would be a second descriptor, as the student is to create a restoration from which deductions are to be made. Without the creation, the intellectual purpose of the activity is lost. Note that the focus of the activity can be captured by these two descriptors. There is reading in the activity about fossils, but the reading is limited. We may not be able to code for all the characteristics of each activity, only one, two, or three, just the most important "doings."

Some categories are self-evident and, therefore, will have limited definitions; as these categories are used, more precise definitions may be developed for them. Deciding a primary or secondary "doing" would be difficult and probably arbitrary. The three codes for each activity will be descriptors without weight or precedence. In coding, the lower number will always be coded first, the next higher number, second, and the highest number, third. In this way activities with the same "doings" will have the same code. If an activity has only one "doing" it will be triple coded for that characteristic. If only two "doings" are assigned, the second "doing" will be repeated, but will not be evaluated as a weighting.

Appreciating. A noncognitive act of positive awareness or positive recognition of some object or event.

Calculating/Computing/Graphing. A single category in which one of more of these operations is central to the conduct of the activity.

Constructing. The student must build, put together, or in some other way construct something in order to carry out the intent of the activity.

Creating. The preparation of something novel, when the student is asked to produce a novel product and not give criteria for judging whether the product is the "right" product.

Deciding. Includes decision making, coming to a choice among alternatives for a course of action, and arriving at a concensus by group. A decision usually implies action or potential action.

Experimenting. The student must gather data systematically under specified conditions. Variables or controls need not be specified. It differs from *Information Gathering* (below) in being systematic and controlled.

Interviewing. Conducting one or more interviews is an essential part of the activity.

Listening/Watching. When the student uses a sound-slide program, sound filmstrip, or sound film.

Nurturing. When students are caring for plants and/or animals over a period of days or weeks, where nurturance is an essential component of successfully meeting the activity focus.

Reading. When a booklet or book integral to the activity must be read for the student to do the activity successfully. Activities with long internal narrative, such as "Time Travel Into the Paleozoic," would be coded once for reading.

Listening. When the activity depends on the student listening to a tape recording, record, stethoscope, or other sound device.

Valuing. Includes the decision that A is of more worth or importance than B. It is comparative and more than two alternatives may be compared. The outcome of the comparison must result in a higher value on one of the alternatives.

Watching/Viewing. Includes the use of silent film, film loops, flat pictures, overhead transparencies, slides, filmstrips with no sound, wall charts, and posters.

Information Gathering. Measuring, counting, taking photos, making prints of objects, diagramming, sketching, describing, and recording observations in natural settings are examples of data gathering. It differs from experimenting in that data gathering takes place in naturalistic environments with no attempt to randomize, to sample, or to control variables.

In summary, each activity will be coded for one, two, or three "doings." These codings will be two-digit numbers, coded in columns 78 and 79 on the optical scan sheet.

Instructions for Coding Activity Descripta onto Pink Optical Scan Sheets

Each activity you are to code has an optical scan sheet already coded for the basic data, and, perhaps, other data. The descripta will be coded in columns 69 through 76. The coding options for each category are shown below.

		Code	Column
A.	Major Activity Focus		69
	Craftsmanship	1	
	Affect	2	
	Cognition	3	
	Craftsmanship and affect	4	
	Craftsmanship and cognition	5	
	Affect and cognition	6	
	Craftsmanship, affect, and cognition	7	
	Not codeable into the above categories	8	
B.	Types of Knowledge		70
	Figurative	1	
	Operative (Concrete):		
	I. Addition of Classes	2	
	III-IV. Multiplication of Classes:		
	A. Intersection	3	
	B. Correspondence	4	
	V. Seriation	5	
	VII-VIII. Multiplication of Relations:		
	A. Intersection	6	
	B. Correspondence	7	
	Formal Operative	8	
	Not codeable into the above categories	9	
D.	Content of the Activity		71-73
	Biology	1	
	Physical Sciences	2	
	Earth Sciences	3	
	Behavioral Sciences	4	
	Social Sciences	5	
	Humanities	6	
	Fine Arts	7	
	Mathematics	8	
	Not codeable into the above categories	9	
E.	What Students Do in the Activity		74-75; 76-77; 78-79
	Appreciating	11	
	Calculating	12	
	Constructing	13	
	Creating	14	
	Deciding	15	
	Experimenting	16	
	Interviewing	17	
	Listening/Watching	18	
	Nurturing	19	
	Reading	20	
	Listening	21	
	Valuing	22	
	Watching/Viewing	23	
	Information gathering	24	
	Not codeable into th4e above categories	25	

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Bloom, B. S. (ed.) Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain. New York: David McKay Company, Inc., 1956.

Flavell, J. H. The Developmental Psychology of Jean Piaget. New Jersey: D. Van Nostrand, 1963.

Inhelder, B. and Piaget, J. The Growth of Logical Thinking: From Childhood to Adolescence. France: Presses Universitaires de France, 1958.

Krathwohl, D. R., Bloom, B. S., and Masia, B. B. Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook II: Affective Domain. New York: David McKay Company, Inc., 1964.

SECTION IV RESEARCH STUDIES OF SCIENCE INSTRUCTION IN MIDDLE AND JUNIOR HIGH SCHOOLS

CHAPTER 1

SCOPE AND PROCEDURES

The goal of this phase of the study of middle and junior high science schooling was twofold. First, a comprehensive bibliography of research to be developed. Second, a topic (or topics) was selected for analysis and synthesis and a report written summarizing the research.

The intitial bibliographic search covered papers published between January 1, 1960 to December 31, 1980. Research prior to 1960 did not reflect the impact of the national commitment to improve science education. In the 1960s, research studies had begun to reflect the availability of computers for statistical analysis, which changed the kinds of studies that could be done. The bibliographic search included primary research sources only and limited the school context to middle and junior high schools, the grade levels to grades six through nine, and the student ages to ten to fifteen years.

A middle school, for purposes of this study, was defined as a school administrative organization including two or more grade levels. Generally, this included grades six through eight, but in some circumstances, grade five. Junior high schools were defined as school organizations with grades seven, eight, and nine.

The assumption was made that school context might influence the outcomes of research. For example, studies of sixth graders in a middle school science program might not be generalizable to sixth-grade science programs in elementary schools. Studies of student attitudes toward science in junior high schools might produce a range of results that differed from student attitudes toward science in a middle school. These conjectures might not hold, but the initial plan was to identify school context as a potential variable and to conduct any analyses within each context before making analyses across contexts.

Literature Search

Building as comprehensive and exhaustive a bibliography as possible was the first task. Initially, a computer search of the ERIC system was made using the parameters of the study as concepts in the search. Searches were also made of Volumes 15, 16, and 17 of the Journal of Research in Science Teaching and of Volumes 63 and 64 of Science

Education. Papers that fell within the parameters were added to the bibliography. Papers cited in the selected papers that appeared to be relevant to the study also were added. When these citations were matched with the output of the computer searches, it became evident that the computer searches were not complete enough to be the only technique used in developing a comprehensive bibliography.

Dissertation Abstracts was searched, through Lockheed's DIALOG system, using the same general techniques as those used with the ERIC data base. The following bibliographies were searched for additional publications and papers:

Helgeson, S. L. Science Education, A Dissertation Bibliography. Ann Arbor, Mich.: University Microfilms International, n.d. (Lists doctoral dissertations from 1950 to May, 1977.)

Helgeson, S. L., Howe, R. W., and White, A. L. Science Education, Abstracts and Index from Research in Education, 1966 to 1972. Worthington, Ohio.: Education Associates, 1973.

Helgeson, S. L., Howe, R. W., and White, A. L. Science Education, A Bibliography of Abstracts from Resources in Education (RIE), from 1973-1975. Columbus, Ohio.: Sciences, Mathematics, and Environmental Education Information Reference Center, n.d.

Table 1. Distribution of doctoral dissertations concerned with science subjects taught in middle and junior high school, 1960 through 1980.

Year	f	cum f
1960	3	3
1961	5	8
1962	6	14
1963	2	16
1964	7	23
1965	17	40
1966	23	63
1967	22	85
1968	31	116
1969	13	129
1970	33	162
1971	27	189
1972	36	225
1973	22	247
1974	21	268
1975	18	286
1976	29	315
1977	26	341
1978	28	369
1979	13	382
1980	17	399

This literature search resulted in a tentative bibliography of 399 doctoral dissertations, 169 periodical articles, 9 technical reports, and 7 unpublished papers. Table 1 shows the distribution by year of doctoral dissertations cited in Dissertations Abstracts International. Relatively few doctoral studies were devoted to these subjects until 1965, with a peak number of studies completed in 1972. Half of the studies found were cited between 1972 and 1980. The period 1972 to 1980 showed variation, with a range of 19. The last two years reflected a decline, probably representing the decline in doctoral students in science education.

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Table 2. Distribution of periodical papers concerned with science subjects taught in middle and junior high schools, 1960 through 1980.

Year	f	cum f
1960	0	0
1961	1	1
1962	2	3
1963	5	8
1964	3	11
1965	4	15
1966	4	19
1967	2	21
1968	4	25
1969	3	28
1970	8	36
1971	9	45
1972	5	50
1973	10	60
1974	7	67
1975	14	81
1976	10	91
1977	16	107
1978	20	127
1979	21	148
1980	21	169

The periodical literature showed a different pattern. Table 2 shows the number of studies published each year from 1960 through 1980. Half of the papers were published in 1975 or later. These data show a steady yearly increase since 1960. This increase in the number of research studies concerned with science teaching and learning of early adolescents is most discouraging. However, if this pattern is directly related to support of research on early adolescents by the National Science Foundation, it may be a short-lived phenomenon.

These various searches produced the bibliography at the end of this section. Most of the actual papers have not been used to ascertain if their substance actually meets the criteria for inclusion in the bibliography.

Topics Selected for Investigation

A review of the citations and of the reviews of science education research published in Science Education led the investigator to select two topics for further investigation: text analysis and inquiry. Text analysis was chosen because of the continuing prevalence of the text as the dominant curriculum material for science teaching in middle and junior high schools. Also, the text analysis was not a prominent topic in published reviews of research in science education. Inquiry was selected as a possible topic because of its apparent limited use in the schools, as reported in Section II of this study, as well as its advocacy by many science educators and its apparent effectiveness in the classroom (1).

New searches using DIALOG were conducted on the ERIC, Doctoral Dissertation, and PSYCINFO data bases. These searches used additional concept terms such as texts, comprehension, text II analysis, inquiry, discovery, and related terms. Both of these searches produced new citations. Papers, microfiche, and microfilm materials were obtained for text analysis and inquiry. Time was available for completion of the study of research in text analysis that makes up the first chapter of this section.

The ERIC and Dissertation Abstracts indices were searched using a set of science descriptors, middle or junior high school, and specified grades five through nine. These sets of descriptors were then combined with a set of text research, content, and evaluation descriptors to produce the final set of search concepts. The yield from this search was 21 doctoral dissertations. Ten of these dissertations had not been found in the initial searches for research studies using identical descriptors except for those regarding text research. Through additional searches of the bibliographies of papers and dissertations and of reviews of relevant research known to the investigator, a set of 50 papers was assembled for the review of text analysis research that involved middle and junior high school texts and/or students.

CHAPTER 2

SCIENCE TEXT MATERIALS FOR EARLY ADOLESCENTS: A REVIEW OF RESEARCH

The textbook continues to be the major curriculum source for instruction of middle and junior high school students in science. This review summarizes current knowledge about text materials from the research literature published within the last two decades. Rather than reviewing all of the research that could be found, the investigator chose to build on the broad base of published reviews of the literature on this subject and to incorporate research reports dealing specifically with students in grades six to nine. Due to lack of specificity of school contexts, students may have been in elementary schools in grade six and in senior high schools in grade nine in some of the research reported. Wherever possible, school context was indicated to avoid confounding interpretations by assuming that school contexts were of no consequence.

In their "A Summary of Research in Science Education--1978," Gabel, Kagan, and Sherwood (2) concluded that studies on reading and language skills can be summarized as follows:

1. Contrary to previous research, no positive relationship was found between science instruction using the science process skills and reading achievement of young children.
2. Reading and science achievement are positively related.
3. Readability formulas can be used to assess the reading level of science texts with good accuracy.
4. Pictorial diagrams may not enhance textual materials sufficiently to cause an increase in achievement.
5. Textual materials with a high kinetic structure are more effective than those with less structure.

In another summary of text research, McDonald-Ross (3) indicated that the past decade of studies had reinforced, but not transformed, the standard procedures of curricular design. This may be the result of the lack of fruitfulness of many research questions. McDonald-Ross observed that there is a "notable lack of how-to and when-to/when-not-to information" that can be supported by research that would assist writers of texts and other instructional materials.

In his review of science education research for 1979, Butts (4) found only 22 studies that were concerned with the "Learning context for

emerging adolescents" that considered content or method of instruction. Within this category, he found limited evidence that content and instructional strategies have different influences on students of different characteristics. His general summary was that instruction in specific content increases achievement and that some instructional strategies were related to achievement, attitudes, and outcomes. In this review, content and strategies of instruction "can be defined as the science curriculum" (p. 378). Advance organizers, graphs, and simulations were categorized as instructional strategies in some studies, and the total science curriculum was similarly categorized in others.

Butts pointed out that the confusion in research about classroom learning may be caused by the independent variables being too global and too unspecified to precisely identify treatments or effects. Someday, direct observation of what students do in classrooms may be more important than terminal outcomes.

This current review takes a more restricted approach by considering only text materials, either as objects of research or as variables in research studies. This chapter reports research on five topics within the study of text materials: content analysis, comprehension, pictorial adjuncts or alternatives, supplementary materials, and readability. It will be terminated with a discussion of the outcomes of the research reported and in the potential use of such research for the improvement of science instruction in middle and junior high schools.

Research Studies of Content in Science Texts

Five studies presented data and interpretations about the content of junior high school science texts. The studies were all empirical, utilizing checklists, categories and tallies, rating scales, or similar devices designed by the investigators. Four of the five studies are briefly described in Table 3.

The study by Janke (5) indicated similarities in which earth sciences concepts were included or excluded. This paper examined the concepts presented, but not how, or in what detail, they were presented. A slightly more detailed analysis (6) indicated greater variation among texts when the unit of analysis was "principles." The paper available to this investigator did not include enough information to determine if "concept" and "principle" were different constructs.

LaDuca (7) and Yost (8) conducted more detailed, but limited, analyses of science texts (grades 4 to 9). In both instances, the more detailed analyses produced greater differences among the texts analyzed (Table 3). LaDuca found that inquiry-oriented texts did not use the same model of inquiry. Yost's findings (Table 3) indicate the arbitrariness of the grade-level placement of content ideas in astronomy.in the texts he analyzed, whether this same arbitrariness of grade placement is found in other content areas needs to be investigated.

