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ABSTRACT

This review for 1975 has been issued to analyze and synthesize research related to the teaching and learning of science completed during the year. The review is intended to provide research information for development personnel, ideas for future research, and an indication of trends in research in science education. Research has been listed in general categories of: (1) History and Status; (2) Piaget; (3) Classical Science Disciplines; (4) the Teacher; (5) Methods; (6) Special Problems; and (7) Foreign Science Programs. In all, 379 separate studies are cited in the bibliography and most are mentioned in the text. Many intermediate summations and generalizations are included at the end of sections and subsections. (SL)

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A SUMMARY OF RESEARCH IN SCIENCE EDUCATION—1975

Foreword

Research Reviews are being issued to analyze and synthesize research related to the teaching and learning of science completed during a one-year period of time. These reviews are developed in cooperation with the National Association for Research in Science Teaching. Appointed NARST committees work with staff of the ERIC Science, Mathematics, and Environmental Education Information Analysis Center to evaluate, review, analyze, and report research results. It is hoped that these reviews will provide research information for development personnel, ideas for future research, and an indication of trends in research in science education.

Your comments and suggestions for this series are invited.

STANLEY L. HELGESON
PATRICIA E. BLOSSER

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Volumes prior to 1973 of the SCIENCE RESEARCH REVIEW SERIES are available from the SMEAC Information Reference Center, The Ohio State University, 1200 Chambers Road, Room 310, Columbus, Ohio 43212. Volumes from 1973 on are available from John Wiley & Sons, Inc., 605 Third Avenue, New York, N.Y. 10016.

Contents

Reviews of Science Education Research — In Retrospect

For more than fifty years, science educators, both individually and cooperatively, have sought to compile from the literature summaries of various types of investigations related to the teaching of science. Among the earliest, and probably the classic efforts, were the three momumental publications listed below prepared by Dr. Francis D. Curtis of the University of Michigan:

A Digest of Investigations in the Teaching of Science in the Elementary and Secondary Schools. Philadelphia: P. Blakiston's Son and Co., Inc., 1926.
(Including the research investigations published prior to 1925.)

Second Digest of Investigations in the Teaching of Science. Philadelphia: P. Blakiston's Son and Co., Inc., 1931.
(Including chiefly the research investigations published from 1925 through 1930.)

Third Digest of Investigations in the Teaching of Science. Philadelphia: P. Blakiston's Son and Co., Inc., 1931.
(Including chiefly the research investigations published from 1931-1937.)

The contents of the first Digest were selected entirely by the author from among the many published and unpublished learning and curricular investigations in the teaching of science. The popularity of the first volume led a number of science educators to recommend that a second volume be prepared but that it should include investigations selected in areas other than learning and curriculum and should be extended to cover the college as well as the elementary and secondary levels. This vastly enlarged the base of studies from which the selections would be made and obviously complicated the procedure for determining what should be included. Members of the National Association for Research in Science Teaching were polled for their recommendations. The studies ultimately included were chiefly those that were recommended most frequently. The popularity of the Second Digest led to recommendations for the Third Digest and the selection procedure for entries was similar to that for the Second. The regard in which these Digests have been held is ample support for their publication.

Curtis had every intention of continuing his activities with additional Digests but the advent of World War II led to a hiatus in his efforts. His decision to discontinue plans for additional Digests was motivated by his severe illness in 1946 and 1947. Further, he had some reservations about the formats of the Digests. The materials included were essentially extensive abstracts that were treated more or less independently, although those dealing with similar problems were grouped

into categories. For all practical purposes no effort was made to synthesize the findings or conclusions of the investigations.

In 1948, Curtis chaired a symposium at the meeting of the American Educational Research Association in Cleveland in which an effort was made to synthesize the findings of selected investigations, completed between 1937 and 1947, at the elementary, secondary and college levels. The author of this review made the presentation for the secondary level. This presentation was published as "The Implications of Recent Research in the Teaching of Science at the Secondary-School Level," Journal of Educational Research (January 1950).

The interest in the synthesis of findings and conclusions of research in science education led the National Association for Research in Science Teaching to request this reviewer to co-author the two following publications:

"Some Implications and Practical Applications of Recent Research in the Teaching of Science at the Secondary-School Level." Science Education, XXXVIII (February 1954).

"Some Implications of Recent Research in the Teaching of Science at the Elementary School Level." Science Education, XXXVIII (February 1954).

Both of these were efforts to complement the Curtis Digests with syntheses of the findings and conclusions of published studies since 1937. But, it was obvious that the task was becoming too great unless a team effort was initiated. So, the National Association for Research in Science Teaching sought to have annual reviews presented by teams at its annual meetings. In addition, reviews of science education research became part of the cycle of research reviews that appeared in Review of Educational Research, a publication of the American Educational Research Association. However, the goal of reinstituting the Digests with modifications to include syntheses of research findings was elusive.

The Digests by now were no longer available from the publisher. However, as a service to the science education community they were reprinted in February, 1972, by Teachers College Press, Teachers College, Columbia University. As a further service, the following three volumes were published under the general editorship of Willard J. Jacobsen:

Boenig, Robert W. Research in Science Education: 1938 through 1947. New York: Teachers College Press, 1969.

Swift, J. Nathan. Research in Science Education: 1948 through 1952. New York: Teachers College Press, 1969.

Lawlor, Elizabeth Phelan. Research in Science Education: 1953 through 1957. New York: Teachers College Press, 1970.

The contents of these three volumes were selected essentially by preparing bibliographies of published science education research for the periods indicated and submitting them to juries of qualified science educators for their evaluation for inclusion. However, the format was similar to that of the Curtis Digests with little effort to synthesize findings.

Again, it became evident that the magnitude of the task was increasing and that organized cooperative efforts would be required to do a quality job. In 1965, the ERIC Information Analysis Center for Science, Mathematics and Environmental Education and the Center for Science and Mathematics Education, The Ohio State University; in cooperation with the National Association for Research in Science Teaching; and with a contract from the National Institutes of Education, Department of Health, Education and Welfare, began a series of reviews of science education research. Three of the more recent reviews are listed below:

Novak, Joseph D. A Summary of Research in Science Education —1972. December 1973.

Rowe, Mary Budd and DeTure, Linda. A Summary of Research in Science Education—1973. December 1974.

Herron, J. Dudley; Jaus, Harold H.; Van Neie, Thom Luce; and O'Heron, Terry O. A Summary of Research in Science Education—1974. December 1975.

This series of annual reviews was initiated when the U.S. Office of Education discontinued their reviews

This reviewer was asked about his willingness to accept responsibility for the 1975 Summary in the series and he agreed. At the time, he assumed the task would be equivalent to that for the studies which he prepared in 1950 and 1954 as well as later ones in the cycle of reviews of science education research that appeared in Review of Educational Research. The task has proved far more formidable. Without the assistance of many staff members of ERIC, it would have been impossible. It was extremely helpful to have been supplied with a list of the research studies that were to be considered for inclusion and to have had nearly all of them available in the Center.

However, since published and unpublished studies and research reports from outside the United States were to be considered, three trips had to be made to Columbus, Ohio to review the materials. Nearly all these studies and research reports, from within and without the United States, were identified by an ERIC journal article resume that did not provide adequate information for reviewing the material. Thus, it was necessary to read each study and research report and abstract it. Every dissertation to be considered was identified by a reproduction of the abstract from Dissertation Abstracts International. It was assumed that these abstracts would be prepared sufficiently well to use them per se without reading the dissertations. For many, the assumption proved

to be incorrect. It was distressing to note that about half the abstracts were so badly or incompletely prepared that it was necessary to obtain copies of the microfilm or microfiche, read the material completely and abstract it. Many of these microfilms and microfiche reproductions were not available at ERIC until December, 1976. It was also discovered that four of the dissertations were typed so badly that the microfilm and microfiche reproductions were unreadable. Thus, it was necessary to get manuscript copies.

When the bibliography was finally assembled, it was evident that a number of studies appeared in several entries. For example, as journal articles, in Dissertation Abstracts International, and/or as a research report in an ERIC journal article resume. Where such repetition occurred, the entry as a published journal article, if available, was retained. If the study appeared as the latter two, the entry for Dissertation Abstracts International was retained. The entry for Dissertation Abstracts International was also retained even if it was necessary to review the reproduction of the entire dissertation from microfilm or microfiche.

The next problem encountered was categorization of the studies for synthesizing the findings and conclusions. This created several problems in that categories, all parallel in structure, were impossible to establish. For example, the studies dealing with the Piagetian model almost inherently form a group despite the purposes of the studies. Also, some of the studies of foreign science programs and activities are sufficiently ethnic and culturally-oriented to make it difficult to group them with studies having similar purposes conducted in the United States. Consequently, they were categorized generally under "foreign studies" although some were grouped with studies conducted in the United States. One such "foreign group" involved research related to the Nuffield programs.

So with all the preamble, this Summary must stand or fall on its own merits. The reviewer offers much commendation to the ERIC Information Analysis Center for Science, Mathematics and Environmental Education and The Ohio State University for the invaluable assistance provided by its staff members. He accepts full responsibility for delays and malaccomplishments that may have occurred.

History and Status

The Way It Was

It is axiomatic that every thesis, dissertation and major research report has a section early in the narrative with a title such as "Background of the Problem." Every such investigation is justified on a number of bases, one being the logic derived from history. It is also true that in the past two decades there has been an upsurge in interest in the history of science, particularly with concerns about the social implications of scientific endeavors. Yet, studies in science education in which the primary purpose is historical analysis are few and far between. In this summary of 379 studies, only five were concerned with historical facets of science education.

Zaidenberg (374) investigated the development of science education at Harvard University for the period 1847-1869. Prior to this period the usual procedure for studying science and technology was either by oneself, or through an apprenticeship. It was Zaidenberg's conviction that the establishment of the Lawrence Scientific School at Harvard helped to transform traditional colleges into modern universities. The reforms necessary for such a transformation during the period with which the study was concerned were backed by teachers of science. Prior to this period, despite efforts to develop a true university, the reformers failed to comprehend the role of the University in modern industrialized society. The latter part of the study deals with the development of scientific spirit at Harvard, the emergence of professionalism, and the impact of the Darwinian controversy on the increased professional spirit in science.

Barnhardt (22) concentrated his efforts on attempting to isolate the curriculum requirement changes that occurred at the School of Engineering and Applied Science at the University of Virginia between 1940 and 1973 and then to identify the forces and agents contributing to the dynamics of curriculum reform. His data were gathered from an analysis of written documents and interviews with faculty and administrators.

He found that there had been a decline in credit and contact hours required for graduation, a de-emphasis on engineering laboratories and "how-to-do-it" courses, an increased emphasis on the physical sciences and mathematics, a trend toward commonality in various engineering curricula, and more opportunity for electives. In effect, the University of Virginia moved, as did many other universities, from strictly applied engineering to what is often termed "science engineering." The major forces suggested for these changes were technological developments, trends at other engineering schools, and the need to attract more undergraduate students. The major agent of change was the Engineers' Council for Professional Development (ECPD)—the accrediting agency for engineering schools.

Farmer (98) was concerned with determining the extent to which Darwinism had been a debated issue in Missouri education, the issue Zaidenberg (374) claimed helped stimulate the professional spirit in science at Harvard. His study was limited to Missouri for the period 1920-1970. Surprisingly most of the source material, including manuscript collections at the State Historical Society in Columbia, pertained to grades 7-12 rather than to education at the college level. In addition, data were gathered with questionnaires sent to 140 randomly selected biology teachers in Missouri and an examination of some biology textbooks used in Missouri in 1970.

Farmer found that the teaching of evolution was a major issue in Missouri only in the 1920's, a period during which the Scopes trial in 1925 drew the attention of Missourians. In 1927 an anti-evolution bill was introduced in the Missouri legislature but after a "hilarious" debate it was defeated. After the 1920's the investigator claims that little opposition to the teaching of evolution was evident, except in a few isolated areas.

According to Ogden (245) his aim was "to prepare a chronological history of the objectives for teaching chemistry in the high schools of the United States during the period 1918-1972 as reflected by statements in articles from selected professional journals." He established six subperiods for his analysis of trends, 1918-1933 (Cardinal Principles, Great Depression, and the 8-year Study); 1932-1941 (Roosevelt to World War II); 1939-1946 (World War II); 1945-1957 (Life adjustment education to Sputnik); 1954-1964 (Criticism of life adjustment and student unrest); and 1963-1972 (Uneasiness over first wave of post-Sputnik science curriculum projects). His data were collected from the science education periodicals for the period, including among others, School Science and Mathematics, Journal of Chemical Education and Journal of Research in Science Teaching.

Ogden found that the numbers of articles published remained fairly constant over the subperiods although prior to 1953 most articles were written by high school teachers, whereas the contributors since then have been largely from colleges and universities. In the first three subperiods the articles on chemistry dealt largely with content, with a shift in later subperiods toward attitudes and interest. Statements about knowledge objectives are predominant in all subperiods but especially so in subperiods 2, 5 and 6. Suggestions for inclusion of specific topics are most prevalent in subperiods 1, 3 and 4. The process types most frequently cited across the subperiods were "scientific method," "processes of science" and "techniques and skills" of inquiry with agreement among author groups highest on the elements in the processes of science.

Calabrese (59) undertook a relatively esoteric historical study with a philosophical bent designed to show the evolutionary basis for logotherapy. Logotherapy is a psychoterapeutic method introduced by Frankl of Vienna in which the study of conflicting behavior drives is de-emphasized with attention being given to the motivating mental level of the individual in order to enable him to discover the meaning of life. This study deals with the origin and basic assumptions of the method, the behavior of man as understood by evolutionary biology, the integrating of logotherapy within the evolutionary design, the influence of evolutionary biology on the economic behavior of humans, and the implications of evolutionary biology in the behavioral areas including science education. There are few practical applications for science education.

The historical studies just reviewed are too few in number and too diverse in purpose to synthesize any findings from which prognostications for science education can be made.

The Way It Is

The late 1950's and early 1960's were years of turmoil for science education. During the post-Sputnik period there were frantic efforts in nearly all states to assess the backgrounds of science teachers, the types of course offerings, the numbers of students enrolling in high school science courses and the like. The enthusiasm for such investigations has waned somewhat although nine status studies appeared in 1975.

The National Assessment of Educational Progress (233) produced a general information yearbook that describes an information-gathering project dealing with the educational attainments of 9-year-olds, 13-year-olds, 17-year-olds and adults (age 25-36) in various learning areas including science. About 100,000 persons were involved in the assessment. The 9, 13 and 17-year-olds participated in eight individualized scientific activities that required the use of scientific apparatus. These included, among others, colored water, volume of rock, and rotation and revolution. It was found that the percentage of students who performed the activities successfully was directly related to age. The greatest growth took place between the ages of 9 and 13, with 13-year-olds often performing as well as the 17-year-olds. There was, however, a "wide gap" between the ability to perform and the ability to explain procedures. Many students at all age levels could do things but could not explain what they were doing or how or why.

Three studies dealt with the area of earth science. A study by Orgren and Doran (248) sought to determine to what extent the adoption of the revised New York State Regents Earth Science Syllabus had on teacher behavior and student achievement. Three groups of classrooms (including teachers and their students) were involved, (a) those in which the traditional program was still being used; (b) those in which the use of the new Syllabus was optional; (c) those in which the teachers participated in the development of the Syllabus. It was found that teachers who followed the new curriculum used different teaching strategies from those who did not, and those who "got in early" behaved significantly more in accord with advocated teaching strategies than those who "got in late." But, the adoption of the new curriculum did not produce significant differences in using processes of science between students who were exposed to the new and those who were not. Neither did students whose teachers "got in early" score significantly better on achievement tests in earth science than students whose teachers "got in late."

Cross (75) conducted a study in Pennsylvania to determine (a) the characteristics of public secondary school teachers of earth science who were certified in that area and taught earth science at least 50 percent of the time and (b) the status of the Earth Science Curriculum Project (ESCP) in the schools. Questionnaires were sent to 495 teachers from whom about 55 percent usable returns were received. The data indicated that about two-thirds of the teachers had participated in at least one training institute, although one out of ten teaching earth science had never taken a course in the area and one out of four were not certified to teach earth science. Cross concluded that the teachers' lack of laboratory experience in earth science resulted in inadequate laboratory experiences in their classrooms. Also, although ESCP materials were used by over half of the earth science teachers in Pennsylvania, in more than half of the classrooms the traditional texts were also in use.

Exline (96) undertook a comprehensive study in 1972-73, somewhat similar to the one by Cross (75), in which he was concerned with the status of earth science in Virginia. He divided the State of Virginia

into seven regions to allow for comparisons and sent direct-mail questionnaires to 324 earth science teachers who devoted at least 50 percent of their time teaching that subject. An 82 percent return was obtained of which 79 percent were usable.

The responses indicated that 18 percent of the respondents were "endorsed" to teach earth science although 84 percent and 52 percent respectively were endorsed to teach general science and biology. More of the teachers were endorsed to teach chemistry and non-science subjects than to teach earth science. About two-thirds of the teachers thought the materials they had available were inadequate and about the same number indicated that their facilities were fair to poor but filled to capacity. The number of students enrolled in earth science in 1961 was 2,270 and in 1972, 40,509. The number of teachers increased from 65 to 430 from 1961-1972, but the number of Virginia teachers participating in college and university earth science programs had been decreasing.

These three studies suggest the need for more and better preservice and inservice education for earth science teachers.

Melko (220) investigated the perceptions of 50 randomly selected Wisconsin public high school teachers concerning science enrollments, adequacies and inadequacies of science courses in their schools, changes needed in science courses, and the types of outside help needed to facilitate the changes. The fifty teachers were interviewed between January 14, 1974 and March 29, 1974. In those cases in which statistical analyses were appropriate, the Chi-square statistic was used as an indicator of significance.

An analysis of the results indicated that the respondents were about equally divided in terms of satisfaction and dissatisfaction with science enrollments, and about half rated their courses and total curriculum in science as being adequate. The major strengths of the courses were claimed to be the laboratory, appropriate level of difficulty, and appropriateness to student needs. The changes proposed were principally modifications of current offerings rather than innovations.

Glass (118) made an evaluation of science education in grades K-12 in Iowa although the report did not indicate clearly the sources of the data. Presumably, they were from the Department of Public Instruction with which he was at one time affiliated. His evaluation indicated that there are many teacher preparation programs in Iowa that differ greatly from one-another and, consequently, the backgrounds of science teachers are varied. He also discovered that in many preservice programs for training science teachers the course content improvement programs supported by the National Science Foundation are never mentioned. In many cases the preservice science teachers meet with, and are supervised by, generalists rather than science education specialists. The report recommends that courses in professional education in all colleges and universities should be handled by specialists.

Another study dealing with science education from grades K-12 was undertaken by Thompson (339) to obtain information about the status of science education and the opinions of five different populations concerning what should be happening in science education in Oregon. The populations included eight stratified random samples of 261 and 255 elementary school teachers, 188, 185 and 208 secondary science teachers, 287 secondary school students, 225 PTA officers, and 204 scientists from Oregon State University. Although not indicated in Dissertation Abstracts International, it is assumed that data were gathered by means of questionnaires. Among the more significant findings were that (a) Science: A Process Approach (SAPA) was the most commonly adopted elementary school science program although Elementary Science Study (ESS) and Science Curriculum Improvement Study (SCIS were evaluated more favorably by elementary teachers; (b) poor facilities, lack of equipment, and poor academic training are not mentioned as barriers to effective science teaching; (c) 71 percent of the secondary science teachers have master's degrees; (d) there is little formal articulation between the elementary and secondary school science programs; (e) the greater the science background of an individual the less likely they perceive a conflict between science and religion; and (f) there was agreement that students should have some input concerning the contents of science courses. In total, thirteen recommendations were made to improve the quality of science education.

In two states studies were focused on the status of elementary science. In Indiana, Potts (271) surveyed 15 school "corporations" within a 75-mile radius of Indianapolis to determine the extent to which the critical thought process, a component of inquiry-discovery techniques, was being developed in elementary classrooms in which the Science Curriculum Improvement Study (SCIS), Science: A Process Approach (SAPA), or Elementary Science Study (ESS) was being used. The questioning techniques of 53 randomly selected teachers were assessed using the Clegg version of the Teacher-Pupil Question Inventory (TPQI) to determine how well the critical thought process was being implemented.

The classrooms in the corporations using SAPA in which questioning techniques were considered "good" had (a) extensive implementation programs; (b) individuals who adhered to the adoption, implementation and follow-through procedures; (c) adequate funding; and (d) involvement of teachers in decision making. The "successful" classrooms in which SCIS and ESS were used had (a) science-oriented teachers; (b) extensive inservice activities; (c) teacher involvement in decision making; (d) administrative support; (e) proximity of college personnel; and (f) adequate funding.

In brief, in the 8 of the 15 corporations judged to be successful, there was a commitment to the program on the parts of the personnel involved.

As part of a three-year cycle of assessment in grades 3, 6 and 9, The Division of Research, North Carolina Department of Public Instruction (379), administered an 80-item instrument to 2,500 randomly selected third graders. The instrument developed by the Science Education Division, North Carolina Department of Public Instruction, contained items dealing with life science, physical science, earth-space science, and process. Sixty-seven of the items were multiple choice, the remainder dealing with attitudes, superstitions and beliefs and enrichment experiences such as planting seeds and raising pets.

The students responded correctly to more of the life science items than to those in other areas, 93 percent responding correctly to the nine items in life sciences. To the three items on physical science, 90 percent, 64 percent and 70 percent responded correctly. On the earth-space science items, only about one-third knew the time lapse between full moons, whereas 97 percent knew that dinosaurs lived long ago.

In summary, the students achieved higher on life science items than on those for physical science or earth-space science. They also performed better on knowledge items than on those involving comprehension and application. Not surprisingly, the amount of education of the members of the family was found to be related to achievement.

The studies cited here differ from the status studies of a decade ago in that there is a greater emphasis on evaluating achievement, particularly with respect to inquiry skills, whereas most of the earlier status studies involved the assessment of teacher backgrounds and types of course offerings.

The World of Piaget

Education is replete with the ascendance and descendance of messiahs who capture the fancy of those who teach. The Twentieth Century has had its share: for example, Thorndike and Connectionism, Dewey and Learning-By-Doing, and Bloom and his Taxonomy of Educational Objectives. There have been, of course, many others but the current star is Piaget.

Piaget, a Swiss psychologist, has been studying learning behavior for about fifty years although his writings are relatively few in number. Reports about Piaget and Piagetian Developmental Theory are largely those prepared by his students and disciples. But, he has made three contributions of importance to science education. It seems appropriate to review these contributions to set the stage for summary of research studies that follows.

The first contribution is Piaget's concept of intelligence, namely, that it is neither qualitatively nor quantitatively fixed at birth. Rather, he believes that intelligence is a "form of adaptation characterized by equilibrium" and involves two processes, assimilation and accommodation. When a child receives new information from his environment, he assimilates it and the equilibrium is upset. As a child uses

the new information in forming a new concept, he accommodates, thus restoring the equilibrium. Of key importance is that Piaget asserts that children do not acquire knowledge merely by being told or by reading about it. Rather, the child must act on the knowledge. The action must involve a mental action, and in addition may involve some physical action. This "need for action" has become a key point in the inquiry approach to science teaching.

A second aspect of Piaget's work is his concept of the properties of logical thought. Piaget theorizes that a child is able to manipulate data that are stored in his mind and cites four important manipulations:

Combinativity—the ability to add ideas (figuratively, to "add two and two")

Identity —the ability to compare and contrast phenomena

Associativity—the ability to "add two and two" in different ways, but still come up with the same results

Reversibility—the ability to "retrace a path" in reverse order mentally

A third postulate of Piaget is the development during the adolescent years of what he calls "propositional thinking." In essence, this is the ability to state propositions in terms of variables that the adolescent has identified. The adolescent then is able to combine the propositions and test all possible combinations.

Piaget's observations and postulates led him to identify and label what most observant parents and teachers recognize, namely, the stages through which children evolve in their mental growth, or development of intelligence. He believes that they are as follows:

Stage 1—The sensori-motor stage of development, beginning at birth and extending through about one and one-half years. During this stage, the infant's a-tions are controlled primarily by basic reflexes and modified reflexes.

Stage 2—The pre-operational stage of development, extending from about 18 months to about seven years of age. During this period, a child's learning is based primarily on his perceptions, or "how things look to him," rather than on the use of logical operations. Ordinarily, during this period children can consider only one variable at a time. In grouping objects for example, a child will concentrate on color, or size, or shape, but seldom on all three characteristics simultaneously.

Stage 3—The logical operation stage, extending from about 7 through 12 years of age. At this time children learn to manipulate data mentally and deal with several variables. They are able to associate, reverse, and combine information.

Stage 4—The formal operations stage of development, extending from age twelve throughout the high school years. Here students are capable of propositional thinking and they mature in their ability to profit from inquiry activities in science. He does indicate that there are transitional stages between the ones listed.

For convenience, most of the studies dealing with Piagetian Developmental Theory are grouped according to the level of the subjects involved —elementary, secondary and college. In those cases in which the boundaries are crossed, the studies have been included with those at the lower level.

Validity of Piaget's Assumptions

Guerin (128) sought to test the validity of four of Piaget's basic assumptions: (1) the stages of development are hierarchically ordered; (2) logical operations associated with the stages are not hierarchically ordered; (3) logical operations contain two factors, one related to concrete, grouping operations, the second to concrete and logical, coordinating operations; and (4) these common factors are related.

Raven's Test of Logical Operations (RTLO) was administered to 896 students from different environments to measure the attainment of seven logical operations associated with the last two stages of cognitive development. Guttman's Simplex Analysis Model, Kaiser's Alpha Factor Model and the independent clusters transformation were used to assess the validity of the assumptions. The results of the analyses supported the four assumptions and indicated there are substages representing transition between concrete, grouping and logical, coordinating operations. The logical operations of classification, seriation, logical multiplication, compensation, proportional thinking, probability and correctional thinking are not hierarchically ordered. Thus, at least according to Guerin's findings, the four Piagetian assumptions are valid.

At the Elementary Level

Schafer and Byers (302) examined one way of inducing change during the development of serial ordering—one of Piaget's logical operations. A serial ordering pretest was given to 95 kindergarten children and they were assigned, on the basis of their scores, to three serial ordering stages. Those in Stage II were assigned to one of two groups, experimental (N=15) and control (N=17). The control group did not receive instruction whereas the experimental group received about 30 minutes of instruction. Posttests involving serial ordering were administered 1, 8 and 132 days after instruction. A special control group of children in Stage III on the pretest was also administered the third posttest. The pretest involved ordering sticks 3/4" square and of different lengths. The three instructional sessions involved (1) ordering sticks of different sizes; (2) making stairs out of sticks, some arranged and some disarranged; and (3) ordering cards with parallel lines in terms of number of lines.

The posttest involved a number of different seriation tasks on which the experimental group showed superior performance on almost identical seriation (near transfer) tasks and tasks involving quite different figures (far - far transfer). It was concluded that the acquisition of seriation skills is partly a function of learning and not solely a function of the development of internal structures.

Espejo, Good and Westmeyer (95) attempted to determine the effectiveness of a "child structured" science curriculum (Child-Structured Learning in Science - CSLS) in further developing selected intellectual factors that appear to be sequentially developed among pre-operational and concrete-operational children. (The term "child structured" refers to the availability of manipulative materials and activities during which the teacher avoids evaluative and directive behaviors and attempts to interact with the children.)

The subjects were first graders from two Tallahassee, Florida schools. The treatment group consisted of 23 children who had experienced CSLS in the Florida State University Research School. The two control groups consisted of children who had not experienced CSLS: 23 from the Research School and 27 from the Astoria Park Elementary School. All the children were interviewed individually and tape recordings were made of their reactions to a cognitive instrument consisting of various tasks with Figural Classes that presumably were developed through experiences with CSLS. The scores of the children were analyzed according to age groups; e.g., age level I (under 6 years and 11 months) and age level II (over 6 years and 11 months).

Results showed that all children were either in the pre-operational or concrete operational stage. At each age level there was a greater percentage of concrete operational students in the treatment than in the control group. It should be noted, however, that the control group from FSU Research School were kindergarteners, not first graders. One may conclude that if children have learning experiences aimed at certain objectives, they are more likely to achieve the objectives than children who have learning experiences not so aimed.

Smith and Padilla (316) sought answers to questions concerning (1) the accuracy with which first graders order objects on the basis of weight and length; (2) the effects of the variable and number of objects on the accuracy; (3) the extent to which they employ Extreme Value Selection (EVS), Insertion Strategy (INS), or Rearrangement (RAR) in ordering the objects; and (4) the relationship of EVS, INS and RAR to the variable and number of objects. The subjects were 24 first graders from each of the four schools selected randomly from 24 urban elementary schools with small black and Latino populations. They were given tasks of arranging 4, 6, 8 or 10 dowels 1/4" in diameter, in order of length and ordering 12-ounce Styrofoam cups containing leadshot in paraffin. It was expected that most children would use EVS or INS strategies and the expectation was supported. Over 36 percent used an ideal EVS strategy, about 26 percent used an ideal INS, and 7 percent used RAR. Consequently, about 69 percent used a systematic approach to the ordering.

Padilla and Smith (254), while attempting to teach children to seriate, focused on the question as to whether teaching strategies for the seriation task resulted in more accurate performance and greater transfer than simply practicing the tasks with outcome feedback. They administered individually to 120 first-grade children, seriation pretests that involved ordering 10 wooden dowels, 1/4" in diameter and ranging in length from 9 cm to 16.2 cm with .8 cm difference. Before doing so, the children were shown five ordered dowels and then given five to insert. They were then separated into three groups on the basis of the results of the pretests: (a) those who could not seriate (I); (b) those who could seriate with difficulty but not insert (II); and (c) those who could do both (III). They were then given a number of seriation practice tasks. From among these children, 36 in Stage I were selected and 36 in Stage III, and two groups of 24 each were taught to seriate using the Extreme Value Selection (EVS) and the Insertion Strategy (INS) respectively. A control (CON) group of 24 received no instruction but practiced the seriation task with feedback on correction. Multivariate analyses indicated significant differences of EVS over INS or CON and INS over CON.

The findings concerning the values of instructional activities support those of the previous study in which these two investigators were involved.

Bowman's (49) study of Piaget's Developmental Theory was an effort "to investigate a number of factors believed to be related to the conservation of quantity." In understandable terms, a person who can recognize the equivalence of a certain quantity of water in a cylindrical container and in a spherical container is a "conserver of quantity." Obviously, one who cannot is a "nonconserver." According to the investigator, the "study was designed in order that the selected factors could be investigated with regard to conservers and nonconservers in a given setting." In order to gather the data, populations of four, five, six and seven-year-olds were involved: 15 boys and 15 girls at each grade level. Four examiners were trained to administer nine Piaget tests, ranging from Piaget's classic Conservation Test to the Justification Test, to the children. Despite the extensive discussion about factors related to the performance of conservers and nonconservers, there appeared to be no evidence of significant differences between the two groups on the NSWT, the exact title of which this reviewer was unable to identify in Dissertation Abstracts International.

Ankney and Joyce (11) attempted to construct a paper-and-pencil test for the evaluation of concrete reasoning ability in the Piagetian Developmental Theory. Two instruments were developed, the Piagetian Interview Instrument (PII) consisting of five concrete reasoning tasks and a Paper-and-Pencil Test (PPT) with 30 multiple choice items that measured the same five concepts as the PII plus five others. The Piagetian cognitive structures measured by both instruments included conservation of weight, volume, transitivity, class inclusion, and Euclidean space. The PPT also examined conservation of length, area, one-to-one correspondence, spatiality and velocity. The population with which the instruments were used consisted of 129 children from ages 8-14.

The results indicated that there was a significant relationship between performance on the PII and PPT and also between age of the subjects and performance on both instruments. However, significant relationships were not found between performance on either instrument and sex, type of community in which the subjects lived, or cultural background. It was concluded that paper-and-pencil objective-type tests could be used to assess concrete reasoning ability.

Polanski's study (268) was based on three premises: (1) logical operations, critical thinking, and creative thinking are all part of science content comprehension; (2) there is a positive correlation between the comprehension model and the intelligence of the student tested; and (3) sixth-grade students will perform better than fourth-grade students on tests used in this study. One test, the Piaget Comprehension Test, was constructed to measure science content comprehension and involved Piaget's operations of classification, seriation, logical multiplication, and compensation. The others administered were the Raven Test of Logical Operations, the Iowa Comprehension Test, the Roberge Critical Thinking Test, and the Torrance Creative Thinking Test. The tests were administered to 111 fourth-grade and 109 sixth-grade students and comparisons were made among the scores on the tests and with scores on intelligence tests.

The results indicated that skills measured by the various tests are closely related to a factor called "comprehension" and that science content comprehension has both a logical operations component and a critical thinking component, but there is little support for the existence of a creative thinking component. The results also showed that the scores of sixth-graders were definitely higher than those of fourth-graders.