Table 3. Investigations of the Content of Science Texts

	Methodology	Findings		Methodology	Findings
Date: 1969 Investigator: Henson, K. T. Purpose of Study: To identify earth science principles in 5 content areas, and to determine if Alabama texts include these principles.	1. Listed principles in astronomy, geology, physical geography, meteorology, oceanography. 2. Expert judges validated principles. 3. Junior high teachers rated importance of each principle in junior high science. 4. Current eighth-grade earth science texts used in Alabama schools were analyzed for inclusion of principles.	1. 199 earth science principles were listed. 2. Expert judges rated 121 principles a essential for understanding earth sciences. 3. Junior high teachers rated 108 principles as essential for junior high science 4. Texts varied widely. a. There were seven times as many meteorological principles as physical geography principles in the combined texts analyzed. b. On the extremes, one text had over seven times as many principles as another.	Date: 1971 Investigator: LaDuca, A. Purpose of Study: To identify teaching models in teachers' editions of selected (5) junior high inquiry science texts.	1. Studied ten categories of teacher behaviors: closed-ended questions, open-ended questions, tell, relate, know (content), know (procedure), demonstrate plan, manage, other. 2. Sentences in teachers' editions were units of analysis. Over 30,000 were coded. 3. Frequency distributions were prepared for all texts. 4. Differences in frequency distributions were determined by pairing texts on one of four dimensions: were physical science programs, were for 9th grade, were for 7th grade, were produced by the same project. 5. Statistical tests for differences were made by the chi-square test and Spearman rank correlation coefficient.	1. All pairs were different ($p \leq .001$). 2. By the Spearman rank correlation coefficient two pairs produced by the same curriculum project were found to be similar in teacher behavior distribution. 3. Three groups were identified, each interpreted as defining a different "inquiry" teaching model. a. Lecture/Dimension Model b. Inquiry/Dimension Model c. Process Management Model 4. Model "a" was judged to be seriously limited in accomplishing inquiry objectives.
Date: 1969 Investigator: Janke, D. L. Purpose of Study: To identify a sample of earth science concepts rated as important by experts for inclusion in K-12 science programs, and to identify if these concepts were included in current science texts, K-12.	1. Used three panels of scholars to prepare and revise list of concepts. 2. Selected random sample of five elementary science series, five physical science series, and five earth science series for analysis.	1. Scholars agreed on 52 earth science concepts. 2. A majority of the 52 concepts are included in: a. a general science series. b. an earth science text. c. an elementary series plus either "a" or "b." d. "a" + "b" + "c."	Date: 1973 Investigator: Yost, M. Purpose of Study: To determine if the number of student responses to questions required by one text were the same as those of others. (Texts were 4th, 5th, and 6th grade.)	1. The number of student responses per chapter ranged from 28 to 90. 2. Five elementary text series, grades 4-6, were randomly selected from 15 series that were available. 3. Only the sections on astronomy were used in the analysis (9 chapters). 4. Expected student responses were listed for each text and compared.	1. 18.6% of the responses required in one text were the same as those required in other texts at the same grade level. 2. 33% of the responses required in a text at one grade level were required by some other text at some other grade level. 3. The text series tended to have twice as much in common across grade levels as compared to within grade levels.

Other Studies

In a study that was broader in its analysis than those discussed above, Zorn (9,10) critiqued seven science curriculum programs designed for junior high schools. These programs were the Earth Science Curriculum Project (ESCP), Elementary School Science Curriculum Project (ESSP), Elementary Science Study (ESS), Inquiry Development Program-- Earth Science (IDP), Intermediate Science Curriculum Study (ISCS), Introductory Physical Science (IPS), and Secondary School Science Project (SSSP). Two instruments were developed for describing and evaluating the programs. A "Statement of Criteria" for junior high school science, developed from a review of the literature, provided a weighted checklist of attributes to be considered in examining these programs. A "Checklist Instrument" was developed to indicate the degree to which each program attribute compared in weighting with the Statement of Criteria. The items for each instrument were organized to assess six areas: methods of stating objectives, methods, materials, content, skills, and relations to other school levels. Four weights or values were marked for each item on each scale: emphasized, definitely included, generally included, not included. The papers cited did not provide information on the content of the two instruments. Zorn's evaluation was that the programs as a group provided a major improvement over traditional junior high science programs. In brief, the improvements were:

1. Removing the responsibility for teachers to develop their own curricula
2. Providing students with active involvement with science materials and equipment
3. Providing up-to-date resource materials, much of it in the form of visuals--film loops, slide, and effective illustrations
4. Including both processes and concepts of science and emphasizing conceptual development rather than partial summarization
5. Emphasizing science as a part of general education rather than as preparation for senior high school work

Zorn criticized the seven programs for their limited specifications of objectives, provision for pursuing special science interests, and attention to basic skill development. He observed that the programs were designed for science discipline in contrast to general science use, the latter being recommended in the literature for seventh and eighth grades. The programs also expected students to be able to use basic skills and provided little assistance to students whose skills did not meet expectations.

Especially noteworthy was the value of these new programs as modules that provided a wider range of student experiences for learning--such as pictorial guides to activities, concrete experiences, small group work--than did traditional programs.

Moore (11) used a questionnaire to identify course content topics recommended by junior high science teachers in Texas, Texas science supervisors, and national science educational specialists. He then compared the emphases recommended across the three groups reporting.

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The three groups were roughly equal on the level of emphasis to be placed on most life, earth, and physical science topics. For topics rated "important" or "essential," teachers and supervisors chose about the same number, but national science educators chose fewer. Similarly, national science educators designated more topics as "unnecessary" or "relatively unimportant" than did the other two groups, who were roughly equivalent. Similar, but not identical, patterns were found in examination of the questionnaire by life, physical, and earth sciences categories. Moore summarized his findings by stating that the junior high science teachers studied tended to be more concerned with content coverage than national science education specialists and Texas science supervisors. This finding is consistent with data reported by Ross (12) regarding the high content (science terms) densities of the most highly used science texts in middle and junior high schools.

Significance of Research Findings

Text differences at the detailed level where it is most likely to impact on student achievement suggests that more and more detailed text analyses are fully warranted. This is especially needed where standardized tests are used to measure student achievement. Content variability indicates that any particular standardized test would most likely match only a single text. Further investigations into content not explored in these limited studies and comparisons of content with standardized tests would be important contributions to instruction assessment interrelationships.

Zorn's (9,10) analysis of nontraditional texts and curriculum programs supports the claims of the developers of nontraditional materials that their products are different from the available texts developed in the author(s)/publishing house tradition. Differences in the methodology and purpose of this study with the analyses of texts developed by publishing houses preclude more substantive comparisons of these two kinds of science curriculum materials.

The methodology of the studies utilized here were essentially empirical Yost (8) used an operant approach grounded in behaviorist theory, an important departure from the norm. New approaches to text analysis (for example, 13) need to be applied to texts used in middle schools and junior high schools. Such approaches are theory-based and provide more powerful systems of analyses than those used here. More detailed, theory-based analyses of texts, if made availble to textbook adoption committees, could make an important contribution to the quality of the text adoption process and perhaps, in the long term, contribute to improvement in the quality of texts used for science teaching in middle and junior high schools.

Limitations of the Studies

The six studies reported examined the content of science texts for middle and junior high schools for purposes of comparison, one with another, or for purposes of inferring what science content ought to be included in curricula for early adolescents. One critical limitation of these studies was that investigators did not apply knowledge from communications theory, from the content analysis literature, or from linguistic theory to improve their methodology.

A second critical limitation was in analyzing texts for inappropriate purposes. A glaring example was the use of experts in subject matter or a concensus from several texts to determine the ideas that would be appropriate for early adolescents. This lack of regard for the developmental characteristics of early adolescents as a criterion for considering content selection, despite available knowledge, should not be repeated in the future.

A third limitation of the studies cited was lack of rigor in conceptualizing and clarifying distinctions, such as concept or principle, that were fundamental to the issues being investigated.

Significant New Approaches

Recently, new approaches to text analysis have appeared in the science education literature. Studies relevant to early adolescents and science texts designed for their use have been initiated by Audrey Champagne and Leo Klopfer and their associates, and by Joseph Novak.

Champagne, Klopfer, De Sena, and Squires (14) and Champagne, Klopfer, Zasloff, De Sena, and Squires (15) developed a concept-structuring analysis technique (ConSAT) as a tool for displaying the content structure of text materials that could be used as a standard against which student knowledge representations could be judged.* This approach to text analysis and to the knowledge structures of students rests on the assumptions that the structure of a subject matter is represented in the writings of scientists in journals and advanced texts and "that knowledge structure may be conceived, at least in part, as a network of concepts and relations between concepts in memory" (p. 2).

A descriptive physical geology unit on Minerals and Rocks, within the Lyell Unit of the Individualized Science (IS) program, was the subject of study. The major thrust of the study was to develop and test the ConSAT to obtain a measure of changes in student knowledge structure

*The ConSAT can be used as a diagnostic technique, an assessment task to display students' knowledge structures, and as a tool for teaching science subject matter. These uses are not germane to the subject of this review.

representations that could be attributed to instruction. In this review, only the use of the ConSAT as a text analysis system is considered. The qualitative system of analysis represents concepts and relations among concepts schematically. Figure 1 shows the hierarchical and transformational relations among 13 words selected from the "rock" task of the Lyell Unit, Individualized Sciences program.

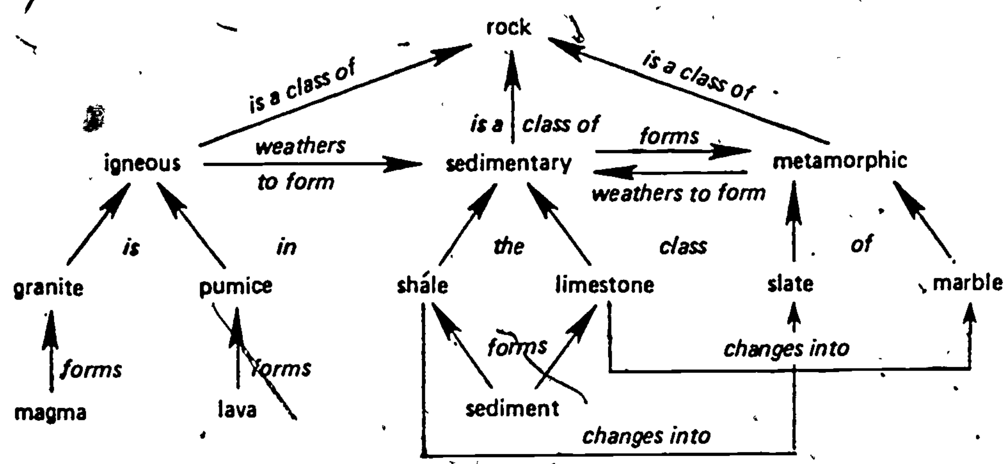

Figure 1. Integrated structure showing hierarchical and transformational relations of the 13 words in the Rock task (15)

The investigators found this qualitative analysis useful as a tool for comparing the content structure of text materials with student knowledge structures. To determine student knowledge structures, students were asked to take the same words, discard those not recognized, and arrange the remainder on a large sheet of paper to show how they think about the words and how the words relate to each other. From the

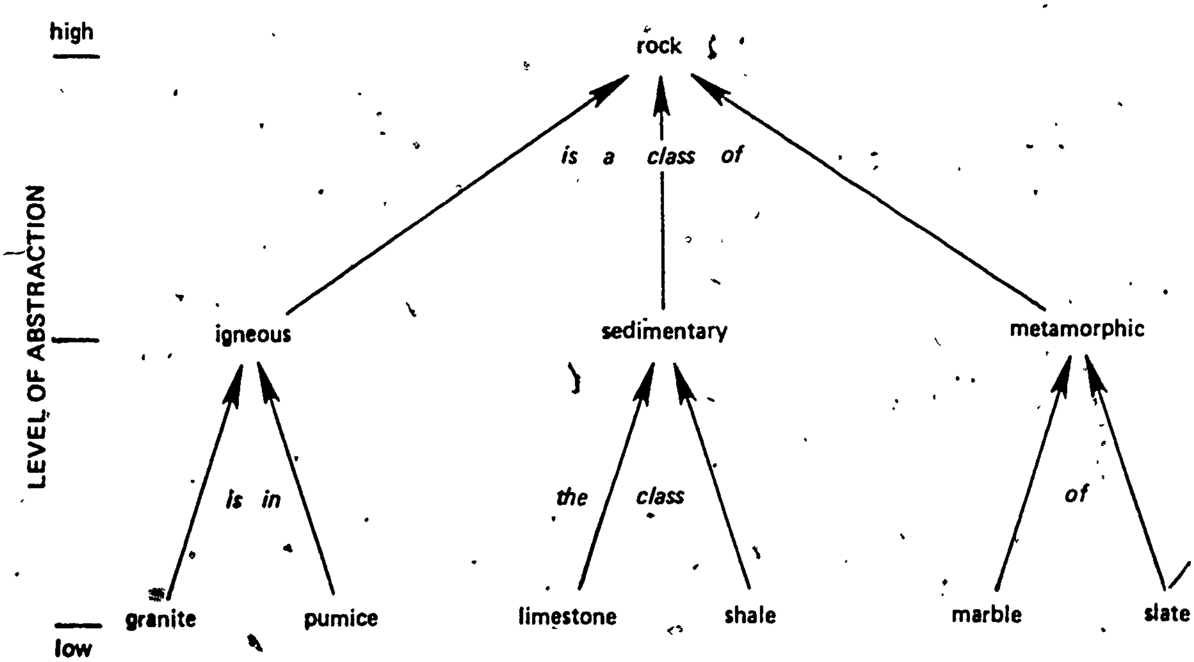

Figure 2. The hierarchical classification structure of the section on rocks, Lyell Unit, Individualized Science program (15)

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analysis of text materials and from card-sort task data collected from students the investigators derived classes of structure for the Rock task.

Figure 1 shows two types of structures, hierarchical class-inclusion and transformational, integrated into a single display. The classification of rocks by class-inclusion and the resulting hierarchical structure is shown separately in Figure 2.

The transformational structure is shown independently in Figure 3. The investigators advocated the use of the ConSAT technique as a diagnostic and assessment tool, as well as a pedagogical device to help students develop their analytic skills in reading expository science text materials. They do not present research on this aspect of ConSAT.

Difficulties were found in providing an integrated structural diagram for the Mineral task from the same text materials (14:53-58). This finding raises questions about the utility of the technique in developing diagrams that would display complex subject matter exposition or that would yield high reliabilities between individuals' structural charts. However, the technique shows enough promise for text analysis (a use not central to the investigators) that it is discussed here to encourage science educators and teachers to consider its use for such purpose.