Dettrick (82) sought to investigate whether definite parallel hierarchical relationships existed between performance on three projective spatial (or perspective) tasks and three classification tasks. The tasks were primary addition of classes, secondary addition of classes, one-to-one multiplication of elements, addition and subtraction of projective elements, complementary perspective relations, and one-to-one multiplication of projective elements. Other questions investigated dealt with the difficulty of the tasks, the relationship between sex and performance and the relationship between task performance and scores on the Iowa Tests of Basic Skills. The data were gathered by administering six Piagetian-type tasks to 108 elementary children (36 born in each of the years 1962, 1963 and 1964). Individual interviews lasted about 30 minutes.

The results indicated that the tasks differed in difficulty and that cognitive processes as measured by the tasks develop with age. Differences in performance were not found to be a function of sex.

It was also indicated that cognitive processes undergo continuous development with growing differentiation and coordination until they become completely functional when the concrete operational period merges with the beginning of formal operational thought at approximately 13 or 14 years of age, two or three years later than suggested by Piaget.

Raven and Guerin (279) attempted to analyze the hierarchical scheme of seven operational structures defined by Piaget. The structures are classification, seriation, logical multiplication, compensation, proportional thinking, probability, and correlational thinking. These operations are found in the concrete and formal stages described by Piaget. The data were gathered by administering the Raven Test of Logical Operations consisting of six items (with four subsamples) of 896 male and female children ranging in age from 8-19. One hundred and twenty-nine of the children were from two core area schools in Philadelphia; 220 from a middle-class elementary school in Cheektowaga, N.Y.; 424 from Salamanca, N.Y., a rural community; and 123 black male and female college freshmen at Clark College in Atlanta, all of whom were in remedial programs designed to prepare them for entering college.

The RTLO has three parts, each requiring 45 minutes for administration. The investigators used Guttman's radex theory as a quantitative model to rank the test items from simple to complex. Their findings supported the hierarchical structure proposed in Piaget's Developmental Theory as Concrete III A, Concrete III B, Formal IV A, and Formal IV B. But, they failed to find a hierarchical order in some of the other structures. It was suggested that some of the logical operations may develop together rather than in a hierarchy.

Graybill (122) attempted to determine the possible existence of sexual differences in intellectual development and problem-solving ability. Her procedure was based on that developed by Piaget and Inhelder (1958) and described in the book Growth of Logical Thinking from Childhood to Adolescence in which simple physics experiments were used to test the development of logical thought structures in subjects ranging in age from 5 to 15 or 16. The subjects in Graybill's study were three pairs of boys and girls of about 9, 11, 13 and 15 years of age who were matched as well as possible with respect to birthdate, intelligence, school achievement and socioeconomic background. The subjects were asked to solve four problems involving equal angles, floating bodies, separation of variables and chemical combinations. The researcher and two separate judges rated the subjects on a scale of 1-4, depending on the substage of development each was judged to have reached. The findings indicated that there were sex differences in the transition from concrete to formal thinking and that boys were more successful than girls on the science problems used. Boys seemed more confident in handling equipment, more sure of their movements, freer in their work and took more pains with their measurements. The girls seemed satisfied with making rough estimates rather than precise measurements. The boys evidenced the formal level at age 13 whereas the girls lagged somewhat behind. These findings must be weighed in terms of the relatively small sample involved.

At the Secondary Level

Chiappetta (64) reviewed ten studies related to formal thought development, as "espoused" by Piaget, in an effort to resolve some questions about Piaget's belief that all adolescents are formal thinkers by the time they are 15 or 16 years of age. His review of studies on

formal thinking seems to support the view that the majority of late adolescents and adults in the United States function at the concrete operational level and not at the formal operational level. An analysis of Piaget's studies in Geneva, Switzerland, indicates that he may have dealt with the more able students who did function at the formal operational level. Chiappetta concluded from the review that curriculum specialists need to develop science programs more geared to concrete operational thinking than are existing programs.

Sayre and Ball (301) conducted an investigation to explore the possible relationships between scholastic grades in science in junior and senior high schools and the ability of students to perform formal operational tasks. The subjects were 419 students enrolled in Weld County (Colorado) Reorganized School District during the Fall Semester 1971: 214 in grades 7-9 and 205 in grades 10-12.

Four trained interviewers administered a Piagetian Task Instrument (PTI) consisting of tasks developed by Piaget and/or Inhelder or by students of Piaget. The instrument contained tasks involving stickmen, the pendulum, the balance, chemicals and syllogisms. The results indicated that students at both the junior and senior high school level who functioned at the formal operational level on the PTI obtained significantly higher grades than did students who did not function at the formal level. It was also noted that there was a gradual growth from grade to grade in the ability of students to complete formal tasks. An exception was noted in that students enrolled in physics did not evidence a significant relationship between scholastic achievement and level of formal operation.

Lawson and Renner (190) indicated that the primary objective of their analysis was to assess the understanding of concrete and formal operational concepts by concrete and formal operational students in secondary school biology, chemistry and physics. Concrete operational concepts are those concepts whose meanings can be developed from first-hand experience with objects or events, whereas formal operational concepts are those whose meanings are derived through their positions within a postulatory-deductive system.

The subjects involved 51 students enrolled in biology, 50 enrolled in chemistry and 33 enrolled in physics from a high school with a population over 2,000. During the last month of the school year these randomly selected students were administered tasks dealing with Conservation of Weight, Conservation of Volume, Separation of Variables, and Equilibrium in the Balance. Their performances on the tasks were rated on a five-point scale. They were also administered subject matter examinations to evaluate their understandings of concrete operational and formal operational concepts. The data were analyzed by multiple correlations, F tests, and multiple regression.

The analyses indicated that 29.5 percent of those enrolled in biology were at the concrete operational level or lower whereas 35.3 percent were post-concrete operational or formal. The majority of the physics students

were between the concrete operational and formal operational levels, but about three times as many physics students were fully formal as were chemistry students. However, the majority of students was below the levels of intellectual development postulated by Piaget. These findings supported the analyses by Chiappetta (64) that a substantial amount of secondary school science subject matter might not be appropriate for the intellectual levels of the learner.

Bautista (27) attempted to develop a concept classification scheme based on the Piagetian model. The operational criteria for identifying concrete concepts were seriation, transitivity, class inclusion, one-to-one correspondence, and conservation. The operational criteria established for formal concepts were propositional thinking, combinatorial operations, proportional reasoning, separation of variables, reciprocal implications and exclusion. The subjects in the study were students enrolled in Chemical Education Materials Study (CHEMS) and Harvard Project Physics (HPP). They were administered two tests: one consisting of Piagetian tasks and the other, achievement tests that are part of CHEMS and Harvard Project Physics materials. The proportions of correct responses made by formal and concrete students to formal questions were subjected to the z-test of a significance of the differences between the two proportions. The same was done to proportions of correct responses made to concrete questions.

The responses to the tests showed that formal students performed significantly better on 57 of 61 formal questions than did concrete students. However, a significant difference was not found in the proportions of formal and concrete students responding correctly to 38 of the 39 concrete test items. The results are claimed as supporting the classification system developed in this study.

Kolodiy (178) set out to ascertain and compare the cognitive levels of three groups of subjects who were at three different educational levels ranging from high school through college and to investigate the relationship of cognitive level to SAT scores and college grades. The subjects were selected from a sophomore Biological Sciences Curriculum Study (BSCS) biology class in a New Jersey high school and from freshmen and senior science majors at a state university. Seventy subjects were presented with two Piagetian-type tasks, one dealing with the inclined plane and the other with a combination of colorless liquids. Randomly selected sessions of administrations of the test instrument were taped and checked independently by three persons familiar with Piagetian tasks. The interobserver reliability was found to be high.

The results failed to indicate significant differences in cognitive level between high school sophomores and college freshmen, although college seniors scored significantly higher than both. Also coefficients of correlation were found to be significant between Piaget scores and SAT mathematics scores and between the chemical task and both SAT mathematics and SAT verbal scores. However, significant coefficients of correlation were not found between college grades and cognitive level or SAT scores.

It was concluded that (1) high school and beginning college students are in a high state of mental disequilibrium; (2) college grades are more closely related to verbal ability than to college functioning; and (3) the majority of adolescents are below the formal level in cognitive functioning.

Abramowitz (1) focused her attention on the characteristics of proportion problems and the underlying skills assumed to be necessary for understanding proportionality. The characteristics of the proportionality tasks investigated were (1) the complexity of the proportions; (2) the repetition of a common difference; and (3) the numbers used. The skills studied were (1) manipulative facility with fractions; (2) the concept of "more than" versus "times as much;" and (3) the inverse relation between unit size and the number of units used in a measuring task.

The effects of four different task variables, eight feedback conditions, and task order were investigated in two sessions with a sample of 32 seventh-grade students of two ability levels. An analysis of the responses indicated that the ability of the subject was a factor in handling proportionality, only about one-fourth of the problems were solved using a strategy that illustrated a well-developed understanding of proportionality. There appeared to be inflexibility in the students' understanding of proportionality.

Rowell and Hoffman (292) stated that "the problem still remains for the teacher . . . to identify the mental development of each child who faces him." In order to contribute to the solution of the problem, they attempted to translate two Piagetian-type problem situations into forms [tests] suitable for administration to groups, together with marking schemes.

The subjects of their study were approximately 20 students selected "without bias" from each of two classes in each of the first four years of a South Australian metropolitan high school. Except for the first year where there was random assignment, students were ability grouped. The top and lower streams of the second, third and fourth years were tested together. In total, 193 students participated in a chemical (color change) experiment and 189 of the same students in a physics (pendulum) experiment, both Piagetian-type. Each student was given instructions plus two worksheets, one dealing with manipulations and the reasons for the manipulations and the other dealing with answers and conclusions.

The results indicated that formal thinking increases with chronological age and that there are more formal thinkers among upper stream (high ability) students than among those in the lower stream. Also, the authors concluded that it seems possible to translate into group form, and administer and assess rapidly with considerable reliability, Piagetian-type problems that measure developmental level. But it was noted that the group method of administration lacks the sensitivity of the clinical approach of assessment.

Robertson and Richardson (288) attempted to (1) replicate and extend a number of tests of "conservation" of some physics concepts; (2) measure the conservation of some concepts not previously tested; (3) administer the test with standardized procedures on a group basis, checking reliability with standard clinical testing; and (4) investigate predictions based on hypotheses of the hierarchical attainment of concepts in physics. They assumed, if a derived quantity is dependent on fundamental quantities, that students should conserve mass before weight, length before area, and length and time before speed.

They also assumed that if a derived quantity depends on prior conservation of its elements, other than the ones from which it was derived, that students should conserve length and area before volume, mass and volume before density, area and force before pressure, mass and acceleration before force, and force before work.

In order to test their assumptions they used a random sample of 25 boys and 25 girls stratified on the basis of sex and age from grades 7-10 in a South Australian high school. The subjects were given a series of four tests dealing with conservation of the factors indicated.

The investigators found, using a 75 percent success criterion, that at grade 7 both boys and girls conserved mass, weight, force, length, distance and speed. At grade 8 both boys and girls added vertical height, and at grade 9 both boys and girls added time, but only boys added volume. Density was conserved by only 30 percent in grade 10. There was definite evidence of a hierarchical development of conservation of quantities since only 35 percent of the subjects in grades 7, 8 and 9 conserved gravitational potential energy, whereas 70 percent of the subjects in grade 10 did.

At the College Level

Three studies related to Piagetian Developmental Theory were found at the college level. In one, Dunlop and Fazio (92) sought to investigate abstract preferences in eighteen problem-solving tasks and the relationship between these preferences and various levels of cognitive development. In addition, the effects of grade level, sex and academic major were examined in relationship to the students' abstract preference scores.

The subjects, consisting of 329 randomly selected students from grades 8, 9, 12, 13 and 16, were administered the Shipley Test of Abstract Reasoning. On the basis of the scores on the test, students were grouped as concrete operational or formal operational. They were also grouped on the basis of grade level and sex. Analyses of the scores for the group failed to indicate significant differences between the cognitive levels of development of college science majors and non-science majors. Neither were significant differences found among the cognitive levels of development or abstract preference scores of students in grades 8, 9, 12, 13 and 16. However, the older students demonstrated greater abstract reasoning ability.

The study suggests that a student's level of reasoning is often below his capacity and that a student's preference toward a specific solution may, in part, be responsible for his below-capacity functioning.

One may also suggest that the discriminating power of the Shipley Test of Abstract Reasoning is suspect.

Waite (351) examined the relationships between the ability of college science students to perform Piagetian-type tasks at the formal operational level and their cultural backgrounds, choices of majors (science or non-science) class levels, scholastic grades in general chemistry or general physics, sexes, ages, and intelligence quotients. The subjects were 193 undergraduate students enrolled in several physical science classes in the University of Guam in the fall, 1973.

The instrument used in the study consisted of five Piagetian-type tasks designed to measure the ability to perform at the formal operational level. A formal operational student was defined as one who could successfully complete four of the five tasks. Six interviewers of different cultural backgrounds administered the instrument after training in a pilot study to determine the effect of administering it in English rather than the mother tongue. The cultural backgrounds involved Guamanian, Mainland-American, Micronesian, and Asian (the latter including Chinese, Japanese, Korean and Filipino).

The results failed to show significant differences between cultural background and overall performance when the analyses dealt exclusively with science majors and exclusively with non-science majors. However, a significant difference did occur when the comparison involved both science and non-science majors. The Micronesians showed a significant lag in ability to perform at the formal operational level as compared with Mainland-Americans. Also, science majors are likely to be significantly more formal operational than are non-science majors. But, significant differences were not found between college science students' ability to perform at the formal operational level and their class level, sex, scholastic grade, age or I.Q.

Parnell (259) tested 60 students from a large land-grant state university and 19 students from an urban municipal university in northeast Kansas to ascertain the existence of an ordered hierarchy in the successful completion of selected Piagetian-type conservation tasks related to different concept areas in a general education science course. The five tasks on the test involved conservation of (I) a discontinuous substance; (II) displaced volume; (III) uniform motion; (IV) motion (the pendulum); and (V) motion in a horizontal plane.

The analyses consisted of a scalogram for testing and proposed hierarchy of difficulty of the tasks, a one-way ANOVA for testing the relationship between the student's natural science ACT score ranks [sic] and achievement, and a Chi-square test to measure the relationship between task performance and the student's percentile ranking in class and letter

grade. A Chi-square test was used also (1) to measure the relationship between task performance and the student's percentile ranking in class and letter grade and (2) to measure the relationship between task performance and 23 conservation-related questions.

The results indicated that the hierarchy of difficulty of the five tasks was III, I, II, IV, V. A significant relationship was found between natural science ACT score rank and task achievement. But significant differences were not found between task performance and student's percentile ranking or letter grade in the physical science course, or between task performance and task-related questions. No significant difference was found between task achievement in this study and in related research. Two characteristics of adult thought were noted: the ability of adults to isolate variables in action but not in thought, and the use of scientific words and principles without knowledge of content.

A summary of what are already summaries seems somewhat redundant. However, the following generalizations seem valid:

1. The stages postulated in Piagetian Developmental Theory, with the insertion of transitional stages, seem to be supported by other researchers. One may suggest, however, that principles of human development consistent with those of Piaget have been fairly common knowledge for many decades.

2. The logical operations of classification, seriation and so on are probably not hierarchically ordered as many have been led to believe. The abilities to perform the logical operations may in many cases develop together.

3. Adolescents may not generally be so formal operational as Piaget has suggested.

The Classical Science Disciplines.

A number of the research studies reviewed focused mainly on the classical science disciplines themselves, rather than on using the disciplines to test various pedagogical principles and learning theories. Consequently, it was decided to include sections dealing with the teaching of biology, chemistry, earth science and physics, with the addition of a section on environment and ecology.

Biology

During the 1972-73 school year, Penick, Schlitt, Bender and Lewis (262)

> . . . set out to assess how a randomly selected group of ninth, tenth and eleventh grade students at the Florida State

Development Research School would react to a biology class which was both highly individualized and open. This class was individualized in that students could choose their own content and method of learning and open to the extent that students were free to pursue or not to pursue this learning whenever and wherever they desired.

The instructional strategy was called Student Structured Learning in Biology (SSLB).

At the beginning of the year the students were informed of the plan and were on their own except for a weekly log and daily interaction between each student and one or more of the instructors. At the end of each three-week interval they were required to give verbal justifications of their self assigned grades. Their activities involved Soils, Animals and Physiology plus Small Things suggested by the students. A control biology class was individualized to some extent and depended heavily on modules and audio-visual aids in areas such as Asking Questions, Reproduction and Development, Genetics, Evolution, and Nature Study. This was called Teacher Structured Learning in Biology (TSLB).

Both experimental and control groups were administered the Torrance Tests of Creative Thinking as pre- and posttests. They also had interviews and nonintervention observation. The analyses of the test scores failed to reveal any significant differences between the two instructional strategies, or aptitude or interaction effect. It was claimed that figural creativity scores indicated that student aptitude on the Florida Ninth-Grade Test was related significantly to figural creativity.

It was suggested, without apparent support, that there were important gains in "poorly measured areas." However, the study seems highly subjective and the sample size, apparently small, was not indicated. It is doubtful that the study could be replicated.

Falk, Malone and Linn (97) described how Outdoor Biology Instructional Strategies (OBIS) develops an activity, discussed the OBIS evaluation of some OBIS lawn activities and the role of evaluation development of the format presently used by OBIS. This study dealt with an activity concerning the "lawn community." The criteria used for developing an OBIS activity are to (1) increase understanding of the ecosystem; (2) be appropriate for 10-15 year olds; (3) be useful at a readily accessible outdoor site; (4) be appropriate for an untrained leader; (5) last about an hour; and (6) involve inexpensive equipment.

The lawn community activity was tried out by students and a staff observer, then rewritten with information about equipment needed, disseminated, and evaluated using photographs to test how well it met the criteria.

It was found that the OBIS development and evaluation resulted in significant changes in the structure of lawn activities, although many community groups had difficulty in arranging ten weekly visits to the lawn site. Also, the test groups generally indicated that they would prefer to visit a number of sites rather than one.

The study was unique in its thrust but the actual procedures and the structure of the test groups could have been described more clearly.

Koran, Koran and Freeman (180) conducted a study in a typical science classroom setting using the classification concept (monocot) as the content for investigating concept acquisition. The basic purpose was to determine which mode of instruction (deductive or inductive) and which time of exposure produced greatest acquisition of a classification concept. Their subjects were 385 students enrolled in 21 classes in rural public high schools in North Central Florida. The classes included ninth grade earth science, 10th grade biology, and eleventh or twelfth grade chemistry, in which there were 177 males and 208 females, and 165 blacks and 220 whites. They were randomly assigned to seven treatments that involved the following conditions: inductive—5 seconds; inductive—8 seconds; inductive—15 seconds; deductive—5 seconds; deductive—8 seconds; deductive—15 seconds; and a posttest only control group. Prior to the timed treatments they were shown slides that gave general information about plants and then were shown 20 slides, some labeled "Yes" and some "No." The slides described monocots and showed three attributes of plants; namely, leaf variation, relative position of fibrovascular bundles and a number of petals. The inductive group was asked to identify characteristics and the deductive group was told what they were. There was a 15-second lapse between the 20 test items.

The responses of the students indicated that the deductive mode was significantly better than the inductive for identifying monocots, and also that increased exposure time with the slides facilitates learning.

Barman (20,21) wanted "to see if value clarification would affect student attitudes toward science and biology and would improve achievement in a BSCS Yellow Version biology course. A control group of students not taught value clarification was compared with an experimental group taught using these techniques." The subjects consisted of 77 control and 78 experimental students in Hale Senior High School, West Allis, Wisconsin. Both groups were taught units in ecology, cell biology, genetics and evolution using the BSCS Yellow Version, 2nd edition. All students were pretested and posttested with the BSCS final examination. They were also administered the Self-Evaluation Inventory (SEI) based on behavioral objectives of BSCS Yellow Version. The affective domain was evaluated with the Schwirian Science Support Scale and the Thurstone-type Affective Domain Measuring Scale. The value clarification lessons, based on consideration of an abortion of a possibly handicapped child and donation of body parts, were integrated during 18 weeks of regular instruction.

The investigators claimed that the achievement of the experimental group as assessed by the BSCS final examination and the SEI was significantly greater than that of the control group. Attitudinal differences were apparently not significantly different as measured by instruments for the affective domain. It was concluded that value clarification improved achievement but the narrative does not indicate clearly the basis for the conclusion. Neither was it indicated if all students had the same teacher.

Lee (195) tried to identify student characteristics that may predict success in two instructional methods used in high school biology. The traits studied were test anxiety, self-concept of academic ability, conceptual level, state anxiety, previous achievement in science, reading comprehension, sex, entering attitudes toward science, and a biology pretest. The criterion variables were achievements in biology, attitudes toward biology, and self-concept of academic ability in science. The subjects were students enrolled in two treatment groups of high school biology. Treatment I consisted of a "traditional" lecture approach to instruction. The rate of instruction was determined by the teacher group and involved a textbook orientation. Treatment II involved "individualized instruction" including self-pacing, individual or small group work, and the use of instructional materials other than the text. The instruments used to measure the traits identified for this experiment were administered at the beginning of the study whereas those to measure the criterion variables were administered at the conclusion. The data collected were analyzed by means of multiple regression.

The analyses failed to indicate significant differences between the two treatment groups for the criterion variables. The only significant treatment interaction (academic self concept and treatment) was found when achievement was used as the criterion variable.

Lawson, Blake and Nordland (187) oriented their investigation to these questions: (1) Can the ability to control variables be taught to high school biology students who, on a written test of logical operations, do not demonstrate formal reasoning? (2) Are students who are classified as early formal thinkers on the written test of logical operations able to benefit more from the training than students who are classified as early or late concrete thinkers? (3) If the ability to control variables can be learned, is it generalizable to problems using novel situations? Since the subjects were high school students and all were over 14 years of age, it was assumed that their level of physical maturation would not be a factor preventing acquisition of the desired ability.

To seek answers to the questions, 65 high school students (29 male and 36 female), ranging in age from 14 years 7 months to 17 years 10 months, in a second semester biology course in Delphi High School in Indiana, were used as subjects. The students from four biology classes were divided randomly into two groups, 33 receiving training on the ability to control variables with 32 receiving no training. The training involved materials identical to those used by Piaget and Inhelder in

the exclusion of irrelevant variables and also materials from SCIS Energy Sources ("rotoplanes").

The students were pretested on three Piagetian tasks and were posttested after training. Prior to both pre- and posttests they were administered a pencil-and-paper test that classified students as concrete, transitional, or formal operational. The results of the posttests showed that the subject responses were 14 percent early concrete operational, 41 percent fully concrete operational, 35 percent early formal operational and 8 percent fully formal operational. However, significant differences were not found between the mean scores of the experimental and the control groups. Consequently, valid conclusions cannot be drawn about the training effort.

Jernigan (158) tried to contrast the effectiveness of five different instructional units or "approaches" on secondary school biology students. The approaches were (a) emphasis on group dynamics or processes; (b) teacher-selected articles for instruction with research periods on questions raised; (c) student selected articles; (d) behavioral objective structured in which students could select a team of up to four peers to form peer tutoring groups; and (e) the BSCS unit with laboratory investigations entitled "Diversity Among Living Things."

The subjects were 274 students in ten biology classes in Shawnee Mission South High School, five of which were taught by the researcher and five by a colleague. All groups of students experienced the five approaches, but in a different order. The evaluation instruments were an Activity Preference Sheet, Biology Preference Sheet, Checklist for Assessing Classroom Inquiry Behavior, Classroom Activities Categories, Comprehensive Final Examination, BSCS Processes of Science Test, Semantic Differential, Subject Preference Survey, and Differential Aptitude Test.

The analyses of the scores on the various instruments indicated that the use and type of peer group relationships in a classroom setting are of paramount importance to students. The more prescribed the instruction, the less interesting they found it. The highest ratings were for peer tutoring and the least preferred approaches were teacher-selected science articles and BSCS materials. But, students indicated they liked the variety of five approaches rather than being limited to the most preferred.

From the viewpoint of achievement, students experiencing the five approaches did show significant gains on the BSCS Comprehensive Final Examination in all of the classes. Significant gains were also found on the Processes of Science Test in the classes of the colleague but not in those of the researcher. A significant gain in attitude toward science was found in the classes of the researcher and also for science as a subject preference in the classes of the colleague.

Armstrong (14) investigated "the biology laboratory curriculum, investigative biology, used in General Biology 101 at the University of Colorado, fall, 1972. It was intended that the results would allow an assessment of investigative biology and evaluate it for possible use in

general biology." It was hypothesized that students in the experimental curriculum would have more interest in the activities of biologists as measured by the Biology Interest Survey, more knowledge of the processes of science as measured by the Processes of Science Test, increased critical thinking ability as measured by the Cornell Critical Thinking Test, increased laboratory attendance, more contributions to student discussions, and that there would be interaction between student aptitude and treatment. The null hypotheses were used involving treatment and teacher, sex of student, and high school biology background (BSCS or other).

Six teachers and 268 students from the University of Colorado were involved. The measurements to gather the data to test the hypotheses were made during the fall, 1972. Analyses of the results showed that the experimental curriculum had a positive effect on students' attitudes toward laboratory biology and interest in majoring in biology. Significant differences were not found between treatment groups on cognitive measures. Students who experienced BSCS biology in high school apparently entered the course with a higher interest in biology than those who experienced non-BSCS biology and also had greater interest in biology at the end of the treatment.

Stevens and Jeveli (322) tested Epstein's format as an alternative to a traditional biology course. The purpose was to investigate whether the technique [discussion of selected papers rather than lectures] did increase student comprehension of scientific processes, whether students did find this approach a more rewarding learning experience, and also whether the approach could transfer as much factual information as a well-designed lecture. Seven students in a course that included majors in biology and non-majors in biology (some with only high school biology background) served as subjects. The group included three biology majors: one senior, one junior and one sophomore and four non-majors: one junior, two sophomores and one freshman. They "were solicited by advertisements about an upper-level experimental course in contemporary biological problems based on reading and discussion of research papers and performing laboratory research."

Each week there was a two-hour discussion and, on another day, a four-hour laboratory. Two topics were covered, physiological and psychological childbirth techniques and biological mechanisms of actomyosin. The last few sessions were general discussion. The students prepared a final research paper analyzing the learning experience.

The investigators concluded that the mysticism the students had about research was lifted and that they learned to read research reports. The laboratory was considered to be essential to understanding the research papers. One can conclude that the effort was an interesting exercise, but there were too few subjects to draw any meaningful conclusions.

Williams (364) attempted "to measure the extent of the loss of knowledge of chemistry among physiology students at Southwest College in order to determine the chemistry knowledge most frequently forgotten, and to devise a laboratory program which will strengthen the chemistry background and examine its relationship to students in the physiology class."

An analysis was made of the chemistry knowledge needed in traditional physiology laboratory experiments. From this a set of integrated physiology-chemistry laboratory experiments was developed and "used against a traditional manual Laboratory Experiments in Physiology." A special test of chemistry was developed to test the weak areas of physiology and questions were formulated in eleven areas to determine the weakness. In addition, a physiology test was developed. The subjects were students from physiology classes enrolling from 8 to 28. They were assigned randomly to experimental and control groups. The classes had two hours of lecture and three hours of laboratory work with a total of 15 experiments.

The test results showed that chemistry retention was about the same for all students without regard for where they had been enrolled, but there was a definite loss because students who had just completed chemistry got higher scores on the chemistry test than those who completed it earlier. It was found that students in the integrated program did significantly better on the tests than the control group.

In the opinion of this reviewer, the study was not well written and it was difficult to analyze.

Chemistry

Gemberling (116) undertook a study "to measure student achievement of cognitive performance objectives which are evident in the Introduction to Applied Chemistry (IAC) program and common to most of today's high school chemistry curricula." The questions to which he sought answers were: (1) can differences in the knowledge of chemistry as measured by a pretest be attributed to sex (male or female), type of chemistry curricula [sic] in which a student is enrolled (IAC or non-IAC), or sex-treatment interaction? (2) Are differences in post-test cognitive achievement related to the type of chemistry curricula [sic] in which a student is enrolled? (3) Are differences in post-test cognitive achievement related to the sex of the student? (4) Is there a sex treatment interaction?

Forty performance objectives compatible with IAC, CHEM Study and Modern Chemistry were used as a basis for construction of a Chemistry Concepts Test (CCT) to measure cognitive achievement in chemistry. A second test used was the ACS-NSTA Cooperative Examination: High School Chemistry, Form 1969S. The subjects to whom the tests were administered were 944 IAC and non-IAC students randomly selected from a larger population. The scores were analyzed with a 2 x 2 factorial analysis.

The results showed that males entered the courses with more knowledge than females but these differences were not found pertaining to IAC or non-IAC students, or sex treatment interaction. Significant differences were not found between the cognitive achievements on the CCT of IAC and non-IAC students. However, the non-IAC students scored significantly higher on the ACS-NSTA Test. Significant differences were not found on either test on the basis of sex or sex treatment interaction.

Barron (23) developed and tested a high school curriculum for mathematics-shy chemistry students. The program and materials had to be written, pilot-tested with about 100 students, edited, and finally placed in a high school setting. Then the effect of this program had to be measured, evaluated, and studied. Two years' effort produced the book Chemistry: Coping With Change. It was pilot-tested at a large urban high school together with a laboratory manual and produced in a soft-cover edition in the spring and summer, 1972. During 1972-73 data were collected using the materials with two teachers, one of whom had two groups of 65 students, and the other with one of 35. The sample "sank" from about 100 to 70 during the study. Measurements were made with tests of mental ability, reasoning in conservation, and ecochemistry. A teacher self-assessment and a student checklist were also administered.

Results on the Cooperative Chemistry Test failed to indicate a significant difference between students with high or low numerical ability, or between upper groups for attitudes on statements about science and reasoning in conservation.

It was concluded that mathematics-shy students will elect to take chemistry, that they can be identified as mathematics-shy, and that they can succeed in a laboratory science.

Besler (39) developed and validated "a high school chemistry sequence that [allegedly] will produce mastery learning and will strengthen student learning toward chemistry." The question to which answers were sought was, "Can a chemistry sequence be developed that will teach a high school student to write and balance a chemical equation correctly and at the same time strengthen his attitude toward chemistry?" The mastery criterion was defined as a minimum of 75 percent of the students scoring 80 percent to 100 percent on the criterion posttest.

Two instructional methods were used, the Self-Instructional Approach (SIA) and the Programmed Class Approach (PCA). The first was a self-paced strategy. Eighteen experimental classes were involved over three semesters, consisting of three experimental classes in the Pilot Project during the first semester; eight experimental classes in the School Project during the second; and seven experimental classes in the City Project during the third. Seven of the classes were taught by the investigator whereas nine different teachers taught eleven project classes in six different schools. The configuration of students in the two instructional methods is not clearly indicated.

Conclusions from the evaluation indicated that of the 15 school and city project classes tested, 14 showed a strengthening of student attitude and/or achievement of mastery learning.

Call (60) proposed to develop a method of presenting a CHEM Study type college preparatory high school course using individualized instruction, to describe the mode of presentation, and to evaluate the effectiveness of the individualized presentation by comparing it with the traditional method suggested by the authors of the textbook in use. An analysis of research on individualized instruction was used to develop a method of individualizing a high school chemistry course. The individualized course and the traditional course were taught by the investigator in classes at Mesa High School in Arizona in 1974. Forty-two students were involved.

Analyses were made using analyses of covariance with IQ scores and previous chemistry knowledge as covariates with scores obtained on the ACS-NSTA Cooperative Chemistry Examination: Form 1965 and Form 1971 and the Anderson-Fisk Chemistry Test, 1966. The results of the analyses failed to indicate significant differences in achievement in 9 of the 14 unit examinations, although significant differences were found in favor of the individualized group on 5. The responses to the student attitude survey indicated that students thought that the individualized instruction was more difficult, but they preferred it because it was more interesting.

Wengert (356) attempted to determine the predictive influence of attitude toward science, sex, grade level, science background, ability to interpret science, and overall academic performance upon the student's degree of self-pacing in chemistry. The subjects of the study were 428 chemistry students in eight Iowa and one Minnesota high schools using the Personalized Adventures in Chemical Education (PACE) curriculum that consists of 20 sequential learning packages designed for a one-year general education chemistry course.

Demographic information about the students was obtained from the Iowa Tests of Educational Development (ITED), Test 2 (Science Background) and Test 6 (Science Interpretation), and composite overall academic performance scores were collected from school records. The attitudes of the subjects were assessed with a 30-item Likert-type questionnaire adapted from the Schwirian Tri-S instrument. The numbers of units completed by the students were used as the criterion of progress in self-pacing.

Analyses of the evaluations indicated that (1) the six predictors accounted for 22 percent of the variability in predicting progress in self-pacing; (2) grade level and overall performance based on the ITED composite test score in combination predicted 21 percent of the 22 percent of the variability; (3) individually, the variables of attitude toward science, and sex were not significant predictors; (4) grade level was a significant predictor with juniors having the greatest progress, but both sophomores and juniors had significantly greater progress than

seniors; and (5) science background, science interpretation, and overall performance were significant, but individually and in combination accounted for no more than 10 percent of progress in self-pacing.