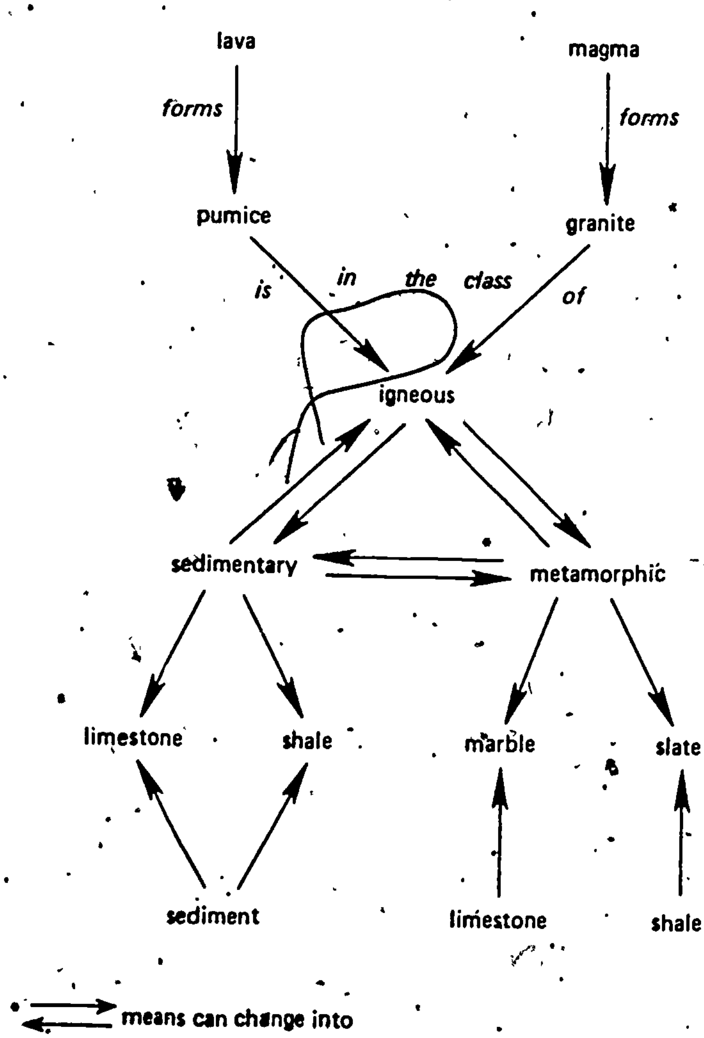

Figure 3. The transformational structure of the section on rocks, Lyell Unit

The investigators' initial procedures, designed to provide a quantitative analytic system developed from the theory of directed graphs simplified to show only the connections between words, were not as powerful as they had hoped. A standard, structured diagraph for the Rock section of the instructional materials was constructed using the methods of Harary, Norman, and Cartwright (16) (Figure 4). A sum matrix was calculated for this standard structure. Student knowledge structures, quantified into sum matrices were secured from sorting, arranging, and

justifying the relations among 13 words in the Rock subject matter. These matrices were compared with the standard matrix by calculating the absolute difference between the two sum matrices.

The investigators expressed dissatisfaction with the information loss from Figure 1 to Figure 4. The quantitative method of analysis resulted in a poor correspondence between the qualitative and quantitative analyses. The investigators are, however, continuing to study ways to improve the quantitative analysis. Comparisons of sum matrices from different text treatments of similar subject matter and studying student comprehension as a dependent variable for substantially different text structures would seem to be fruitful fields for study.

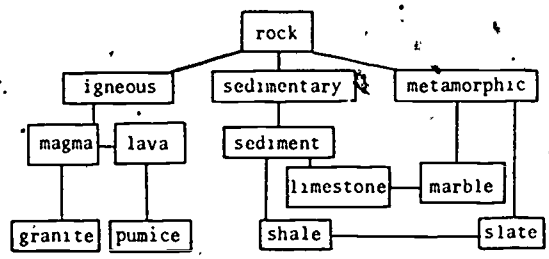

Figure 4. Diagraph of the relations among words in the Rock section of the Lyell Unit of Individualized Science (IS)

Novak, et al. (17) used concept mapping and Gowan's "V" in their Learning to Learn project. Concept mapping is a process by which the science concepts of a topic on text or laboratory exercises are arranged hierarchically and then connected by lines labeled to show relationships. This technique, grounded in Ausubelian learning theory, would seem to have promise as a basis for a text analysis system. As Novak, et al. point out, they "found gapping 'holes' in the laboratory exercises, or when the text presumed that the learner knew more than he/she actually did" (p. 187). "V" mapping shows the active interplay between the conceptual structure of the topic as presented and the methodology employed by that discipline in the inquiry into the topic.

Together, these analytic systems might be used to display similarities and differences among texts or laboratory activities. Experimentation with different text or laboratory treatments might then be studied more effectively in relation to student comprehension, achievement, or other variables.

Science Text Comprehension

The persistent claims of science teachers in middle and junior high schools that their students cannot read science texts has failed to stimulate the development of a community of science education scholars devoted to the study of the comprehension of science texts. Six reports

of research concerned with comprehension of science text were found that used 11- to 14-year-olds as subjects.

Research Studies

In the earliest study, Blue (18) prepared eight science selections of approximately 900 words that were different from each other in three textual factors: readability score, style of writing, and use of author's definitions. His purpose was to determine if science reading comprehension was influenced by these factors and to explore the relationship of students' general reading comprehension and science background to their comprehension of science materials. For the study, 240 seventh-graders were selected randomly from a suburban community. A single 25-item, multiple-choice test was used to measure student comprehension of all eight passages.

Blue found that the three textual factors did not result in significant differences in science reading comprehension. Science comprehension was related to high and low intelligence scores as measured by the CTMM, Short Form, 1963. The exploratory data results suggested a slightly more positive relationship between measures of general reading comprehension and science reading comprehension than between measures of science information and science reading comprehension. The exact content of the two measures of reading comprehension (general and science) and of science information would be needed to determine whether further research using these measures is warranted. The constructionist model of reading comprehension could be challenged if knowledge brought to the reading task (science information) that related to the task was not a significant variable in comprehension.

The effects of three types of advance organizers in learning a biological concept by seventh graders was investigated by Lucas (1972). The treatment used an audio, a visual, and a written advance organizer, and a control. An investigator-designed achievement test was administered at the end of the four-week treatment. No differences were found across treatments, nor were there any interaction effects for treatment, I. Q., abstract reasoning scores, or sex.

Shmurak (19) used 161 middle school eighth-graders in a study to determine if advance organizers designed to match student cognitive styles would produce greater learning and retention of expository science material than unmatched organizers. Each student was classified as having a categorical-inferential, descriptive-part-whole, or relational cognitive style. Each subject received one of four introductory passages, about 300 words, that matched his or her cognitive style, matched one of the other cognitive styles, or was a non-organizer. Random assignment, stratified by sex, reading ability, and cognitive style, was made to treatment groups. Students were given one introductory passage and an 1,100-word expository passage about the action of insulin. A 20-item, multiple-choice test was administered immediately after the reading and again one week later.

The data did not support the hypothesis that a match of organizer style with cognitive style would produce greater learning and retention. Cognitive style was shown to have a relationship to learning and retention for boys only, with a disadvantage for boys with a relational cognitive style.

Rivers (20) investigated the relationship between the use of ISCS materials as a reading course and gains in reading comprehension and vocabulary. Two content groups, one traditional science and one ISCS, and one treatment group, ISCS-Reading Course, were established. Intact seventh-grade classes in three schools were administered a standardized reading test as a pretest in the fall and an alternate form as a post-test in mid-year. Teachers of the ISCS-Reading Course were given a short workshop on special reading instruction. Analysis of covariance indicated that both ISCS groups made significantly ($p \leq .05$) higher mean gains in both comprehension and vocabulary than did the students in traditional science. Descriptive analysis indicated that most of the differences in gains between groups were made by students reading below grade level. Adapting ISCS for reading instruction did not seem to warrant the effort.

Holiday, Loose, and Whittaker (21) predicted that students who were low in verbal ability and who were given a science text would out-perform students with low verbal ability who were given the same text with adjunct verbatim study questions and that students with high verbal ability would not be differentially affected by either treatment. In this carefully done ATI study the investigators found that verbatim study questions adjunct to a science text were disfunctional, especially for students with low scores on a verbal ability test. High verbal ability students either circumvented or were unaffected by such questions.

Karahalios, Tonjes, and Towner (22) proposed that prereading instruction in the form of advance organizers would enhance achievement. In a small rural school, 76 seventh-graders were randomly assigned to one of these treatment groups.

Group 1.	Read the chapter and answered questions at the end.
Group 2.	Skimmed the chapter, attending to major heading vocabulary terms in boldface or italic type prior to reading the chapter and answering the questions.
Group 3.	Studied a written handout that explained the major concepts using a simplified vocabulary plus a repeat of instructions for Group 2.

A one-week unit on the measurement of mass and length was the topic of study. All groups were given an identical multiple-choice test covering the materials in the text at the end of the week. A significant difference was found among groups (F 2,227 = 4.93, p .01) and on individual comparisons (Scheffe Test) between groups 1 and 3 (p .05). Within the limitations of the small sample size and lack of control of prior knowledge, the investigators concluded that advance organizers increased mean performance in achievement.

Schulz (23) also studied the effects of advance organizers on learning concepts of energy transformation, photosynthesis, and respiration with sixth graders. Evidence about the role of advance organizers in facilitating learning was inconclusive.

Significance of Research Findings

The study by Holliday, Loose, and Whittaker (21) was the only theory-grounded study in this group and hopefully points science education research in the direction of joining with and building on the important contributions being developed in cognitive science. Their finding of the differential effects of verbatim study questions on students with low and high verbal abilities is especially important. If this finding is replicable across subject matter fields with early adolescents, the commonsense practice of using verbatim adjunct study questions with text would be highly suspect. Theory-grounded research on comprehension of expository science texts by early adolescents would seem to have greater promise than the use of a fragment of Ausubel's theory of meaningful verbal learning that separates advance organizers from subsumption theory and concept formation.

Reviews of text comprehension research, such as that of McConkie (24) and McDonald (3), cite a large body of literature that provides a theoretical basis for science education research in text comprehension. No citations from the leading science education research journals appear in these reviews. It is hoped that this state of affairs will change in the near future.

Pictorial Research Related to Science Instruction

Holliday (25) prepared a critical analysis of 73 papers and books concerned with the effectiveness of pictorials and graphics as communication media for science education. He presented four general recommendations directed toward developers of instructional materials in science that could be supported by empirical evidence. Although it could be stated in 1973 that pictures, in conjunction with related materials, could facilitate recall of a combination of verbal and visual information, more empirical evidence is needed to fully support the claim. There was enough research evidence to indicate that the "preference for certain types of pictures by students and teachers might not be a reliable predictor of optimal picture types as defined by student achievement" (p. 210).

The research cited by Holliday pointed out complexities of what seems to be, intuitively, a simple problem. The interrelationships of picture types, picture sizes, subject-matter presentation formats, and learner characteristics would seem to require carefully planned, inter-

related studies with standardization of pictorial replications and materials. Holliday suggested that aptitude treatment interaction studies would seem to hold promise for contributing to more reliable instruction decision making.

Research Studies

Holliday and Harvey (26) examined the effect of a science text description in comparison to the same description plus adjunct labeled drawings. The question was studied using density, pressure, and Archimedes' Principle as science content and adjunct two- and three-dimensional drawings of labeled geometric configurations without descriptive captions. The posttest required learners to solve a type of quantitative problem or to identify descriptions of behavior associated with fluids under given conditions.

Sixty-one ninth-graders in a junior high school physical science class participated in the study. The major hypothesis proposed was that the addition of adjunct labeled drawings to a science text would facilitate verbal quantitative learning. Two days were used in the study with a test each day. Students were assigned randomly to an experimental group (drawing plus text) or a central group (text only).

Differences in test scores between treatment groups significantly favored the drawing-plus-text group. The investigators suggested, however, that aptitude-treatment interactions should be studied to determine if differential effects would be found.

Holliday, Brunner, and Donais (27) investigated differential cognitive and affective responses made by high school biology students toward a picture-word diagram and a block-word diagram. Although the students were out of range by the criterion set for this paper, the findings of different effects for different learners is important for this research summary. The study produced higher achievement with picture-word diagrams, especially for learners with lower verbal performance. Learners with higher verbal performance had less difficulty learning from verbally dependent materials.

Koran and Koran (28) found results consistent with that of Holliday, Brunner, and Donais with 84 seventh- and eighth-grade students. They found significant treatment-by-grade-level interactions with groups assigned to three treatments using a schematic diagram of the hydrologic cycle. Seventh graders on the study performed significantly better in the two experimental groups containing text plus diagram (one diagram before, one diagram after, text) than did eighth graders. Inductive reasoning scores were positively related to performance in the central treatment but were unrelated to performance in both diagram-plus-text groups. Low ability subjects benefitted most by inclusion of the diagram, regardless of position, while high ability subjects performed best without the diagram.

McDonald-Ross (29) devotes two pages (with six citations relevant to science texts) to a review of scientific and technical diagrams in his 31-page chapter reviewing research on graphics in texts. He observes that experimental studies in scientific diagrams are few and far between. A most important comment made by McDonald-Ross was that experimental work in this field that will stand up to rigorous cross-examination is not easy to do.

Kauchak, Eggen, and Kirk (30) investigated the relationships of "cue specificity," grade level, and ability level to the acquisition of science content. A "specific cue" group was given a specific question, such as, "In what temperature did the plants grow most...?" A "general cue" group was asked to write a description of the results. The control group cue was that the results were below (in the graphed data). Results of four experiments with plants were presented in bar graphs but not in the written test. A total of 143 fourth-, fifth-, and sixth-graders were given the same reading passages.

Textual cues were found to increase significantly the amount of information gained from graphed materials. To be effective, the cues must be specific, telling students the exact information to be learned. There were significant differences due to age and ability, with more able students and higher-grade-level students performing better. No interaction effects were found.

Holliday (31) noted that since science education deals with a relatively large number of pictorial phenomena that should, theoretically, increase the learner's use of imagery; a linguistic-imaginal-process analysis model of aptitudes related to treatments and criterion measures would represent a fruitful means of conceptualizing and evaluating learner variables related to potential, individually prescribed instruction. The terms linguistic and imaginal refer to the mediational phase of learning rather than to either the stimulus or response phase. Holliday indicated that, although these mediating processes cannot be precisely described, they may be similar to Anderson's (32) suggested three-step process of encoding prose materials. Koran and Koran (28) suggested four conceivable mediating functions of pictorial and visual stimuli.

1. Schematic diagrams that present all structural relationships simultaneously may help overcome a limited capability of the learner to structure and retain a sequence of ideas.
2. When language is an insufficient referent, either because the receiver has not learned the concept or because the concept has not been adequately coded in language, pictorials may perform a mediating function.
3. Pictorials may provide a scheme for organizing incoming textual material and may also have an attention-directing and -controlling effect as the learner proceeds through related text.
4. When pictorial adjuncts occur at the end of text they may stimulate selective review and covert reorganization of previously processed material (28:478).