It was concluded that indicators of success in a conventional classroom are not adequate predictors of self-pacing in an individualized classroom.

Freeman (105) made use of information in the files of the Jesse O. Sanderson High School, Raleigh, North Carolina in order to (1) determine the relationship between intelligence, aptitudes, and mathematics and natural science grades and achievement in high school chemistry; (2) use this [sic] data to develop prediction equations that could be employed to predict a grade in chemistry.

The data were collected for 255 students who studied high school chemistry during the school year 1971-72. Achievement in chemistry was based on the chemistry grade; 14 independent variables were obtained for scores on the Otis-Lennon Mental Ability Test, 9 aptitude scores on the Differential Aptitudes Test (DAT); and the grades on Algebra I, Algebra II, ninth grade physical science, and tenth grade biology. Coefficients of correlation and multiple regression equations were used in the data analysis.

The results of the analyses indicated that the scores with the highest relationship with achievement for chemistry with females were the Algebra II grade, Verbal Reasoning plus Numerical Ability of the DAT, and Numerical Ability of the DAT. For males the scores with the highest relationship were the Algebra II grade, the Otis-Lennon Test of Mental Ability score, and the physical science grade.

It was concluded that students who enroll in chemistry should have an average or better grade in Algebra II and grades on ninth grade physical science and tenth grade biology should be used in advising prospective chemistry students.

Torop (341) evaluated the relative effectiveness of an individualized approach to an introductory chemistry course including a computer-managed instructional system and its effect on student attitude. The study was undertaken at West Chester State College where the Individualized Learning System Chemistry (ILS Chem) involving a multimedia approach was the subject of the investigation.

In the first part of the study 30 of 167 students in Chemistry 100 served as an experimental group under the investigator whereas three regular sections under three different instructors served as a control. These three groups met twice a week for a one-hour 20 minute lecture and once a week for 50 minutes for recitation-discussion. All students were given the same computer-generated examination the first week, at the middle of the semester, and at the end. All used the same basic textbook and were administered a chemistry attitude scale developed by the investigator.

The ANOVA used in the analyses of the scores failed to indicate that the control group was significantly different from the pretest to the midterm examination and to the final. But, the scores of the experimental group improved significantly at the end of the study. The experimental group also showed positive attitudes that were significantly more positive than did the control group although significant differences were not found in the beginning.

Fazio and Dunlop (99) had the objective of designing an instrument to assess the preferences of college non-science majors concerning certain aspects of environmental chemistry. They also sought to evaluate similar preferences of those who had completed some chemistry courses. A pilot study provided a basis for the construction of the test instrument that consisted of 28 sets of statements to which three choices were possible based on (1) humanistic values, (2) theoretical values, and (3) technological values.

The test was administered to a group of junior level elementary education majors, small groups of junior and senior majors in chemistry and biology and health science, and to 19 chemistry teachers from Western Pennsylvania. An ANOVA was used to analyze the scores of the groups.

The results of the analyses indicated that significant differences were found with three sets of scores. The humanistics scores were found to be significantly higher for all groups. The technological scores were higher than the theoretical scores for the physical science, health science and elementary education students. For science majors and chemistry teachers the theoretical scores were significantly higher than the others. None of the other analyses were found to be significant.

Biersmith, Hinton, Normand and Raymond (41) described a study in which students worked as individuals in an undergraduate organic chemistry laboratory course and compared their achievement with those who had worked in groups. The study was designed to develop an alternative instructional program [from individual] in which group interaction was included by design and not left to chance.

The laboratory was divided into two sections, in one of which students worked individually and in the second, they worked in groups of three. To establish the group mystique, group members were assigned titles of chief chemist, laboratory technician and production analyst. At the end of each step of a multiple synthesis, the students were given an examination and the average scores of the groups were compared. It was indicated that students were assigned randomly to the sections.

The results on the examinations showed that students working in groups and with averages of 70 percent or lower on first examinations had greater achievement on the next five examinations than those working as individuals. The small numbers, however, precluded statistical significance.

The groups, despite their composition, consistently finished ahead of individuals. It was discovered, however, that group leadership was not always best in hands of the best students. The responses of students to the group activity, however, was highly favorable.

Leavers (191) described the philosophy and contents of a chemistry course for non-scientists in which 130 students were enrolled. The aim was to avoid a diluted version of the regular course, but to keep the mathematics content to the minimum. An effort was made to teach students that instructors' opinions are different from facts and chemistry presents a limited view of the world.

The contents were determined largely by the students and dealt with the energy crisis, drugs, chemicals in food, pesticides, and the basic concept of the atom. A 20-item opinion survey was administered the first day and another, with additional questions, the ninth week.

It was reported that the attitudes of the students improved "significantly." Students believed chemistry to be less difficult than they first thought, and negative attitudes towards science and scientists appear to be reversible.

Huston (153) investigated the questions: (1) How are student characteristics such as sex, intelligence, age, and academic achievement related to student orientation to humanistic, theoretical, and technological aspects of chemistry? (2) What is the influence of a teacher's university chemistry preparation, length of teaching experience, and a significant teaching involvement in another discipline, biology, on their value orientations? (3) Does the length of teaching experience have any effect? and (4) Do teachers who have a significant teaching load in biology have a different chemistry orientation than those who do not?

The subjects in the pilot effort were presented with sets of three affirmative statements with humanistic, theoretical, and technological orientations to chemistry and were asked to rate them, similar to responding to the Kuder Preference Record. The test was then revised. The sample in the final investigation to whom the test was administered consisted of 120 students in grade 12 chemistry in London, Ontario, and 39 chemistry teachers from the same school system. Background information was also collected on the teachers and students.

Analyses using t and r failed to indicate significant relationships between value orientations and student I.Q., GPA or chemistry grade. It was, however, found that girls have significantly greater humanistic orientation than do boys, boys have significantly greater technological orientation than do girls, and teachers tend to be theoretically oriented. Also, teachers with the greatest teaching experience evidence less theoretical but more humanistic and technological orientation than those with the least teaching experience. The concomitant teaching of biology appears to be associated with a lower theoretical but a higher technological orientation on the part of teachers.

Kempa and Ward (168) examined the effects of three different modes of task orientation on observational attainment in chemistry. The modes were (1) an open-ended approach in which no cuing was provided; (2) a partial direction in which the student received some cuing; and (3) a checklist approach in which observational tasks were carried out in accord with a comprehensive schedule that listed "all possible observations." Observational attainment was measured by the success rate of a student's making observations, with two types of errors considered, errors of omission and illusory errors; namely, those in which the student "fails to observe or observes what isn't."

The subjects were 140 fourth-year "O" level chemistry students from three schools that were assigned randomly to the three treatment groups. Two pretests were given, a chemistry theory test, and a color vision test since the observations involved color discrimination. Ten observational tasks involving test tube reactions such as color changes, formation or disappearance of solids, liberation of gases, and temperature changes were used. The number of observations to be made ranged from zero to nine.

The results indicated that students in the checklist group were most successful on the observational tasks whereas students in the partial cuing group were least successful. It was also noted that omission errors increased significantly as the observational tasks became more complex, whereas illusory errors increased byt not significantly. The checklist mode produced more illusory errors although it seemed best for high observational attainment.

An analysis of these reviews of chemistry studies indicates an increasing interest in courses of applied chemistry and for non-science majors. Also objectives other than subject matter knowledge, such as value clarification and attitudes, are getting the attention of researchers.

Earth Science

Despite the growing interest in earth science, only five studies were found in this particular category.

Scott (303) attempted to develop a model course in earth science for the junior high school in Idaho. Pertinent materials related to earth science education were reviewed, revised and modified, and an "exemplary" one-year trial curriculum of twelve units with five methodologies was developed. The units of the course were apparently preceded by a one-hour survey lesson after which materials were distributed. The students viewed films, took notes, were administered short-answer questions, and were given problems, activities and experiments exemplifying the "investigatory component."

The subjects involved were five earth science classes of approximately 150 students during the school year 1973-74. The evaluation consisted of measuring, scoring, and reporting evidence of student accomplishments. Part of the accomplishments were the points students accumulated on the Earth Science Unit Reports they prepared, on notes they had taken, and on tests they were administered. It was claimed that the students thought note taking was worthwhile and students, parents and administrators were positive about the adaptive effort.

The purpose of the Suggs (327) study was to seek answers to three questions: (1) What are the major areas of divergence among goals among professional groups engaged in astronomical education? (2) What are the major areas of consensus among professional groups engaged in astronomical education? and (3) What conclusions can be drawn from questions (1) and (2) which have implications concerning the nature of curriculum materials and teaching in astronomy?

The Delphi Method was used with three groups—research astronomers, Planetarium educators and physics instructors—to gather data for answering the questions. With the Delphi Method a "panel of experts" replies to questionnaires, the first completed in isolation and the others with the knowledge of the responses of the experts. The initial round is to generate goal responses to open-ended questions and those of the second round are circulated with the responses of the group members who are asked to rank order the responses. On the third round respondents receive a compilation of the rank orders of the group and are asked to modify their own views or justify a minority opinion. The questions in the study by Suggs were: (1) What do you perceive as the future of secondary school or introductory college astronomy? and (2) What do you perceive as the most effective way of teaching astronomy for secondary school or introductory college students?

The results indicated (1) the growth of descriptive college offerings and mini-courses in secondary schools, (2) the lack of content astronomy in teacher education programs, (3) the need for better dissemination of astronomy materials, and (4) the relative non-acceptance of innovative teaching formats.

Copeland (73) surveyed night geology offerings in continuing education programs in community colleges in the states of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming. A questionnaire survey conducted with 152 community colleges provided the data.

The responses indicated that (1) the most frequently taught night geology course was physical geography, (2) the night offerings were more varied than those offered during the day, (3) at least one geology course was taught in each of the seven states with 50 different courses being named, (4) 112 of the 152 colleges offered night geology courses of which eight offered them on a non-credit basis, and (5) there has been a 45 percent increase in enrollments in these night courses.

Passow (260) in an exploratory study, developed and evaluated a new program for teaching college introductory earth science. Although within the usual framework of traditional courses, the program differed from the traditional by focusing on the needs, interests and abilities of the learners, rather than the organized content of the discipline.

The participants in the study were 39 students enrolled in a physical geology class at Fairleigh Dickinson University, Rutherford, New Jersey in the Autumn 1973. Data concerning the enrollees indicated they were mainly first- and second-year students seeking to fulfill science requirements for graduation. The unifying theme for the three-week instructional unit was "Water Resources." The weekly two-hour lecture and two-hour laboratory sessions dealt with water and other geological cycles, surface and subsurface water, water budgets, geochemical cycles, topographic maps, land use planning, flood control, and rock studies.

The evaluation of achievement was based mainly on parallel tests, used as pre- and posttests, prepared especially for the study. The results indicated that substantial content learning occurred. However, no basis for comparison with students in traditional courses was provided.

Affective considerations were evaluated with a Likert-type scale prepared especially for the study. Seventy percent of the students reacted favorably and 20 percent were neutral. It was concluded that the program studied offers a viable alternative to traditional approaches. Without some specific comparisons, the validity of the conclusion can be challenged.

Moyle (230) developed an innovative curriculum for introductory geology organized around an analysis of certain aspects of the history of geologic thought, using the philosophical principles of Henry Margeneau and Thomas Kuhn. The focus was on the evolution of thought from Genesis to global tectonics with the intent of causing students' attitudes about conceptual change to become more neutral and increasing their openmindedness. The project involved the development of laboratory exercises, a book of selected primary sources, and a teacher's guide.

The curriculum was evaluated in a pilot field study with juniors and seniors in a suburban high school. The study was claimed to have produced improved curriculum materials, but the hypotheses presumably based on changing students' attitudes were not rejected at the 5 percent level. It was indicated that controlled research on the problem of this study be extended.

The reviewer believes that the last four studies related to earth science were clearly reported. They did deal with innovative efforts which is laudatory. However, the lack of controls in some of them makes the conclusions suspect.

Physics

Houlihan (146) evaluated an innovative instructional approach for high school physics that involved learning materials in a textbook, written by the investigator, for an experimental course. The material is based on five conceptual categories including "Newtonian Physics," "Energy," "The Field," "The Wave," and "Modern Physics." The organization emphasizes underlying concepts and the retention of essential facts while eliminating nonessential concepts and anecdotal learning. This organization is claimed to constitute an application of the investigator's functional approach which included the organizer framework suggested by Ausubel.

The subjects were approximately 70 high school students from the Chicago area in the 1973-74 school year who were taught by two participating teachers in an experimental and a control group. The teacher variable was provided by the control group and the other variables included the academic abilities and initial interest areas of the students. The design involved the evaluation of both cognitive and affective factors.

Results from the covariate analysis of test scores indicated significantly superior cognitive achievement for the experimental group in "The Wave" and "Modern Physics," whereas the results for the experimental group were inconclusive. Questionnaire responses from both classes indicated that students considered the functionally oriented activities as being most valuable, and that the solution of sample problems and review in class were most helpful.

Huegel (150) searched for the interrelating factors among several previously used classroom observational systems, specifically those of Bellack, Anderson, and Oguntonade. The common factors were then used to prepare a multidimensional observational system for use in describing cognitive qualities of teaching presentations recorded during parent study entitled Teaching Physics: Current Trends and Practices. The system was also used to describe the cognitive qualities of selected lessons to (1) identify some of the variables therein; (2) look for normative patterns and compare these with the findings of previous studies; and (3) establish the validity of the categories used in the observation instrument.

Twenty lessons were selected according to topic and then analyzed using Anderson's kinetic-structure technique. Kinetic structure refers to the extent to which there are sequence and rational linkages between the elements of learning experiences provided by the teacher. The four that ranked highest and the four that ranked lowest were then analyzed more critically. The analysis involved further study of kinetic structure and for Oguntonade's "syntactical" level categories including encounters, meanings and systems.

It was indicated that, as a limited exploratory study, the findings are more conceptual and suggestive than definitive. However, some findings were (1) significant differences were not found between discourses in high or low kinetic structure, (2) there were no clearly distinct patterns between high structured and low structured spans of discourse, (3) higher structured lessons involved less student interaction than low, (4) high structure teachers used fewer content specific terms but used these more intensively than did low structure teachers, (5) significant relationships were not found between kinetic structure and substantive logical meanings, and (6) 20 percent of discourse in high structure and 27 percent in low structure was devoted to assignments, materials and procedures. (Simple terminology would have made this report more readable.)

Driskill (91) sought to identify and order priorities in high school physics education for the decade 1975-85 and to identify factors both enhancing and inhibiting to the realization of these priorities.

A modification of the Delphi forecasting technique was used, consisting of four rounds of mailed questionnaires to two groups: (1) 11 university physics professors, physics educators, and science educators; and (2) 100 randomly selected high school physics teachers. The participants identified and ranked priorities for high school physics education that were reduced to 15 for the next round. In the second round both groups ranked the 15 priority statements in order of their perceived importance. The responses were analyzed to determine a mean rank and SD for each priority item. In the third round, all participants were asked to re-evaluate their original rankings in light of information about the total group mean rankings in the second round. They were asked to change their rankings to conform with those of the total group or explain why they did not change. The 15 statements were then ordered into a hierarchial arrangement; in found four the participants were asked to identify factors that would enhance, and those that would inhibit, the realization of the priorities.

The analyses involved two-way analysis of variance by ranks, coefficients of correlation, and the coefficient of concordance. The analysis indicated great agreement in ranking the priorities, the highest to make physics more appealing and interesting to students. Other priorities with high rankings were: (1) emphasize the investigatory nature of physics; (2) improve teacher competence; and (3) emphasize the social and moral dimensions of physics, the coherent structure of physics, and the practical nature of physics.

The report of this investigation was one of the most coherent this reviewer examined.

True (343) indicated that the purpose of his study was to (1) determine the areas of student difficulty in solving physics problems, (2) compare two different types of problem-solving instruction as to their effectiveness, and (3) analyze the problem-solving approach used by five successful problem solvers and five students who generally had difficulty in reaching a solution.

The subjects were 112 high-school physics students who were given a diagnostic test including mathematical operations, physical concepts, and physics problems. After the diagnostic test, 46 of the students received instruction in Polya's heuristics [encouraging the students to discover for themselves], 42 received instruction in Daniel's scanning of properties of the elements in a problem, and the remaining 24 students, who served as a control, received instruction in problem solving without the specific use of any heuristics. The three groups were given a problem-solving test after one semester of instruction; an ANOVA was used to test for differences. In the third part of the study, the five successful and five unsuccessful problem solvers were observed and questioned as they thought "out loud" while attempting to solve a problem.

The results of the diagnostic tests indicated: (1) a student's lack of knowledge of physics concepts has about the same influence on problem-solving ability as does lack of mathematical skill; (2) many students knew the mathematics and understood the physics concepts and still couldn't solve physics problems; and (3) many failures in problem solving came from errors in mathematics, lack of knowledge, carelessness, use of incorrect formulas, and applying wrong principles.

Both experimental groups scored significantly better on scores on problem-solving tests than did the control. However, the experimental groups did not differ significantly. The analysis of the five successful and five unsuccessful problem solvers indicated that the successful made greater use of heuristics than did the unsuccessful.

The reviewer applauds this study for being well organized and well reported.

Hoggard (143) attempted to encourage more non-science students to enroll in introductory college physics by using a mini-course approach. In the approach the student could elect short courses, offering one semester hour of credit, that were developed from historical, contemporary and theoretical sources. Each student was required to take one mini-laboratory course along with as many classroom mini-courses as he wished.

Enrolled in the mini-courses were 370 students; enrolled in the regular Physics 1005 - Survey of Physics at Southwest Missouri State College class were 95 students. The students were given pre- and post-tests in the processes of science and scientific attitudes. In addition a factual test and attitude toward class presentation instrument were administered to students in the mini-course group that finished five of the courses.

The analyses of the scores indicated that both groups gained significantly in knowledge of processes of science. But, significant differences were not found between the mean scores on scientific attitudes of the two groups. The factual knowledge of the Physics 1005 group was significantly greater than that of students in the mini-courses. It was noted that the numbers of women enrolling in physics increased significantly with the availability of mini-courses.

Hilbelink (141) gathered information concerning physics instruction for engineering technology students from the professional literature, personal correspondence with leaders in technical education, and a survey questionnaire to representative instructors and technical school administrators at institutions with at least one engineering technology program accredited by the Engineering Council for Professional Development. The questionnaire sought information about current programs, unfulfilled needs, desirable innovations, and probable future trends in physics instruction for the target group.

Analyses indicated only one significant curriculum development project in physics for technology students, namely, the Tech Physics Project which uses a modular "hands-on" approach and behavioral objectives. But, there are no journals or channels of communication routinely available to faculty and administrators that deal with curriculum matters in these programs.

Current instructional patterns in physics for technology students are best described as "classical" although they are characterized by examinations that emphasize engineering applications rather than general principles. There does not seem to be general agreement among physics instructors and faculty in engineering technology programs about the appropriate content of the physics courses for engineering technology students; neither does there seem to be much student input. There does, however, seem to be general agreement that the liberal arts physics course is not generally appropriate and both groups recognize the need for additional "hands-on" learning experiences.

Lillich (198) attempted "to determine whether cognitive structure would be useful as a predictor of an individual's achievement or satisfaction in Project Physics Course classes; and to determine relationships between [sic] cognitive preference, prior knowledge of physics, and two dimensions of classroom learning environment, Goal Direction and Goal Satisfaction."

In order to obtain data, a sample consisting of one class was chosen randomly from classes using Project Physics from each of 21 secondary schools in Ohio. The sample included 293 males and 101 females, with all teachers being male. The study extended from September, 1972 through May, 1973. A Pupil Achievement Test (PAT) was administered as a pre- and posttest for measuring gains in cognitive achievement. In addition, the students were administered the Cognitive Preference Test (CPT), the Learning Environment Inventory (LEI), and the Student Questionnaire all developed and used by the Evaluation Group of Harvard Project Physics.

The analyses were made with canonical correlations to relate the scores on the PAT pretest, CPT, and two of the 15 LEI scales as predictors to regression-adjusted PAT gain scores and individual satisfaction scores. The analyses indicated that (1) there was significant relationship between cognitive preference and achievement for both males and females, (2) individual satisfaction with the course—for males the significant relationship was noted between preference

for science facts and individual satisfaction, (3) individual perceptions of group satisfaction for both males and females, (4) individual perceptions of the classroom climate dimension of goal direction for both males and females, and (5) prior knowledge of physics for both males and females.

It was indicated that restraint should be used in making interpretations because of high interrelations about the various scales.

Leboutet (192) presented a narrative review of the application of research in learning to physics education. He claimed that the research indicated an emphasis on learning of concepts, the organization of knowledge, and programmed learning. His recommendations for research included (1) the analysis of the content of physics in terms of learning tasks, (2) better understanding of the child's and adolescent's capacity for learning by memory, (3) preconceptions and their elaboration in the courst of learning, (4) the operations of logic, and (5) scientific language and the learning of physics. (Delivered in 1975, the paper is hardly more than "armchair philosophy.")

Nelson and Dietrich (237) expressed concern, as many have, with declining physics enrollments. "In searching complex systems for cause and effect relationships, [they stated that] it is first necessary to identify variables which might interact and affect each other. This paper probes into data gathered in a previous study in order to identify variables which could be manipulated in a future study in order to establish a causal relationship."

During 1969-70, Wisconsin high schools offering physics were ranked according to the percent of the student body enrolled in physics. The top 17 enrolling 25 to 51 percent and the bottom 18 enrolling 3 to 12 percent were selected for analysis. Questionnaires were sent to the principals and physics teachers, visits were made and students were interviewed. Interviewed were five students selected from those enrolled in physics classes and five from the twelfth grade list who were not. Data were sought on numerous characteristics of students, teachers, classroom techniques, physics students, student physics grades, student science GPA's and overall GPA, and information about those who recommended that students elect physics. Twenty indices were analyzed with r and regression analysis.

The results indicated there was a negative correlation between students planning to go to college and enrollments in physics. It was noted also that schools with less adequately prepared teachers had lower enrollments. There was a positive relationship between enrollments and recommendations from adults, including counselors and teachers, for the student to elect physics. The higher enrollment schools apparently had more stringent grading standards, apparently course difficulty did not seem to cause low enrollments. The counselor's recommendation, however, seemed to be the only significant factor in high enrollments.

Many of the studies reviewed for physics education seem to be concerned with low enrollments and the need for more appropriate content at both the high-school and post-high-school levels. Yet it's interesting to note that these concerns have existed for decades and little seems to have been done to alleviate them.

Environment and Ecology

Although environment and ecology are among the "hot" social and scientific concerns, only four research studies were found that were addressed to these topics.

Trent (342) investigated two questions: (1) "Are colleges of education and state departments of education increasing their involvement in environmental education?" and (2) "What are the trends as perceived by colleges of education and state departments of education?" The data were collected for the period 1970-75. It was decided not to include this study with the other historical studies because of the short time span involved.

Questionnaires were developed and sent to fifty state departments of education and to a random sample of teacher education institutions listed in the 1967 AACTE Yearbook. The questionnaire to teacher education institutions sought information about methods courses in environmental education, content courses in that area, faculty involvement, inservice activities, and the availability of majors and minors. The questionnaire to state departments of education sought information about the appointment of state directors, the existence of state plans for environmental education, availability of state monies for inservice workshops, and the level of development of state programs. The responses received in December 1970, January 1972, February 1973 and February 1974 were tabulated and analyzed using the Chi-square statistic to assess differences. About an 80 percent response was received from the state departments, but apparently less than 20 percent from teacher education institutions.

The responses indicated that most states had a coordinator and used federal funds to support programs; less than 50 percent of the states had a full-time coordinator, a syllabus or a certifiable teaching major. It was indicated that there were significant increases in state materials, production of syllabi and use of state monies, but there had been a "leveling-off" over the period. The 1970 data for teacher education institutions indicated that the majority were not offering methods courses but were offering content courses. A significant change was not evident from 1970-72. From 1972-73 there was a significant increase in methods courses offered. There were also significant increases in faculty involvement in federally-funded environmental education projects and in the number of colleges offering majors or minors.

The Sarnowski (300) study had the purpose of developing and validating an instrument to assess the value perspectives of students through alternative approaches toward environmental solutions. He hypothesized that environmental values differed from general values and therefore an instrument used to measure one should produce results different from those of an instrument used to measure the other.

The environmental values instrument consisted of 20 environmental problems representing abusage and pollution problems resulting from agricultural, building, energy, transportation and private practices that result in biological and psychological harm to all living things. The Environmental Values Inventory (EVI), written in an "if-then" format, required the ranking of responses for five value dimensions (aesthetic, economic, political, social, and theoretical) similar to the mode for ranking the items on the modified Allport-Vernon-Lindzey Study of Values (AVL) that was used to measure general values. The instruments, plus other inventories, were administered to 555 ninth and twelfth grade students from urban, suburban and rural schools. Data were analyzed and attempts were made to determine relationships between the test scores and general values and variables of sex, age and geographical residence.

There were significant relationships between factors on the EVI and AVL. However, consistent similarities were not found for the responses among the urban, suburban and rural subjects. The investigator concluded that the EVI was a valid instrument and recommended its further use in the assessment of students' environmental values. It was somewhat difficult to determine from the report how firmly this conclusion could be supported unless further investigations were undertaken.

Shoemaker (307) listed four purposes for his study: (1) provide a set of field exercises that would assist the secondary science teacher in the teaching of ecology; (2) develop an evaluative tool which could be used by teachers to determine the teachability of the field exercises; (3) compare the performance of an experimental group with that of a control group; and (4) compare the performance of students on the Ecological Conceptual Knowledge Test before and after the field study exercises.

Consultants were used to develop field exercises in (1) Aquatic Study: Pond or Lake; (2) Entomology Study; (3) Habitats: A Field Study; (4) Small Mammal Study; (5) A Comparative Study of Two Contrasting Environments; (6) What is Man's Natural Environment? and (7) Field Research Project. The exercises were evaluated for their teachability on the basis of responses by teachers to a checklist and the progress made by students as indicated by gains between the pre- and post-Ecological Conceptual Knowledge Test.

An analysis of the data indicated: (1) a synthesis of procedures and techniques that illustrate ecological concepts was accomplished; (2) ecological concepts can be presented effectively at the secondary level through field exercises; (3) students who participate in field exercises have a better understanding of ecological principles than those who do not; and (4) the field exercises were judged to be teachable by experienced biology teachers.

Thies (338) was concerned with outdoor-environmental education programs and undertook a study to (1) determine efficient procedures for operating a residency outdoor-environmental program; (2) determine subject matter, instructional materials and teaching techniques for an interdisciplinary curriculum; (3) establish personnel needs and procedures for environmental programs; and (4) ascertain the administrative and supervisory roles best suited to the objectives and programs of outdoor-environmental education facilities.

Information was gathered through two 14-week internships at environmental centers and 65 visits at outdoor-environmental programs in 16 western states. During these experiences daily logs were kept and the salient ideas were abstracted for the preparation of a leader's manual.

The information gathered led the investigator to conclude that (1) universities should include outdoor-environmental education courses in course offerings for teachers; (2) environmental programs are weak if not integrated with on-going educational curricula; (3) better training programs and certification requirements need to be developed for leaders of these programs; (4) many facilities are outmoded and need upgrading; (5) inquiry methods with hands-on student activities need to be developed for such programs; and (6) the current interest in environmental education needs to be exploited for program support.

The few studies published do not allow for valid comparison of findings. However, tacitly or directly, all of them indicate the need for hands-on, outdoor environmental activities.

Who Does It? — The Teacher

This reviewer believes preceding reviews have considerably less significance than the ones in this section that deal with the only irreplaceable learning strategy—the teacher. For coherence, the reviews have been placed in four categories: (1) Teacher Characteristics, (2) Teacher Training, (3) Preservice Experiences, and (4) Inservice Experiences. There is obviously some overlap among sections, but the scope of each section will be described prior to a review of the related studies.

Teacher Characteristics

The studies reviewed in this section deal mainly with the selection, employability, behaviors, perceptions and productivity of science teachers. Two in particular dealt with selection and employability.

Nelson (235) attempted to answer four questions related to teacher selection: (1) What effect does the credential have on a candidate's ranking for employment? (2) Which information in the prototypic credential is most useful in ranking candidates for employment? (3) Which prototypic credential provides the most confidence in teacher ranking? and (4) What do potential employers look for in a videotaped teaching sequence?

In order to gather data to answer the questions, a sample of administrators and science supervisors from Wisconsin was asked to participate in the study, and 32 agreed. They consisted of six science teachers or science department heads; seven personnel directors; six principals; six assistant superintendents; and the remaining seven, miscellaneous staff personnel such as coordinators of personnel or directors of operations. All received credentials of four biology and four chemistry students who were planning to teach; they were asked to rank the credentials from least desirable to most desirable on a scale of 0-6. There were seven types of prototypic credentials, W (written letters of reference, course types, grades and assessments of directed teaching), O (performance in seven areas of objectives and comparisons with other beginners), V (videotaped discussion, lecture and laboratory sessions involving the students), and combinations including WO, WV, OV and WOV. Seven groups of four were ranked with different prototypic credentials.

The results were analyzed by rank-order correlations and Kendall's Coefficient of Concordance. It was found that as credentials became more representative of teaching performance, there was greater agreement in ranking candidates; as more information about the candidate's teaching ability is provided, the rankings of those who see prototypic credentials are in greater agreement with rankings of individuals who actually see the applicants teach. There seems to be little relationship between claims on credentials of teaching ability and rankings of desirability for employment. There was greater agreement in ranking biology candidates than in ranking chemistry candidates. In brief, the greater the information supplied and the more closely it matched the teaching behavior of the candidate, the more consistent were the rankings. Also, potential employers were most concerned with information about classroom behaviors.

Tamppari and Johnson (336) attempted to gather specific information from prospective employers of science teachers which could be used by teacher-training institutions to better advise and prepare science teacher candidates. A "science teacher" was defined as anyone who would teach any of the sciences in grades 7-12.

There were 2771 schools identified from the educational directories of the states of Arizona, California, Colorado, Nevada, New Mexico and Utah. The schools were categorized as Metropolitan, Metropolitan

Other, and Non-Metropolitan using the Standard Metropolitan Statistical Area (SMSA) System; those with fewer than 270 students were not considered in the study. Questionnaires were sent to a stratified random sample of 10 percent of the schools in each of the three categories. Questionnaires were mailed to 277 schools, and 168 usable replies were received. Information was sought about attributes administrators look for and weigh when considering candidates for a science position. The attributes appeared as items on the questionnaire and were judged on a scale of 1-5.

The responses indicated that the highest attributes were (1) high motivation for secondary science teaching and capability of the candidate to communicate that motivation to hiring officials and students; (2) broad training in the sciences rather than narrow; (3) successful student teaching experience; (4) the ability to relate science concepts to practical applications; (5) an above average GPA but not necessarily a superior one; (6) experience in working with adolescents in teaching situations; (7) training in science education methods; and, above all, (8) good communication skills. Little weight was given to professional education courses, to participation in college activities, or rapport with other teachers or supervisors. There was a preference for the MS over the MAT or MEd, but the BA was preferred overall.

It is interesting to note that these last two studies complement one another in that one describes the desired attributes and the other gives information about the most suitable credentials to provide that information.

Classroom behaviors and practices and their relationships to teacher characteristics are the concerns of the next nine studies.

Nelson and White (234) indicated the purposes of their study as being to: (1) identify relationships between elementary science-teacher variables and the science-teacher practices used; (2) hypothesize a model to describe and explain the complex relationships between elementary science-teacher variables and the science-teaching practices used; and (3) test the hypothesized model explaining the complex relationships between elementary science-teacher variables and science teaching practices used.

The population consisted of a sample of 2948 of the public elementary schools in the Midwest, New England and Southwest regions of the United States during the 1970-71 school year from which 1444 positive responses were received for participation. Questionnaires that sought to elicit information appropriate to the purposes of the study were sent to all the positive respondents and usable data were obtained from 880. A model was developed using the Midwest data and a questionnaire was developed with 128 variables that were later reduced to eight interpretable variables by factor analysis. A path analysis model was used to represent associations among the variables and these were used to compute path regression coefficients.

The results of the analyses indicated that innovative science teaching techniques may have been influenced by funds available for supplies after teachers had inservice training in science; the same seems to be true for adopting course content improvement programs. When funds were "high" the use of course content improvement programs was "low" by experienced teachers but "high" by inexperienced teachers. It was concluded that past inservice experience was not enough to get experienced teachers to use course content improvement programs. Another conclusion may be that the experience gives teachers the wisdom to avoid course content improvement programs if they are not perceived to be vehicles for teaching elementary science.

Strawitz (325) investigated the relationship between dogmatism and the beliefs of preservice and inservice elementary teachers about teaching science. The data were gathered in 1974 by administering two instruments to 61 elementary education majors and 32 inservice elementary teachers at Louisiana State University after 13 weeks of instruction. The preservice teachers were in three undergraduate science methods courses and the inservice in two graduate science methods courses. The Rokeach Dogmatism Scale: Form E was used to measure dogmatism. A revised questionnaire by Good was used to assess teacher beliefs about teaching science in the elementary school. The assumption behind the use of the questionnaire is that if one assumes what a teacher does in a classroom is in part related to what he intends to do, then beliefs may be a valid criterion of classroom behavior.

An analysis of scores indicated a significant negative relationship between dogmatism and beliefs. The results therefore are consistent with the theoretical principle that highly dogmatic teachers are less able than those with less dogmatism to learn new beliefs about science. In other words, openmindedness is likely to enhance, and closemindedness likely to inhibit, innovate thinking.

Young (371) studied the possibility that measurable differences exist between the self-concepts and professional practices of female teachers of secondary school science and mathematics and those of male and female teachers who teach other secondary school subjects. The study also dealt with the possible exclusion of female teachers of science and mathematics by other teachers from their social and professional interactions. Both of these facets were based on the premise that science and mathematics are the "property of males."

In order to gather data, four groups of secondary teachers were identified, including female teachers of mathematics and science, female teachers of French and Spanish, male teachers of mathematics and science and male teachers of social studies. The inventories and scales were the Veldman-Parker Adjective Self-Description; The Personal-Practices Inventory-Inside; and The Personal-Practices Inventory-Outside. The latter two dealt, respectively, with the time spent on classroom teaching practices and involvement with professional activities outside the classroom. The female teachers of mathematics and science also completed the Young Exclusion Scale designed to indicate perceptions of exclusions from social and professional interactions of their colleagues. A total of 309 teachers participated.

The results of the analyses of the scores on the inventories and scales failed to suggest that there were differences between the self concepts of female teachers of mathematics and science and their male colleagues. Neither was there support for the premises of exclusion. However, when the data were examined by age groups, there seemed to be perceptions of females in the age group 30-49 of exclusion at professional meetings, and also perceptions of females in the age groups 30-39 and 50-59 of exclusion during graduate study by male colleagues. It was concluded that significant differences were not evident among the four groups and the stereotype in the literature of female teachers of mathematics and science is not tenable. Neither are significant differences evident between teaching practices of females and males.

Smigelski (313) evaluated the effect of performance-based teacher education (PBTE) training on selected humanistic behaviors of science teachers using four specially designed instruments. In addition, the influence of eleven other factors was studied including college or university schools where certification was achieved; teacher perception of the size of its student population and the number of science teachers it certified; age and sex of the teacher; and the level at which, and the subjects, they taught.

Fifty-six science teachers and one class taught by each teacher were included in the study. The teachers had been certified in six different colleges and universities in three different states.

An analysis of the scores on the instruments and data on other factors failed to indicate significant differences between the importance teachers with and without PBTE training gave to humanistic and non-humanistic objectives, or in the progress their students perceived that they had made toward these objectives. Neither were significant differences found between the two groups for any aspect of classroom environment except for the use of texts and resources in which increasing PBTE training resulted in teachers being viewed as less humanistic. Significant differences failed to be evident between the groups on any of the eleven other factors that were studied. In general, the humanistic behaviors of teachers were apparently not influenced by the type of PBTE training used in this study.

Patelmo (261) studied which of certain characteristics of the science teacher and his classroom behavior are related to the enhancement of critical thinking skills in students. The subjects in his study were 20 junior high school science teachers teaching the Introductory Physical Science (IPS) Program to eighth grade students in six school districts in Eastern Montgomery County, Pennsylvania. One section of students was selected from each teacher's class load for participation. The 20 sections included 450 students.

The data were gathered with a pre- and posttest design using the Watson-Glaser Critical Thinking Appraisal. An analysis of covariance was made on the mean posttest scores on the critical thinking test using the intelligence quotient and the mean pretest scores as

covariates. The adjusted posttest mean scores on the critical thinking test were used to separate the teachers into ten groups each of "more effective" and "Less effective" teachers of critical thinking. Teacher characteristic data were collected with the Watson-Glaser Critical Thinking Appraisal; California Test of Mental Maturity; Wisconsin Inventory of Science Processes; Guilford-Zimmerman Temperament Survey; Minnesota Teacher Attitude Inventory; and a teacher questionnaire. The Ladd-Anderson questioning classification scheme was used with tape recordings to evaluate the questioning behavior of the teachers.

A Science Classroom Activity Checklist was developed and used to allow students to check the classroom and laboratory activities used by the teachers. The data were then pooled and compared using various statistical procedures.

The results of the analyses indicated that there were significant differences between "more effective" and "less effective" teachers in that "more effective" teachers had more teaching experience and showed more positive personality traits such as emotional stability, objectivity, and better personal relations, and asked more high-inquiry type questions.

Significant differences were not found between the two groups on a number of factors, among them (1) numbers of hours of academic course training in science or science education; (2) number of years teaching IPS; (3) critical thinking ability or mental ability; (4) knowledge of processes of science; (5) attitudes toward teacher-pupil relationships or toward science; and (6) traits such as general activity, restraint, ascendance, sociability, friendliness, or masculinity. Neither were differences found between their classroom practices. Significant relationships were found between student achievement on the posttest of critical thinking ability and teachers' emotional stability, objectivity, personal relations, and questioning behavior.

This study by Patelmo appeared to be among the best reviewed.

Taylor and Armstrong (337) attempted to distinguish between activity-centered and textbook-centered preservice elementary science teachers and to identify personality factors associated with each group. It was hypothesized that activity-centered preservice teachers would be likely to use materials and methods of SAPA, ESS, SCIS and the like whereas textbook-centered teachers would be likely to use textbooks with limited student involvement with materials. (At the outset, the reviewer supports the right of the investigators to establish such definitions for this study, but he believes that it is highly fallacious to assume that all activity-centered teachers use course content improvement programs or that classrooms in which such programs have been adopted are activity centered.) The investigators also defined the "teacher emphasis role" as being "didactic" and the "student emphasis role" as being the freedom of the student to experiment.

In order to accomplish the purposes of the study, 111 students—18 males and 93 females—in four sections of a course in undergraduate elementary science methods at the University of Idaho served as subjects. During the first week they were administered the Predicted Role Measure and Cattell's 16-Personality Factor Inventory. The Predicted Role Measure was scored on a five-cell [sic] Likert Scale.

An analysis of the scores on the instruments indicated that preservice activity-centered elementary science teachers are above average in self-sufficiency, whereas textbook-centered were average in "group dependent" on a self-sufficient continuum. Also activity-centered teachers had higher mean scores on humble-assertive, expedient-conscientious, trusting-suspicious, practical-imaginative, self assured-apprehensive, and group dependent-self sufficient items. The preservice activity-centered teachers were found also to be more suspicious and conservative than their counterparts. The directions of the higher mean scores are not always indicated. Some of the findings seem to be contradictory, an example being that activity-centered teachers are more self-sufficient but also are more conservative.

Powell (272) tried to determine the extent to which teacher personality traits are related to teacher success as described by the Intermediate Science Curriculum Study (ISCS). He further examined the relationship between teacher attitudes toward ISCS and verbal interaction patterns in ISCS classrooms.

The subjects were eight teachers who participated in an ISCS Inservice Institute supported by the National Science Foundation and two of the classes of each. The teachers consisted of seven males and one female; the students were seventh and eighth graders. Data were collected from: (1) teacher attitude scales about ISCS, (2) student attitude scales toward ISCS, (3) teacher scores on 18 California Personality Inventory Scales, and (4) four hours of verbal interaction taped in the fall and spring and coded by a trained observer.

The analyses of the data indicated that (1) teachers thought students had success in the ISCS program and a better knowledge of science; (2) both teachers and students believed there was good rapport; (3) students liked ISCS better than previous science classes; (4) much of the time was in laboratory activity and more than half the class time was student controlled; (5) teachers used more model than non-model behaviors; and (6) six of the scales on the CPI were positively correlated and six negatively correlated with model behaviors and positive teacher and student attitudes. These relationships therefore must be considered generally inconclusive.

Clark (68) tested the relationships between teacher characteristics and classroom behaviors recommended by Intermediate Science Curriculum Study (ISCS) and pupil achievement in ISCS Level I. The subjects were 22 teachers in 18 Philadelphia junior high schools who were administered the Guilford-Zimmerman Temperament Scale; the

Scientific Attitude Inventory; the Minnesota Teacher Attitude Inventory; a test of knowledge of content of the ISCS Level I using ISCS Test - Level I; and the Wisconsin Inventory of Science Processes. the Science Teacher Behavior Inventory was developed to determine the frequencies of teacher and student classroom behaviors. Pupil achievement was measured with the ISCS Test - Level I.

Statistical analyses for relationships and differences failed to indicate significant differences in pupil achievement based on sex or grade, but there were statistically significant differences in pupil achievement based on the teacher factor. It appears that teacher knowledge of processes of science and knowledge of content taught through ISCS are the significant teacher characteristics enhancing pupil achievement. But, teacher attitude toward science and teacher-pupil relationships were not found to be related significantly to pupil achievement.

It was concluded that ISCS recommendations concerning teacher characteristics are valid and that, if followed in implementing the ISCS program, should result in greater pupil achievement. But, there is some question as to whether these recommendations are indigenous to ISCS. They seem to be well known principles of desirable teacher behavior and should apply to any program, not just ISCS.

Shymansky, Penick, Good and Matthews (308) studied the use of a modification of the macroanalytic technique developed by Campbell to analyze the behavior patterns of a fifth grade science teacher. The modification represented the reduction of uninterrupted chains of behavior (XAAAX) to single units (XAX) rather than repeating them. The behavior was coded every three seconds.

Observational data were obtained using the SCAS Classroom Interaction Categories-Teacher Behaviors that consisted of 18 categories of teacher behavior coded every three seconds. One fifth grade teacher was observed for about 32 minutes and 770 observational tallies were made and analyzed using the standard macroanalytic technique and the modified technique.

Comparisons of the analyses indicated that only four patterns were common to both. Patterns ranked 1, 2, 3 and 4 with the modified technique were ranked 2, 7, 15 and 18 with the standard technique. Those four represented 33 percent of the total patterns in the modified technique but only 10 percent in standard.

In the remaining 21 of the top 25 in the standard sequence S2 S2 S2, S2 occurred three times as often as other patterns; this is not revealed with the modified technique. Also, of the 21 remaining in the modified, 19 did not appear in the top 50 using the standard analysis and 6 of the 21 did not appear in any of the 208 different patterns using the standard. Fifty-one additional patterns in the modified technique did not appear in the standard.

One may conclude that the modified macroanalytic technique does not produce results consistent with those of the standard. The modified technique seems to be the most effective in examination of "long term" behavior patterns, namely, coding every 15 seconds rather than every three.

The studies in this group are too diverse to synthesize many general conclusions, but two seem to emerge: (1) the extent to which a teacher is cognizant of the content and technique relevant to a learning experience, the greater is pupil achievement; and (2) the extent to which the content and technique are applied in the experience and the student is aware of them, the greater is the achievement.

Four studies that dealt with perceptions were identified. Margan-off (208) undertook research to investigate the relationship between present and future perceptions of "ideal" Supervisor-Teacher interactions in an effort to determine whether they are indeed different. The subjects consisted of related groups of current science supervisors, science teachers, and science supervisory interns whose perceptions of "ideal" supervisory interactions were examined in five dimensions: (1) the perceived "present idea" interaction; (2) the perceived "future ideal" interaction; (3) the desirability of future change in specific educational areas; (4) the selection of agents influencing future change; and (5) the anticipated time sequence of future change. The process of anticipating future oriented "ideals" is fostered by the use of a "Future News Event," a technique alleged to help participants break away from current mind sets.

The data were collected with a questionnaire consisting of 36 stimulus variable items drawn from the Opinion Inventory of Supervisors. Participants ranked their present and future "ideal" perceptions based on the perceived frequency of occurrence of specific stimulus variables. These variables were compared for nine areas of supervisory behavior, some examples of which are Instructional Organization, Coordinating Special Services, and Staffing. The data were tested for significant differences. A Modified Delphi format was used to obtain participant consensus on perceived changes.

The major findings were: (1) there is a significant difference between "present ideal" and "future ideal" perceptions; (2) significant differences exist among the study population scores on perceived frequency of occurrence of the two supervisory behaviors, Evaluation and Staffing; (3) significant differences were not found among the groups, the time, and the categories of supervisory behavior; and (4) the Modified Delphi instrument data indicate that future supervisory changes are most desirable in Providing Inservice Education, Curriculum Development, and Providing Instructional Aids. The participants indicated that the most influential agent for change between 1973 and 1977 would be the school principal.

Bybee (58) proposed to establish a profile of hierarchy of perceptions relative to aspects of the interaction of teaching science using three populations: (1) elementary children; (2) preservice teachers, and

(3) elementary inservice teachers. The subjects in the three groups consisted of 43 middle class children of slightly above average IQ in the fourth, fifth and sixth grades of the Laboratory School at the University of Northern Colorado; 38 elementary education majors (36 of whom were women and 3 men) who had not completed student teaching; and 20 elementary education majors (18 of whom were women and 1, a man) who had completed student teaching; 43 inservice teachers (40 of whom were women and 1, a man) from urban and suburban schools in the Denver area; and 33 inservice teachers (29 of whom were women and 4 men) from eight rural schools who participated in a science workshop in the Summer 1971.

The data were collected in the Spring and Summer, 1971, using a 50-item Q-sort, ten items of which were keyed to each of the five categories examined in the study: (1) knowledge and organization of subject matter, (2) adequacy of relations with students in science classes, (3) adequacy of plans and procedures in science classes, (4) enthusiasm in working with science students, and (5) techniques or methods of teaching elementary science. The items were divided into three piles: positive, neutral and negative, and then keyed back to the five categories.

The findings indicated that, with one exception, adequacy of personal relations in the science class was most important and the second was enthusiasm in working with students. Children ranked subject matter third whereas all groups of teachers ranked that category fourth.

It was indicated that most preservice programs emphasize knowledge of subject matter, and ability to use appropriate methods, and curriculum. Interpersonal relations, considered most important, get less emphasis.

The purpose of a study by Dieter and Hounshell (88) was "to determine the importance of various criteria actually being used when evaluating the competence of biology teachers . . . In order to do so data was [sic] gained about the traits and characteristics for which they were being held accountable by judges in a formal assessment effort." In simple terms, the "formal assessment effort" refers to the Outstanding Biology Teacher Award (OBTA) Program of the National Association of Biology Teachers. Assumptions were made that although many studies show disagreement among judges in rating teachers, criteria do exist for making valid judgments, the NABT has selected qualified persons to make judgments, and these judges do use criteria that are appropriate. However, it was also assumed that the different judges had different "value hierarchies" for the different criteria.

In order to identify these assumed hierarchies, if indeed they existed, all the judges in the 1970 OBTA Program were asked to rate the various criteria they employed in evaluating candidates for the award. The list of criteria they rated consisted of 111 items that were synthesized from the literature and materials dealing with

characteristics that might be used as criteria for making judgments. Two hundred and twenty members of 47 state selection committees active in the 1970 OBTA Program provided 179 usable returns.

The analysis of the responses indicated that the judges perceived 21 criteria as being significant including interest and enthusiasm for biology, interest in self improvement, concerns for student understanding of essential science processes, poise and self confidence, ability to inspire self confidence in students, concern for understanding of essential concepts, and interest and enthusiasm in the activities and accomplishments of students.

Despite the fact that the judges included secondary school biology teachers, public school supervisors and administrators, and state science supervisors, the criteria they considered most significant were quite similar. It was concluded that specific criteria do exist for making judgments in this program.

A study, corollary to the one just reviewed, was reported by Dieter (87) and Hounshell and Dieter (147). Its purpose was to determine how recipients of the Outstanding Biology Teacher Award (OBTA) in the Program of the National Association of Biology Teachers perceive themselves when responding to the items on the Gough Adjective Checklist (ACL). Forty-three of 46 of the 1970 award recipients (29 males and 14 females) responded to the ACL, which has 24 separate scales containing groups of related adjectives. The scales are claimed to measure personal adjustment, self control, heterosexuality, dominance, endurance and aggression.

The responses failed to indicate significant differences between the self-perceptions of males and females. However, significant differences were found at the 1 percent level between the responses of the award recipients and the norm population on a number of items. The award recipients considered themselves exceptional in achievement, endurance, order, intraception dominance, nuturance, defensiveness, personal adjustment, favorable [sic], self confidence, self control, and succurance.

The studies together suggest that award recipients of OBTA perceive themselves as having the characteristics judged to be desirable in competent teachers.

Two studies were found that might be referred generally to the factor of productivity. Bernstein (37) undertook a study that had a number of purposes: (1) identify those factors that are likely to be related to the productivity of the contemporary American secondary school science teacher; (2) devise a scale appropriate to measure that productivity, and (3) determine the relationships between selected educational, professional, and personal factors. Productivity was defined as his/her contributions to the professional growth of his/her "workshop," such as publishing in professional journals and/or contributions to science education such as developing a new curriculum, writing a textbook, developing or improving apparatus, or undertaking science education research.

With the assistance of five science educators and seven other teachers a 10-item productivity scale was developed from twelve other productivity scales. The productivity items and questions related to selected educational, professional and personal factors were incorporated into a checklist that was sent to a random sample of 1000 secondary school science teachers. The 474 returns were evaluated to determine the relationships between the factors indicated and teacher productivity, and to estimate which activities of the average science teacher are likely to have the greatest affect [sic].

The evaluation indicated that the highly and the minimally productive teachers were males. The moderately more productive belong to more organizations, and the minimally productive seem to come from the smaller schools. Productivity also seemed to be related to science credits earned and services available to the teacher. The average science teacher apparently affects his colleagues and profession by speaking and revising curricula rather than by writing. It was noted in particular that the higher the undergraduate GPA and the greater the amount of graduate work taken, the greater the productivity.

Lawrenz (185) probed issues related to productivity in a study designed to determine if a relationship exists between selected teacher characteristics and student outcomes and to provide some indication of the relative importance of the teacher characteristics. The teacher characteristics of concern were knowledge of subject matter and training methods, experience, attitude toward science, professional self-improvement, and type of learning environment created. The student outcomes of concern were increased achievement and improvement in attitude toward science.

In order to gather data, a stratified random sample of 236 secondary science teachers from 14 states were selected as subjects. Eighty-four taught biology, 111 taught chemistry, and 41 taught physics. The teachers completed a questionnaire; the National Teachers Examination (NTE) in Science, The Science Process Inventory (SPI), and the Science Attitude Inventory (SAI). Each teacher randomly selected one of his classes to complete four instruments; the Learning Environment Inventory (LEI), Test on Achievement in Science (TAS), and the SPI and SAI. Canonical correlation was used to examine the relationships between teacher and student variables.

The results indicated only one significant relationship; namely, a .61 coefficient of correlation between the teacher characteristics and student achievement and attitude. It was found that Formality was negatively related to student achievement, although Goal Direction was positively related. A positive relationship did exist between Self-Improvement and knowledge of science, but none of these relationships was significant.

Preservice-Experiences

Research on preservice experiences accounted for 25 of the reports in this Summary. It was extremely difficult to classify the studies into groups since most of them dealt with several factors. However, an attempt has been made, where possible, to group although some studies are dealt with separately.

A study undertaken by Cohen (70) was extremely difficult to classify, but it was included here because of its implications for preservice programs for training science teachers. The study was concerned with developing a procedure for reducing professional conflict between [sic] scientists, secondary science methodologists, and educationists. It was undertaken at Trenton State College where conflict was perceived and it was hoped that the procedure developed would allow for the reduction of "high, dysfunctioning conflict levels to low, productive conflict levels."

In order to accomplish the purpose, an ad hoc committee of nine faculty members (from the three areas indicated) was established with the charge of discussing the curriculum for training future secondary school science teachers. Prior to committee activity, all members completed an Initial Questionnaire to assess their perceptions of issues raised in the literature and issues that would probably be discussed in the procedure. At the end of four of the five meetings members completed an Ends of Meetings Questionnaire that assessed their perceptions of the committee's functioning effectiveness. After the five meetings the members completed a Final Questionnaire which assessed their perceptions of the issues raised in the literature, issues raised at the meetings, and the effectiveness of the process.

The evaluation consisted of the use of nonparametric methods to analyze the responses to (a) objective items from the three questionnaires; (b) subject statements made by committee members on the Initial and Final Questionnaires; and (c) statements made during the committee meetings. A total of 32 hypotheses were evaluated. Of the 32 null hypotheses, 13 were rejected. The findings suggested that there was a significant change in the ranking of (a) the committee's perceived ability to comply with the agenda and mediate positions; (b) conflict between science and education faculty; (c) awareness of conflict for the dean of liberal arts, dean of education, and department chairmen; and (d) concern about the conflict for the department chairmen and science faculty. The conflict level was perceived as being significantly reduced, although not all issues were resolved between academic scientists and educationists.

The study was somewhat redundant in that it merely reaffirmed what is common knowledge; namely, that if sensible people will sit down and interact with one another rationally, issues can at least be partly resolved.

The study of Butzow and Ryan (57) investigated three hypotheses:

1. If there is a relationship between philosophical position and teaching style, measured philosophical position should be consistent with the philosophical position manifested in the actual sample of classroom teaching.

2. If there is a relationship between philosophical position and student teacher attitudes towards the purpose and method of teaching, questionnaire responses to teaching procedure and the role of the school should be consistent with measured philosophical position.

3. If a student teacher is restricted to a narrow range of personality types in Holland's theory and subsequently to a narrow range of vocational choice, there should be a narrow range of philosophical positions measured and operating in such a sample.

Holland's theory lists five philosophical positions: Idealism, Realism, Pragmatism, Phenomenologist, and Existentialist. These are included in the Ames Philosophical Belief Inventory (APBI) used in the study. The APBI was administered to a randomly selected sample from among all students who were registered for student teaching at the University of Maine at Orono. The subjects were required to provide an audiotape of a teaching lesson of their choice and also complete a questionnaire that posed questions about their educational background, vocational choice, and purposes and procedures inherent in teaching methods and schools. Twelve females and six males agreed to participate. Each audiotape was rated simultaneously by two investigators and responses on the APBI, questionnaires, and tapes were compared.

The results of the analyses indicated that: (1) teaching behavior manifested on the audiotapes bore little resemblance to APBI scores, (2) schools may demand more realistic behavior than student teachers believe in, (3) emphasis on student teacher evaluation and stresses in schools force student teachers to behave in a less eclectic manner than they would choose, (4) student teachers act as though the school is designed mainly to perpetuate culture, (5) most student teachers view the learner as a self-disciplinary person, and (6) the predominant style is a mixture of pragmatism and realism.

Heard (136) dealt with the issue of authoritarianism in a study to investigate the relationship between the degree of authoritarianism expressed by preservice secondary science teachers and the way in which they spent their instructional time. The study was conducted with 55 students enrolled in the secondary science instructional methods course at a large North Texas area university during the fall and spring semesters 1972-73.

The instrument used to identify authoritarian attitudes was the Adorno Fascism Scale that was administered the first week of each semester. The ways prospective science teachers used their instructional time was described using the Flanders' Interaction Analysis technique. Three observers collected data the second week of each semester by observing each prospective science teacher as he taught a lesson to the class. Pearson Product-Moment coefficients of correlation were computed between the student's fascism scores and the amount of time spent in various categories of Flanders Interaction Analysis.

An analysis of the findings failed to indicate significant relationships between the degree of authoritarianism expressed by a student teacher and his use of student ideas, acceptance of student feelings, use of lecture method of instruction, justification of his own authority, criticism of students, the amount of time his students spent in silence or confusion, the amount of directions he gave, the amount of student-initiated talk, or his own Flanders' Indirect/Direct ratio. Two negative relations found to be significant were between the degree of authoritarianism expressed and (1) the amount of time they spent in asking questions, and (2) the amount of time their students spent in responding to teacher questions.

Santiesteban (299) attempted to determine the relative effects of video and audio models on the acquisition of a teaching skill by preservice elementary teachers and on concomitant science learning. To carry out the study, 48 preservice elementary teachers were randomly assigned to a vadeo model, an audio model, or a control model treatment condition. Those in the video model observed a videotape of a teacher using observation and classification behavior with four fourth-grade students. Those in the audio model listed to an audio version of the video model. The control group observed neither. All subjects prepared 15-minute microteaching lessons and used them with three third- or fourth-grade students randomly assigned to them. Then the preservice teachers were tested with a written criterion test to measure identification and classification questions. Also, the elementary students were tested with a written process test to measure their ability to observe and classify according to item criteria.

The microteaching lessons were videotaped and analyzed by three trained raters for the frequency of classification questions and the frequency of observation questions. The classification questions were then coded according to whether the teacher selected the characteristic to be classified or whether the student devised the classification system.

The results indicated that students in the audio model performed significantly better than those in the control model on the teacher criterion test, although significant differences were not found between those in the audio and visual models, or between those in the video and control models. Neither were significant differences found for the

main effects on the student process test. Both those in the audio and video models performed significantly better than those in the control model on the frequency of observation questions, frequency of teacher-imposed classification questions, and total number of classification questions. Significant differences were not found between those in the audio and video models on any of the audio tape interaction categories; however, elementary students exposed to teachers in both the audio and video models responded significantly more than the controls on observation, teacher imposed classification, and total classification questions.

Three studies were found dealing with biology for preservice teachers, two dealt with biology courses for elementary teachers and the third with the evaluation of prospective biology teachers at the secondary level.

Simpson (311) undertook a study of 27 undergraduate students who were enrolled in Biology 108, a biology course for elementary teachers at the University of Georgia. The purpose was to assess the relationship between the affective measures used to evaluate the students and the course and the cognitive performance of the students.

A subject preference scale was designed and administered to the students on the first day of class on which their preferences for biology, and for science in general, were assessed. A number of tests were administered during the course including measures for student achievement on laboratory exercises and extraclass assignments. In addition a checklist designed by the instructor was used to measure affective behaviors and four instructors maintained records on the 27 students.

The results indicated that there was a high correlation between test grades and scores from a checklist of affective behaviors. Also there was a comparatively high degree of relationship between achievement on laboratory and extraclass assignments. Preference for biology was not significantly related to achievement in the course.

Chrouser (66) compared two approaches to the teaching of biology for prospective elementary teachers. Each approach, (a) the indoor laboratory and (b) the outdoor laboratory, was analyzed with respect to gain in understanding of (1) the social concepts of science, (2) certain biological principles, (3) science as a process, and (4) ability to think critically.

The subjects were students who were enrolled in a biology course for prospective biology teachers at the University of Northern Colorado during the spring and summer quarters of 1969. Each class was divided into an indoor and outdoor group. All had the same lectures and the laboratory was carried on at the same time using audio-tutorial methods, but one was all indoor and the other all outdoor. All subjects were administered four instruments, the first as a pretest during the first classroom session and laboratory sessions, and the second as a posttest during the last classroom and laboratory sessions. These

included the Test on Social Aspects of Science consisting of 52 statements to which students responded on a 5-point scale from strongly agree to strongly disagree; the Methods and Procedures of Science: An Examination (MPSE); the Watson-Glaser Critical Thinking Appraisal; and the Understanding of Selected Biological Principles: An Examination.

An analysis of the difference scores on the test indicated that a biology course that emphasizes field experiences was more effective than one with only indoor laboratory experiences. The field experiences helped students achieve understanding of (1) social aspects of science; (2) selected biological principles; and (3) science as a process. The experiences did not seem more effective, however, in helping students understand biological principles in general or increase their critical thinking ability.

Stronck (326) collected evaluations on instruction performed by student teachers of biology with the aim of comparing the evaluations made by their peers with those of their students. Another objective was to compare the evaluations of the first performance with those of the second performance to ascertain any changes. The study covered nine lessons taught by 58 student teachers during four different semesters. Each lesson was about a half hour in length and was related to a typical experiment in biology.

In order to gather the data, a nine category questionnaire was prepared, each category rated on a 5-point scale. The nine categories included: (1) knowledge of subject matter; (2) attitude toward subject; (3) explanations given; (4) speaking ability; (5) attitudes towards students; (6) personality; (7) evidence of planning in procedures and materials; (8) students' attention rated as active, adequate, and distracted; and (9) objectives rated as clear, confusing, and unknown. Two thousand three hundred and thirty-nine questionnaires were completed by students in the classrooms and 314 by peers.

The t-tests indicated significant differences between the evaluations of peers and those of students in seven of the nine categories, with the ratings of students being lower than those of peers. However, significant differences were not found between student evaluations of the first and second performances.

The three studies reviewed were too diverse in purposes to synthesize the findings.

The concern with measurement of attitudinal change is evidenced by seven studies dealing with that issue, five of which were concerned with elementary education.

Lawson, Nordland and DeVito (188) investigated the interrelations of student's scores among four Piagetian-styled tasks to assess formal reasoning abilities with scores on commonly used standardized verbal and mathematical aptitude examinations and with those from achievement examinations in science, mathematics and English. In addition, they examined the relationship of scores from formal reasoning measures with those from measures of science attitude and science process.

The subjects were 71 freshman and sophomore elementary education majors (68 females and 3 males) at Purdue University to whom four tasks used to measure formal reasoning abilities were administered in interviews of about 20 minutes. The tasks included Conservation of Volume using clay, Conservation of Volume using metal cylinders, Separation of Variables, and Expulsion of Irrelevant Variables. The responses were categorized as Early Concrete Operational, Concrete Operational, Transition to Formal Operational, and Formal Operational and were categorized on a scale of 1-4. The achievement measures used were from the College Entrance Board Examination and Sequential Test of Educational Progress - Science, Form IA. The measures of aptitude for mathematics was the SAT-M, and for verbal, the SAT-V. The other measures used were the Bratt Attitude Test and the Wisconsin Inventory of Science Processes.

The results indicated that 90 percent of the subjects exhibited Conservation Reasoning on Conservation of Volume using clay; 13 subjects exhibited only concrete responses, whereas 47 exhibited transitional responses and 11 fully formal operational responses. It was concluded that Piagetian measures of formal operational reasoning ability are significantly related to attitude, aptitude, achievement and knowledge of science processes.

It should be pointed out, however, that the coefficients of correlation on which these relationships are postulated are all less than the corollary coefficients of alienation.

Riley (287) attempted to determine the effects of science process training using two different inquiry strategies with preservice teachers on (1) knowledge of the process skills; (2) understanding of science; (3) attitude toward science; (4) attitude toward science teaching; and (5) attitude toward the inquiry strategy employed in the process training. The subjects were student teachers in grades 1-4 who were randomly assigned to one of three treatment groups: (a) the Active-Inquiry Level in which science materials were manipulated; (b) the Vicarious-Inquiry Level in which they were trained in process skills without the opportunity to manipulate materials; and (c) the Control that involved about the same amount of time in neutral activities.

The collection of data was accomplished with the (1) Process Measure for Teachers; (2) Test on Understanding Science; (3) Attitude Toward Science and Science Teaching Scales; and (4) Attitude Toward Methods of Instruction Inventory.

The analyses of the results using analysis of covariance and the Newman-Keuls Multiple comparison test indicated that preservice teachers in both the activity-inquiry and vicarious-inquiry groups performed significantly higher than those in the control, although significant differences were not found in understanding science and attitude toward science or science teaching.

Yeany (370) assessed the effectiveness of three treatments for encouraging and training prospective elementary teachers in the use of inductive/indirect strategies in science teaching. The subjects consisted of 84 prospective elementary teachers at the University of Colorado who were assigned randomly to one of four treatment groups. These were the (1) Strategy Analysis Level, (S), who were trained using the Teaching Strategies Observation Differential (YSOD); (2) Modeling Level, (M), who viewed videotapes of model science lessons illustrating the inductive/indirect teaching strategies; (3) Combination Level, (MS), who were treated to both of the above; and (4) Control Level, (C), who viewed films of neutral relationship to the treatments for about the same amount of time.

Data were collected on the three dependent variables using the (1) Teaching Strategies Observation Differential (TSOD); (2) Elementary Science Activities Checklist (ESAC); and (3) the Science Activities Attitude Sort-(SAAS). The data were collected from 16 subjects randomly selected from the 21 in each group.

A multiple analysis of covariance was used with the TSOD and ESAC data, and an analysis of variance with the SAAS data. These analyses indicated that preservice teachers who experienced the Combination Level (MS) adopted a significantly more inductive/indirect science teaching style than did subjects in the Control Level (D), and a similar significant difference was shown with the SAAS data.

Wish (367) described (1) the Instrument for Observing Classroom Science Behavior (IOCSB) that was designed to measure the frequency of classroom science behavior at the elementary school level, and (2) a technique used to test the instrument. The IOCSB is a six-category science classroom observation instrument with 33 subcategories containing behavioral items allegedly consistent with those in SCIS, SAPA, ESS, the state syllabus of North Carolina, and college level elementary science methods books.