Significance of Research Findings

An increasingly theory-based research program, as exemplified by Holliday and his colleagues and the Korans, is beginning to yield promising results for writers and publishers of science materials. The work reported here and by previous AIT research suggests that high-ability students perform best in instructional treatments that leave much of the organization and interpretation of verbal abstract material to the learner. Pictorial adjuncts benefit low-ability students apparently by reducing the reasoning demands. The grade-level difference in pictorial adjuncts presented ahead of the text reading was explained by Koran and Koran (28) as clarifying the text for younger students but having little effectiveness for more experienced students. Pictorial adjuncts seem to facilitate comprehension when they are relevant to potentially difficult text description.

The differential findings--grade-level and aptitude effects--suggest that simple formulas for pictorial adjuncts usage will not be possible. The use of these elements of text design, however, cannot be taken lightly. Indeed, they relate to goals and objectives of science instruction and to the developmental level of students. What is appropriate for one goal for one developmental level of students may be inappropriate for another. A greater and more detailed effort of research using early adolescents as participants, with careful assessment of aptitudes, treatments, and curriculum and school contexts is required before science materials can be developed with a pictorial adjunct research base.

Implications for Teaching

Holliday (33) observed that science teachers seem to spend little time training students to interpret the pictures and diagrams in science texts. The middle and junior high school level is an appropriate time for this training to begin. Explicit and carefully thought out teaching methods for helping early adolescents learn from science texts would seem to be an important pedagogical strategy. This learning would attend to the interrelations of prose, pictures, diagrams, schemata, headings and captions, and the kinds and placement of questions. Emphasis could be placed on how these text features are interrelated to aid learning. The differential values of the various elements for different individuals in a class would also be emphasized and valued. This emphasis on learning from text does not preclude enabling early adolescents to learn directly from objects and events in the natural world.

One must think more carefully, too, about goals and the pictorial adjuncts in text. For example, if the development of reasoning is accepted as a goal for early adolescent science education, it may be important to have students make their own diagrams from prose passages. Although providing pictorial adjuncts facilitated comprehension by students with low verbal ability, reduced reasoning demands may deprive

these students of opportunities to develop reasoning competence as a trade-off for comprehension.

Readability

Readability measures are designed to predict the extent to which science text and other print materials are likely to be read and understood by a target group of readers. Generally, readability formulas are more reliable than the opinions of individual judges (34). Their general use by writers and publishers as predictors of reading difficulty are helpful in the analysis and revision of text materials. They do not, of course, show how these materials should be written.

Two types of measures are in general use: readability formulas, such as the Dale-Chall and Flesch; and direct measures, such as the cloze procedure. A most perplexing problem in readability research is to account for the fact that two texts with similar sentence lengths and word difficulties can be quite different in the ease with which they are understood. Additionally, texts with identical readability scores can be difficult for one reader and easy for another (35).

Research Studies

Bennett (36) sought to determine if sixth-grade science texts could be read by sixth-grade students, if some sixth-grade texts were easier to read than others, and if boys and girls differed in their ability to read the texts. Using cloze procedure with 999 students and randomly selected passages from 12 sixth-grade science texts, Bennett found only two texts that were readable by 75 percent or none of the students. Only 43.9 percent of the students had passing scores in the cloze procedure (75 percent comprehension). Six texts were readable by less than 45 percent of the students. Dale-Chall readability formula scores placed two texts at grade levels five and six, five at grade levels seven and eight, and five at grade levels nine and ten. There were no sex-by-text interactions.

Using the CTBS, Clarke (37) found that 300 eighth grade students in two middle schools were placed at reading levels from 6.0 to 12.0. Students were given an examiner-made comprehension test based in samples from social studies and science texts. Readability for the texts used was determined by readability formulas. Clarke found that the minimum reading level needed by eighth-grade students to satisfactorily comprehend their assigned science texts was eleventh grade. This compared with a minimum tenth-grade level to comprehend their social studies texts.

In a related study, Cohen (38) chose selections from seventh-grade

literature, social studies, and science texts to examine the effect of content on cloze test performance of 63 seventh-grade students. The mean percent scores on the cloze tests were literature, 31 percent; science, 37 percent; and social studies, 40 percent. The Dale-Chall formula and cloze tests ranked the passages on the same order of difficulty. Multiple-choice tests over the three content areas conflicted with these rankings. Cloze test and multiple-choice test results yielded correlations of: social studies, .35; science, .40; and literature, .55. Questionnaires for each content area to determine student preferences and reactions to the readings showed that a large majority of students reported difficulties in reading the materials. Poor comprehension, density of facts, vocabulary load, difficulties studying, and lack of interest characterized these difficulties.

In earlier studies, Driver (39), Kline (40), and Ramsey (41) found science texts for fourth through ninth grade to be written at from one to four grade levels above the grades they were designated to serve. Rewriting science text materials to Yoakam's readability formula scores at the third-grade level increased reading rates and comprehension of sixth-graders with low, average, and above average scores as determined by the reading test of the Stanford Achievement Test (42).

Significance of Research Findings

The most significant aspect of the studies reviewed is that readability is still being treated as a property of text materials whereas the literature on readability has conceptualized readability measures as an interactive process of reader and prose. Readability formula studies per se have outlived their usefulness and need to be replaced by studies grounded in psycholinguistics, cognitive science, or conceptual analyses, such as ConSAT, and to relate text structure to comprehension.

Alternatives to Textbooks

Research Studies

Alternatives to textbooks as the central curriculum source were investigated by Wachs (43), Barrillieux (44,45), and Fisher (46). Wachs used ten "source" papers related to the subject matter of a seventh-grade science program to determine if the source papers would result in improved understanding of science without affecting science achievement. Students were stratified by ability level and sex and then randomly assigned to experimental (source papers plus regular materials) or control (regular materials only) groups. Each student's difference score (pre- to posttest) on the TOUS test was analyzed using ANOVA. Comparisons by t-tests of the "net difference in change" (pre- to posttest) group scores on an achievement test were used to determine treatment

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effects. The experimental group produced significantly higher gains on the TOUS test. Achievement tests analysis produced no differences in the group. Control for regression effects was not made.

Barrillieux conducted a two-year study beginning with 42 eighth-graders to determine the effects of multiple library sources and basic texts in science instruction in one junior high school. Students were stratified into "high" and "average" ability levels and randomly assigned to treatment groups: a library sources only and a textbook only group. The independent variables used in the study were: ITED Test 2 and Test 6; STEP Science, Grades 7-9; TOUS; Watson-Glaser, Critical Thinking Appraisal; eight papers written during grade nine; and 25 oneday observation records of student library behavior.

The experimental group exceeded the control group ($p = .05$) on the STEP test, TOUS, writing mean scores, and on hours spent in the library. No significant differences were found on the other independent variables, but the trend on every measure was in favor of the experimental group.

Fisher conducted a nine-week experiment with 174 seventh-graders in a junior high school to compare the use of science trade books and other science literature with text instruction. The purpose of the study was to determine the effectiveness of two ways of integrating the use of trade books in a life science unit on cells, anatomy, and physiology. Two experimental groups and one control group were included in a post-test only design. One experimental group was free to use the trade literature, the second was required to read selected trade literature. The control group was neither provided nor encouraged to use the trade literature. All groups were divided into "high" and "low" ability subgroups as determined by a cloze test.

A locally prepared cognitive test (KR20 $r = .84$) and an affective test (KR20 $r = .83$), were administered at the end of nine weeks. Experimental groups performed significantly better than the control groups on the cognitive measure. No analysis of the affective measure was presented. The investigator stated that students with high reading ability responded favorably to the required readings and students with low reading ability enjoyed free, but not required, readings (mean scores, free 55.18, assigned 51.95).

Significance of Research Findings

These three very limited studies indicated that supplementary and trade resources literature, used with or without science texts, resulted in achievement equivalent to or better than when texts were the only resource and generally resulted in better understanding of science and scientists, as measured by TOUS.

Conclusions and Recommendations

The text is the central curriculum resource used by students to learn science, yet research on science texts, their characteristics and structures and how these characteristics and structures affect learning outcomes is limited. The study of science texts designed for early adolescents is an especially fertile field for research, for reasons that needs some elaboration.

First, in most educational settings the middle or junior high school years introduce students to expository text as a major source for learning science. This event takes place with little or no instruction in the differences between readers that students have used and this new kind of text. Second, the sciences use common terms as names for concepts that are more restrictive and precise than the everyday term they replace. Furthermore, most science concepts derive their full meaning within scientific theory. They have both formal and empirical relations (meanings) within theory that cannot be captured by dictionary-type definitions. For example, the term "adaptation" can be defined easily, but the biological concept "adaptation" derives its full meaning from evolution theory or from homeostasis and regulation. Texts can also provide opportunities to contribute to, or to completely preclude, the development of logical thinking.

The studies reported here suggest that intuitively developed texts have features, such as graphics, that enhance learning. The casual use of adjunct questions must be reexamined for effectiveness. The amount of content packed into texts designed for early adolescents seems to be much greater than can be understood by students, unless science concepts are reduced to vocabulary terms, presented without the theory from which they derive full meaning, and without their multiple connections with other concepts, with scientific principles, and laws.

Theory-based research in text analysis has yielded more knowledge and generated more interesting questions to be investigated than the empirical studies reviewed here. Aptitude-treatment interaction studies suggest that the design of effective texts in the future may have to have greater differentiation than is currently available in the market place, if learning opportunities are to be maximized for all students.

Text difficulty is not resolved by selecting the text with the lowest reading formula score. In the comparative studies reviewed, science texts were found to be more difficult to read with comprehension than social studies texts, but they were less difficult than literature texts. Comprehension can be improved by rewriting materials to lower readability levels (as measured by formula), but there is some question as to the effects of this procedure on interest, and more important, from a recent summary of reading research (47), easy words and short sentences can make texts hard to understand.

The opportunity is now available for those with a knowledge in science disciplines to build on theory for new research into texts and text comprehension. The critical work from cognitive science, content

analysis, linguistics, and reading research can provide more powerful bases from which new research can be conducted. Empirical studies seem to hold comparatively less promise for future research. Generalization of research on children or adolescents should be generalized to early adolescents with great caution. The most significant contributions to the improvement of science teaching in middle and junior high schools will come from research that carefully documents the science content, school context, and grade levels of students and from research that builds on the current research base from cognitive science or linguistics.

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SECTION V INNOVATIVE AND EXEMPLARY SCIENCE PROGRAMS

CHAPTER 1

INNOVATIVE SCIENCE PROGRAMS

"The junior high school and the college are the two most vulnerable institutions since neither has made major efforts to reflect the pressures and challenges of the time or seek new roles" (1:78). This description of the junior high school science situation in 1970 was a very accurate and perceptive one. The 1960s saw major curriculum development efforts at the elementary and secondary levels with the "school in the middle" once again being slighted. The first round of curriculum development efforts had not stimulated much interest in the development of materials for the "schools in the middle." The first efforts resulted in major alternatives for high school science. These high school efforts were closely followed with many elementary science projects. By 1970, a "middle school" movement could be identified, and a great deal of discussion was occurring about meaningful change for this age level.

A prospective synthesis for the 1970s was provided by Dr. Paul DeHart Hurd in his book <u>New Curriculum Perspectives for Junior High School Science</u>. Dr. Hurd presented an analysis of the planned or extant innovative programs and attempted to outline some of the mistakes that produced failure in earlier curriculum development efforts at other levels. He analyzed 23 innovative curricular models in his work and described each in some detail. Dr. Hurd used the following criteria in selecting the projects for his reporting in 1970:

1. They are the result of group thinking, reflecting discussion and debate among people with special interests in junior high school education.

2. They are experimental in the sense that they were tested with pupils and efforts were made to refine the materials. Several of the models remain theoretical, in that they are new and do not have supporting curricular materials at this time.

3. One or more innovative ideas is involved, such as the rationale of the program, content and organization of the curriculum, mode of teaching, learning demands, instructional media, or the concept of laboratory work.

The innovative programs that Dr. Hurd analyzed were:

BSCS Human Sciences Program
ERC Life Science
Quantitative Physical Science (QPS)
Introductory Physical Science (IPS)
Time, Space and Matter (TSM)
Earth Science Curriculum Project (ESCP)
University of Illinois Astronomy Project
Stanford University Junior High School Science Project
Inquiry Development Program (IDP)
Michigan State Curriculum Committee Junior High School Project (MSCC-HGCP)
Nuffield Junior Science Project
Elementary Science Study (ESS)
Mathematics through Science
NSTA K-12 Science Curriculum Plan
Modern Junior High School Science Manpower Project
Science Teacher's Adaptable Curriculum (STAC)
Pennsylvania Curriculum Development Program
New York City Science Grades 7-8-9 Project
Project PLAN
The Nova School Science Plan
Intermediate Science Curriculum Study
Foundational Approaches in Science Teaching Project
American Association for the Advancement of Science

Now that the 1970s have come and gone, it is important to reflect on these 23 model projects, as well as others that arose during the 1970s, and determine their current status and/or impact. This will be done in a general way, as opposed to reporting on the status of each of the projects individually. As a group, the projects can be characterized and their impact reviewed collectively.

All of the innovative programs shared the common purpose of challenging the "old" materials and methods and offered a new curriculum and/or learning model. The rationales and goal statements for all of these model programs discussed the limited view of learning that was so prevalent in the currently used science materials. All of the programs addressed in a new way several of the following areas:

1. The characteristics of the learner
2. The structure of the science discipline (its modes of inquiry and/or the province of its concepts)
3. The appropriateness of learning processes
4. The instruction and/or teaching mode
5. The nature and/or design of the instructional materials

All of the programs were saying that the science offering for 10-to 15-year-olds had to be more than just a "vocabulary of science" course. The philosophies stated that in order to represent the discipline of science accurately, the materials should involve students in more than just memorization of science facts or concepts. There was a general cry for developing materials that would give to the student an understanding

of the relationships between important ideas in science and their own experiences. This thrust in the rationales of all of the programs took many forms and each project used different terminology, but the "feeling" expressed by the entire group was strong and quite similar in emphasis. Involving students in their own individualized learning of science was common in the rationales of the model programs. Emphasis on science process skills, such as observing and describing, were being designed into the student materials being developed. The processes of science were being given at least an equal emphasis with the knowledge orientation of the science found in most of the text programs of the time.

What were the effects and/or impacts of these model programs? The answer to this question is complex and time referenced, as are most educational questions. One can describe the impact in the 1970s, the potential impact today, and then speculate on the impact in the future. The first concrete observation can be made by looking at the data reported in the Iris Weiss study of 1977. By 1977, 2 of the 23 model programs (IPS and ISCS) identified by Dr. Hurd had made it onto the list of most widely used materials at this level (2:B44-45). This marketplace impact is certainly noteworthy and cannot be denied. These two programs did influence the marketplace and certainly made the publishers at this level take notice. Collectively, the other programs had major impact as each dented the marketplace or influenced other published materials. None of the other programs, however, had enough single sales to make it on the Weiss best-selling list. Optimistically stated, the 23 programs served a useful function in the seventies and had a measurable impact.