In the spring of 1975 at Campbell College, North Carolina, 38 K-8 preservice teachers were observed during student teaching for two 30-minute sessions by two outside observers making direct observation and immediately encoding the behavior using the IOCSB.

The data obtained with the subjects indicated that 25 subcategories were found to be consistent with teaching the nature of science in current classrooms. It was concluded that the instrument with its six categories, Observational Behaviors, Classification Behaviors, Mesurement Behaviors, Prediction Behaviors, Experimental Behaviors, and Other Behaviors could be used for science curriculum development and evaluation in the elementary school.

Bogut (45) had the objectives of (1) exploring the attitudinal changes of preservice elementary teachers that result from exposure to structured and unstructured teaching strategies and if (a) the sequencing of the strategies or (b) the initial degree of open- and closed-

mindedness of the preservice teachers had any relationship to these attitudinal changes; and (2) determining whether the degree of open-mindedness existing in students could be increased through the use of either of the instructional strategies.

The subjects were 21 preservice teachers enrolled in a large midwestern university, most of whom were first semester seniors although a few were second semester juniors. Seven concepts of elementary preservice teachers were investigated, (a) myself as an elementary science teacher; (b) pupil directed and initiated learning experiences; (c) science; (d) open education; (e) discrepant events or torpedoing; (f) time used in "messing around" or "exploration"; and (g) myself not knowing the right answers.

The data were gathered by administering the Semantic Differential Attitude Inventory and the Rokeach Dogmatism Scale (Form E) as pretests at the first class meeting and again as posttests. On the basis of the pretest on the Rokeach, the ten students with the highest and the ten with the lowest scores were assigned randomly into two subgroups each. Five of each were used to form randomly assigned high and low dogmatic groups of ten. The first week all experienced group orientation and initial observation. During the second through fifth weeks, Group A experienced unstructured teaching strategies and Group B, structured. The unstructured had high student involvement and "hands on" experiences whereas the structured involved tape recorders and slide projectors. During the sixth through ninth weeks the treatments were reversed. From the tenth through the sixteenth weeks all had open explorations and investigations.

An analysis of the results indicated that (1) sequencing of structured and unstructured experiences does not seem to bear a relationship to attitudinal change; (2) the openminded remained openminded after instructional experiences, whereas the closeminded became more openminded after unstructured; (3) the openminded became more closeminded after structured experiences, whereas the closeminded became more openminded after such experiences. Thus the closeminded seemed to benefit from either.

The research in which attitudinal changes of preservice elementary teachers are involved fails to yield evidence that any particular methods are very effective.

Two studies were located that dealt at least partly with attitudinal changes of prospective secondary school teachers. In the first, Pizzini (267) attempted to determine the effects of an exploratory teaching program on the development of attitudes toward teaching and related educational concepts. The eleven concepts selected for testing were determined by field testing a preliminary set of concepts, some of which were identified by Lacey as being important. Examples are individualized learning, being a science teacher, classroom management and record keeping, and exploratory teaching.

The exploratory teaching program was designed to provide University of Iowa sophomores with an opportunity to observe and participate in the duties and responsibilities of teaching. Twenty-one students served as subjects in this investigation and participated on a daily basis in the public schools. The null hypothesis tested was that there would be no significant differences between pre- and posttest scores on the Semantic Differential Attitude Inventory with the subjects.

The analysis of the results indicated that the null hypothesis was rejected for 11 of the 12 variables finally used. The only one not rejected was growth in attitude for the concept of discipline. It was concluded that the exploratory teaching program contributed to the growth of positive attitudes toward teaching in the secondary school.

The second study by Repicky (284) was designed to determine the effectiveness of feedback from systematic observation in modifying specific behaviors of student teachers and as a vehicle for improving cooperation between the university and the secondary school. Self-instructional modules were used to instruct cooperating teachers in the collection and reporting of data from systematic observation.

The data were collected by using three groups of cooperating teachers, each of which concentrated on one teaching skill, (a) preparation and use of performance objectives; (b) preparation and use of lesson plans; and (c) intellectual levels of classroom questions. With these data as feedback, the student teachers evaluated their performance using the modal behaviors presented in the methods instructions as a guide. A non-equivalent control group was established for each treatment group. The attitudes of the treatment group members were measured before and after the treatment.

The conclusions were that (1) student teachers in the treatment groups showed consistent improvement in their preparation and use of performance objectives and lesson plans; (2) in half the cases student teachers in the lesson plan group who had low initial scores showed significant improvement; (3) student teachers who were high in initial performance on lesson plans and performance objectives remained high; (4) the intellectual levels of the questions used by the treatment groups were not found to improve significantly; (5) student teachers in the lesson plan and performance objective groups consistently outperformed the control group subjects; and (6) the attitudes of student teachers (presumably from the control group) toward systematic observation became significantly less positive whereas the attitudes of cooperating teachers showed moderate improvement. In brief, if subjects are notified immediately about the quality of their performance, gains in performance may be expected.

Both of these secondary studies indicate that information about a situation has positive values.

Three studies were found that dealt directly with the directed teaching experience, two were at the elementary level and one at the secondary.

Wideen and Butt (363) conducted an investigation to seek answers to two questions: (1) How do students who have freedom to make decisions about their own program compare with students exposed to a more directed course in terms of attaining course objectives? and (2) Do students pursuing a primary option (K-3) or an intermediate option (4-8) differ in the attainment of course objectives for the two approaches mentioned above?

The subjects were 76 undergraduates (69 female and 7 male) who were enrolled in an introductory science methods class for prospective teachers. Most of them were in the second year of preparation, with the primary group having a slightly higher GPA and having experienced a three-week teaching session which the intermediate group had not. At the first class meeting they were divided randomly into two treatment groups. In the course they were expected to learn about three elementary science programs developed recently in Saskatchewan, using curriculum materials in microteaching situations, and demonstrate competence in scientific processes. In addition, they had access to a library and audiovisual media. The subjects in the Student Directed Approach group were allowed to make decisions about their activities; they had self instructional learning modules, videotapes and information packages and pursued activities when they chose. Those in the Instructor Directed Approach met on a regular basis with lectures and workshop type activities. The groups were then compared using scores on the Science Process Measure for Teachers: Form A; AAAS, a cognitive test, and an attitude scale and ratings from an interview.

The results showed that subjects in the Student Directed Approach were frustrated at the beginning and had an intense period of output at the end, whereas those in the Instructor Directed Approach followed a more regular pattern. Only one significant difference was found between the groups on the various measures and that was on the cognitive test in favor of the intermediate group.

Jaus (156) attempted to ascertain the effectiveness of integrated science process skill instruction on prospective elementary teachers in terms of (1) achievement of the integrated science process skills; (2) selection of integrated science process skill instructional objectives; (3) writing of science process skill learning objectives in lesson plans; (4) writing of science process skill learning activities in lesson plans; and (5) attitude toward the use of these skills in the elementary classroom. A corollary aim was to determine the effects of persuasive communication on the five above variables.

Ninety prospective elementary teachers who were juniors enrolled in three elementary science methods classes in a large university were subjects. A one-way analysis of variance using scores of the subjects on the SAT-V and SAT-M and cumulative GPAs showed the groups were equivalent. (The reviewer notes that this is statistically impossible, since the results could only fail to show that the groups were not equivalent.) Instruction in the integrated science process

skills was provided by ten self instructional pamphlets that required about eight hours of reading. The persuasive communication was a three-page 700 word handout pointing out the drawbacks of emphasizing facts and concepts but extolling the teaching of process. Class A (N-26) had placebo instruction involving elements of contracting, contingency and mastery learning; Class B (n-31) had integrated science process skill instruction using the pamphlets; and Class C (N-33) used the pamphlets and the persuasive communication.

The subjects were tested using (1) an investigator-developed measure for acquisition of integrated science process skill behaviors; (2) a selection of objectives questionnaire containing 20 objectives for a unit on Plants and Plant Growth designed for third and fourth graders on which they were to identify whether the objective was content or process; (3) an investigator-developed Likert-type scale of 30 statements dealing with the measurement of integrated science process skills; and (4) lesson plans on Heat that had to contain.

The results indicated that the control group performed significantly less well on the achievement test than did the other two groups but the other two were not found to differ significantly. The same was found to be true for responses to the selection of objectives questionnaire. Significant differences were not found among the groups with respect to attitudes.

In summary, if instruction is provided, the recipients are likely to do better than those who are not provided instruction. The design appears to be a "stacked deck" against the control if definitive recommendations for action are made on the basis of the findings.

Nelson (236) asked the question, "Is there a correlation between the behaviors a science cooperating teacher has acquired in a training program and the classroom performance of his assigned student teacher?" Parenthetically, one may say that the answer is absolutely "Yes." The question should be directed to the size, and direction of the coefficient of correlation, not to its existence.

In order to answer the question posed, the investigation was carried out during 1970-71 and the following summer and involved six inservice workshops with two-hour sessions for cooperating teachers who worked with preservice science teachers at the University of Wisconsin-Madison. The objectives were to (1) identify various strengths and weaknesses of beginning student teachers; (2) communicate the information to cooperating teachers; and (3) plan experiences to remove the weaknesses.

Ten-minute videotaped science lessons were used during the six sessions, the first of which showed microteaching by a novice that was critiqued with the novice receiving feedback and then reteaching the lesson. The other tapes, involving novices who had organized and

practiced demonstrations and those who had not, were evaluated by the cooperating teachers. There were also tapes on questioning techniques. Within the constraints of subject-matter area involved and other assignments, 52 beginning teachers were assigned randomly to 39 cooperating teachers, 19 of whom had taken the training program. Twenty-two of the beginning teachers completed their field experiences as externs.

A questionnaire of 26 items was administered to all science interns and student teachers who had practicum and intern experiences in 1971-72. Two videotaped minilessons of ten minutes each were used as criterion measures to judge the competence of the student teachers.

The data gathered showed that irrespective of replication or type of experiences, novices rated cooperating teachers in training programs as making more comments about planning, questioning techniques, and student involvement than those who had not been in the training program. The differences for the latter two were significant. It appeared obvious that the results of the training program were positive.

These last three studies emphasize a point that is well known: instruction pays off.

Two studies were found that dealt with competency-based teacher education. One by Diclemente (86) had a threefold purpose, namely to (1) investigate the importance of the STP preservice secondary science competencies as perceived by a random sample of New York State secondary science teachers; (2) collect recommendations from the science teacher surveys as to the educational level (preservice; inservices, or teaching experience) at which each specific competency should be acquired; and (3) obtain information designating the source (preservice, inservice, or teaching experience) from which the teachers surveyed obtained the competency.

Multiple matrix sampling was used to gather data concerning 248 professional competencies from 1000 science teachers. The 248 were divided into eight subtests of 31 competencies each. Each was mailed to 125 secondary science teachers drawn randomly from the 1000. The response was about 30 percent, but it was claimed that the respondents were fairly representative of secondary science teachers in New York State.

The results indicated that 88 percent of the respondents considered the competencies important. Most of the respondents indicated that they had attained the competencies at the level they recommended, but it was not necessarily at the preservice level recommended by STP. Many competencies were neither recommended nor attained at the preservice level and, consequently, re-evaluation of STP recommendations seems to be desirable.

West (357) investigated the effects of presenting the process of measuring to preservice elementary school science teachers by the abstract and applied modes of instruction. The primary concern of the study was to compare the gains made by students receiving the abstract mode with those of students receiving the applied, and the secondary concern, to compare student gains according to area of interest.

The design involved assessing the process of measuring that is one of the elements of Science - A Process Approach which was used for the instructional materials in the study. The subjects were students enrolled in four elementary science education classes during one semester at Murray State University, Kentucky. Twenty-five students were in each of two classes, and 26 in each of the other two. They were assigned to two treatment groups, one referred to as the abstract mode involving the presentation of artificial and abstract ideas; and the other as the applied mode in which students used measuring instruments in simulated real life situations. Tests A and B were constructed on which items were included representing the competencies in SAPA related to the process of measuring. The items on A were from the competency measures of odd-numbered lessons in SAPA and from even-numbered lessons on the parallel form. The items on Test B were reversed. Test A was used as the pretest for one class in each mode and B as the posttest, and the reverse in the other two.

The findings indicated that (1) the classes in the applied mode gained more in the process of measuring than did those in the abstract mode, (2) the level of the students, junior or senior, did not seem to be a factor in achievement, and (3) science-oriented students gained more in processes of science by both methods than did students oriented to language arts or social studies.

These two studies dealing with competency were too diverse to warrant synthesizing generalizations.

Three studies were found that dealt with the evaluation of preservice teacher education programs.

One undertaken by Renner and Lawson (283) dealing with the Purdue Undergraduate Preservice Teacher Education Program, referred to as "An integrated Science Approach for Preservice Elementary School Teachers," sought "to evaluate whether or not the Purdue experimental program through its concrete curricular materials and inquiry-oriented procedures had been successful in promoting formal reasoning abilities in its students."

In order to accomplish the evaluation, 20 experimental and 17 control students enrolled in a traditional physics course for elementary school teachers were pretested on a battery of six Piagetian-style tasks including conservation of (1) weight, (2) volume using clay, and (3) volume using metal cylinders, and (4) separation of variables, (5) exclusion of irrelevant variables, and (6) equilibrium in the balance.

Students were categorized on the basis of their scores into substages of intellectual development. Following two semesters of the experimental instructional program with the experimental group, both groups were posttested with the same battery and again categorized. The categories or substages were early, middle, late and post concrete operational and early, middle and late formal operational.

An analysis of the results indicated that 7 of 20 in the experimental group advanced two categories (substages), ten gained one, one did not change, and three regressed one stage. However, an analysis of the differences using pretest scores as a covariate failed to yield significant differences between the gains of the two groups. The superior values of the Purdue experimental program were not established.

Knight (176) explored the results of the early field experience in the Secondary Science Teacher Preparation Program at Indiana University where the field based program was located in classrooms in which ISCS was adopted. Some of the questions investigated were: (1) Will early experience change the preservice teacher's commitment to science teaching and his attitude toward the teacher preparation program? (2) Will it change the preservice teacher's view of the role and the nature of science? and (3) Will it change their views of students or affect the preservice teacher's major concerns about his abilities and needs as a teacher and cause the teachers to express a need for a broader science background?

Three ISCS teachers who were given adjunct status and worked with 31 preservice teachers in 18 hours of ISCS Preparation and ISCS Participation. Preparation consisted of four units, Rationale for Individualization, Questioning, Model Testing and Modifying, and Energy and Systems. Participation involved 20 hours of classroom contact under the adjuncts. A questionnaire was administered to senior high school students about the teacher's role and the 31 preservice teachers were pre- and posttested with the Nature of Science Scale, Teaching Profession Scale, and Word Association Scale.

The responses from pre- to posttest showed a change about the concept of the nature of science from the theoretical model. More disagreed with the ideas that (1) the fundamental drawing force in science is curiosity about the physical universe; (2) in the search for knowledge, science is process oriented and dynamic rather than information accumulation; (3) science is aimed at comprehensiveness and simplification; there is no one scientific method; and (4) there is openness of science unlimited by religion, politics or geography. None agreed that (1) methods of science are value, rather than technique, oriented; and (2) the physical universe is susceptible to human ordering and understanding. Other findings were that a significant change was not found in commitment to teaching although significant decreases were evident toward course work in education and in attitude toward course experience. However, there was a shift toward positive attitudes toward junior high school students and teaching in the junior high school.

In other words, there seemed to be as many negative effects to the program as positive effects.

Swami (330) undertook a followup study of graduates of a preservice field-based program at Ohio State University in order to determine its effectiveness. The field-based activities involved teaching for a period of from one to five quarters in urban and suburban elementary, junior high and senior high schools. The subjects were 86 former graduates who had fulltime science teaching positions in Ohio in 1974-75, or about 80 percent of the graduates of the program still teaching in the state.

Inservice data were collected in the Spring 1975 from the teachers, students in a single class taught by each of the sample teachers, and science supervisors or school administrators. The instruments administered for data collection were the Science Classroom Activity Checklist: Teachers Perception (SCACL:TP); Checklist for Assessment of Science Teachers: Supervisor's Perceptions; Teacher Questionnaire; Student Questionnaire; Administrator's Questionnaire; and Facilities Checklist. The preservice scores on the SCACL:TP were obtained for each sample teacher from old college records.

An analysis of the data failed to indicate significant changes of teacher's views about appropriate types of classroom activities. Neither were significant differences found among types of activities implemented by teachers of one to five years of teaching experience. Thus, graduates of this field-based program held about the same views about teaching and the use of activities in the classroom as they had at the time they completed their programs; they did not regress.

Inservice Experiences

Twelve studies were found that were focused mainly on inservice training for science teachers. Two dealing with support for teachers from the National Science Foundation and the State of Georgia, seven with elementary, and three with secondary, inservice programs.

Helgeson (137) reviewed literature that appeared from 1957-1974 concerning the impact of National Science Foundation supported institutes on elementary and secondary school teachers, and the impact of these teachers on their students. The literature included 63 dissertations and theses; 41 journal articles; 23 reports to the National Science Foundation, both interim and final; 9 papers presented at meetings; and two books. From his review he prepared a synthesis of the findings.

He reported that much of the research was descriptive in nature, dealing with the characteristics of the institute participants, their attitudes, various aspects of the institutes and changes in teaching and changes in behavior perceived by students, administrators, and the teachers themselves. Several studies were concerned with changes in

the subject matter competence of the participants. Few studies dealt with the impact of the participants on their students, although those that did, emphasized effects on student achievement, attitudes and understandings of science.

Institute participants were generally more qualified teachers than nonparticipants, had more contact with their students, tended to teach more science courses, held leadership roles, and were more likely to remain in science teaching. Although there was almost unanimous agreement that subject-matter competence increased, there was no clear evidence of attitude change toward teaching. Changes in classroom teaching behaviors appeared likely, although any permanence of change was not established. Insofar as the participant's students were concerned, there was no evidence of changes in their attitudes or interest, or an increase in their understanding of science. There were many areas of cogency in which the data are scant and nondefinitive.

McCarthy (214) stated that the purpose of her "investigation was to gather and organize data on the background of NSF and Georgia Grant-in-Aid recipients who teach in grades 9 through 12 in the public school systems of Georgia." An effort was also made to determine what additional benefits may have been accrued by the recipients. The extent of accrual was judged by comparing the changes in the academic backgrounds of the teachers who participated in a number of continuing education programs and with those of teachers who did not.

The final sample consisted of 315 science teachers in the 125 schools randomly selected from three, four and six-year high schools listed in the Georgia Educational Director (1969-70).

Data were gathered from (1) the Georgia Principals' Annual Reports on file in the Office of the State Department of Education in Atlanta, and (2) from a questionnaire completed by the science teachers in each school represented by the sample. Data were studied in terms of four discrete and four combination groups of teachers including (a) NSF Institute and Program participants; (b) Georgia Grant-in-Aid Recipients; (c) those who financed their own graduate education; and (d) those who had not returned to college since meeting the minimal qualifications for certification. Among the combination groups were (a) those supported by both the NSF and the Georgia Grant-in-Aid program; (b) those financed by Georgia and by personal funds; (c) those supported by the NSF and personal funds; and (d) those supported by the NSF, financed by Georgia and by personal funds.

The findings indicated that of 213 teachers who received graduate credit, 129 were subsidized, 84 paid their own way, and 110 received some support from the National Science Foundation, whereas about 40 were Georgia Grant-in-Aid recipients. About 61 percent had support from the NSF or Georgia or both. It was concluded that these grant mechanisms were the most effective motivations for those with the least extensive academic backgrounds.

Bogut and McFarland (45) attempted to determine (1) if there is any significant relationship between elementary teachers' realistic and idealistic attitudes toward selected science related topics; (2) if the degree of open- and closedmindedness of the teachers has any relationship to these realistic or idealistic attitudes; and (3) if instruction has any effect upon the changing of these attitudes. The study was pursued with six sections of inservice elementary teachers enrolled in the summer session of a large midwestern university. Two of the sections consisted of enrollees in a graduate course in elementary science methods and four, in a graduate course in general elementary methods, two of which were designated as the experimental and four as the control. All students were administered the Semantic Differential Attitude Inventory and the Rokeach Dogmatism Scale (Form E) as pre- and posttests. Three major concepts were investigated from both the realistic and idealistic viewpoints, namely, the way the subjects felt (realistic) and the way they would like to feel (idealistic) about (a) themselves as elementary science teachers; (b) science; and (c) noise during science class. The Campbell and Stanley Non-Equivalent Control Design was used with the Rokeach scores employed to designate subjects as experimental—open; experimental—closed; control—open; and control—closed. Fifteen subjects were randomly assigned from each population to form sample groups. All participants in the experimental groups received instruction in basic and integrated process skills as well as having experiences with ESS and SCIS units.

The conclusions from an analysis of the test scores were that (1) openminded teachers in both groups became consistently more realistic; and (2) the experimental group exhibited positive realistic attitudinal change.

Moore (228) investigated the attitudes toward science and science teaching of participants in an alementary science Cooperative College-School Science Program (CCSSP) in Butler County, Pennsylvania that began with a four-week workshop in the Summer 1971. Materials related to new elementary science curricula being used in their schools were supplied to them in the Fall 1971 and twelve meetings were held during the school year 1971-72, with 31 teachers participating.

The Science Teacher Attitude Scales were administered five times to the 31 participants during the two years: (1) in Spring 1971 after selection to participate; (2) on June 14, 1971 during the workshop; (3) on July 9, 1971 during the workshop; (4) in the Spring 1972 when the programs had been in use for about one year; and (5) in the Spring 1973. The differences among the scores were analyzed by the F - ratio.

The results of the analyses indicated significant increases in positive attitudes toward science and science teaching from the beginning to the end of the summer workshop. However, there was a significant decrease in positive attitudes between Spring, 1972 and Spring, 1973, and also from the Summer, 1971 to Spring, 1973. But, positive attitudes increased significantly from Spring, 1971 to Spring, 1973. Initially the Hawthorne effect may be suggested but once changes

reach a peak they seem to decline. The reasons for the decline are a reasonable subject for investigation.

Westcott (358) wanted to determine if there were differences, on the basis of selected characteristics related to science education, among three groups of teachers and their students. The teacher groups were designated as T-1, T-2 and T-3; the first received an indepth inservice elementary school science training program by personnel from the University of South Dakota; the second received a similar program conducted by teachers in T-1; and the third received no inservice experiences. The corollary pupils of the three groups were designated as P-1, P-2 and P-3.

The subjects, both teachers and pupils, were selected from the Sioux City Community School District, Iowa, with three randomly selected teachers and ten randomly selected students from 6 of 28 elementary schools. Thus, the total number of subjects in the (T-1) (P-1); (T-2) (P-2); and (T-3) (P-3) populations were 18 teachers and 180 pupils.

The teachers' attitudes toward science were measured with a Likert-type scale that was administered individually. The time spent in the classroom on science was judged on the basis of a "best estimate" in which three interviewers consulted with each teacher and principal. The "scienceness" of the classroom was determined by three raters using a questionnaire to judge activity level. Pupil attitudes toward science were measured with "Faces," an instrument used in SCIS, and an adaptation of "Our Science Class" from SCIS was used to determine how pupils perceived their science classes.

Analysis of variance was used to measure differences among the three treatments and, except for the fact that teachers in group T-1 spent significantly more time on science instruction than did teachers in the other groups, no significant differences were found.

Darlington (78) designed a study to determine whether a randomly selected group of Delaware public elementary school teachers, grades 3-6, who worked with a Del Mod Field Agent demonstrated significantly different understandings of the nature of science and scientists and significantly different teaching methods from a similarly selected group who had never worked with a Del Mod Field Agent. The subjects in the sample consisted of 50 fulltime elementary teachers, 25 of whom had worked with an agent in 1973-74 and 20 of whom had not worked with an agent in that school year. They were designated as the experimental and control groups, respectively.

In October, 1973, the Test on Understanding Science (TOUS) was administered to all subjects. In May, 1974, continuous five-minute teaching segments of all subjects were videotaped and a panel of six judges viewed the tapes without knowledge of which group the teachers represented. The judges rated the videotaped teaching behaviors on a seven-point scale based on a series of questions, the content of which represented desirable science teaching practices. The TOUS was then used as a posttest with all subjects and the t-test was used to

compare the scores. The entry in Dissertation Abstracts International does not indicate whether the posttest scores or gains between pre- and posttest scores were used in the comparison but it is assumed the latter.

The analysis failed to indicate that there were significant differences between the two groups on understandings of the nature of science and scientists; with respect to using materials other than the textbook in teaching science; using concrete examples or experiences, using abstractions, ideas and verbalizations; or giving praise and encouragement to students. It was indicated that "probably" teachers who worked with a Delt Mod Field Agent used an inquiry-based approach and individualized instruction to a greater degree than did those who had not.

Bedwell (29, 30) attempted to determine if teachers trained in question-asking skills and in using a high level questioning strategy would cause greater cognitive achievement and more positive attitudes among pupils they instructed than would those teachers using a low level questioning strategy. In the first phase of the study teachers were trained in question-asking skills, in the second phase they used the skills in the classroom and data were collected to determine the effects of two questioning strategies on student achievement and attitude.

The subjects were nine inservice elementary teachers who participated in a workshop designed to improve their question-asking skills. The results of the workshop training procedure were analyzed by comparing (1) the level of questions asked by the teachers before and after instruction, and (2) the ability of teachers to classify and to write questions according to cognitive level before and after the workshop. In order to determine the effects on student achievement and attitudes, all teachers conducted discussion lessons following the workshop training. The lessons were based on three stories selected from a fourth grade reading series. The pupils in each class were divided into two groups, one of which participated in discussion lessons in which high level questions were used, and in the other, the emphasis was on low level questions. Each teacher taught three lessons using each strategy and then the students were administered three post-tests measuring six levels of cognition, and also an attitude test.

An analysis of the results indicated that (1) teachers can be trained to classify and write questions according to cognitive level using the procedures in this study; (2) they were able to improve significantly in the ability to classify and write questions at six levels of cognition; (3) they can raise the cognitive level of their class discussions through instruction in question-asking skills; and (4) there was no evidence to suggest that teachers using high level questions effect greater student achievement and more positive attitudes than did those using low level questions.

The next four studies deal with inservice activities related to NSF supported Course Content Improvement Programs.

Wideen (362) undertook a study to examine patterns of teacher behavior and to compare student outcomes from two settings in which different elementary science programs were used based on alternative psychological approaches. The two psychological approaches were claimed to be the "cognitive restructuring approach" exemplified by Elementary Science Study (ESS); and the "behavioral approach" exemplified by Science—A Process Approach (SAPA).

Six teachers were randomly divided into two groups and trained in four-month workshops. In one group, three teachers learned the psychological underpinnings and methods of implementing ESS; the three teachers in the other, SAPA. During the workshop period they taught elementary science using the curriculum materials reflecting the two approaches. A 53-item pretest was administered to the students, about one-third of the items describing science activities and about two-thirds of the items describing science processes and related subjects. In addition, a seven-item multiple choice test was administered with two openended problems designed to measure abilities to make observations and inferences.

An analysis of the results indicated that the interest of boys waned and that of girls increased during the treatment. No differences found between students in the two programs with respect to differences in cognitive structure to demonstrations involving changes in physical phenomena. Also, it was not possible to evaluate relationships between teacher behavior and student performance. However, it appeared that the two classroom environments were perceived differently by teachers.

Mullens (231) proposed to examine and describe the amount of change agent activity and self-use engaged in by the science educators, science teachers, and science curriculum coordinators who were participants in the College Teachers Workshop in Elementary Science at Michigan State University. The programs of concern were Science—A Process Approach (SAPA) and the Science Curriculum Improvement Study (SCIS).

Measures were taken during the workshop of the participants' attitudes toward, and knowledge of, the two programs of concern. Questionnaires were administered twice to the participants during the school year, following the workshop, to assess the amount and type of change agent activity and the self-use of the programs. Statistical tests were used to investigate relationships between participant knowledge and (1) amount of change agent activity; (2) self-use of programs; and (3) immediacy of change agent activity, and between participant attitude and (4) amount of change agent activity; (5) self-use of programs; and (6) immediacy of change agent activity.

An analysis of the data indicated that (1) the amount of change agent activity decreased during the second half of the year following the workshop, (2) the role of the participant and his geographic location influenced the amount of his change agent activity, and (3) only the science educators indicated any self-use of the programs.

Significant partial correlations were found between participant attitude and the amount and immediacy of change agent activity, and between participant knowledge and immediacy of change agent activity.

McNair (218) investigated the extent to which a group of novice ISCS science teachers implemented the Project's intents as actual classroom practices. The subjects involved were 18 novice ISCS teachers who were among 80 junior high school teachers who had participated in three ISCS Institutes. The final research sample consisted of eleven novice teachers from three counties.

Three instruments were developed in a pilot study in 1973 involving two seventh grade ISCS classes for use in gathering data. These were the Teacher Questionnaire for Individualization (TQI); Student Questionnaire for Individualization (SQI); and Classroom Observation Record Individualization. They were claimed to measure four instructional dimensions related to the ISCS commitment to individualization: (1) managing equipment and materials; (2) evaluating individual student progress; (3) establishing classroom setting; and (4) individualizing instruction.

Statistical analyses of scores obtained from administering the measures did not indicate significant differences among the scores for the commitment index, the TQI and SQI; significant differences were found among teachers. This seemed to support the idea that teachers implement ISCS in different degrees. It was indicated that (1) these three measures are capable of indicating the extent to which ISCS intents are actually practiced in the classroom, (2) teacher commitment to ISCS intents for individualization is related to the extent to which teachers actually put them into practice, (3) student's perceptions of classroom instructional practices are as valid as any other source, and (4) significant differences exist among the levels to which ISCS teachers implement the ISCS Project's intents as actual classroom practices.

A number of the findings are difficult to judge as emerging from the data that were collected; the sample only included eleven subjects.

Mayer, Disinger and White (212) undertook an evaluation of an inservice program for earth science teachers. It was dealt with here rather than with studies in an earlier section including studies on evaluation because of the inservice emphasis. Specifically, a grant was made in 1969 by the NSF to The Ohio State University for support of a Cooperative College-School Science Program (CCSSP) with five school systems in North Central Ohio with the specific objective of promulgating the Earth Science Curriculum Project (ESCP). The intent was to improve teachers' understandings of principles and concepts of earth science, assist them in using investigatory techniques, and help them develop and implement laboratory oriented earth science programs in their schools. A continuation grant was received in 1970.

In implementing the grant, a four-week summer workshop was held in the Summer 1969 at Ohio State with 32 participants. In 1969-70, during the inservice phase, twelve teachers piloted the ESCP materials at three junior high school grade levels whereas the others used traditional earth science or general science textbooks. All participants met at OSU once a month to review progress. In the Summer of 1970, 20 of the 32 returned for a six-week session and the pilot materials were studied and revised. The revised material was implemented in 1970-71 in the participating schools.

During the first summer pre- and posttests were developed by staff from Investigating the Earth. The classroom effects were tested over three years with Test of Science Knowledge (TOSK); Concept Process Test (CPT); and Science Classroom Activity Checklist: Student Perception (SCAL:SP). At each test interval a random selection of classroom students took the SCAL:SP, and TOSK or CPT.

Analyses of the data indicate that probably only two objectives were met: (1) improve teachers' understandings of earth science principles and concepts, and (2) assist teachers in using investigatory techniques in the classroom. It was reasonable to assume that the development and implementation of laboratory courses in earth science did occur. There was no direct evaluation of teachers' ability to self assess classroom behaviors. Despite the lack of extensive positive findings, the study appeared to be well designed and managed.

The final study in this section was one by Rhodes (285) in which he tested assumptions by Bloom, Krathwohl, Tyler, Metos and others that an inservice program for teachers which involved test item writing, and which focused on higher cognitive levels would modify verbal behavior in the classroom.

In order to test the assumptions, a posttest-only control group experimental design was used with biology teachers from rural central Alberta who were using the BSCS Green Version textbook. The teachers were randomly assigned to an experimental group (N=8) or a control group (N=11). Those in the experimental group shared in structuring their own activities but within broad guidelines including (1) joint participant planning, (2) task-centered utilitarian activities, (3) systematic feedback and reinforcement, and (4) model materials for judging their performance. Inservice activities involved writing test items and meetings with the investigator for three months.

Post treatment measurements of teacher and pupil classroom discussions for both experimental and control groups were accomplished by analyzing videotapes of classroom activities. These were coded using a modification of the Content Interaction Analysis category system developed by Hansen.

Statistical analyses of the data failed to yield significant differences between the experimental and control groups insofar as verbal behaviors in the classroom were concerned. Thus, the inservice program was not found to be reflected in changes in verbal behavior

in the classroom. It was discovered that teachers spent about 63 percent of classroom time talking and pupils about 15 percent. Teacher questioning involved about 10 percent of the time with less than 1 percent for pupils.

The small numbers of subjects in the experimental and control groups almost preclude statistically significant differences unless the differences are "pathological." This may be a reason for the failure to find significant differences.

The studies on inservice education indicate changes do occur but their stability beyond a year is questionable. Most changes seem to occur in knowledge areas and not in the behavioral and affective areas. Less than adequate instruments to measure characteristics in these latter two areas may be a factor in these results.

Teacher Training — General

Six of the studies dealing with the preparation of science teachers were difficult to categorize. Consequently, they were dealt with in this "general" section.

In the first reported here, Bozardt (50) attempted to answer three questions: Will teachers having instruction in systematically asking questions (1) ask more questions at cognitive levels higher than memory than will teachers not having the instruction? (2) ask more questions in a systematic teaching situation than will teachers not having the instruction? and (3) involve a greater proportion of class time at cognitive levels higher than memory than will teachers not having the instruction?

Self-paced written modules were used for the instruction of the subjects who were enrolled in three sections of a science methods course in a large southeastern university in the winter quarter of 1972. The techniques involved using a Posttest Only Control Group Design with modules on question strategy covering cognitive levels of learning of Application, Interpretation, Translation Memory, and Memory. The learning experiences offered familiarization with a question classification system, field experience in using the system, and feedback by self analysis and audiotape. In addition, the experimental group was familiarized with, and practiced, a sequential questioning strategy. The subjects were arbitrarily assigned to one of three class sections and randomly assigned to experimental and control groups within those sections. After attrition, 38 subjects were involved, about equally divided between the experimental and control groups.

Data were collected by means of tape recordings of teaching in a portal school and trained judges classified the questions on the tapes. Three hypotheses based on the questions were tested using multivariate and univariate analyses of variance.

The statistical analyses failed to show any significant differences between the experimental and control groups on any of the hypotheses. The instruction provided the experimental group apparently had no effect.

Berger (33) sought to (1) develop a set of elementary school science teaching competencies with significant elementary school teacher input and (2) compare ratings of elementary school teachers with [those of] science teacher educators on two scales: (a) when competency should be attained, and (b) how important the competency is to elementary science teaching. The competencies were generated, grouped and then rated in a cooperative enterprise involving 14 elementary classroom teachers and 7 teacher educators at the University of Michigan. The responses of these two groups produced a list of 230 competencies.

The contributions of the two groups provided the data base that was analyzed using the Mann-Whitney U statistic. The analyses indicated there were significant differences between the two groups on 19 percent of the 230 categories. Among the items for which differences were found were the categories of Control, Materials, Inservice Opportunities, and Involvement of Students. In general, teacher educators rated inservice opportunities, child centered activities, and competencies in the use of materials higher than did the teachers. However, teachers rated classroom control and organization of materials as being more important for science education than did the teacher educators.

Yeany (369) reviewed studies with research findings that suggested that it would be pedagogically sound to make an attempt to analyze our [sic] research strategies and, if needed, adjust them to more indirect interactions.

He claimed he reviewed fifty research studies relevant to more indirect interactions in teaching strategies. According to his statements there was strong support from the research studies for concluding that the type of teaching strategies employed were related to student outcomes and therefore the types of teaching strategies had implications for training teachers and encouraging them to use inductive/indirect teaching strategies. It was alleged that this could be accomplished by analyzing model lessons with a systematic observation instrument.

Armstrong and Ladd (13) undertook an investigation that developed from the need to produce more inner-directed and more internally controlled teachers. They indicated that inner-direction refers to the degree to which a subject is controlled by internal goals and desires and that the inner-directed person tends to be more autonomous or self-supportive. They defined inner control as the degree to which an individual believes that his own behavior skills or internal dispositions determine what reinforcements he receives.

The investigation involved the implementation and evaluation of Rotating Peer Supervision in a science teaching methods course. Rotating Peer Supervision was defined as a process in which students teach other students and themselves about the teaching process through observation, analysis, and evaluation of their own teaching and that of their colleagues. The subjects were 74 college juniors enrolled on a random basis in three sections of an elementary science methods course. Two sections followed the course syllabus and experienced Rotating Peer Supervision with a 15-minute presentation in class, whereas the third section used only the syllabus. The treatment involved (1) preobservation in which the trainee submitted a science less plan to each member of the "supervisory" team of five or more colleagues, (2) microteaching a lesson that was videotaped before colleagues who acted like children, (3) an analysis of the videotape by the supervisory team that made suggestions for improvement, (4) review of the videotape by the trainee alone, and 5) a supervisory conference.

The pre- and posttests administered were the Inner Direction Scale of Personal Orientation Inventory and the Internal versus External Control of Reinforcement Scale. The results failed to show significant differences between pre- and posttest scores of the two "method" groups, or between the control and experimental groups. It was concluded that choices and decisions were based more on their own internal motivations than on external forces, and that perceived reinforcement seemed to depend largely on luck, chance or the influence of "more powerful individuals." The findings could not be construed as being consequential.

Shanks (305) attempted "to determine if there was a 'cognitive style' which influenced the ability of female pre-service elementary teachers to acquire the science concepts presented in a general elementary credential preparation course that was taught at San Francisco State University. In this study cognitive style . . . [was] defined as a stable and preferred mode of perceptual organization and conceptual classification of stimuli, as determined by the environmental situation and the individual." The design is an example of ex post facto research in which a measure of the science concepts presented in the two-semester course provided the criterion test (dependent variable) for the study.

The test for understanding science concepts consisted of 32 explanation (cause-effect) problems, 24 prediction problems, and an additional 54 multiple-choice items. The subjects, 95 females, were also administered the Sigel Cognitive Style Test (SGCT) consisting of 35 picture sets of three pictures, two of which were similar. The responses were categorized and scored as Descriptive Part, Descriptive Whole, Categorical, Inferential, and Relational.

An analysis of the results indicated that high achievers in science concepts preferred to use simple labels on the SGCT such as "round" and "both are girls." This was construed to be a descriptive-categorical

or analytical cognitive style. The low achievers in science concepts evidenced memory-oriented responses. It was concluded that a person's cognitive style is related to the ability to grasp and understand new meanings.

In the last study in this general group, Perkes (263) sought to measure what bearing selected background factors have on teachers' reported proclivity to teach science. The intent was to probe relationships between teacher background and reported commitment and confidence to teach science.

The subjects in this investigation were 52 prospective elementary teachers enrolled in a teacher education program at the University of California at Davis. Data were gathered by administering three instruments to the subjects, (1) a questionnaire requesting biographical information, (2) the Omnibus Personality Inventory (OPI), and (3) Methods and Procedures of Science: An Examination (MPE). The information requested on the questionnaire included, among other things, number of high school science courses completed, the science courses they had taken such as IPS and BSCS in which new projects were adopted, number of college science courses and number that involved laboratory experiences, difficulty encountered in academic study of science, preference of areas to teach in the elementary school curriculum, and opinions about adequacy to teach elementary science.

Correlational analyses used with 21 variables indicated that (1) unsatisfactory or frustrating encounters between the prospective teacher and the academic study of science are significantly and negatively related to the election of additional science courses and the expressed preferences, and opinion of adequacy, to teacher elementary science, (2) there was a low relationship between MPE scores and preference and adequacy values; and (3) none of the 13 OPI scales was found to be significantly related to the background of the prospective teacher, the understanding of the methodology of science, or to preference and adequacy values. The factor that stands out is the extent to which the interfaces between students and science courses are positive.

Generalizations on this miscellaneous group of studies are difficult to come by. However, it does seem that the extent to which a prospective teacher views his academic science courses positively is most important in fostering positive attitudes toward teaching science. Also, efforts to influence science teachers at all levels to be innovative must permeate all preservice as well as all inservice programs. Innovations will not emerge from short-term efforts.

How Do They do It? — The Methods

The previous major section was concerned with the most important "learning experience" in science teaching, namely, the science teacher. In this major section, studies about learning experiences provided in the teaching situation are considered. Obviously, many of these studies have purposes that overlap with some of the studies in the preceding sections, as well as with some of those in the sections that follow. The reviewer accepts the responsibility for the decision to consider them here.

Self-Paced Instruction

The preoccupation with self-paced or individualized instruction is evidenced by the 49 research studies, published in 1975, that dealt with this topic. Many terms are used for this instructional format including self-paced instruction, individualized learning strategies, and personalized learning. The type currently investigated most frequently is the audio-tutorial method. For convenience the studies are dealt with in four major categories: (1) the two studies that were reviews of research in the area, and the remainder involving the (2) elementary, (3) secondary, and (4) college levels.

Reviews of Research. Mintzes (224) stated that "this paper reviews, summarizes, and evaluates the research on A-T instruction and attempts to provide some direction for future study."

His search of the literature revealed 19 research studies that he classified into general categories, those which (1) attempted to compare the A-T approach with a more conventional approach, (2) sought to find a relationship among student variables and achievement in an A-T course, and (3) investigated a series of instructional variables associated with the A-T approach. He indicated that the difficult pedagogical and administrative problems that faced science departments in colleges and universities in dealing with large numbers of undergraduates in introductory courses in the 1950's led to efforts to find alternate modes of instruction. He claims that Postlethwait in 1961 was the first to audiotape discussions for use in carrels with tape recorders although these were later supplemented with other types of learning packages and the students were guided to mastery by behavioral objectives.

With respect to the research, he indicated that comparative studies seem to be inconclusive and even contradictory with A-T groups performing better in some cases, conventional groups in others, and in still other cases, no evident differences. It appears that students with strong academic backgrounds and/or aptitudes in science and mathematics seem to achieve significantly better in A-T than do students in other fields. Also, certain personality traits as measured by the Guilford-Zimmerman Temperament Scale (GZTS), and

scores on the intelligence scale on the Sixteen Factor Personality Inventory seem to be related to achievement in A-T. He concluded that the results were disappointing, possibly because the questions addressed in the research were not of sufficient importance.

As with most comparative studies methods are seldom found to be significantly different with respect to achievement, with intelligence being the most influential factor.

Royce and Shank (296) stated that "what we hope to do is to summarize the results of research papers on individualized teaching, and to draw conclusions about its usefulness and appropriateness in science education. Specifically, we hope to answer these questions: What is individualized learning? Will it provide students with a better education? Under what circumstances?" The literature was reviewed for the period 1967-1974. Twenty-one articles found in science education journals or Dissertation Abstracts were considered. These were examined for achievement in terms of cognitive objectives, critical thinking and inquiry.

The investigators stated that most of the literature was descriptive and that few studies compared individualized methods with traditional group-paced instruction. They indicated that little difference was found for achievement in cognitive objectives, inquiry skills, and critical thinking between individualized and group-paced when measuring understandings of science, and the nature of the scientific enterprise, in favor of the individualized in two of six studies, four being inconclusive. Generally, the self-paced groups had more supplies and equipment available and needed more assistance from teachers. Also, most individualized studies were undertaken in atypical schools with small classes, many in laboratory schools, and conducted for short periods of time.

The reviewer wonders why only 21 studies were considered for the period 1967-74 when 49 are considered in this review for 1975 alone. Also, contradictory to a statement by the investigators, many of the studies published in 1975 compared individualized with group paced instruction.

Elementary Level. Two studies were found that dealt with the audio-tutorial method for teaching elementary science. Tamir and Amir (334) wanted to learn (1) if A-T science programs developed in the United States could be adapted for Israel, (2) what effect maturation has on pupil's learning by the A-T method, (3) how the socio-economic status of pupils may be related to their achievement in science using the A-T method, (4) what effect classroom composition and regime may have on learning by the A-T method, (5) if differences in achievement exist between boys and girls in A-T classrooms, and (6) how different modes of performance may be used to measure pupil achievement.

In order to gather data, audio-tutorial science programs developed at Cornell University were translated into Hebrew and adapted for first (N=304) and second (N=294) grade pupils in five

schools located in different parts of Israel. Four hundred seventy-three pupils in 14 classrooms were designated as the experimental group and 125 in five classrooms were designated at the control. The experimental group used the A-T materials and the control group regular materials. The control group had two to three hours per week of study whereas the experimental group spent about 30 minutes in individual study at the carrels. At the end of two weeks when the whole class cycled, the teacher had a one-hour discussion. In total, the experimental group in the first grade had 15 A-T lessons, the same as the second grade group had when it was in the first, and then had an additional 12 lessons the second year. An observation checklist was used to follow the students during the A-T program; the students also were administered multiple-choice cognitive pre- and posttests and practical tests.

The results indicated that second grade students generally do better than first graders on the pretests, which was to be expected. It was also found that (1) the A-T materials developed in the United States could be adapted for Israel; (2) the A-T lessons were useful in formal classrooms, but best in flexible classrooms with small numbers of students; (3) both experimental and control groups demonstrated significant achievement from pre- to posttests; (4) regular pupils generally achieved better than did the culturally deprived; and (5) boys did better than girls on manipulative activities.

Hibbard and Novak (139) attempted to show how pupil achievement of science concepts follows patterns consistent with the learning theory of Ausubel. The attempt involved audio-tutorial instruction. The subjects were 118 first grade children in two elementary schools in Ithaca, New York. Eighty-four received A-T instruction, whereas 24 received only an introductory set of A-T lessons. The "uninstructed" children received a four-lesson sequence designed to familiarize them with A-T, but science concepts that were dealt with in this study were not covered. "Instructed" children got the four-lesson sequence to familiarize them with A-T and then a 10-lesson sequence dealing with the particulate nature of matter and the effect of energy exchanges on particles of matter. There was one new lesson a week, each requiring about 18 minutes to complete.

The evaluation included crayon and paper tests involving production and recognition questions followed by individual interviews using Piaget's clinical technique. An example of a production question was a picture of a person near a bottle of smelly liquid with the subject being asked to draw the "smell." An example of a recognition question was one showing a person and a set of drawings depicting smelly conditions with the student being expected to select the best representation of a "smell." Over a period of two weeks, 100 picture-test questions in four booklets were administered.

The results indicated that (1) 66 percent of the instructed children but only 6 percent of the uninstructed children drew a "dot" model to represent "smell," (2) 55 percent of the instructed children but only 2 percent of the uninstructed drew a version of "dot" model

that showed diffusion, (3) 55 percent of the instructed but only 12 percent of the uninstructed drew "smell" models that showed smell emanating from a source rather than hovering about, and (4) 23 percent of the instructed but none of the uninstructed showed "dot" models for "smell" originating at source and diffusing about the room.

Rowell (293) attempted to determine the extent to which children are able to formulate mental models to explain their observations of natural phenomena. Three questions were matters of concern: (1) How typical of the larger population of elementary school children are the concepts used by children in this study group? (2) What is the nature of the major scientific concepts and models used by instructed children to describe several natural phenomena? and (3) Does a clinical interview followed by a novel evaluation form provide an adequate description of these models?

The study was based on the summary findings of a series of studies that indicated that many children who received instruction, organized around a few major concepts of science, do use scientific models. In September, 1971, all first grade children in the Ithaca City School District, New York were using the Audio Tutorial Elementary Science Program (ATESP). The organized instruction they received in ATESP covered major concepts dealing with Energy, Conservation, Continuity of Life, Heat, Kinetics, States of Matter, Particulate Nature of Matter, Gravity, the Universe, Population Dynamics, and Ecosystems. Over 60 lessons were involved. In 1973-74 there were 95 students from the original group who had completed the lessons.

The "leftover" children agreed to leave the A-T classroom for four recorded interviews of about 25 minutes each in which six to ten questions were covered. On the basis of the interviews the children were categorized as "modelers," "transitional," or "non-modelers." The results were grounds for the belief that about half the ATESP children learning science concepts for meaningfully viewing the world clearly evidenced scientific modeling, about one-third gave some evidence, and about one-fourth of the uninstructed children formed acceptable and stable models despite a smorgasbord of science instruction.

Anderson and Butts (7) sought to answer questions about the advantages and disadvantages of teaching with individualized and self-paced materials, whether children learn more from the self-paced or traditional, which type of instruction children prefer, what characteristics differentiate students who prefer one over the other, whether sex differences are related to preferences, and whether high achievers differ from low achievers in their preferences.

In order to seek answers to the questions, a series of worksheets were developed based on the unit in the Elementary Science Study (ESS), "Batteries and Bulbs," and used to teach three classes of sixth grade students. Two other classes covered the same material by lecture-

discussion. The worksheet group consisted of 49 boys and 32 girls, the traditional group of 33 boys and 20 girls. They were pre- and posttested with items related to the subject matter of the unit, the pretest failing to show a difference between the groups. Their attitudes were measured with the Semantic Differential Attitude Inventory.

An analysis of the mean gains failed to show significant differences between the two groups. Neither was there evidence of differences between preferences of methods based on sex. The net preference of both groups was for lecture-discussion although, taken alone, the worksheet group rated worksheets higher than did the discussion group.

In other words, self-pacing did not "get the nod" in this study and it's difficult to suggest that the previous study gave much staunch support.

Secondary Level. Four studies were published in 1975 that dealt directly with the Intermediate Science Curriculum Study (ISCS) that espouses, and allegedly accomplishes, individualized instruction.

McCurdy (215) assessed the relationships between ten variables related to self direction of students in ISCS and (1) success in the course, (2) level of the student in the ISCS program (Levels I, II and III), (3) school which student attended, and (4) sex of the student.

In order to gather data, a group of teachers in an ISCS inservice course were asked to administer a Self-Directed Rating Scale (SDRS) to their ISCS students during the Spring, 1973. The participants were 1108 students in six schools in the Omaha area. Data were analyzed using t and F to test for significant differences among variables.

From the data, three groups of students were identified in terms of their achievement grades: the top 15 percent, the middle 70 percent, and the bottom 15 percent. The ratings of the students in the top 15 percent indicated that they viewed themselves as being more capable in terms of self direction than the bottom 15 percent, the differences being significant for all ten variables. Based on the test results, there was also a greater degree of self direction among eighth graders than among seventh and ninth graders. However, there was consequential variance among the participating schools. Girls perceived themselves as being more self-directed than boys, except on seeking answers independently and willingness to skip activities and assignments. Girls also perceived themselves as making "greater" use of time, planning better work schedules, using study skills, and controlling the pace of their activities.

It was concluded that success in highly individualized programs like ISCS requires self direction, with Level II requiring more self direction than Level I. The study was well written and easy to follow.

Jensen (157) compared the self-perceptions of individualized instruction among teachers having one of the following training experiences: (1) an NSF Institute in ISCS, (2) workshop for ISCS, (3) ISCS ITP modules, or (4) no ISCS training. He hypothesized that there were no significant differences in the overall philosophy of individualized instruction among the four populations.

An instrument was designed by the investigator to determine the self perception of ISCS individualized instruction. It consisted of a questionnaire of 24 items, two statements for each of twelve issues that were rated on a scale of 1 to 5. The reliability of the instrument was checked by statistical procedures and was found to be .7128, the validity was "established" by consultation with authorities in ISCS. The instrument was field tested by established ISCS instructors. The instrument was then sent to ISCS instructors throughout the United States and apparently 163 were returned.

A statistical analysis of the responses indicated that of the 13 hypotheses developed from the ISCS individualized philosophy, only one was rejected: the self pacing variable. Although the investigator indicates that he does not conclude from this that a teacher can conduct an ISCS class as well without instruction as with instruction, it is evident that ISCS training does not seem to influence philosophy toward individualized instruction as exemplified by ISCS.

Gabel (108) investigated two strategies that might have an effect on achievement in an individualized science program; namely, ISCS. One strategy involved the alternative of setting a definite deadline for the completion of a unit of work versus allowing students as much time as they needed while insisting that they reach a given level of mastery before proceeding to the next unit. The other strategy involved the alternative of having students work alone versus being paired with other students.

The subjects were 1022 seventh grade students in 43 classrooms in ten Indiana schools, 4 being rural schools with a total of 4 participating teachers, and 6 being urban schools with a total of 8 participating teachers; all apparently using ISCS in grades 7 and 8. The twelve teachers were assigned to groups of three, and the treatments were randomly assigned to the groups. The first treatment involved the students working alone or in pairs, and the second, the group-paced or self-paced completion of the units to the mastery criterion. All students were administered the same tests; namely, A Scale to Measure Attitude Toward Any School Subject (Purdue), the Otis-Lennon Test of Mental Ability: Form J, and chapter tests from the program. In addition, a retention test was administered after the completion of Chapter 4.

An analysis of the results indicated that self-pacing produced higher learning rates and retention scores than did the deadline format, particularly for low ability students, but the self-paced

students were learning the contents of fewer chapters to a greater extent and therefore learning more difficult chapters. Also, there was little difference in students' attitudes toward ISCS whether they have self pacing or deadlines, so it was concluded that self pacing was more desirable. It was also discovered that low ability students working with partners had better retention than when working alone. Retention was considered to be a more important educational objective than was learning rate.

In summary, it appears to be advantageous to allow students to pace themselves while working to a criterion level and to work with a partner.

Lashier and Nieft (183) tried to determine whether school use of ISCS (Level I) corresponded with specific aspects of the stated rationale and philosophy of the ISCS program. It is claimed that ISCS materials are supposed to allow the teacher time to interact personally with each student in guiding him/her through the self-paced material. Consequently, the primary objective of this study was to seek relationships and differences between the responses of students in ISCS classes and those in non-ISCS classes as measured by the Classroom Activity Checklist (CAC), and the Student Inventory (WDM), and differences between the low and high achievers in ISCS using the Scientific Attitude Inventory.

An experimental group was formed from 18 of 35 ISCS teachers who attended an NSF supported Cooperative College-School Science Program in Kansas in 1971. Six non-ISCS teachers from three suburban school districts in Kansas served as a control. Test data were gathered from about 900 seventh graders in the experimental group, and from about 200 students in the control over a period of two years. In the Spring 1971, two instruments were administered to students of the 18 teachers who were slated to enroll as participants in the subsequent CCSSP and also to those of the control group. At regular intervals during the course of the study, ten cognitive achievement tests were administered to the ISCS students.

Analyses of the test data did not reveal significant relationships between (1) achievement in student perception of classroom activity in classrooms that implemented ISCS materials and in those that did not; (2) students' cognitive achievement progress in ISCS and their perceptions of classroom activity; (3) student perception of teacher's personality traits and student's experiences in classrooms with ISCS materials and in those using non-ISCS materials; (4) student cognitive achievement progress in ISCS and their perceptions of teacher variables of warmth, demand, and use of intrinsic motivation; and (5) student cognitive achievement progress in ISCS and student attitude.

The findings of the four studies related to ISCS together generally fail to support the use of ISCS over non-ISCS programs.

Two studies were identified that dealt with the ISIS program.

Neufeld (238) set out to compare the validity of students' activity decisions, the attainment of instructional objectives, and the time spent on learning activities between students provided with knowledge at "instructional branch points," in the form of model answers to self-test questions, as they worked through instructional materials using learner-controlled branching, and students working through the same materials without those answers.

In order to make the comparisons, ten minicourses developed by the Individualized Science Instructional System (ISIS) project were used including (1) heart attack; (2) buying and selling; (3) sounds of music; and (4) household energy, as well as others. Each minicourse occupied about 15 hours of student time over a period of three weeks. Students worked at their own pace, selecting core-level activities on the basis of diagnostic self tests. They were expected to demonstrate mastery of all the core-level objectives whether or not they did the related activities.

Thirty-six matched pairs of classes consisting of about 1300 students from 19 schools across the United States were subjects. The classes were assigned randomly to treatments with one class of each pair under each treatment and each teacher having one class under each treatment. Each student was administered the pre- and posttests for each minicourse and recorded the amount of time spent on each activity. An incorrect response to an item on both tests and omitting the related activity was considered a "liberal choice" whereas a correct response to an item on both tests and doing the related activity was considered a "conservative choice." Gain scores were used to assess the attainment of objectives. Students were classified for the purposes of analysis from IQ scores as "above average," "average," or "below average."

The findings did not indicate differences between treatments in the choices made, gain scores, or time spent on core level activities when all students were considered. Neither were consistent differences found between treatments in the proportion of conservative choices among students at the three ability levels. However, average and above average students with access to answers made fewer liberal choices than those without access, whereas below average ability students with access made more liberal choices than those without. Without regard for treatment, average and above average ability students made more conservative choices whereas below average ability students made more liberal choices.

Ramsey (277) conducted a study to assess the relationship between the number of Individualized Science Instructional System (ISIS) minicourses completed containing the same cumulative objectives, achievement gain on the posttest of an examination measuring the ISIS minicourse cumulative objectives, and reading comprehension as determined by a standardized achievement examination.

The data were gathered beginning in the Fall 1974 in four high schools in San Diego County that were participating in the ISIS program. The subjects consisted of 396 students in 22 classes taught by 8 science teachers. The subjects were administered an evaluation instrument developed by the researcher and designed to test students on the five cumulative objectives selected for investigation in this study, at the beginning and end of the fall semester 1974. Other information of importance to the study was obtained from school records, the statistical posttest and gain scores for the five cumulative objectives. The .05 level was the criterion of significance.

The results of the analysis indicated that there was a relationship between student achievement on the pretest and posttest for one cumulative objective, but significant relationships were not found between (1) student achievement on the pretest and posttest measuring four of the cumulative objectives and the number of corresponding minicourses completed; (2) reading comprehension and achievement of the minicourse cumulative objectives; and (3) reading comprehension, the number of minicourses completed, or the achievement gain on the posttest for any of the five cumulative objectives.

It was concluded that there are no evidences of relationships between (1) achievement of a particular concept in ISIS and the number of times the concept is presented in different contexts; (2) reading ability and achievement in the ISIS minicourse cumulative objectives; or (3) reading ability and the number of minicourses a student can complete satisfactorily in a given period of time.

Neither of the ISIS studies can be construed as producing results that have definitive implications for educational practices.

Five studies dealt specifically with high school biology. One by Urbancic (344) tested the assumption made by the producers of an A-T unit "that the individual achieves as well as the group." The group studied was a sophomore class in unified science in an all-male suburban, Catholic college-preparatory high school during the Fall, 1974. The topic presented was an audio-tutorial type of unit in Mendelian inheritance. Class sections were randomly assigned to one of three treatments: individual, student directed, or teacher directed. The individual treatment involved the student completing the program by himself according to directions. The student-directed group was a situation in which the teacher was allowed only to operate equipment. The teacher-directed treatment involved "the normal classroom situation." Performance was measured by a 40-item objective test constructed using the stated objectives of the program. Each item was classified according to Blooms categories of knowledge (13 items), comprehension (10 items), and application (17 items).

The analysis of the results indicated that the teacher-directed treatment was significantly superior to the student-directed treatment ($p < .01$) for treatment and total score; learning ability,

treatment, and total score; and GPA, treatment and total score. The teacher-directed treatment was significantly superior to the individual and the student-directed treatments for the category of application for treatment and subtest score; learning ability, treatment, and subtest score; and GPA, treatment, and subtest score.

It was concluded that in using packaged programmed materials, the type of student involved in this study achieves as well individually as in the classroom in terms of total and comprehension, but in terms of application, achieves better in a normal classroom.

Nordland, Kahle, Randak and Watts (243) compared student achievement after instruction by an individualized, audio-tutorial system with that by a group classroom situation. Of particular interest was an analysis of the two modes of instruction on students with probable learning deficiencies. The latter were those identified as performing below the 40th percentile on selected standardized measures. Relationships were also studied between scores and standardized tests and the treatments.

The subjects were 118 students in grades 9-12 in a rural consolidated school who were enrolled in introductory high school biology under two teachers. They were divided randomly into two treatment groups, one (AT) receiving all instruction by the audio-tutorial format, and the other (NAT), in a group classroom situation. The instruction involved three weeks with four instructional units dealing with the topics of mitosis, meiosis, probability, and genetics. Both groups had equal access to the instructional materials that were developed jointly by the cooperating teachers and the senior investigators. Achievement was measured by a series of unit tests, validated by experts in biology education, and administered after each instructional unit. Differences between the AT and NAT groups were measured using t-tests.

The analysis did not indicate significant differences between the two groups on the unit tests or the average scores. It was also noted that standardized tests such as SCAT, Otis IQ, STEP reading, and OTI are less predictive of achievement when AT is used. Significant differences were not found between the two treatments with students above the 40th percentile, but those below the 40th percentile did better with AT than NAT.

Hunt and Lamkin (152) evaluated the effect on cognitive learning of an auto-tutorial system which they defined as an independent mode of learning through the aid of a cassette tape recorder and visual devices. Specifically, they compared the performance of students receiving immediate reinforcement and feedback with that of students not receiving immediate reinforcement and feedback. The objectives of the instruction were to enable students to identify (1) types of inflorescences used in plant taxonomy, (2) selected vegetative structures, and (3) unknown plant specimens using keys.

As a first step they prepared a 50-item multiple-choice test to be used pre and post plus materials for the instruction and tested them in 1969-70 in Stephen F. Austin High School, Port Arthur, Texas. The revised tests and materials (scripts) were used with students in the Waco Independent School District, Texas from April 2-19, 1973. The revised pre- and posttests were reduced from 50 to 25 multiple-choice items. The scripts on the cassettes for the experimental group had comments such as, "You are doing a great job!", whereas there was no feedback or reinforcement in the scripts used with the students in the control.

Fourteen teachers of biology in grades 9 and 10 were asked to participate; from those who agreed two tenth grade biology teachers at Richfield High School in Waco were selected at random. Twenty-four students were selected as subjects for each experimental and control group from two class rolls of 150. Seventeen boys in the control and 16 girls in the experimental were black with Mexican American and whites filling out the groups. Their IQs were measured in November, 1972 with the California Test of Mental Maturity.

Analysis of the data collected indicated that IQ was related significantly and positively to the cognitive gains in both groups. Also, the system with immediate reinforcement and feedback produced significantly greater gains than did the system without.

Littlefield and Gatta (201) indicated that the primary purpose of their study was to investigate the various characteristics of successful and less successful students and to determine what effect these characteristics have on achievement in an individualized learning program. More specifically, the characteristics were those designated as "high," "expected" and "low" achievers in an individualized biology program at Glenbrook North High School, Northbrook, Illinois.

The subjects were 406 pupils enrolled in a "34 contract learning unit" during 1973-74. The Nelson Biology Test and aptitude measures from the Classification and Placement Examination (CAPE) were used to predict achievement. During the program the work rate was left to the student. Seven psychological inventories were used to measure such characteristics as (1) attitudes, (2) motivation, (3) understandings about science, (4) personality, (5) scholastic ability, and (6) ability to think critically. Among the instruments used were the Nelson Biology Test: Forms E and F; the Watson-Glaser Critical Thinking Appraisal: Form ZM (WGCTA); Test on Understanding Science; School Motivation Analysis Test: Form A, Research Edition (SMAT); and aptitude measures from the Classification and Placement Examination (CAPE).

An analysis of the results did not indicate significant differences among the predicted "high," "expected" and "low" achievers on the individualized learning biology on the following variables: (1) personality; (2) motivation; (3) attitude toward science; (4) understandings about science; (5) critical thinking ability; and (6) scholastic aptitude, although in nearly all cases the scores of the predicted "high"

were above those of the predicted "low." The "high" and "expected" achievers scored significantly higher on the WGCTA than did the "low" achievers and the successful students were those who had a high interest and positive attitude toward school.

Seymour and Padberg (304) tested "the use of a simulated problem-solving game in a field test of the Inquiry Role Approach program that provided an opportunity to study two proposed values of group work; one, whether group work is more effective than individual work for successful completion of problem-solving tasks, and two, whether group work following individual work is more effective than group work alone." To introduce group work to students, the Inquiry Role Approach was field tested with four-member student groups using the simulated problem-solving game "Lost on the Moon." The game involves the ranking of the value of 15 items available to a crew of astronauts stranded on the Moon 200 miles from a rendezvous point. The students were expected to rank the items individually according to their usefulness and then form small groups and rank the items as a group. Data were collected for mean individual scores within a group, group scores, and difference between mean individual and group score.

In the study 32 tenth grade biology classes taught by 15 teachers were used to obtain data. The students had "mean percentile ranks" [sic] of 60 and 40 on the Verbal Reasoning and Numerical Ability sections of the Differential Aptitude Tests. The "Lost on the Moon" exercise was used as the fourth class activity and preceded by pre-testing using achievement tests not related to the exercise, an inquiry filmloop, and a multi-media presentation of the goals on the Inquiry Role Approach program. The classes, that averaged 28 in size, were divided randomly into two teams; Team 1 completing "Lost on the Moon" individually, and Team 2 completing the exercise in groups and then individually.

An analysis of the results based on correct responses indicated that group work had an apparent advantage over individual work, although students working in groups with previous individual work seemed to do better, although not significantly, than group work without the previous individual.

An analysis of the five studies dealing with biology are inconclusive. In some individualized instruction seems to have merits beyond that of group paced, in other cases, the opposite is true. And, with some variables, differences are not observed. Apparently, individual-pacing or group-pacing is affected by factors extrinsic to the method itself.

Two studies dealt with physical and earth science for ninth graders. The one concerned with physical science was undertaken by Reed (280) and examined student achievement, attitude toward science, and self-concept of ninth grade physical science students in an individualized science program and of ninth grade physical science

students in a traditional science class, and interrelationships among these factors. The subjects were inner-city junior high school students in the ninth grade, 150 of whom were in an individualized program and 150 in a traditional program.