Is the glass half full or half empty? It is equally safe to say that the programs did not, individually or collectively, take the educational world by storm. None of the programs dislodged the major best-selling series at this level and, in fact, probably did little to influence the nature of the best-selling series. Thus, one might legitimately conclude that the long-term impact of the model projects might be minimal; especially if one takes the rumors of the fate of IPS and ISCS seriously; that is, that they will not continue to be revised but rather will slowly be phased out by their publishers.

Considering the 19 precollege projects supported by NSF between 1975 and 1980, other curriculum development efforts, and the 23 projects described by Dr. Hurd in 1970, the state of the art of science education at this level in 1981 seems to lead one to an obvious conclusion: The rhetoric of a tremendous input of resources into middle and junior high school science during the 1970s never happened! Only one project (OBIS) can be added to Dr. Hurd's 1970 list (using his criteria for inclusion) as a new project for science at the middle and junior high school level during the 1970s. In short, the big movement to do something for science for the "schools in the middle," once again, never materialized. Thus, to judge the effort as a failure would not be valid, since the effort never really was in full operation. The National Science Foundation did not publicly identify the 10- to 15-year-old as a priority focus in their guidelines until 1978-79. By this time it was too late. Attacks on the Science Education Directorate of NSF in 1975-77 were not

weathered well, and the new focus on 10- to 15-year-olds was far too late. It is safe to say that the big emphasis at this level never received the support equal to that given earlier to the elementary and secondary projects.

In summary, the impact of the innovative programs at this level, though very real, may well be judged to be minimal in the long term. The best-selling encyclopedic ("science as a foreign language") courses of 1970 continued to be the best-sellers in 1981.

How the impact will be judged in 1990 is very obviously dependent on one variable--what comes next. A whole group of teachers and administrators have been sensitized to the new rationales and are still eager to teach in these new paradigms. What will they have as support materials through the 1980s? Will there be another round of materials produced for this use? Or will publishers just print more of the old? These are politically laden questions and difficult ones to answer. The fact seems clear, however, that without continued support for change, it is not likely to occur.

Of the 23 projects Dr. Hurd analyzed in 1970 perhaps one of the projects still offers a glimmer of hope as the intermediate model to bridge the gap going into the 1980s, that is, the Human Sciences Program. Through a variety of circumstances beyond description here, this model program has been unduly delayed in its preparation for the marketplace. If this program has an impact when it is marketed, the delays might be viewed as blessings in disguise, since no new model programs are under development in 1981, nor are there any plans for any in the immediate future. The Human Sciences Program might well serve as a model curriculum going into and throughout the 1980s. It was the largest curriculum development effort during the 1970s; and, as it becomes available to schools in the early 1980s, its extremely innovative nature might place it in the position of being the model for the foreseeable future. As a large and comprehensive curriculum development project, the Human Sciences Program considered many variables in the complex of teaching science to 10- to 15-year-olds and probably deserves the billing of the model curriculum for the 1980s.

Only time will tell if any publisher in the country can be or wants to be innovative and whether the Human Sciences Program will be a huge pacesetting success or whether it will be judged another federal boondoggle. Only time will tell its fate, and only time will determine whether the momentum of the model projects developed to this date for middle and junior high schools will be intensified, maintained, or lost during the 1980s.

CHAPTER 2

EXEMPLARY SCIENCE PROGRAMS

As one way of identifying selected aspects of middle and junior high school science instruction, announcements inviting educators to send information about their own exemplary science programs were placed in the National Science Teachers Association Middle/Junior High Science Bulletin and the National Middle School Association Bulletin. The article in the NSTA publication included the questionnaire in full (a copy of the questionnaire is included on page 284). The article in the NMSA Bulletin did not include the specific questions. Respondents to the NMSA announcement were sent a questionnaire and invited to respond to the questions by May 15, 1981.

Eight responses were received that are included in the chart on page 282, which summarizes responses to the questionnaire. Three of the programs were for seventh-graders, three for eighth-graders, one for seventh- or eighth-graders, and one for ninth- or tenth-graders. Three of the programs were environmental in emphasis, two emphasized earth science, one was a program on developing laboratory skills, one was an interdisciplinary mathematics program, and one a human growth and development program. Most of the programs were developed at the local school or school district level.

In addition to these identified programs, the articles about the study prompted seven inquiries requesting information about the results of the study. These respondents were seeking information about exemplary science schooling for middle and junior high schools.

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1. What is the name of your course (program)?		Meteorology	Synergy	ESCAPE-Environmental Science Concepts and Processes-Enquiry	Basic Science Skills in a General Science Program
2. What student population participates in the course (program)?		Age 12-13, Grade 7	Age 12-13, Grade 7, above average students	Grades 7-8, all ability groups	Grade 7, honors, average, modified (slow)
3. What are the main goals of the program?		a. Describe main components of weather b. Explain how air masses, fronts, and cyclones relate to weather c. Read and interpret weather instruments d. Explain formation of pressure areas, thunderstorms, hurricanes, tornadoes	Emphasis on building three-dimensional models and relating them to different disciplines (mathematics, science, social studies, art). Based on the geometry of R. Buckminster Fuller	To assist students in becoming scientifically literate citizens. To unify important concepts, processes, phenomena, and persistent problems of science	To teach a. An appreciation of scientific thought and methods b Basic principles of biology and chemistry c. Scientific vocabulary and terminology d. Basic lab skills e. Organizational skills f. Basic laboratory report-writing techniques g. American Red Cross Basic First Aid
4. What published materials, if any, do you use?		Spaceship Earth/Earth Science, Joseph Jackson, Edward Evans, 1973, Section on weather	Synergy, Gerry Segal, Denis Franco, Board of Education, New York City	A variety of texts can be used.	Multi-text approach Some are Interaction of Man and the Biosphere, Rand McNally Physical Science and Life Science, Holt, Rinehart & Winston Concepts and Challenges in Physical Science, Cebco Science Is Explaining, Scott, Forsman & Co
5. What published materials, if any, do your students use?		Same as 4	Students use teacher-developed materials and independent library research.	A variety of materials are used.	Same as 4
6 What unpublished materials are used?		Sample worksheets, weather charts, included	"Why Buildings Stand Up," teacher-developed lesson materials included	Unit 1 included, 18 units are available	Teacher-constructed handouts, puzzles, games, lab experiments, models of scientific equipment
7. How was the course (program) developed?	Individual teacher	X	Originally X		2 teachers
	School committee				
	District committee			X	
	State program				
	Other		Now team of teachers using resource persons		
8. How long has the course (program) been in operation?		5 years	4 years	Since 1973	7 years, frequently revised
9. What components are included in the course (program)?	Laboratory experiments	X	X	X	X
	Other "hands on"	X	X	X	[illegible]
	Field investigations		X	X	X
	Individual units			X	
	Textbook reading and exercises	X		X	X
	Other reading	Library books	Library research	X	Library
	Small group discussions			X	
	Other		X		Note-taking science projects
10. Briefly describe one of your favorite learning experiences included in the program.		Project "Up, Up and Away." Students launch post cards attached to helium-filled balloons. When cards are returned, distances are measured. Exercise relating temperatures and barometer readings also included.	Lessons from The World of Mathematics, James R. Newman	A field-trip experience to local aquatic and terrestrial ecosystems climaxes each grade level.	The written lab report is the culminating activity; students are called upon to use all the skills learned during the year. The students see how all the various other units tie together.
11. What characteristics identify the program as being outstanding?		Students are amazed at the distances the balloons and cards travel.	Students are exposed to a holistic view, see interconnections between disciplines; exposed to latest scientific findings	Unified Science Approach, 14 sequenced units; unit rationale and objectives; program evaluation model; student choice; environmental awareness; integration of concepts and processes	Feedback from upper level teachers; students better prepared in basic concepts and lab skills
12. Who is the contact person for further information?		George Probasco Arapahoe Public Schools 1102 Cherry St. Arapahoe, Nebraska 68922	Ellen Goldstein 348 W. 48th St. New York, N.Y. 10036	Thomas Rourke ESCAPE Demonstration Center Sand Creek Junior High School 329 Sand Creek Road Albany, New York 12205	Andrew DePino, Jr., or Deborah Solomon Science Department Kosciuszko Junior High School 170 Elm St. Enfield, Connecticut

Earth Science	Environmental Problem Solving	Human Growth and Development	Science, Energy, and Environmental Change	3 Environmental 2 Earth Science Meteorology 1 Laboratory Skills 1 Human Growth 1 Math-Interdisciplinary
Grade 8, gifted and talented	Grade 8, average and above	Grade 8	Grades 9-10, average and below	3 Grade 7 3 Grade 8 1 Grades 7-8 1 Grades 9-10
a. Provide basic skills b. Develop basic concepts in earth science c. Pursue own interests via investigations	a. To develop an awareness of how individual and collective actions influence quality of life and of the environment b. To develop knowledge and skills necessary to investigate environmental issues and to evaluate alternative solutions c. To develop skills necessary to take positive environmental action	To give 8th graders opportunities to a. Learn about themselves as unique individuals b. To care for themselves properly	To make students aware that a. The earth's resources are limited b. That there are alternatives to consuming all these resources	
Science and Children Science Activities Science Digest	Teaching Environmental Education, H.R.Hungerford, R.B.Peyton, J. Weston Walch, Portland, Maine, 1975 Understanding Basic Ecological Concepts, Audrey N. Tomera, J. Weston Walch, Portland, Maine	Not given	None	
Earth Science, Holt; Spaceship Earth/Earth Science, Houghton Mifflin	Investigations and Action Skills for Environmental Problem-Solving, Hungerford, et al., Stipes Publishing, Champaign, Illinois	Scholastic Science World, Current Health, Investigating Your Health, pamphlets from various health-related organizations	Materials being considered for publication	
None	None	Not included	Teacher-developed materials	
X			X	5
	X	X		3
	X			1
3 years	3 years	2 years	2nd semester.	
X		Information	X	6
X			X	6
X	X	not		5
	X		X	3
X	X	included	X	6
Newspapers, science periodicals	Library, research			4 library,
X	X		and research	3
Small group excursions into the community	Primary data collection; values clarification exercises		Energy surveys	
A team of 2 students takes one concept/activity and develops the activity for use in 3rd or 4th grade classes. All materials and instructions must fit into a shoe box.	Autonomous research carried out by each student. A contractual form is provided to be a basic guideline for each student. A seminar format is used in which students share information with other students and with faculty.	Information not included	The home energy survey	
Student involvement; students have freedom to use their own talents; extensive group work allows greater interaction without sacrificing basic goals	Behavioral objectives communicate clearly to students; interdisciplinary nature; providing skill training in environmental literacy	Information not included	A practical program for students who will not go to college. They will find out how to make a house fuel-efficient and something about business costs.	
Myra Vachon Rufus King Middle School for Gifted and Talented Milwaukee Public Schools P. O. Drawer 10K Milwaukee, Wisconsin 53201	Trudi L. Volk 229 W. Carroll, Apt. 1 Macomb, Illinois 61455	Donald J. Beaudette Hooksett Memorial School Daniel Webster Highway North Hooksett, New Hampshire 03106	James Martino Talawanda High School Oxford, Ohio 45056	

STUDY OF MIDDLE AND JUNIOR HIGH SCHOOL SCIENCE SCHOOLING

by Mary C. McConnell

The Center for Educational Research and Evaluation (CERE) of the BSCS is currently engaged in a National Science Foundation-supported Middle and Junior High School Science Schooling Study. One aspect of the study includes the identification of exemplary middle school and junior high school science programs across the nation that are specifically designed to meet the needs and characteristics of early adolescents and that are in keeping with current trends in science education.

If you have such a science class or program that you are proud of, please take a few moments to answer the following questions about it. Data received will be incorporated into the study. Results from the study will be included in a final report to the National Science Foundation and will be reported in a variety of professional publications.

1. What is the name of your program?
2. What student population participates in the program? (age/grade levels) (gifted, special)
3. What are the main goals of the program?
4. What published materials, if any, are used by you?
5. What published materials, if any, are used by your students?
6. What unpublished materials are used? (Please send sample materials, if possible.)
7. How was the program developed?
8. How long has the program been in operation?
9. What components are included in the program?
10. Briefly describe one of your favorite learning experiences included in the program.
11. What characteristics of the program identify it as being outstanding?

SECTION VI A CONTEXT FOR SCIENCE EDUCATION: A CONCEPTUAL FRAMEWORK FOR THE EIGHTIES AND BEYOND

CHAPTER 1

IS THERE A CRISIS IN SCIENCE EDUCATION?

The state of science education in middle and junior high schools was examined from five perspectives. Each perspective was explored from a different data base. Section I of this report summarized the philosophical assumptions that underlie the middle school. Section II analyzed nationwide surveys on science education to determine the status of science teaching goals, instructional procedures, and constraints on educational practices. Section III considered the commonly adopted textbooks for grades 6 through 9 to identify the nature of the middle school curriculum. Section IV analyzed empirical research on learning activities and curriculum materials for early adolescents. Section V reviewed science programs, perceived to be an improvement over traditional curricula, that have been formulated in a few middle schools.

The investigators learned much from these studies about the state of science education in middle and junior high schools in the United States. The problems and issues identified seem to indicate that all is not well with science programs designed for the early adolescent.

Concerns About Science Education

Judging from reports, the public press, and the professional literature, science education in general appears to be at a critical juncture. Criticism is being directed at all levels of science instruction, from the elementary school through high school. To learn more precisely what these concerns are, an analysis was made of various committee or panel reports on science education published in the years 1970 to 1981. (See Chapter 3 of this Section.) The earlier date (1970) coincides with a series of events—social, technological, and scientific—that stimulated a questioning of the viability of many American institutions including education, scientific research, and technological development. The reports selected for review were those developed from the deliberations of organized groups of scientists, educators, or citizens and included statements that appear to represent a degree of consensus.

While the focus of this study was on science education for the early adolescent, reports on the state of science education are not oriented that precisely. It was not always possible to distinguish

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concerns about American education in general from those peculiar to science education. However, it was possible to identify problems and issues that were specific to precollege science education and had implications for science instruction in the middle and junior high school years.

A Composite View of Problems and Issues

The present cultural climate is seen as an important factor influencing science education (Chapter 3, IIA, IIB, IV, VI, IX, X, and XII). The public does not strongly support sicence education. It is not so much that science is considered unimportant, but rather that it is given a low priority in schooling.

The major problem appears to be disagreements about the traditional goals of science education and about the need to reexamine their validity (Chapter 3, IIA, IIB, IV, VIII, IX, X, and XI). A subtle but not explicit recognition exists that the rationale for the teaching of precollege science should be reexamined. The major reason proposed is that "times have changed." The conceptual framework essential to formulating new goals or examining long-standing goals for science education appears not to exist. It is quite clear that the goals currently accepted for teaching precollege science courses are suspect.