The experimental design was patterned after the Posttest Only Control Group Design. Data were gathered by administering the Stanford Achievement Test: Science; Remmers' Attitude Toward Any School Subject Scale; and the Piers-Harris Children's Self Concept Scale. t-tests were used with various types of data to assess equivalence of the two groups, and the results did not indicate that the groups were equivalent.

An analysis of the results of the data that were collected did not indicate significant differences between the subjects in the individualized program and in the traditional programs with respect to (1) scores on achievement tests in science, (2) attitude toward science, or (3) self concept. It was indicated, however, that there were significant relationships between intelligence, background in science and composite achievement level and achievement in science. Further significant relationships were found between grade point average in science and (1) achievement in science; (2) attitude toward science; and (3) self concept.

Boudreaux (48) investigated the relative effectiveness of three approaches to teaching ninth grade earth science. These were referred to as Treatments A, B and C and were identified respectively as the teacher-textbook approach, the multi-media approach, and the multi-media activity packet approach.

The subjects consisted of 85 ninth grade students enrolled for the first time in regular sections of earth science during the first 18 weeks of the 1972-73 school term at Ruston High School. The treatment approaches were conducted by the same teacher in the same classroom during consecutive class periods. Science achievement change scores and attitude change scores were the outcome variables. These scores were analyzed using the Wilcoxson rank test with the .05 level as the criterion for significance.

The results of the analysis showed that the multi-media and multi-media activity package approaches produced significantly greater gains although students in the teacher-textbook program had a higher posttest mean. None of the attitude change scores (gains) were found to be statistically significant for any treatment.

Neither this, nor the previous study, provides substantial support for the individualized approach over the teacher-textbook or what is commonly called the "traditional" approach. That approach may not have all the drawbacks that have been claimed for it.

A study by Denton and Gies (81) was the only one found to deal with individualized instruction in secondary school physics. Its purpose was to ascertain if an instructional program in secondary

school physics that mandated the achievement of all student selected objectives before proceeding to the next instructional unit affected the number of objectives that were achieved. It was hypothesized that (1) the achievement of student selected objectives in secondary school physics is enhanced by the requirement of mastery before proceeding, (2) the cognitive levels selected by students for their objectives will be influenced by the requirement, and (3) the proficiency levels selected by students for their objectives will not be influenced by such a requirement.

The study was conducted in a large senior high school in which one instructor taught three classes in physics. Two classes of 24 each, one mastery and one nonmastery, were selected by a table of random numbers; students were oriented for twelve weeks (60 class periods) to the instructional techniques that would be used and how the techniques were different from previous instructional techniques. A five-week experimental period followed the orientation during which PSSC units were used. The students selected the units and activities they desired which also involved selecting behavioral objectives from planning sheets and using a computer printed assignment and activity guide. The mastery group was required to master the objectives of a unit before proceeding whereas the nonmastery group was not. Criterion referenced tests were administered to each student to determine if the selected objectives had been achieved. If the objectives had not been achieved by a student in the nonmastery group, he was not permitted to undergo remediation or reassessment, but had to move ahead.

An analysis of the results indicated that students in both groups selected objectives with the same proficiency levels; but different cognitive levels.

College Level. Interest in the auto-tutorial (or audio-tutorial) mode is obvious at the college level with five studies related to the biological sciences, four to the physical sciences, and one in allied health being found.

Two of the studies in the biological sciences concerned biology in the junior college. In the first, King (171) had the objective of determining the effects of two different methods of laboratory teaching, one an audio-tutorial biology laboratory and the other, a traditional biology laboratory, on the attitudes of junior college students toward biology. The subjects consisted of 140 students enrolled in general biology for non-science majors at Copiah-Lincoln Junior College during the first semester 1972-73. Seventy-two were in the experimental (audio-tutorial) group and 68 in the control (traditional) group. It was hypothesized that neither the treatment mode, the factor of sex, nor academic ability would result in significant differences in attitudes.

Data were collected with A Scale to Measure Attitude Toward Any School Subject, Form A of the Purdue Master Attitude Scales, and (for academic abilities) The American College Test and analyzed at the end

of the semester. The analysis indicated there was a significant improvement in attitude toward biology for the experimental group, but sex and academic ability were not found to be significantly related to attitudinal change. It was concluded that the audio-tutorial approach was a satisfactory way to teach biology laboratory at this level.

The second study by Ganz (110) was conducted in October, 1972 at Rhode Island Junior College to determine what effect television was having on student attitude toward its use. The study was based on an audio-tutorial instructional program for a general biology laboratory that had been directly adapted to television in a video-tutorial format. In order to carry out the study, three groups were established. For the two experimental, one used video equipment that could be self-paced by the student, while for the other, the equipment and pace were controlled by the instructor. The third group, a control, used the established audio-tutorial program.

The results of an attitude survey conducted after six weeks indicated that the control group had a significantly lower attitude toward the television format (what they had not experienced) than did either experimental group. Age was not found to contribute to significant differences in attitude although sex did.

Another study, conducted in 1973 and similar to the earlier one, retained the formats with an experimental self-paced television group, and a control audio-tutorial group. However, the other experimental group was changed to a self-paced video-tutorial format with behavioral objectives and guidelines written by the faculty. Pre- and posttests were administered to the three groups to measure attitudes toward the laboratory, and a laboratory test was used to measure achievement in the laboratory. In addition, the students were surveyed about previous biology course experiences.

An analysis of the data for this study indicated declines in attitude toward the laboratory, particularly with the behaviorally oriented group. Neither sex, age, nor prior experiences in biology were found to be responsible for the declines in attitudes. Sex was found to be significantly related to gains in laboratory achievement. It was concluded that the data did not justify the use of television as a substitute for an audio-tutorial presentation.

Wheatley (359) attempted to show that the higher levels of the cognitive domain (Analysis, Synthesis and Evaluation of Bloom's Taxonomy) can be successfully taught and evaluated in the science laboratory. The subjects were all students registered for Biology 100 at The Ohio State University during the autumn and winter quarters, 1970-71. The course is an introductory biology course taught by an audio-tutorial format over a period of ten weeks and covers the topics typically found in such introductory courses. In addition to the audio-tutorial experiences, the students met in recitation sections in groups of less than 35 two or three times at the Bio-Learning Center.

During each quarter five recitation sections each were randomly designated as experimental or control. The experimental groups performed special activities designed to teach for higher cognitive levels of thinking, including seven laboratory activities 20-30 minutes in length prepared by the investigator. The control group had the regular Biology 100 plus special pretests and three specially designed posttests. The three cognitive posttests administered to both the experimental and control groups contained items at all six levels of Bloom's Taxonomy: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation.

None of the F tests used to examine background variables such as effects of pretest on posttest performance, college class of student, influence of participating teacher or sex were found to be significant at the 5 percent level. Neither were significant differences found between treatment groups on pretest performance.

However, on one posttest, significant differences were found for the experimental group on the Application, Analysis, Synthesis and Evaluation subtests. On the same posttest, students in the experimental group who performed less than half of the special activities, scored significantly lower than those who performed more than half. When compared on scores obtained on two regular midterm and final examinations, significant differences were not found between the experimental and control groups. But, those in the experimental group who performed more than half the special activities scored significantly higher than those who performed less than half.

Rowsey and Mason (294) analyzed the outcomes of two methods of instruction, conventional lecture-laboratory and audio-tutorial as they were related to immediate achievement and to retention in a university course in animal biology. The contents of the courses were alike for both methods—the course syllabus and objectives being the same.

The subjects were 109 students in Biology 103 at Auburn who were taught by experienced instructors in the conventional manner, and 134 students who received instruction audio-tutorially, except for group discussions once a week. The subjects were assigned randomly to the treatment groups.

Both groups were pre- and posttested with the Achievement in Biology Test developed by the investigators in cooperation with the Department of Zoology-Entomology at Auburn University, and "face validity" by "experts" was used to endorse the test. It consisted of 60 five-stemmed [sic] multiple-choice items, 48 of which were covered in the course. The instructors involved in the study had no knowledge of the test. t-tests were used to determine any differences.

The analysis of the pretest scores failed to indicate any significant differences between the two groups, although the posttest score was significantly in favor of the audio-tutorial group.

Twenty-nine percent of the control and 34 percent of the experimental group took the retention test eleven weeks after the course was completed. The results were significantly in favor of the audio-tutorial (experimental) group.

Coombs (72) reported a study in which he described and evaluated an individualized program in an introductory course in genetics for college students. The investigator worked with students in the development of the course. Since support was not available from his institution, students donated the cassette recorders and tapes and made the duplicate tapes. They used The Science of Genetics as a study guide and developed instructional objectives for the first 13 chapters plus a course syllabus that outlined the individualized system. The program was student-paced. The students were allowed to do additional work beyond the 60 percent mastery level to get grades above C.

The scores of the 1972-74 AT students were compared with those of conventional program students in 1970 and 1971. It was found that 25 percent more A's were earned in the individualized system, together more A's and B's, and fewer C's. It was concluded that the increments were attributable to immediate feedback on test results, and the practice sessions associated with the audio-tutorial program.

Of the four studies in the physical sciences involving the audio-tutorial method, two dealt with survey-type courses in the physical sciences, and two with the more conventional physics courses. In one of the first two, Brantley (51) compared the audio-tutorial method of instruction with the traditional lecture-demonstration method for "producing achievement in students in physical science survey classes." The physical science survey covered one semester and included physics and astronomy. Other variables that were considered were the age and sex of the students.

The subjects were students enrolled in the day sections of Physical Science 101 at Pensacola Junior College during the spring term, 1974. The students were randomly assigned to two groups. One group of 114 students in two sections was taught by the audio-tutorial method, and the other of 76 in two sections was taught by the traditional lecture-demonstration method. Both groups spent equal time in the planetarium, however. At the end of seven weeks of studying astronomy, all students were administered a Standardized Test in Collegiate Descriptive Astronomy on Selected Concepts Which Can Be Demonstrated in the Planetarium (apparently developed by the investigator) and at the end of the term the Dunning-Abeles Physics Test: Form E to measure the physics component. A three-way analysis of variance was used to examine the data.

The results indicated that (1) the lecture-demonstration, with small class sizes, was more effective in producing achievement than was the audio-tutorial methods, (2) significant differences in achievement were not found between males and females, and (3) differences in achievement were found between older and younger students.

The purpose of the study by Pare and Butzow (257) was based on two assumptions, (1) students that are more independent in their work habits will be able to complete more of the course objectives in the span of one semester than their less independent peers, and (2) will have a more positive attitude toward the AT course (a mode of instruction with which the study was concerned). Ninety students (most of them women majoring in elementary education) enrolled in Studies in the Physical Sciences I (SPS) at the University of Maine at Orono during the fall semester, 1972-73, were subjects. The group, all non-science majors, ranged from freshmen to seniors.

All the subjects were taught SPS by a combination of total use of AT and a contract grading system involving 16 instructional units: five to be completed for A, four for B, and three for C. To complete a unit satisfactorily, the subjects were expected to demonstrate competence on each objective and to take (1) a course attitude inventory, (2) a test of independent work habits of 40 items developed by the investigators using a five-poing Likert-type scale, and (3) a laboratory practical examination on each instructional unit.

Coefficients of correlation (r) were used to compare course grades, pre- and posttest attitude scores, total time spent on the course work, and independence scores. The analyses indicated small, non-significant r's between independence scores and (1) total time, and (2) pre- and posttest scores from the attitude instruments. Low, but significant r's were found between (1) independence scores and total units completed, (2) total time and posttest attitude, and (3) total time and posttest attitude toward method of instruction.

It was concluded that the more independent students were generally higher achievers, but independence did not seem to be a factor in attitude toward the course or AT.

Thorsland (340) dealt with the formative evaluation of one step in implementing a major change in a university physics course. The change, a move to AT, was made because of the lack of articulation between the laboratory and other course activities and the lack of individualization.

During 1969-70, two three-week units in a physics course were pilot-tested in an AT format. The format was tested on an extended basis in the Fall, 1970, with 70 of 420 students enrolled in a non-calculus physics course for a period of ten weeks with the remaining 350 students following the traditional approach. The traditional non-AT format involved two demonstration lectures and two recitation-problem solving sessions per week with one two-hour laboratory session on alternate weeks. The AT group had weekly self-paced units of material with audiotape sessions, study guides, and self demonstrations with the instruction being held in an open learning center with carrels and laboratory facilities. The lessons for both AT and non-AT groups covered ten weeks and dealt with Newtonian mechanics and thermodynamics. Achievement was measured with norm-referenced tests at four-week

intervals. The students were also administered a questionnaire with 15 statements concerning their attitudes toward the course, and another questionnaire eliciting information about their backgrounds. The data from the questionnaires were analyzed by Chi-square and those from the achievement tests with ANOVA.

The results did not show that the backgrounds of the students were significantly different. A significantly greater number of the AT students were favorable to the course than were non-AT students, although there was hesitation in both groups about recommending that their friends enroll. Also significantly greater numbers of the AT group said the laboratory work was informative. Statistically significant differences related to achievement were not found.

Ott and Macklin (252) used a trait-treatment interaction approach to analyze the achievement of first-year college physics students in two instructional treatments, one an audio-tutorial treatment and the other, a lecture-recitation-laboratory treatment. The dependent variable was student achievement as measured by the final grade. The subjects were selected from about 575 engineering physics majors in a one-semester freshman level physics course at Cornell University. About 98 percent of whom were freshmen, 91 percent enrolled in engineering and 96 percent males.

Homework, laboratory assignments and examinations were the same for both groups with the difference only in the instructional methods. In the "standard" treatment students had two hours of lecture and two hours of recitation weekly with two hours of laboratory on alternate weeks. The audio-tutorial included one hour of recitation per week with the center for audio-tutorial instruction being staffed by tutors 52 hours per week. The analysis involved data from 115 AT and 188 "standard" students. Three traits were considered in the interaction analysis; (1) mathematical aptitude as measured by the College Entrance Board Scholastic Aptitude Test (SATM), (2) verbal aptitude from the Verbal Section of the same test (SATV), and (3) mathematical achievement as measured by the pretest. All students took six quizzes, as well as two interim and one final examinations which, together with scores on the laboratory reports, determined the final grade.

The analyses failed to indicate significant differences between the final grades of the two treatment groups, although the standard treatment seemed preferable for students with a score of nine or above on the mathematics pretest used at Cornell, or an SATM of 725 or above. However, the audio-tutorial treatment seemed preferable for students with a pretest score of four or below or an SATM of 625 or below.

Griggs (126) developed an auto-tutorial, audio-visual, minicourse to: (1) inform and prepare Allied Health personnel, particularly respiratory therapists, nurses, and pediatric assistants, to handle effectively problems associated with contamination and decontamination

of inhalation therapy equipment, and (2) investigate how different combinations of instructional methods are related to student achievement, and (3) determine an effective approach for implementing the minicourse.

The effects of four different treatment levels were studied with 137 third quarter Allied Health students enrolled in Introductory Microbiology at Georgia State University in the Spring, 1974. They were randomly assigned to one of four treatments, (1) programmed instruction alone, (2) audiovisuals alone consisting of slides with audio cassette tapes, (3) use of entire auto-tutorial, audio-visual, minicourse, and (4) the control, having no exposure to the auto-tutorial, audio-visual minicourse. Achievement was measured with pre- and posttest gains using ANOVA.

The analyses indicated significant differences between the groups using variations of the auto-tutorial and the control treatments. There was also a significant difference between the group using the entire auto-tutorial, audio-visual minicourse, and the one using the audio-visual alone. In other words, the greater the number of instructional modes used, the greater was the achievement.

One may summarize the findings of the various studies related to the auto- (or audio-) tutorial method by stating that sometimes it seems to be more effective than other instructional methods and sometimes it does not. As with numerous studies in which instructional methods are compared with one another, factors other than the method itself seem to be more influential in enhancing various types of achievement.

Although many seem to equate self-paced or self-instructional methods with AT, there are many other formats of self-pacing and self-instruction that have been investigated. Two reported here are in the biological sciences, four in courses in physical science for non-science majors, two in physics and one in chemistry.

Brecheisen (52) reported the development and evaluation of self-instructional supplementary materials in the form of minicourses for use in teaching introductory genetics. Seven minicourses were developed including behavioral objectives and corresponding test items; study activities; and an audiotape and a study guide. The original materials were tested with students and two or more revisions were made of each minicourse.

In determining whether the materials met their objectives, pre- and posttests were administered to a treatment group that completed the minicourses and to a control group that did not. The mean effectiveness and mean modified gain score were then computed for each group. In six of the minicourses the mean effectiveness was above 50 percent and in six the mean modified gain score was above .80. It was stated that these values indicated that the minicourses were effective in meeting their objectives. In addition, F and

t-tests indicated that the posttest scores and gain scores were significantly higher for the experimental group than the control. A questionnaire to the students indicated that the majority favored the availability of the minicourses. However, when the scores of low achieving students using the minicourses were compared with those of similar students not using the minicourses, significant differences were not found.

Pultorak (274) developed and tested a self-paced laboratory module in vascular plant taxonomy designed to aid undergraduate biology students in understanding both traditional and contemporary activities of the plant taxonomist.

The collaborators, number not indicated, were student participants and instructors in three community colleges, who "assessed" the module in terms of its effectiveness as an instructional aid and made recommendations for revisions. The revised module consists of a Diagnostic Pretest; a Student Laboratory Manual with two sections, The Common Laboratory Experiences, and The Divergent Laboratory Experiences; and an Instructor Manual. It was indicated that, in general, students preferred this method of instruction to a traditional type of biology laboratory.

Oms (246) described the development and evaluation of an introductory course in astronomy for non-science majors in which the mode of instruction selected was modeled after the Personalized System of Instruction (PSI) used by Ferster. The course was developed in the Summer, 1971, with the theme being "Western Man's View of the Universe." The texts used in the course were Kuhn, The Copernican Revolution; Munitz, Theories of the Universe; two books from the Harvard Project Physics series, the reader and text for Unit 2; and Asimov, The Universe. The content was divided into 36 small units and student guides were developed for each. The characteristics of PSI are (1) unit perfection (mastery) required for advancement to a new unit; (2) self-pacing; (3) a reliance on the written word for information transmittal; (4) use of lectures and demonstrations as motivational procedures; and (5) the use of student proctors.

In the Spring, 1973, all students—120 in number—who had only conventional courses were divided into two groups; an experimental or modified self-paced, and a control or self-paced. Mastery of a unit was measured through a minilecture or a written exercise with a criterion of 90 percent.

According to the investigator, PSI was well received by the vast majority of students. The experimental group received more A's and B's than did the control group. However, a significant difference was not found between the two groups in mastery on the written examination.

Robinson (290) designed a study to determine whether students studying astronomy using a moderately structured program would learn astronomy as effectively, understand the nature and processes of

scientific investigation as well, and develop as positive attitudes toward astronomy, research and teaching as those studying astronomy by a conventional lecture-demonstration-discussion approach.

Fifty-four students enrolling in an elective introductory astronomy course in the fall semester 1973 entered one of two sections on the basis of personal choice or scheduling constraint. The students were mainly freshman and sophomores and had no knowledge that one section would be taught by individualized instruction. The first three meetings were orientation and testing during which they were administered an astronomy achievement test and an attitude scale of the semantic differential type, both developed by the investigator, and the Test on Understanding Science (TOUS). After the initial testing, one section pursued an individualized approach with study guides, behavioral objectives, instructional handouts, supplementary readings, and participation in an audio-visual astronomy learning laboratory. The other section met for three 50-minute periods each week for lecture, demonstration and discussion with the usual supplementary activities. The individualized group had a final examination whereas the "regular" group had short quizzes, three hour examinations and a final examination. The data from the tests that were administered pre and post were analyzed using F and t.

The results failed to indicate significant differences between the two groups on understanding astronomy concepts, understandings about science and scientists as measured with the TOUS; or attitudes toward scientists. It was noted that students in the conventional group developed negative attitudes toward research.

Bard (19) attempted to develop a programmed, self-paced variable-step guide and determine if the guide was as effective as the traditional textbook lecture method of instruction in assisting the students to achieve in the cognitive domain while improving the students' attitudes towards taking a required general education science course.

A study guide was developed and used in a college physical science class, Physical Science 100 at Southern Colorado State College during the Fall of 1973 to supplant two hours of lecture demonstration per week. The performance of 22 students who used the study guide was compared with that of a control group of 48 regularly enrolled students in the same course during the winter and spring quarters, 1973, using three multiple-choice open-book tests. In addition, the students evaluated the study guide using a 20-item questionnaire.

An analysis of the results failed to indicate a significant difference in achievement between the experimental and control groups. However, students in the study guide section indicated that they preferred the self-paced study guide over the conventional presentations they experienced in other classes. They also preferred to participate in the selection of learning activities, and in small discussion groups over large lecture sections.

Steele (321) sought to determine (1) whether differences exist between the achievement of students in physics having traditional lecture methods of instruction and that of students in a laboratory setting using individualized learning packets; and (2) changes in students' attitudes toward science instruction, science content and science teachers.

The subjects were 36 nonscience majors enrolled in Physics 306 D at the University of Wyoming, who were randomly assigned to either an experimental or control group. For the first four weeks all subjects were required to attend a series of physics sessions, conducted in the traditional classroom fashion, during which the basic mathematics needed for the rest of the course was presented. Then the subjects in the individualized section were free to choose one of four individualized study guides and master the objectives including one of the alternative activities listed in each study guide. The subjects in the traditional setting had group instruction and guided lecture-demonstrations provided by the investigator.

Analysis of the results was made with pre- and posttest scores from a (1) content teacher made physics test [sic]; (2) Harvard Project physics test [sic]; and (3) Physics problem solving test. The analysis indicated significant differences between the scores of the two groups in favor of the self-paced group. An analysis of pre- and posttest scores on the Affective Domain Scale indicated significant higher scores for the self-paced group for attitude toward science. Further, the majority of students thought they could learn more when working at their own rates, and would like to take additional courses in which self-paced instruction is used.

Greenwood (125) had the goal of searching for a relationship between the career relevance of subject material in physics as perceived by the student and achievement in self-paced and traditionally taught sections of an undergraduate physics course. It was hypothesized that (1) the correlation between perceived relevance would be positive in both treatments, but greater in the self-paced; (2) students in the self-paced would earn higher grades than those in the traditional; and (3) there would be differences in final grades and in the relationship between perceived relevance and achievement on the basis of sex, high and low dogmatism, high and low test anxiety, and high and low reading aptitude.

The subjects consisted of 126 of 236 students from the traditional section and 35 of 104 from the self-paced section of an undergraduate physics course. The subjects were self selected, consisting of students who completed and returned usable questionnaires. The questionnaire obtained demographic data and contained the Rokeach Dogmatism Scale, the Sarason True-False Test Anxiety Scale, and a relevance scale. Michigan State University Reading and Mathematics Test scores were obtained from University records.

An analysis of the scores generally supported the hypotheses of the study. The relationships between perceived relevance and achievement were positive and higher for the self-paced than for the traditional group. Also, mean final grades were generally higher for the self-paced than for the traditional group.

Ijaz (154) sought to develop a method of individualizing instruction that results in greater achievement in college physics while developing better attitudes and self esteem, and building confidence. The subjects were 80 students enrolled in a sophomore physics course at Virginia Polytechnic Institute and State University during the fall and winter quarters 1974-75 for each of whom was developed an individualized course. The effort was a test of the effectiveness of what was referred to by the researchers as the "Triple Stage Interaction Model."

In the first stage, the subject's attitudes, interests and aptitudes were assessed; their cognitive styles were analyzed with the Embedded Figures Test, the Pattigrew Paper and Pencil Questionnaire, the Triad Pictorial Stimuli Test, and Matching Familiar Figures Test, and the Stroop Color Word Interference Test. In the second stage, the self-paced physics course was divided into small units, each consisting of a law or concept to be learned to mastery. Each unit was individualized into tasks for each learner. In the third stage, the learner worked on the tasks involving a variety of experiences including lectures, demonstrations, experimentation, tutoring and independent study, all involving various types of audio and visual media. The classroom atmosphere was informal and individual help was always available.

The data from pre- and posttests and examinations were compared for the experimental (individualized) group and a control group taught by a lecture approach. The findings indicated that the experimental group achieved a greater mastery and retention of subject matter in physics and had developed more positive attitudes toward physics.

Vanderbroucke (346) described a Personalized Instructional System (PSI) for teaching general chemistry at Wartburg College and the method used for evaluating its effectiveness. The system, without formal lectures, is supplemented by tutorial assistance from paid undergraduate chemistry majors.

At the time of the study Wartburg was on a 4-4-1 calendar in which a student took four courses during the fall and winter terms, and one in May. General Chemistry was sequential and covered all three, but the report deals only with the fall and winter terms that covered 14 weeks. The course was divided into morning (A) and afternoon (B) sessions for the first two years with an exploration of alternatives during the third year. During the first year a programmed text was used in B with the traditional instruction in A. The programmed section had two lectures and two help sessions per week. During the second year, PSI was used in B with three 50-minute testing sessions each week. During the third year, a fourth testing session

was put in B. Students in A and B took the same final examination at the end of the first term and the ACS-Cooperative Examination in General Chemistry at the end of the second. There was no distinction in laboratory activity that involved a three-hour session.

An analysis of grades indicated PSI students are learning at about a level comparable with those in lecture sessions. But, PSI students seem to think they learn more based on results from a student attitude assessment.

Six research studies dealt with various aspects of self-paced courses for prospective elementary teachers. They might have been put in several other categories, but they were put here because of the target population.

Futrell (107) attempted to design a science course for prospective elementary teachers that would demonstrate its (1) appropriateness as an instructional model suitable for transfer to elementary science teaching and exportable to other college settings, and (2) effectiveness in developing desirable cognitive and affective behaviors in prospective elementary teachers. An effort was made to prepare an individualized program in the processes of science, followed by a pilot implementation that led to revisions; the implementation involved a sample of 25 subjects. The effectiveness of the effort was judged using discrepancy analysis evaluation techniques to compare program outcomes with program goals. The criterion level of performance for the program was set at achievement of 90 percent of the objectives by at least 90 percent of the students. Performance below this level indicated failure to meet the designer's specifications. The cognitive goal of the course was student mastery of a set of science process objectives; and the affective goals were positive attitudes toward science and science teacher; and positive attitudes towards, and accurate perceptions of, the instructional program as represented by a set of attitude objectives. The appropriateness of the program for transfer to elementary science teaching was ascertained by comparing its characteristics with a set recommended by AAAS. The suitability of the program for use in other college settings was made by obtaining data from a trial implementation at another university.

An analysis of the data collected from the measurements was claimed to indicate that the program (1) met the 90/90 criterion level of performance, (2) incorporated 100 percent of the characteristics of science programs recommended by the AAAS for transfer to elementary science teaching, and (3) was implemented in another university with less than 20 percent modification.

Hendrix (138) produced and tested individually-paced curricular materials designed to develop basic science process skill competency in preservice elementary teachers. The four basic processes selected for the study were observing, measuring, classifying and predicting. The content for developing observation was adapted from Elementary Science Study (ESS); for measurement, from Science - A Process Approach (SAPA); for classification from Science Curriculum Improvement Study

(SCIS); and for predicting process skill, materials developed by the research. Among the first steps was the development of specifically stated performance objectives for each process skill with which the study was concerned. Then eight prototype process skill tests were constructed, a pre- and posttest for each of the four skills, and learning guides were produced for use by the preservice elementary teachers in elementary science methods courses, together with an instructor's guide to accompany the student materials.

The prototype materials were tested during the spring and summer quarters of 1973 and revisions were made. The revised materials were pilot tested during the fall quarter, 1973-74, with six sections of elementary science methods students at Ball State University. Further revisions were made and the curricular materials were tested in final form during the winter quarter 1973-74. Statistical analyses were made using scores from the pre- and posttests to determine whether the subjects who used the materials met the competency criterion.

Individually-paced science process skill materials were created by means of the methods used in this study, and the subjects met the competency criterion for all process skills.

Ponzio (269) developed an auto-tutorial criterion-referenced (A-T/C-R) program to teach preservice elementary school teachers how to use six science process skills: observing, communicating, comparing, organizing, experimenting, and inferring; and evaluated the program's effectiveness in improving the skills of the preservice elementary teachers in using these six processes, and effect on teachers' attitudes.

The subjects were 74 preservice elementary school teachers enrolled at the University of California at Berkeley. They were randomly assigned to experimental and control groups using "Woodson's Limited Resources Design" for the first part of the experiment. Both groups were simultaneously administered skill and attitude assessment measures, but the experimental group then had six weeks of experience with A-T/C-R, whereas the control group did not. After six weeks both groups were administered a posttest for both process skills and attitudes. A multivariate analysis of variance was used to analyze the data.

The results indicated that those who used the A-T instructional modules for various processes of science scored consistently higher on all measures of process skills than did those in the control. In most cases, those who were unable to pass the C-R science skills pretest scored significantly higher on retests for those subsections after they used the A-T modules. Significant effects on attitude change were not observed.

Markle (209) stated that the specific objectives of his study were to determine if (1) use of written questions within an activity-centered module resulted in greater immediate and delayed learning than using no questions; (2) location of written questions relative

and Community Resources, although only the results with Science Process Skills were used in the analysis. All subjects completed the Rokeach Dogmatism Scale (Form E) for measuring "openmindedness" and "closed-mindedness;" The Scientific Attitude Inventory (SAI); Basic Science Process Skills (BSPS); and Integrated Science Process Skills (ISPS).

t-tests and r were used to measure differences and relationships. The results of the analyses failed to indicate significant differences between the self-paced and teacher-paced groups in achievement on basic science process skills or in attitudes toward science. However, a significant difference was found in favor of the self-paced group on the test of Integrated Science Process Skills. Also it was noted that the openminded students did better on the skills tests than did the closedminded.

The studies involving self paced materials with prospective elementary teachers are generally inconclusive. Where significant results do favor treatment groups, in many cases the control groups are left to "forage for themselves." Under such circumstances, one can hardly assume that comparisons have much validity.

Kahle and Nordland (165) undertook a study involving AT but since it was concerned also with the concept of advanced organizers, the study is dealt with separately here. Its stated purpose was to measure the differential effect of an advanced organizer on the meaningful learning and retention of information presented to the learner in a sequential, structured program of individualized instruction.

The subjects were 293 students enrolled in a biology course for elementary education majors during the fall semester, 1970. Most of the students were female, non-science major underclassmen. They were randomly assigned to two treatment groups that had identical instructional materials, but one group received an advanced organizer and one did not. The instructional materials were AT units covering change, atomic structure, molecular bonding, energy in complex molecules, kinetics catalysis, equilibrium, entropy and enthalpy and extended from September 28, 1970 to October 23, 1970.

At the beginning of each unit the subjects were tested on micro-learning tasks; took self administered multiple-choice tests at the end of A and B divisions of each unit that lasted a week; and took weekly oral quizzes. The advanced organizer was a 500 word audio-script on a cassette tape and a brief film loop. A short experiment was also performed as part of the advanced organizer.

The analyses involved 38 measures of time and scores that were tested with ANOVA. Only four significant F ratios were found. It was concluded that there was no discernible pattern of results. It was suggested that the advanced organizer may have taken up valuable learning time, but this does not seem to be tenable since it appears that only 10 minutes of the four week period were used.

to the enabling activities affected immediate and delayed learning from an activity-centered module; (3) cognitive level of instructional questions used in an activity-centered module affected immediate and delayed learning; (4) location of instructional questions relative to the enabling activities of an activity-centered module affected immediate and delayed learning of relevant and incidental information; and (5) use of knowledge and comprehension rather than only knowledge instructional questions affected application and/or knowledge scores on immediate and delayed posttests.

The subjects were 99 students enrolled in an elementary science methods course at the University of Georgia during the winter quarter 1974 who were divided into nine treatment groups. The groups were treated indentically [sic] except for the location and cognitive level of the instructional questions they encountered on an activity-centered module dealing with measuring and the metric system.

Multivariate analysis showed significantly higher immediate and delayed posttest scores for those who had instructional questions over those who did not encounter them, but significant differences were not found among the various groups receiving questions at different locations and at different cognitive levels. Significant differences were found, however, for incidental test scores in favor of those groups that had the instructional questions clustered near the end of the module.

Hubbard (149) set out to examine the feasibility of modifying prospective elementary teachers' self-concepts and attitudes toward biology. A self-concept of ability scale was constructed and, using students and a panel of judges, the researcher determined that it was sufficiently reliable and valid for use in the study. Three discussion methods were compared for their effects on prospective [elementary] teachers' attitudes toward biology.

According to the researcher, significant differences, between pre- and posttests, were found for the improvement of attitudes toward biology of the prospective elementary teachers who used AT, but significant differences were not found for methods including biology teaching videotapes, biology videotapes, and biology experiments. The changes that were observed were attributed to relevance of learning materials to elementary science, and characteristics of the audio-tutorial system, the instructor and the students.