The subject matter that comprises science courses and the organization of the curriculum are being questioned (Chapter 3, I, II, III, IV, XI). What the appropriate subject matter is for precollege science courses lacks consensus. Some groups decry the lack of "practical" information in science courses, while others find little wrong with the present curriculum. There is more agreement on the issue that the science curriculum has become overly "fractionated" or "molecularized." There seem to be two interpretations of this issue: There are too many mini- or short courses on special topics (environment, energy, ecology) or the traditional courses have become overly specialized--for example, life, physical, and earth sciences in contrast to general science.

Other factors identified as contributing to the crisis in science education are lack of leadership to plan changes (IIB, III, IV) and inadequate pre- and in-service teacher education programs (I, IIA, IIB). Factors mentioned less frequently are lack of parental interest, "anti-science tenor" of the public, loss of public confidence in schools, unfavorable student attitudes toward schooling, insufficient financial support, declining enrollments in science courses, difficult teaching conditions in schools, misassignment of teachers, minimal science requirements for school graduation, students' dislike of science courses, and diversity among students.

Factors and Decisive Events

The documents studied point to a crisis in science education and identify certain problems and related issues. One of the major issues is outside the schools. This is a lessening in public interest about the importance of science as compared to that of the 1950s and 1960s. School science programs reflect this situation and suffer as a result. Second, the shift in social and cultural attitudes of our nation toward science is broadly recognized by people concerned with precollege science education. In turn, two educational tasks are perceived as necessary to begin coping with the crisis in science education. One of these tasks is a validation of the existing goals for science education in terms of present social conditions in the United States. The second task is a reformulation of the science curriculum to meet the evolutionary changes taking place in American culture.

CHAPTER 2

A CONCEPTUAL FRAMEWORK*

The purpose of establishing a conceptual framework is to postulate the next steps in the evolution of precollege science education. A conceptual framework provides a normative base for shaping and giving direction to revitalizing science education. In the absence of a philosophical base, educational efforts frequently give rise to faddism, romantic slogans, and superficial structural modifications of existing practices. What is done does not appear to be rooted in any identifiable theory of science education nor in any long-range recognition of what ought to be done.

The need to reexamine the current condition of science education is indicated by a variety of concerns expressed as a crisis situation. That the crisis is broadly recognized is documented in Chapter 1 of this section. In other chapters of this report, data on conditions that characterize the status of science education in middle and junior high schools are presented. A study of conditions and concerns about an educational program, however, is not sufficient to project what ought to be done. The problem is a philosophical one and not one of simply revising school practices or structure in an unplanned hope that a more effective program will emerge. This is like planning basic research in the sciences without the benefit of theory or a conceptual model.

Methodological Considerations

To provide a basis for a prospective framework for precollege science education, several relevant panel or committee reports were analyzed. All were published in the 1970s or early 1980s. The reports selected had the benefit of input from a group of people as well as evidence of discussion and debate. Local or state publications and

*Special thanks are due to the 26 people external to the research staff who reviewed a draft of this section and made recommendations for its organization and clarification. Any opinions, findings, conclusions, or recommendations expressed in this final report are those of the authors and do not necessarily reflect positions of the reviewers, the National Science Foundation, or any other agency of the United States Government.

individually written articles on "new goals for science teaching" were not used, nor were those representing special subjects such as biology, chemistry, or earth science. Roughly, the reports selected for study were of two kinds: those exploring the present condition of science in America and those related more directly to the status of education in the sciences.

Each report was analyzed for basic ideas or themes identifying the present conditions of the scientific enterprise and implications these conditions have for a general education in science. The next step was to form a conceptual synthesis of related ideas from the analysis to find patterns of consensus. It is important to recognize that the process of conceptual analysis differs from trend analysis in that the treatment of conceptual data is qualitative (normative) rather than statistical. Interpretations of the synthesis and refinements were made from a background of extended readings on concepts identified in the synthesis. Each of the readings, in the main, represented scholarly interpretations of a finding and served to sharpen its conceptual context. These readings also assisted in raising the validity of the respeachers' interpretations.

A preliminary statement of the findings was sent to 26 people, none associated with the research team, for critical review. The reviewers were scientists, educators, philosophers, citizens, precollege teachers, school administrators, sociologists, and futurists. Their comments aided in clarifying the interpretation of statements and the organization of the report. A substantial number of the reviewers raised questions about how the conceptual framework would be implemented in curriculum practices and in the education of science teachers. These are important issues, but they necessarily must follow the acceptance of a conceptual framework as a basis for long-range planning. Our study is limited to the theoretical or philosophical aspects of science education that can serve in charting what ought to be done in reformulating science education practices.

Findings

The findings are reported in eight arbitrary categories that represent a pattern of consensus about charting the revitalization of precollege science education. (The categories are reported later in this section.) The study revealed that paradigmatic changes are taking place in the sciences and the scientific enterprise. This is illustrated in the links that have developed between technology and society and their impact on basic and applied scientific research. In schools, science teaching that does not recognize these paradigm changes can only drift more and more into a perspective that has only historical meaning.

Less clear from our analysis is the influence social and cultural changes are having on educational policy anbd notions of what precollege education should accomplish. It was difficult to distinguish in the

analysis between problems and issues of education in general and those pecular to science education. It was clear, however, that the shifting paradigm of science does have major implications for precollege education in the sciences.

Making Use of the Projective Synthesis

The conceptual synthesis is not intended to serve as a blueprint for the revitalization of science education. Rather, it is a postulated educational position that reflects a paradigm shift in science as an enterprise. These changes are relevant to the context, rationale, and goals for precollege science education. It seems reasonable to assume that an education in the sciences should reflect the intellectual path science is taking. It follows, then, that a first step in charting a course for the revitalization of science education is to examine the current status of science itself and its philosophical meanings for the teaching of science. The eight categories of findings in this report provide a base for deliberation in reformulating aspects of science education. From these deliberations, a rationale and broad goals for an education in the sciences should emerge that can serve as long-range goals for curriculum restructuring, teaching objectives, and other aspects of schooling and teacher education.

Categories of Change

<u>The Social Context of Science and Technology</u>. Science and technology are responsible for much of the cultural uniqueness of contemporary American life. They serve as agents of social and economic changes and, in turn, are impacted by cultural changes. Individuals and the nation are increasingly asked to make decisions that influence human well-being and the quality of life. The quality of these decisions frequently depends on people having an accurate understanding of science and technology, which includes an understanding of

Science as processes for generating bodies of knowledge that are science

The powers and limitations of scientific methods and of scientific information

The social impacts of science and technology

Science and technology, each in its own way, influence social and cultural changes. For more than a century, links between science and technology have become fused as a force in personal and social affairs. Typically, precollege science courses omit technological considerations. Science is taught as if it had no connections with human affairs. In the everyday experiences of students, the primary contact with science

is through technology. Science teaching that recognizes the importance of human needs and the progress of society stresses not only the importance of scientific inquiry but also the rational use of technology.

Science and technology, through their extensive intermix and social interactions, have a direct bearing on the goals for general education in the sciences. This brings into questions science courses that focus exclusively on the "structure of a discipline," its theories, and research processes and on courses in which only problems internal to the discipline are discussed. The emerging paradigm of science acknowledges problems external to a specific discipline as a part of the scientific enterprise. The paradigm broadly includes scientific and technological problems that relate to human welfare and national interests. For science education, this presents an alternative curriculum context with a science/technology/society perspective.

Science taught in a social context must be based on valid scientific information. An understanding of the processes, concepts, and interpretive principles of science is fundamental to the intellectual extension of science to social systems. Equally important is to recognize what sciences can and cannot do.

Values and Ethics in Science and Technology. The presentation of science and technology in a social context invariably raises value and ethical questions. These issues arise from conflicts in deciding how best to use, or even whether to use, scientific information or technological developments for real-life purposes; value judgments differ. Conflicts also arise from differing perceptions of individual well-being and social progress. New knowledge and new technological achievements alter the range of choices people have and this, in turn, brings into question personal and social values. Although technological innovations may be of great benefit to most of society, almost always there are negative impacts for a portion of the public. As a pluralistic society, we must respect the value judgments of each member. On the other hand, there are value decisions, such as environmental quality, that are the prerogative of the public.

The increasing tendency of scientific inquiry to be influenced by social needs and the unanticipated consequences of technological innovations carries a high probability of inducing ethical and value conflicts both for individuals and for society generally. Questions about the direction science research should take and the pursuit of new technology have become ethical, value, and sometimes moral issues. These are not issues to be avoided in precollege science education.

In teaching about values in precollege science, the focus of instruction is not to instill a particular set of values, but rather to encourage student judgments consistent with validated scientific information and within the capabilities of technology. It is not expected, however, that two equally informed students will make similar value judgments.

The Utilization of Knowledge. A primary concern in all teaching has been the role of knowledge. Traditionally, a science curriculum

consisted of a selection of facts, concepts, and principles organized into courses representing a synopsis of broad disciplines such as biology, chemistry, physics, or earth science. The criterion for the selection of the subject matter was that the information was historically representative of a discipline. The essential task of the teacher was to see that the selected package of information was presented to students. Tests determined what information was acquired.

There is a growing recognition that the measure of general education in the sciences is one's ability to apply knowledge wisely in the context of intelligent thought and action. This means that at least as much effort in teaching should be given to the use of knowledge as to its attainment. The instructional task is one of developing the intellectual skills to optimize the personal and social use of information. Linking science as a knowledge-producing system with society as a knowledge-using system is the challenge confronting science education.

There is a long history of studies of knowledge creation, diffusion, and use. The links among knowledge creation, diffusion, and use have not been a serious consideration of science curriculum developers or educational researchers. Questions about contextual factors, levels of generalizability, ways of using knowledge, effective levels of knowledge conceptualization or insight, attitudes and values related to knowledge use, and other conditional variables are not fully answered. It is clear, however, that the acquisition of factual information, by itself, does not assure one's capabilities for using knowledge.

The current emphasis on the development of information-processing skills in science education stems from achievements in information technology. Microelectronic technology extends the capacity of the human brain for information storage and retrieval. The degree to which the vast pool of information becomes meaningful to a student rests on acquiring skills of information processing. Quite likely, the "disadvantaged" learners of the near future will be those who lack the skills to exploit microelectronic information resources and to synthesize the findings.

Logical Reasoning and Decision Making. To derive new explanations, scientists use theories or models and intellectual processes that differ from those the average citizen needs to make use of scientific information. It is important that students understand the intellectual demands for scientific inquiry and learn what is meant by reliable or valid knowledge. Equally important for nonspecialists is that they understand how to use scientific knowledge rationally in both personal and societal contexts. To be able to use what is learned means crossing the barrier from learning to logical reasoning and decision making. It also means going beyond narrowly defined inquiry or investigative skills and calls for interpretive skills that link science with the common realities of life and living.

Processes for the use of scientific knowledge in a social context involve not only conceptual skills but also consideration of personal and social values and projections for action. Human problems involve a condition and an action, which may be a choice, a plan, a judgment, a

decision, an answer, or a next step. Simply marshalling facts, though essential, is not sufficient for decision making. An answer to a human problem is not a byproduct of information alone. There are nearly always related questions: What are the elements of probability, risk, uncertainty, cost, and benefit? Who wins and what do they win? Who loses and what do they lose? What will do the most good? What is plausible and what is probable? What is maximum and optimum? What is appropriate and what is acceptable? The decisions people make in the course of living have qualitative and judgmental aspects as well as quantitative ones.

Among the conceptual skills needed for the application of scientific and technological information are applied logic, analytical and inductive reasoning, scientific problem-solving and decision-making techniques. Students will need to know how to locate sources of information and how to recover, organize, synthesize, and evaluate knowledge. These skills are best developed and refined by experience in solving problems and confronting issues in personal and social contexts. Although experience in finding answers to discipline-based laboratory problems has its values, the experience is not transferred easily to scientific/social problems.

Thus, a central call for the teaching of science is the development of logical procedures for processing scientific and technological information to make it possible for the nonspecialist to use such information in human affairs.

<u>Career Awareness</u>. The responsibility of the science teacher in providing career information is to alert students to the importance of communication skills such as mathematics, writing, reading, and a general ability for logical reasoning. The content of instruction should acquaint students with vocational options in the scientific and technical fields, while offering them optimum opportunities to develop freely special interests in science. What is not desirable is career counseling that assigns students to specific vocational slots. Achievements in science and technology should be recognized as the work of people with appropriate education and training.

<u>The Organization of Science Courses</u>. The shift in the rationale of science teaching toward a recognition of the interactions of science, technology, and society carries with it implications for the organization of the science curriculum. Underlying this rationale is the belief that science teaching should relate to persistent, science-based societal problems that students are likely to encounter, such as population growth, management of natural resources and energy, and environmental quality. These are also issues that have scientific, technological, economic, political, and ethical aspects. It is likely that analysis of, and actions on, these problems will require intellectual techniques and information from several sciences, as well as from other disciplines. This suggests that science courses may need to be organized on a cross-disciplinary basis.

If we expect students to become proficient in using science information to resolve scientific/social problems, we must give them

opportunities to deal with such problems that are appropriate to their developmental level. To meet this requirement means that some parts of the curriculum must contain activities that require a search for information, judgment of thought, and value interpretations. To acquire a sense of social responsibility and a social perspective, students must engage in problems of concern to the community at large. Experience is also needed in actions of particular concern to the individual, such as health maintenance and the use of science and technology for intellectual enjoyment and for economic and political judgments.

A section of the curriculum should be organized to provide conditions for students to study scientists' conceptions of the natural world and descriptions of common phenomena. By one means or another, students should come to understand something of the theoretical and experimental processes by which scientists came to know what they know.

There is no need for a science course to be organized in the same way throughout the entire school year. To be effective, each section of a course should be structured in a manner that is supportive of the type of learning desired. One phase of the course might be organized in terms of a problem or issue, another historically presented, and a third discipline based. The traditional science course, organized entirely in terms of the codification of factual information (a misrepresentation of science), is least likely to achieve an understanding of scientific activity, as well as its benefits and uses in life. A conceptual framework embodied in personal and social themes provides the organizational structure to give coherence to the science curriculum.

Science Education: A Future Perspective. The basic assumption underlying the future perspective for science education is that science, technology, and society are not static. The very essence of science is the seeking of new knowledge and insights. With advancements in science and technology come change in society and the character of our culture. What these changes mean for life and living in the future is always uncertain; the fact of change is not.

Historically, the subject matter and teaching objectives of science education have been oriented almost entirely to the past and, at best, to the present. The tone of instruction is "this is what scientists have learned," as though science were a closed book. Seldom are lessons devoted to what is not known, what might be a future direction for research on a problem, or what new technologies are likely to be spawned from research information at hand. Nor do most students leave a science course with the notion that the world they are going into will be different from the one they have been studying.

A future perspective to science teaching recognizes that most of our existing social problems that are related to science and technology are likely to persist but under conditions different from those of today. These problems will be influenced by new discoveries in science, new technologies, new human insights, and unexpected changes in the social system. These conditions, separately or together, will influence the students' options as citizens and the decisions that must be made to resolve disjunctions among science, technology, and society. Within

limitations, the future can be planned and directed. It need not just happen. Alternative plans for dealing with future problems, and the likely results of such plans, can be developed from what is currently known about science and technology. This is the basis of environmental impact studies and technological assessments. The results of such studies provide information for determining a future action.

A future perspective for science education focuses attention on the challenges raised by the powers of science and technology to alter, intentionally or unintentionally, the basic conditions of living and to modify social systems. In a broad way, human beings now have the capacity to direct their own evolution through the way science and technology are manipulated. People survive today who in yesteryears would have died. The mismanagement of the environment can serve to shorten life, or the same forces of science and technology can be marshalled to improve the quality of life.

A future perspective for science education expands the goals and objective of science education. These extensions include

Sensitizing students to expect change and to anticipate change

Recognizing that the future of human beings and the quality of life are not capricious

Enhancing the student's self-concept so that, as an individual, he or she can use the knowledge of science and technology to make decisions that can lead to a more desirable world

Helping students to acquire capacities to cope with changes as well as to shape changes

Overall, a future perspective for education in science and technology provides a means for students to learn their civic responsibilities as custodians of the future. Furthermore, it is expected that students will recognize that with change there are demands for more knowledge and that learning is an organic part of life. A future theme in science teaching is an effort to overcome the traditional passivity of science learning.

The Sciences: Methodologies and Generic Concepts. A precollege science curriculum should include the essence of scientific methods employed in special branches of science such as physics and biology. In addition, the student should acquire an understanding of the generic concepts that depict each of several science disciplines. The concepts to be taught should be those having the widest potential for use in the ordinary affairs of people.

In the study of science, students are expected to learn about the significance and limitations of scientific methodolgies, how scientific knowledge is advanced, and how science differs from other ways of knowing. The purpose is to comprehend what is meant by reliable or valid knowledge and the limits of this knowledge. Equally important is an

opportunity for students to become acquainted with common phenomena and how scientists describe these phenomena.

By the time students complete the secondary school, they should have an idea of what is meant by basic and applied research and technological development. The purpose of this information is to minimize the false images of science so common in the public mind.

CHAPTER 3

DOCUMENTS RELATED TO THE CRISIS IN SCIENCE EDUCATION

Between 1970 and 1980 various citizen, science, and education groups analyzed the crisis in science teaching. Most such committees were more specific in isolating apparent causes of the crisis than in suggesting remedies. Following are summaries of published committee reports on problems and issues in science teaching in the United States.

I. Science Education: Accomplishments and Needs. Washington, D. C.: National Science Teachers Association, 1978, pp. 1-60. Factors perceived as related to the crisis in science teaching:

Decline in student population
Increasing diversity among students
Decline in local and national funding
Loss of public confidence in science and public education
Decline in science course enrollments
Unfavorable student attitudes toward schooling
Science curricula unsuited to current needs
Inappropriate preservice and in-service teacher education
Unionization of teachers
Mandated accountability

II. R. E. Yager (Ed.). Status study of graduate science education in the United States, 1960-1980. Final Report. Iowa City: Science Education Center, University of Iowa, 1980, pp. 91-116.

Study A. Only sections that refer to precollege science education are reported here. One hundred fifty college and university faculty members, representing nearly all the science education research centers in the United States, identified the following factors as contributing to the crisis in precollege science education:

General anti-science tenor in the United States
Declining enrollments in science courses
Diminishing financial support
Lack of leadership in science education
Lack of a theoretical base to guide research
Poor quality of teacher education programs
Inappropriate school science curricula

Study B. This study included precollege science teachers, inservice supervisors, department chairpersons, graduate students in science, and college science educators (N = 150, 30 in each category). The respondents listed the following factors as contributing to the crisis in science teaching:

Confusion about goals and objectives
Lack of vision and leadership in schools and universities
Public apathy toward science
Limited budgets
Poor quality of teacher education
Limited scholarly dialogue between educational researchers and practitioners
Declining enrollments
Lack of a theoretical base for education in the sciences

III. A national agenda for the eighties. Report of the President's Commission for a National Agenda for the Eighties. Washington, D. C.: U. S. Government Printing Office, 1980, p. 48. Contributing factors to the crisis in education were identified as follows:

"One reason for some of the public school's difficulties is the absence of planning for future demographic and social change" (p. 85).

"The fractionalism that engulfed public education during the 1970s was not conducive to learning or excellence in the public schools, nor was it healthy for the scientific, technological, and economic growth that is stimulated by a thriving educational system" (p. 89).

IV. National Science Foundation, Office of Program Integration. What are the needs in pre-college science, mathematics, and social science education? Views from the field. SE 80-9. Washington, D. C.: Government Printing Office, 1980. The National Science Foundation obtained reactions from nine different science, education, and citizen organizations on their views of the status of science education after reviewing the results of three national surveys of science teaching. Reactions from these reviewing groups include:

"Secondary school science education seems to lack a sense of direction and a theory and philosophy which should provide guidance to curriculum development and instruction. What students should learn also remains unclear" (p. 67).

"It seems doubtful that there has ever been a time in which there was so much uncertainty about the purposes of education" (p. 67). A further examination of the goals and purposes of science teaching is needed (pp. 50,75,176) especially in terms of what the nonspecialist needs to know (pp. 98,68,130,159).

"The school climate under which teachers are working is less favorable to the pursuit of excellence than it was in the latter part of the 1950s and most of the 1960s" (p. 96).

"Although the 'return to the basics' has shifted into high gear in school systems throughout the United States it is paradoxical that this activity has been accompanied in many schools by an increased molecularization of the curriculum into disembodied learning objectives, the achievement of which is usually indicated on...tests (which) emphasize the most superficial aspects of learning..." (p. 93). Lack of teacher preparation (p. 203), the misassignment of teachers (p. 75), and the lack or weakness of in-service programs were recognized (pp. 43,65,182,145).

V. National Assessment of Educational Progress. Three national assessments of science: Changes in achievement, 1969-1977. Denver: Education Commission of the States, 1978. This study revealed a decline in scores from one test period to the next with the largest drop in the physical sciences. The smallest drop was in junior high school science. (See Section II of this report for details.)

VI. E. J. Ogletree. The status of state-legislated curriculum in the U. S. Phi Delta Kappan, 1979, 61, 133-135. One indication of the low priority of science in the school curriculum is the small amount of science mandated by a state for all students. A survey of state-legislated curriculum requirements shows:

> Half of the 50 states require at least one science course at some grade level between kindergarten and high school graduation; five states require two or more years. In seven states the mandated course is physiology.
>
> Eighteen states mandate one or more courses in health and hygiene and for five of these states these courses are the only science requirement.
>
> Local school systems frequently require more science courses than those mandated by the state. Universities typically require two years of high school science for admission.

VII. P. S. George (Ed.). The middle school: A look ahead. Fairborn, Ohio: National Middle School Association, 1977. An interdisciplinary panel reported factors likely to influence the future of education in the middle schools of the United States and made the following predictions:

"The percentage of American children living in poverty will increase.

"Family expectations, attitudes, and aspirations toward students' education will decline.

"The self concepts of students will become more negative.

"The general ability of students, as measured by IQ tests, will decrease.

"Student motivation will decrease and attitudes toward school will become more negative.

"The students' sense of control of their own fate will decline.

"Peer group expectations, attitudes, and aspirations toward school will become more negative.

"Teachers will expect less and less in terms of performance from their students.

"Teaching, how the teacher actually carries out the tasks of teaching, will get better.

"Leadership styles and organizational climate of schools will get better" (p. 156).

Correctives for some factors were seen as a possiblity if the educational community can be mobilized.

VIII. National Commission on the Reform of Secondary Education. _The reform of secondary education_. New York: McGraw-Hill Book Co., 1973. This study surveyed "panels of superintendents, principals, teachers, parents, and students representing a mix of urban, suburban, and rural populations" regarding national goals for education.

"There is very little disagreement among the four groups polled on the desirability of the goals, the responsibility of the schools for achieving them, or the levels of success of recent graduates. Parents, much more than anyone in the schools, regard computation skills as 'essential'; teachers, much less than any of the others, regard occupational competence as essential; parents and students are less likely than the others to say that 'knowledge of self' and 'appreciation of others' are responsibilities of the schools. But even in this area, agreement is more common than disagreement" (p.31).

IX. University of Southern California, and Sutherland Learning Associates, Inc. _Science education for early adolescents: A needs assessment and feasibility study_. Los Angeles: University of Southern California, 1979. Parents, who were members of school advisory councils associated with junior high schools, were asked to react to the teaching of science. A digest of these discussions shows that:

"Most parents are not particularly concerned about the science education of their children."

"Science education should be practical. It should equip students with tools they can use in coping with the real world."

"Most children are not interested in science, and the schools must shoulder much of the blame."

Science instruction ignores the fact that junior high school students "are full of curiosity, wonder, and fun."

Science instruction would be of greater value "by making students aware of career possibilities and the preparations necessary" (pp. 50-51).

X. F. B. Evans and J. A. Harmon. Opinions of Wisconsin citizens about educational goals. Phi Delta Kappan, 1979, 61, 131-132. The investigators randomly selected 444 adult Wisconsin citizens and interviewed them for opinions on 18 educational goals and the emphasis that should be given to them in schools. To "know about recent scientific advances and understand how our ways of living are affected by them" was rated an important educational goal by 76% of the citizens interviewed. Forty-eight percent of the citizens thought this goal should receive more emphasis. Though, in general, there was a favorable attitude toward science, the goal was ranked 17th both in importance and in terms of the need for more emphasis among the 18 educational goals rated. Some of the stated educational goals that could be achieved through science such as "enjoy our natural environment and want to protect it" and "be able to think for themselves" were rated above 90% in importance, and above 70% as needing much more emphasis in schools. Citizens tend to view the importance of educational goals in terms of their meaning for the practical affairs of life and living (pp. 131-132).

XI. J. I. Goodland, K. A. Sirontnik, and B. C. Overman. An overview of a study of schooling. Phi Delta Kappan, 1979, 61, 174-178. Observing directly what goes on in schools combined with the reactions of those associated with schools (parents, students, teachers, central office administrators, school board members, and nonteaching staff members) can serve to provide some insight as well as generate thoughtful questions. This project had these characteristics. Some of the findings were:

A. M. Bentzen, C. Williams, and P. Heckman. A study of schooling: Adult experiences in schools. Phi Delta Kappan, 1980, 61, 394-397. Over 75% of the teachers were satisfied with the organization, type of leadership, and decision-making policies of the school. However, only 12% agree strongly with this position. Less than half of the secondary school teachers with inner-city assignments thought their jobs were moderately or strongly satisfactory (pp. 395,397).

B. J. Benhan, P. Giesen, and J. Oakes. A study of schooling: Students' experiences in schools. Phi Delta Kappan, 1980, 61, 337-340. General student self-concept shows small gradual increases from one grade level to the next; peer self-concept remains fairly stable; and academic self-concept scores show a slight downward trend as a student progresses through the grades.

Students who plan on some form of higher education have higher self-concept scores (of all types) than those who plan to quit school, just finish high school, or don't know (p. 338).

M. F. Klein, K. A. Tye, and J. E. Wright. A study of schooling: Curriculum. Phi Delta Kappan, 1979, 61, 244-248. The goals of schooling (intellectual, social, personal, and vocational) were studied as one aspect of the curriculum. Approximately 50% of parents and teachers stated the intellectual goal should be emphasized; next, personal goals (30% parents and 20% teachers); followed by vocational goals (20% parents and 10% teachers); and social goals were ranked evenly by parents and teacher (pp. 245-246). Although there was a great variation from school to school "on the average, parents, teachers and students are fairly well satisfied with the curriculum, at least as they perceived it" (p. 246). Teachers at all educational levels judged curriculum materials as appropriate for about 75% of their students, except in schools serving predominantly Hispanic or black students where the rating dropped to 50% (p. 247).

XII. Science education for the 1980s. Washington, D. C.: National Science Foundation, 1980. The Advisory Committee for Science Education of the National Science Foundation, in its report to the National Science Board, noted that "at the very time that the strong federal effort in support of science is having its major impact, education of our citizenry to understand and cope with this impact is declining in effectiveness" (p. 1).

CHAPTER 4

DOCUMENTS SUGGESTING PERSPECTIVE AND DIRECTIONS FOR PRECOLLEGE EDUCATION IN THE SCIENCES

In a report developed for the National Science Foundation by the National Academy of Sciences--National Research Council, the following purposes for the teaching of science were recognized (1):

"Knowledge is a value in itself" as it serves to expand the world view of the learner.

"Knowledge may be useful by helping the individual to live in greater health and happiness, and even to survive better in a competitive society.

"Important economic and social values are involved. Citizens with knowledge of science and mathematics are necessary for a healthy economy and for future progress; and intelligent action on many public issues depends upon understanding their scientific and technical content.

"The education may be preparatory to a professional career in science or one of the technical professions (p. 98-99).

The committee specifically recommends that "knowledge useful for one's own well-being and knowledge useful for good citizenship" need to be emphasized, as well as information on career awareness, as new science curricula are developed.

In a joint report prepared by the National Science Foundation and the Department of Education, it was proposed that (2):

The goals of science teaching should extend beyond scientific and technological enlightenment to include social, political, and economic considerations.

Precollege science courses should be more "directed toward personal or societal problems involving science and technology," providing "students with a better basis for understanding and dealing with the science and technology they encounter as citizens, workers, and private individuals."

There is a need "to prepare students to understand and use the new electronic aids to the human mind."

"The curriculum should develop a better connection of science and mathematics with the future needs of students."

Courses should include information on career awareness of opportunities in science and technology.

Curriculum materials should be developed that "focus on the science and technology basis of essential national problems such as energy, natural resources, and health."

Curriculum materials are needed "with a special emphasis on the special needs of minorities, women, and the physically handicapped. This is specially important for students in the middle and junior high schools" (pp. 3-7,45-51).

Science Education for the 1980s, a statement to the National Sciences Board by the NSF Advisory Committee for Science Education (3), includes suggestions that new perspectives are needed for the teaching of science that:

Respond to the "new problems in the changing relationship between science and technology and the larger society" and make it possible for citizens to understand their role in modern life as well as facilitate the use of science and technology in matters of personal choice and public policy (p. 7).

Emphasize science career awareness that relates to the special needs of the gifted, women, and minorities in science (p. 9)

Throughout the report there is heavy emphasis on the need to include the study of technology along with science.

The National Science Foundation (4) panel report on early adolescence contains the following perspectives and recommendations for the reformulation of science teaching in middle and junior high schools:

A curriculum oriented to the real world of life and living of early adolescents

A wider use of out-of-school learning resources to extend an appreciation of science

Special efforts to provide students with opportunties to become aware of careers in science

A greater integration of science with other school subjects such as mathematics and social studies

Greater opportunities for critical thinking and social interaction in learning

A change in curriculum context from that of discipline to scientific/social problems and issues.

A 1971 report of the Advisory Committee for Science Education of the National Science Foundation made recommendations for the future course of science education (5). The report stresses one overriding goal: "To educate scientists who will be at home in society and to educate a society that will be at home with science" (p. 21). Other educational recommendations with goal implications are:

"Increased emphasis on the understanding of science and technology by those who are not, and do not expect to be, professional scientists and technologists"

A shift, in part, "from the traditional discipline orientation to interdisciplinary approaches centered upon problems faced by informed citizens"

An extension of science education to include out-of-classroom resources such as museums, traveling exhibits, films, amateur science, television, newspapers, and magazines

A "second generation" of curriculum development that is more "genuinely problem-oriented rather than discipline-oriented" (pp. 21-26)

The committee saw the need for "a larger common body of knowledge and experience which is shared by all our citizens," a strengthening of career and vocational experience in the sciences, a consideration of the social relevance of science, and innovations in science teacher education.

The National Academy of Sciences, in a series of Academy Forums, considered the following issues to be of central importance as perspectives on citizens and science, and on scientists and society in the current of history (6). Major issues identified that could have implications for a general education in the sciences were:

Scientific theories and social values
The citizen and the expert
The use of knowledge: frontier expansion or inward development

In 1980, the National Research Council sponsored a series of panels on educational policies in science and engineering (7). Implicit in the discussion by panel members was a recognition of the interconnectedness of science, technology, society, the economy, and education for the nation's well-being and security. Progress in science and technology is vital to the quality of life and welfare of the nation. The full use of human resources (women, minorities, handicapped, talented) must be marshalled to advance science and technology. The education system must assure in our population:

A broad grasp of basic mathematics, science, and technology among the general citizenry, and the technical skills needed for economic productivity among our workers

A high level of scientific literacy including a familiarity with scientific concepts and the tools of technology for understanding the world in which we live and to make decisions that are affected by scientific and technological development

People with skills in data analysis, logical reasoning, and problem-solving, backed by scientific training

The science curriculum must be responsive to changing social needs, student interests, and technological developments. A basic knowledge of science is essential for understanding the consequences of discovery and for making informed decisions on science and technology as they are now a part of the political process. Career awareness and basic preparation for scientific and technological vocations are recognized as essential objectives in the teaching of science.

A 1971 report of the Joint International Conference of the American Geographical Society and the American Division of the World Academy of Arts and Sciences stressed the importance of connecting scientific knowledge with public policy (8). This will require a "plenary flow of accurate knowledge," including all aspects of scientific knowledge and social processes likely to influence the social character and decisions about the future of all humans. Knowledge is viewed as ineffectual unless means exist for bringing it into use. The knowledge needed in a changing society will require continuous responsible reviewing, renewing, and innovation recognizing there is an inexorable progression in the adaptation of knowledge for the improvement of life (p. 601). This means equipping students with the capacity to learn (p. 599). The report stresses the importance of interdisciplinary considerations of science, the global nature of scientific/social problems, and the importance of skills in decision making.

An American Association for the Advancement of Science committe, in reviewing the broad picture of precollege science education, "stressed the importance of understanding the science and technology that bear upon the human condition" (9).

The commission for a National Agenda for the Eighties based its education recommendations on the themes of equality, competence, and excellence (10). The commission recognized that the changing world order challenges the conventional expectations about the future of science and technology (pp. 155-156). The most important issues on the agenda for the eighties occur at the interface of science, technology, and society (p. 157). The desire of the citizen for more participation in science and technology policy making will require instilling in the public some basic knowledge about what science can and cannot do, and the limitations of expert opinion.

"Conceptual skills such as logical reasoning, problem solving, and analytical thinking must be developed throughout the citizenry. An awareness of the realities of probability, risk, and uncertainty will also be critical in understanding options involving the development and implementation of the technologies of the future....In this regard, taking risks for society as a whole should once again be acknowledged not only as acceptable but also as necessary for social progress" p. 159).

The effects that discoveries in science and technological innovations are having on society are increasingly complex. They are altering social values as well as public attitudes. The interpretation of information in a scientific/societal context involves ultimate policy and value judgments. "At each point in the decision-making process, the basic value questions and the trade-offs involved need to be dealt with directly" (p. 112).

The National Science Board (11) points out the importance of advancing general scientific knowledge as a means of dealing with major problems facing the nation and the world, such as population growth, health care, food supply, energy demands, mineral resources, climatic changes, and environmental alterations. "Principal attention, however, is focused on the new challenge posed by man's increasing power to shape the future, to modify, intentionally and unintentionally, the basic conditions of life" (p. 49).

Science and technology cannot solve scientific/societal problems alone; "a broader commitment and larger strategy" are needed. "The principal role of science and technology is to provide better options than are now available for meeting these problems." The task is one of "improving the understanding of interpersonal, institutional, and social problems, and developing and gauging the success of alternative approaches for alleviating them." This will require that "knowledge from the diverse scientific disciplines be synthesized and focused on the complex of problems identified....Such integration could sharpen the understanding of the interactions among the problems, help to identify knowledge gaps and priorities for filling them, and suggest directions for attacking the problems which would neither aggravate related problems nor create serious new ones" (p. 50-51).

The report of the President's Commission on Government and the Advancement of Social Justice (12) states that the "essential mission of the school is to give students the basic skills and social experience required to become functional and productive citizens in a democratic society" (p. 76). General recommendations of the commission include:

More real-world experiences for students

New up-to-date vocational programs

A broader involvement with learning resources outside the schools

More attention to the processing and transmittal of information

Equal educational opportunities with the meeting of special needs of individuals

"The talents of promising and high-achieving students must be given full scope" (p. 87).

"The middle school would offer a rigorous completion of basic school training and a common knowledge of history, global studies, future studies, and human relations" (p. 91). "A core of knowledge" plus "community-based, active learning"

Students should be promoted on the basis of "mastery of subject matter."

The panel recognized that "financial, structural, and programmatic changes are necessary but not sufficient to remedy the problems and the malaise in public education" (p. 102).

A 1970 Educational Policy Research Center report (13) isolated the dominant problems in the world that have been brought about by a combination of rampant technological application and industrial development, together with high population levels. If these macroproblems are to be resolved, educational efforts must, directly or indirectly, be focused on change. Change might take place in several directions that could be described as alternative futures. A framework of education oriented to thinking about and coping with an uncertain future would differ markedly from traditional educational roles and practices. It would require a transdisciplinary, problem-centered curriculum; a strong emphasis on inquiry training; and a reconsideration of basic premises, values, attitudes, beliefs, and perceptions. The knowledge base would need to be relevant and useful. An education for change requires that the learner develop skills essential to provide a continuing access to knowledge. The management of knowledge in dealing with problems involving humans will require training in ecological thinking and an appreciation of human diversity.

The Exeter Conference report was formulated by 38 secondary school science teachers from throughout the United States and ten specialists in science after a week-long consideration of the "crisis in science education" (14). The conferees were unanimous in recommending that societal and ethical consequences of modern science and technology should be a part of the science curriculum in schools.

Project Synthesis, a two-year study of the "countenance of science education," based on the three national status studies of science teaching supported by the National Science Foundation, resulted in the following recommendations (15):

"A major redefinition and reformulation of goals for science education; a new rationale, a new focus, a new statement of purpose are needed. These new goals must take into account the fact that students today will soon be operating as adults in a society which is even more technologically oriented than at present; they will be participating as citizens in important science-related societal decisions. Almost total concern for the academic preparation goal, as is currently the case, is a limiting view of school science.

"A new conceptualization of the science curriculum to meet new goals, redesigns of courses, course sequences/articulation, and discipline alliances are needed. The new curricula should include components of science not currently defined and/or used in schools. Direct student experiences, technology, personal and societal concerns should be foci" (p. 129).

"The involvement of ethics and values in the practice of science and technology...is the renewed and growing concern of a variety of scholars and practitioners" (16, p.v). This trend has implications for science education in schools. To the present time, the issue has received more attention at the college and university levels. The results of a national survey to determine the extent of academic activities in the field of science, technology, and human values in institutions of higher education revealed that courses or programs were offered in 919 colleges or universities (p. 182). In addition, courses or programs related to science, technology, and society; environmental concerns; health care; and contemporary moral and ethical problems related to science and technology were offered in 879 higher institutions (pp. 185-202). These results are from 2,000 completed questionnaires.

The general concern about issues of science, technology, society and associated value, ethical, and moral questions is widespread throughout colleges and universities. These issues are considered in courses found in departments of engineering, social sciences, physics, history, English, communications, humanities, biological sciences, anthropology, chemistry, philosophy, economics, political science, urban affairs, psychology, medicine, allied health fields, astronomy, computer science, geosciences, religious studies, law, business, geography, and agriculture. Some schools created special departments or organized interdisciplinary programs identified as "science, technology and society," "environmental studies," or "general studies" to teach the new course (pp. 33-35).

The National Science Teachers Association has taken the position that the teaching of science should make a difference in the lives of students and the quality of the environment (17). If citizens are to be literate in science they must be able to understand and use the knowledge, methods, and attitudes of science for coping with and resolving the many problems and dilemmas in contemporary society, both personal and social:

Faith, Science and the Future, a report by the World Council of Churches (18), explores the church's role in resolving social problems and dilemmas involving the application of science and technology. The report recognizes an essential relationship between "the venture of science and technology and the venture of faith" (p. 21). Science and technology are seen as critical to improving the quality of life and attaining economic security in any country of the world, but they are insufficient in the absence of philosophical and ethical considerations. Traditional attitudes and value systems representing the interaction of technology, science, and the economy will need to be changed if the concept of a "post-modern society" characterized by a highly refined economic/technological/industrialized system is to be achieved. A number of science/technology-based social and economic problems were explored and the need for an "intellectual enlargement built around a specific set of assumptions" was recognized.

The American Academy of Arts and Sciences examined the growing challenge to the theoretical foundations of science and its place in society from a number of viewpoints by scientists, social scientists, engineers, philosophers of science, and others in an issue of *Daedalus* on "science and its public" (19). Although no effort was made to achieve a consensus on the issue, several ideas were recurrent. "At least until recently, the relationship between man and nature which has evolved from modern science has been more or less tacitly understood (at least in the western world) in about the same way among those who have received any substantial education. In this relationship, science was thought to have two largely beneficial functions: first, to provide a method for gaining a deeper understanding of the links between man and wider nature, and in this way to make him intellectually (and perhaps spiritually) more exalted; and second, to help him transcend his physical limitations, for example, by paving the ground for medical and other technological developments" (p. vi).

Since the close of World War II, the intellectual character of science has been increasingly challenged. "Whereas the goals of science are largely derived from the structure of science itself, those of technology frequently derive from political, economic, and other external affairs" (p. 105). Science claims a kind of morality and justification intrinsic unto itself; technology is often judged in relation to outside values. This distinction is not typically made by the public, where science is most often viewed in forms of technological applications. Few people seem interested in science as an intellectual, aesthetic, or "methodological enterprise." "The overwhelming majority of the public seems to confuse science and technology and sees science in a very technological, instrumental light" (p. 203). Of all the American institutions, science seems to be the least understood by the public at large.

There are those who claim that the limit of science is simply providing information about the world. Essentially, this is an appeal for other ways of knowing the world that contrast with the essential objective view of the scientists.

The deliberations reported in the volume on "modern technology" published in Daedalus note that many public discussions of technology are more appropriate to the nineteenth century than to the twentieth (20). Older views of technology focus more on machinery than on system. A modern view insists "that it be thought of not as a collection of artifacts, however sophisticated and complex, but as a system whose social, cultural, intellectual, managerial, and political components are seen as integral to it" (p. v). We also need to recognize that the relationship of science and technology is more complexly intertwined than often imagined. "The connections between science and technology have become increasingly strong in the modern era of systems development and application" (p. 81).

Advances in technology very often bring about a reexamination of human values, influence our "evolving economic design," foment changes in professional education, and open new possibilities for scientific achievement. "It is worth noting that the conjunction of technology and human desires represents a fundamental meeting between the natural law and the reaches of the human mind" (p. 177).

An international organizaton of scholars in several social science disciplines examined "the social and policy dimensions of science and technology" (21). The group recognized that, while studies of the interaction of science, technology, and society have yet to form a coherent discipline, they do have a background of serious academic inquiry. "Never before have the economic as well as the social and ecological consequences of scientific discovery and technological innovation been so influential upon the fortunes of particular nations and upon the entire world system. Scientists and technologists have therefore become important contributors in the quest for economic growth and security, and for the alleviation of disease, poverty and overpopulation" (22).

Science has become a part of social policy, and technology a part of scientific policy. These new relationships have brought about efforts that combine the solution of practical problems with the progress of basic knowledge in the sciences. The links between social processes and scientific knowledge, and how each system influences the other, are generating new perspectives about the place of science in society. The new emphasis in technology is how to make it more socially responsive to human needs. The growing importance of the forces of science and technology in changing structural trends in society and politics is not to be overlooked.

The interaction of science and technology with human values is where some of our more pressing problems arise as changes are stimulated in human ecologies and social norms. "The central problem in both controlling technological change and setting priorities for the future development of science and technology is choosing between (such) conflicting and incommensurate values" (23).

Sociotechnical achievements have served to extend human capacities: for example, transportation and communication systems. Economic,

political, and social issues are associated with advances in technology. Technology is a distinctive form of cultural activity with its own character and processes. Because technology creates new social arrangements, new forms of culture, and--through culture--changes in human values, it is essential that it be studied from a cross-disciplinary perspective.

Education for a New Millennium (1981) presents a composite view of 132 international scholars on the role of the future in educational planning and in curriculum development (24). The focus of the study was to identify the content of general education likely to be suitable for the next two decades. The central question was "how to cope and improve our present levels of thinking and acting, rooted as they are in a world in which traditional ways of thinking and acting often are neither adequate nor relevant" (p. 31).

The source of "curriculum content for the future should be influenced by the concepts that natural and social scientists believe people of every age must understand" (p. 118). In the natural sciences, some of these basic concepts identified were (pp. 33-47):

"The doctrine of limits; the need to conserve"

"The ecological concepts of interdependence found in nature, including human interdependence".

"The threat of ecocide" (destruction of the earth)

"Entropy and conservation"

"The dangers of explosive population growth"

"The scientific method" and need to recognize its limitations

"The concept of evolution"

"The unity of nature"

"Photosynthesis, oxidation, and cycles in nature"

"The particulate nature of matter"

Resources and the conservation of energy

Probability, in order to make rational decisions

"The conservation of energy"

The assumption was made that scientific knowledge, to be useful in decision making, must be at a conceptual level. The majority of concepts have an interdisciplinary "thread" with links to other natural sciences and often to the social sciences.

The information overload in the sciences and the enormous production of new information means that procedures for lifelong learning and rational and methodological approaches to handling knowledge must be developed (p. 46). "The goals of instruction, insofar as possible, should be modified to reflect the images of the probable future" (p. 119).

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