Campbell and Martinez-Perez (61) had the major purpose of determining the effects of self-pacing instruction in a science methods course on preservice elementary teachers' achievement and attitudes toward science. A second purpose was to examine the relationship between "openmindedness" and "closemindedness" and achievement in science methods instruction. The subjects were 20 preservice teachers (19 females and 1 male, all being juniors or first semester seniors) who were assigned randomly to two groups, one self-paced and one traditionally instructor paced. They received four instructional modules, What is Science; Science Process Skills; Science Curriculum Materials;

Anderson, DeMelo, Szabo and Toth (8) attempted to answer the question, "What is the effect of behavioral objectives on immediate learning from an inquiry-oriented instructional program which incorporates knowledge and higher than knowledge cognitive behaviors as defined by Bloom?" It was hypothesized that significant interactions would not be found between (a) students who received behavioral objectives and those who get a placebo; (b) high and low students on a test of ability to use scientific processes; and (c) the treatment conditions and learner facility with scientific processes, and the criterion of specific subject matter achievement.

The instructional unit was based on the BSCS Inquiry Slides: Structure and Function; Control of Blood Sugar; and A Homeostatic Mechanism; it included 24 behavioral, 16 knowledge, and 8 higher than cognitive objectives that were submitted to science educators for validation. Two weeks prior to treatment 40 students in an elementary science methods course in a major eastern university were administered the Processes of Science Test (POST) and were assigned random, from two class sections, to treatment groups based on these scores. Prior to the experiment the subjects read a passage that contained behavioral objectives or a placebo that consisted of an unrelated discussion of a recently developed science curriculum. They then used the BSCS units.

An analysis of the scores of the criterion test based on knowledge levels and on other scores obtained from tests administered to the subjects indicated that the experimental and control groups were not randomly selected from the same population, nor were the high and low scorers on POST. Further, significant interactions were not found between the type of treatment and attainment of process skills. Nevertheless, it was concluded that under inquiry-oriented instructional sequences that are designed to elicit both knowledge and higher than knowledge cognitive functions, the use of behaviorally-stated learning outcomes facilitates immediate learning.

A generalization that seems reasonable from the findings of these studies on individualized instruction and self pacing is that achievement in any dimension depends greatly on factors other than the treatment. ment.

Instructional Methods

The studies in this section overlap in purpose with studies in other sections. For example, this section contains studies dealing with advanced organizers. However, one study dealing with advanced organizers was included in the preceding section since it also dealt with AT. Since "Instructional Methods" make up a broad spectrum of studies, the groupings are not parallel in structure. Those first reviewed are grouped according to educational level. Those reviewed later are grouped according to certain educational strategies.

Elementary Level. Hadar (129) conducted a study, as much related to mathematics as to science to determine if fifth graders can significantly improve their use of logical analysis through a suitable

instructional unit taught under ordinary classroom conditions. Concrete teaching materials were developed to help the students distinguish between valid and fallacious inference patterns. The valid patterns were referred to as Modus Ponendo Ponens and Modus Tollendo Tollens; the fallacious as Affirming the Consequent and Denying the Antecedent. No formal rules of inference were taught. The subjects were 210 fifth grade students in a suburban area, 104 in four experimental classes and 106 in four control.

The teachers participated in a 12-hour pretraining workshop to become familiar with the concrete materials in the experimental unit. The experimental unit was then implemented by four fifth grade teachers in their ordinary classes with a pretest/posttest, treatment/no treatment design to assess improvement in the conditional reasoning ability of the students.

An analysis of the test results did not indicate differences between the groups on the pretest, but there was significant difference between the two groups on posttest means and gains from pre- to posttest in favor of the treatment (experimental) group. The gains were most evident on the activities related to fallacious inference patterns.

Barber (18) developed and evaluated a three-week integrated unit in mathematics and science for fourth graders using the guidelines of the Cambridge Conference report entitled, Goals for the Correlation of Mathematics and Science. The unit included a pretest, posttest and planetarium trip as part of three discovery-style investigations, each of which has several days' lessons intended to promote an understanding of the [sic] scientific method. The geometry and astronomy concepts were integrated so as to complement one another.

In the winter 1974, the unit was used, preceded by a pretest, with three fourth grade classes involving 78 students and their classroom teachers in the Colorado Springs Public Schools. The classes were considered to be below average, average, or above average based on scores on the mean Thorndike Cognitive Abilities intelligence scores and Iowa Test of Basic Skills area scores. The subjects were then posttested.

An analysis of the scores indicated there was a significant mean gain from pre- to posttesters. Significant positive relations were found between posttest scores and scores on the (1) Thorndike Cognitive Abilities, and (2) Total Work Study Skills, Reading Comprehension, and Total Mathematics area scores of the Iowa Test of Basic Skills. Significant differences were not found between posttest scores of boys and girls. Further, the mean evaluative instrument posttest score for students in the below average class was significantly higher than that for students in the above average class. [Reviewer's note: This point needs further study.]

It was concluded that integration of mathematics and science such as that attempted in this study is feasible.

Barufaldi and Dietz (24) sought answers to two questions: (1) Do the differences in perceptions of solid objects and two-dimensional representations of the objects affect the performance of children on visual observation and comparison tasks? and (2) Do the different types of two-dimensional representations (photographs or drawings) affect the performance of children on visual observation and comparison tasks?

The subjects were 228 children in grades 1,2,4, and 6 randomly selected from elementary school in a large eastern city. Twenty-six tasks were administered verbally involving four objects: a cube, cylinder, pyramid and cone. The edge of the cube and pyramid were the same length and the cone and cylinder were the same height. The faces of the cube were painted red, yellow and blue and those of the pyramid, red or yellow. Color photographs were then taken, and colored drawings then made of the same objects.

Groups of not more than 20 subjects were then presented with one object or representation (one on each subject's desk) and were read tenobservation tasks. Then a second object or representation was added and 16 comparison tasks were administered. About 25 minutes were required for the activities.

The results indicated that sixth graders were more skillful on observation and comparison tasks with objects than with drawings; fourth graders did better with photographs than drawings; first, fourth and sixth graders performed better with solid objects than with photographs; and children at all grade levels did better with photographs than with drawings.

In other words, "kids" work better with real things than with the abstract or unreal.

Wideen (361) investigated the effectiveness of Science - A Process Approach (SAPA) as compared to [sic] traditional science teaching on the basis of scores from cognitive, process, interest, attitude, and classroom perception measures to find out if any differences could be attributed to the factors of sex, IQ, achievement and grade. The subjects were 531 students from 25 classrooms in grades 3-6. Those from the Spearfish School District, South Dakota formed the experimental group and those from the Sturgis, Piedmont and Whitewood Schools formed the control. The mean IQs based on the Lorge-Thorndike Intelligence Test were about 107 and 108, respectively.

The experimental group used SAPA and the control group had traditional programs. All subjects were measured with the Sequential Test of Educational Progress: Science; Revised Attitude Inventory Interest Inventory; SAPA Pupil Progress Measure: Part B; and Student Survey of Teaching-Learning Environment. Analysis of covariance was used to compare the groups for six dependent variables.

Not surprisingly, intelligence was found to be a significant main effect for nearly all dependent variables, but the treatment, SAPA or traditional, was not found to have an effect in improving student interest in science or making student perceptions of the teacher-learning environment more positive.

The results did indicate that SAPA students had greater science knowledge than did traditional students but apparently the difference favored SAPA students rather than being statistically significant. This is supported by the statement that the results indicate in a general way that students exposed to SAPA do better on cognitive process oriented tasks than do traditional students but there is not much effect on affective outcomes.

It was found that boys performed better than girls on the cognitive outcomes and also showed more interest in science than did girls.

Quinn and George (275) attempted to evaluate a method for teaching hypothesis formation to sixth graders by seeking answers to these questions: (1) Could children's hypotheses be improved?; (2) What criteria should be used to determine an acceptable hypothesis?; and (3) Which students form the best hypotheses based on these criteria? An acceptable hypothesis was defined as one that met at least one of these criteria: (1) it makes sense; (2) it is empirically based; (3) it is adequate; (4) it is precise; and (5) it states a test. A Hypothesis Quality Scale was developed on the basis of the criteria and a set of Principles of Precision was identified to determine when a hypothesis is precise. The reliability of the measures was tested on sample hypotheses by three science educators and was found to be adequate ($r = .94$).

The subjects were students in four intact sixth grades; two from a Catholic school in a low socioeconomic urban area, and two from a Catholic school in an upper middle class area. One class from each school was assigned to each of the experimental and control groups. The treatment group viewed 12 filmloops and had six discussion sessions 40 minutes in length. Each filmloop, three minutes in length, dealt with a single physical science concept. The filmloop was shown and the teacher then questioned the students about their understanding. The filmloop was reshown with more questions, and the students then wrote as many hypotheses as they could. The students were then taught to judge their own hypotheses with the Hypothesis Quality Scale. The control group was in effect a non-treatment group although the members were introduced to the use of the Hypothesis Quality Scale.

The scores made by both experimental and control students in rating hypotheses they wrote were compared using analyses of covariance with scores on the Otis Test of Mental Maturity as the covariate. The groups were analyzed on the basis of High-Low IQ, High-Low GPA, High-Low Reading Ability, and Girls-Boys.

The results indicated the method used in the experiment can be used successfully to teach hypothesis formation. The Hypothesis Quality Scale can be used to measure the quality of hypotheses, and given equal instruction low socioeconomic children do as well as high socioeconomic children in the skill of hypothesizing. It was also stated that the ability to form hypotheses is related to intelligence, overall GPA, reading ability, and sex; the latter relationship is not described.

Bedwell (30) carried out an experimental study to determine if teachers trained in question-asking skills could cause greater cognitive achievement and more positive attitudes by using a high level questioning strategy than by using a low level questioning strategy. The high level questioning strategy was operationally defined as a discussion lesson procedure in which at least 40 percent of the teacher's verbal questions were above the comprehension level of Bloom's Taxonomy. In lessons using the low level questioning strategy, the teacher's verbal questions were below application level.

The subjects consisted of nine volunteering teachers, four from the fourth grade, three from the fifth, and two from combined fourth and fifth. They were prepared in a workshop on question-asking skills with a self-instructional module entitled Question-Asking Skills for Teachers that had audio segments for class discussion. Before the training sessions, the teachers prepared 15-20 minute recordings of one of their classroom discussions for comparison. Then the nine teachers conducted discussion lessons with their students based on science history stories from a fourth grade reading series. Pupils within each class were assigned randomly to one of two groups. One group participated in discussion lessons involving the extensive use of high level questions by the teacher. The teachers of the second group used a preponderance of low level questions.

Effects were evaluated with three lesson posttests that measured achievement at six levels of cognition and with a measure that assessed student's attitudes toward the instruction and subject matter.

An analysis of the data indicated that three teachers did not ask 40 percent of the questions at a level higher than comprehension and so were not considered implementers. Teachers 3 and 9 withdrew from the study. Teachers 2, 4, 7 and 8 did ask more than 40 percent of the questions at a level higher than comprehension and so were considered to be implementers.

But, significant differences were not found among the mean scores of students on the attitude measure despite the questioning strategy, nor were significant differences found among students on the posttests based on the questioning strategy although fifth graders did better than fourth graders on items above the comprehension level.

An analysis of the findings of all these studies fails to suggest that any consequential generalizations can be made. Many of the studies do show that treatment groups may generally do somewhat better than non-treatment groups, but the differences, generally non-significant, are logically attributable to the bias of the researcher for the treatment and to the Hawthorne Effect.

Junior-High Level. Two studies were found at this level, one dealing with seventh graders and the other with ninth graders. In the first, McIntosh (216) developed packages of quantitative measurement operations intended for use in the teaching of seventh grade life science; explored the mechanics of their use in the classroom; and

examined the instructional effects of these materials. Five packages of quantitative measurement operations were developed related to seventh grade life science and employing inexpensive or easily-made instruments such as metric rules, balances and protractors. Each package consisted of several Manipulative Learning Operations (MLOS) and two tests.

The subjects were 386 students in 12 seventh grade classes of 5 teachers in the Martinsville City and Henry County, Virginia School Systems. Seven of the classes used the MLOS in their life science classes and the teachers were allowed to use them in the manner they chose. The other five classes used the State adopted textbook and followed the regular classroom procedures. All 12 classes took the pretests and posttests related to the materials covered in the packages. The tests were author developed and consisted of multiple choice items.

An analysis of the test scores failed to indicate significant differences between the treatment and non-treatment groups on pre- and posttests. Also, the groups were not found to differ with respect to change in mean score in using measurement operations.

Wright and Fowler (368) set out to explore the effects of Intensive Instruction (II) in either observation of details or Cue Attendance (CA) in a science problem or the production of tenable hypotheses (HG) about a science problem on future open exploration behavior. The investigation was pursued by measuring performance, on five dependent variables, by ninth graders after experiencing II in either CA or HG which included (1) quantity of CA; (2) quantity of HG; (3) quality of HG; (4) quantity of Information Search (IS); and (5) diversity of IS.

One hundred twenty ninth grade students were randomly selected from those of high and low ability from two school districts in Pennsylvania; 40 of the 120 were assigned to each of three treatment groups; (1) Group A-II in CA; (2) Group B - II in HG; and (3) Group C - control with II. The numbers of males and females in each group were about the same.

Prior to treatment, all students were shown the filmloop entitled "The Knife" from the Inquiry Development Program in Physical Science (IDPPS). Then apparently Group A received II in CA; Group B received II in HG; and Group C received neither.

In II each of the students viewed the IDPPS filmloop entitled "The Balloon in the Jar" until they reached mastery criterion of either 75 details or 5 hypotheses. Then all students viewed three other filmloops in random order, followed by posttests.

An analysis of the results indicated that both II students in CA and HG performed better than the control groups except in the case of quantity of CA in which significant differences were not found between the HG group and the control group. Both CA and HG seemed to perform equally well on all dependent variables except for the quantity of CA in which II CA observed a greater number of details. Significant

differences were not found among the low ability subgroups or among the high ability subgroups of Groups A, B and C on each of the dependent variables.

Neither of the two junior high level studies provided conclusive evidence for any generalizations.

High School Level. Four studies were found in this topic area at the high school level; three in biology, and one in chemistry.

Ryvicker (297) compared three instructional strategies—coordinate, superordinate, and tangential—in an effort to answer the question, "Does one present a multitude of concepts which are subordinate to and/or coordinate with the others in the schema or present a superordinate concept to subsume and organize those which follow into a schema?" The concept dealt with food chains and the strategies had these characteristics, (1) coordinate—overlearning the food chains at conceptual levels coordinate with those employed in criterion-oriented instruction; (2) superordinate—opportunity for overlearning the food chain by working from the food web concept; and (3) tangential—explaining terms related to food chain concept without concern for the level of abstraction.

The subjects were students enrolled in biology courses in Rotterdam High School, Rotterdam, New York. They were separated into two language ability groups on the basis of the scores from the eighth grade administration of the "Vocabulary" and "Reading Comprehension" subtests of the Iowa Tests of Basic Skills. Those who scored 18.3 or above on the test of language were considered the high group, and those 17.7 and below, the low group. Thirty were selected at random from each of the two groups; ten from each group experienced one of the instructional strategies that was presented by videotape on closed circuit TV. Retention after 1 and 15 days was measured by final tests developed by the investigator and an advisory panel.

The results indicated that the high ability language group scored consistently higher than the low ability language group on the post- and post-post retention tests. Also, on the post-post test, those in the superordinate treatment scored significantly higher than those in the coordinate or in the tangential.

Hazen (135) compared the effectiveness of an innovative technique, simulation gaming, with that of a more traditional question-answer approach to teaching. Effectiveness was measured in terms of immediate cognitive learning and retention of cognitive learning. The experimental group's affective reaction or attitude toward simulation was determined. In addition, the relationships among the three dependent variables and two independent variables, sex and general learning ability, were determined for the experimental group.

The subjects were students in two schools selected from the Stark County area, Ohio that did not have ability grouping, individualized

instruction, or the BSCS Green Version for their tenth grade biology classes. The "nonequivalent control group design" was used with four intact classes at each school (N = 116), that were randomly assigned to experimental and control groups. The design for both groups involved a pretest, a four-day unit, a posttest, and a retention test three weeks later and the content of the lessons was identical. However, the experimental group played the science simulation game, "Dirty Water," and was involved in daily 15 minute debriefing sessions. The control group followed the more traditional unit instruction with films, question and answer discussions, and notetaking. The posttest and retention test were unannounced.

ANOVA was used to test for differences between the two groups and r for relationships among variables. The results revealed significantly higher scores for the experimental group on retention of cognitive learning, and significant positive correlations between general learning ability and posttest cognitive learning scores, and retention test scores. However, significant differences were not found between the two groups on immediate cognitive learning, nor were significant correlations found between students' attitudes toward simulations gaming and sex or general learning ability, or posttest scores; or between sex and posttest cognitive learning scores or retention test scores. However, a significant positive correlation was found between students' attitudes toward simulation gaming and retention test scores.

In summary, learning ability is an important factor in cognitive achievement and retention seems to be fostered by simulation gaming.

The Holliday (144) study had the purpose of examining two instructional stimulus units, (1) Verbal statements (Vs) and (2) textbook-like pictures (Pt) + Vs. In this study Pt consisted of simple block line drawings that illustrated the verbal statements on the page.

Eighty subjects were drawn randomly from 221 students enrolled in seven tenth grade biology classes, in two Calgary, Alberta high schools. The subjects were randomly assigned to one of two treatment groups, Vs and Pt+Vs. Vs treatment consisted of a 23-page "prose" description of natural and experimental effects of the plant growth hormone, auxin, on stem and root growth under various conditions. The Pt + Vs treatment consisted of the same prose plus block line drawings with verbal labels and verbal descriptions where appropriate. The verbal posttest consisted of 30 multiple-choice items dealing with 12 experimental situations similar to those in the learning materials.

A one-way ANOVA to test differences between the two treatments indicated significantly higher scores in favor of the Pt + Vs over Vs. The study demonstrates that a certain type of illustration for certain topics enhances achievement.

Coltrin (71) investigated what happened to the student participants in an introductory chemistry course in high school in which the [sic] scientific method was stressed in a democratic learning environment. The students in the democratic classroom were compared with students in a traditionally instructed classroom in which the [sic] scientific method was also stressed as a valuable tool to problem solving.

The investigator instructed both the experimental and traditional classes. He assumed a typical teacher controlling role in the traditional class by selecting the textbook, choosing the laboratory workbook, and outlining the major areas for student study. He operated from a list of behavioral objectives and lesson plans that stressed the scientific method. In the experimental class, the investigator and student planned the course together. The course materials were not determined in advance and so student input was accepted.

The investigator claimed that the results indicated that the students in the experimental group (1) had understandings of chemistry and science concepts and laboratory skills equivalent to those in the traditional group; (2) asked more questions about the world of science and became more involved in investigations than those in the traditional group; and (3) showed greater shifts in attitudes toward the values of science in their lives than those in the traditional group. However, those in the experimental group were not found to use more resources than did those in the traditional group develop warm, cooperative relationships with their peers to a greater extent than did those in the traditional group.

The studies at the high school level were too diverse in purpose to warrant synthesizing generalizations.

Junior and Community College Level. Only two studies were found at this level. In one, Micek (221) stated that the purpose was two-fold, (1) to determine if training students about the purpose and use of behavioral objectives they receive in instruction has a positive influence on their mastery of the objectives and their learning-time expenditure; and (2) to ascertain whether allowing students to participate in the selection of objectives for different units of instruction positively enhances their mastery of the objectives and learning-time expenditure.

The subjects were four groups of eight enrolled in an introductory biology course at Shoreline Community College in Seattle, Washington during the summer, 1971, and were randomly assigned to one of four treatment groups. A simple posttest—only 2 x 2 factorial design was employed since each of the variables had two levels, (1) training in the purpose and use of behavioral objectives versus no training; and (2) participation in the selection of objectives versus no participation. The two dependent variables were number of objectives successfully mastered in a unit of instruction, and amount of time spent studying toward mastery of the objectives selected for each unit of instruction.

The results indicated that training students in the purpose and use of behavioral objectives had a significant positive effect on the number of objectives mastered on the initial unit of instruction, but it was not found to have a significant influence on the amount of learning time expended toward achieving the unit objectives. The results failed to show that participation in selecting behavioral objectives for three instructional units had a positive effect on the number of

objectives mastered, but indeed showed there was a significant negative effect. Neither was participation in selection of objectives found to have a significant effect on learning time expended to achieve mastery.

It was concluded that training in the purpose and use of behavioral objectives has merit, but students may view their participation as an inappropriate and illegitimate activity. Because of the small size of the sample, the latter finding needs further study.

Garner (114) carried out a study at the El Reno Junior College to determine if the use of more than one instructor in teaching a general physical science course produces a significant change in achievement as measured by gain scores. The changes were related to the variables of sex of the student, ACT scores, high school mathematics and science backgrounds, and the amount of time that had elapsed since high school graduation.

The investigator indicated that students taught by more than one instructor scored significantly better on the chemistry unit in the physical science course than did students with one instructor; the reverse was true for the geology section of the course. Significant differences were not found between the one and more-than-one instructor treatments for achievement in the physics-astronomy units, even when related to the variables. In summary, one teacher, at least under the conditions of this study, is as good as "more than one."

Generalizations could not be made from two studies with such diverse purposes.

Wait-Time

Two studies were found that dealt with the instructional technique of "wait-time," both concerned with elementary science instruction.

Fowler (104) investigated the non-verbal teacher behavior of wait-time which is the silence in a conversation following a teacher or student utterance. Specific forms of wait-time are (1) Teacher Reaction Wait-Time - the silence between student and teacher utterances; (2) Student Reaction Wait-Time - the silence between teacher and student utterances; (3) Teacher Initiated Wait-Time - silence between student utterances; and (4) Student Initiated Wait-Time - silence between teacher utterances. The primary purpose of this investigation was to (a) document some of the behavioral and cognitive effects of wait-time, and (b) delineate the interrelationships among the various forms of wait-time. The secondary purpose was to study the expected inverse relationships between teacher scores on the Pupil Control Ideology Form (PCI) and the duration of natural Teacher Reaction Wait-Time.

The subjects were 51 preservice teachers. Thirty-one were trained to use Teacher Reaction Wait-Times of .5 and 2.0 seconds with inner city elementary school children. Twenty teachers instructing junior high school students were randomly assigned to use shorter or longer wait-times

while teaching an inquiry science lesson. Students were randomly assigned to groups of three to five, the lessons were tape recorded, the wait-times measured and the incidence of product variables noted.

An analysis of the results showed that, with increased Teacher Reaction Wait-Time, (1) the incidence of student-to-student interactions increased; (2) student inferences decreased; (3) the length of Student Reaction Wait-Times increased; (4) the length of Teacher Initiated Wait-Times increased; (5) the difference between Teacher Reaction Wait-Time and Teacher Initiated Wait-Time increased; and (6) student initiated statements increased. Unfortunately little was said about the relationships between the scores on the PCI and the various findings about wait-time or about the consequential implications of the findings.

In brief, if the teacher uses judicious silence at the appropriate times, the student may be able to think and make some sensible statements.

Anshutz (12) designed a study to compare the effectiveness of training in wait-time and questioning techniques on subsequent classroom behavior of preservice elementary school teachers. Third and fourth grade SCIS students taught by the preservice teachers were tested for the dependent variables of achievement, subject preference, and attitude toward science.

In order to make the comparisions, 180 third and fourth grade students were selected from four elementary schools and were taught by 13 experimental and 13 control preservice teachers who were randomly selected from two science methods classes. The study had two phases: (1) the on-compus phases during which the experimental group had experiences to modify their questioning and wait-time techniques using the Science Curriculum Improvement Study (SCIS); and (2) the field experience during which all the preservice teachers worked in microteaching situations with elementary students for 12 30-minute sessions over a period of three weeks. Comparisions were made for the two groups on wait-time, questioning, achievement, attitude, and subject preference in four testing situations, including two audiotapings; pre- and posttests with the Subject Preference Test; pre- and posttests with the Attitude Test; and posttest of the Evaluation Test.

The findings failed to indicate significant differences between the two groups in the initial taped classroom teaching in terms of average number of questions asked and average wait-times. After four weeks of teaching it was claimed that the experimental group asked significantly more probing types of questions and showed significantly longer wait-times than did the control group. However, significant differences were not found between the two groups on the SCIS Evaluation Test at the end of instruction or on the pre- and posttests of Subject Preference Test. It was noted, however, that the control group scored significantly higher than the experimental group on the pretest of Attitude Toward Science; significant differences were not found on the posttest. The increments experienced by the experimental group with respect to question categories asked and wait-time were not reflected in student achievement or positive change in attitude when the experimental and control classes were compared.

The two wait-time studies did not produce findings from which consequential generalizations can be made.

Kinetic Structure

According to Garrigan (115), "O. Roger Anderson has proposed that the sequencing of substantive words within a lecture imposes a recognizable and definable structure on the discourse. He calls this verbal structure 'Kinetic Structure.' Anderson defines Kinetic Structure in terms of coefficients which can be calculated after an appropriate coding of a lecture. Among the various coefficients defined by Anderson, two, Mean B_1 and Mean B_2, provide a measure of the gross Kinetic Structure of the lecture. Three others, Mean D, Mean NAC, and Mean RAC provide information on specific segments of the lecture."

In brief, "If an instructor has the common sense to explain phenomena using simple terminology in a rational sequence with linkages between ideas, the students are likely to know what he is talking about. Otherwise, they probably won't understand him." In providing further information about "Kinetic Structure," it may be appropriate to review a study by Anderson and Lee (9) that "presents a theoretical discussion of structure in communication and its relationship to student knowledge acquisition."

In developing the report, the investigators used as subjects 61 female ninth and tenth graders from an urban private school. They formed two groups of mean age 15.1 and 16.3 with above average I.Q.'s. A treatment communication of African sleeping sickness was prepared. The first was prepared with high structure compared with many classroom teachers' communications with highly discernible meanings linking ideas between statements. This was rewritten so that each space of communication involved low structure. A third treatment had alternating spans of high and low communication and a fourth, began with low alternating with high. The treatments were administered to the subjects using audiotape. After administration the subjects were asked to write as many statements as they could recall. Recall scores were then computed and two-tailed t tests were used to compare mean scores.

A second communication, "Life in the Ocean," was then prepared with spans of varying structure and presented to 41 male and female students in an urban junior high school who were of average mental ability and had a mean age of 13.3. An analysis was made similar to that for the first communication.

The results showed, not surprisingly, that high structure spans produced more recall than did low structure and that total recall scores with high spans were significantly greater than were those with low spans. It was concluded that the amount of structure is directly related to the amount of recall.

Garrigan (115) studied three lectures in general chemistry for each of six chemistry professors, that were recorded, transcribed and coded according to Anderson's coefficients. A comparison among the assigned

coefficients showed that significant differences between the 18 possible lecture pairs for each coefficient, occurred seven times for B_2, five times for NAC, four times for D, once for B_1, and never for RAC. It was concluded that individuals whose lectures are distinct in terms of dependent variables tend to produce lectures of high Kinetic Structure with Kinetograms recognizably different from those of the lectures of their peers. Also, lecture topics were not found to have effects on the Kinetic Structure of lectures within a discipline. A comparison of Kinetic Structure of lectures between disciplines indicated significant differences between chemistry and both physics and biology, but failed to show a significant difference between physics and biology. However, Kinetic Structure did not appear to be a function of any discipline.

Simmons (309) had the objective of examining the effects of verbal communications on student knowledge about, and performance of, a psychomotor skill, namely, the use of a compound microscope. The two independent variables were structure and method. The study was designed so that half the subjects received information having high structure whereas the other half received it with low structure. Also, half received a communication containing parts of the microscope and definitions integrated within the presentation, the other half received a communication containing the same definitions that were "separated and administered" before the presentation. Accordingly, the design had four treatments:

1. Low structure with integrated definitions.
2. Low structure with separated definitions.
3. High structure with integrated definitions.
4. High structure with separated definitions.

Eighty ninth grade students at a New York City high school who were used as subjects were randomly assigned to one of the four groups. The treatment and test procedures were administered to individual subjects and a two-way fixed analysis of variance was used to detect any significant differences.

The results of the analysis were claimed to indicate that high structure produced higher scores than low structure, and separate definitions produced [sic] higher scores than intergrated definitions. It was concluded that the best way to learn a performance task is by mastery of the subordinate phase which in turn facilitates positive transfer to the subsequent higher phase. In other words, one works most successfully from the bottom up.

Advance Organizers

One study dealing with advanced [sic] organizers has been dealt with earlier since the major purpose of the study was not focused directly on the advance organizer. In this section, four studies on advance organizers are dealt with that are focused mainly on that topic.

Lucas and Fowler (204) undertook an investigation to determine (1) the effects that three types of advance organizers had upon learning of a biological concept; and (2) whether student variables of I.Q., abstract

reasoning, and sex had any effect upon learning of a biological concept when utilizing three types of advance organizers. The subjects of the investigation were 120 seventh graders selected randomly from 196 enrolled in a middle school in northwest Pennsylvania. The subjects were stratified on the basis of I.Q. scores and assigned to four treatment groups: one received an audio advance organizer; the second, a video advance organizer; the third, a written advance; and the fourth was a control. All subjects were administered the Academic Promise Test for assessing abstract reasoning ability and the California Test of Mental Maturity: Short Form.

The treatment period lasted four weeks and dealt with the concept, "Interdependence of Living Things and Energy Transformation." The advance organizer was administered for one hour with the control group being given a "historical passage.".

An author constructed multiple-choice test of 30 items was administered at the end of the treatment and ANOVA was used to investigate differences. The results did not indicate significant effects between the three organizers and scores on the achievement test. Neither were interactive effects found for I.Q., abstract reasoning ability, or sex on treatments. In effect, significant differences were not found between the experimental and control groups on any of the factors studied.

Jones (160) wanted to determine if advance organizers, generally described as more abstract, general, and inclusive than the materials they precede, are also level specific; that is, selectively beneficial only to subjects at a particular level of demonstrated scholastic ability. To resolve the issue, a relatively abstract advance organizer was prepared for high school students enrolled in a college preparatory curriculum (abstract subjects) and a relatively concrete one on the same topic was prepared for high school students enrolled in a basic curriculum (concrete subjects). An advance organizer on the same topic was prepared for experimental control [sic] groups.

The abstract subjects (students) were randomly assigned to three groups: one received the abstract organizer; the second, the concrete organizer; and the third, the non-organizer. The concrete subjects were similarly divided and treated. Following the introductory experience, the subjects received four days of classroom instruction followed by a performance test. A retention test was administered three weeks later. The statistical analyses for ascertaining differences involved various types of ANOVA.

The results of the analyses indicated that abstract subjects receiving the abstract organizer performed significantly better than did their peers who received the concrete organizer or the non-organizer. Concrete subjects receiving the concrete organizer performed significantly better than did their peers who received the abstract organizer, but not significantly better than did those who received the non-organizer. Significant differences were not found between concrete subjects receiving the abstract organizer or the non-organizer. The retention tests did not indicate significant differences among treatment groups for either abstract or concrete subjects.

It was concluded that advance organizers can be prepared that are selectively beneficial for subjects at a certain level of scholastic ability, but in terms of the findings of this study, are beneficial for short-term achievement rather than long-term retention.

Slock (312) made an effort to determine if an advance organizer would cause both short-term and long-term increases in student performance on an achievement test. In order to gather data, the investigator divided freshman medical students who were taking the medical microbiology course into two groups, an experimental and a control. On two occasions prior to the instructional unit on bacteriology, students in both groups read a six-page written passage. The passage for the experimental group was an advance organizer, whereas that for the control group was a non-conceptual passage. The advance organizer discussed the basic concepts of how bacterial cause disease and procedures for solving clinical problems. The non-conceptual passage dealt with common sense use of antibiotics by medical practitioners but did not discuss bacteria as disease causing organisms.

At the conclusion of the bacteriological unit, an Achievement Test was administered to all subjects to measure short-term post-instructional achievement, and again six months later to measure long-term retention. The scores of the two groups were analyzed using a three-factor ANOVA. The results of the analyses indicated that the experimental group performed significantly better than the control on both short-term achievement and long-term retention.

The study supports little more than what sensible teachers have known for decades; namely, if students are apprised of the learning experiences ahead of them, they are likely to perform better than students who are not apprised.

Kennedy (169) undertook a study to determine the effectiveness of a comparative advance organizer in the learning and retention of metric system concepts with respect to (1) student ability - measured by the subject's grade point average; (2) cognitive structure - the number of high school and college courses in science and mathemetics completed; and (3) treatment group - comparison of advance organizer, historical introduction, and/or control group.

The subjects used in the investigation were enrolled in Physical Science for Elementary Teachers which is a required course in the elementary education program at St. Cloud State College, Minnesota and were assigned randomly to one of three groups. Group 1 received an instructor-developed comparative advance organizer prior to instruction in the metric system; group 2, an investigator-written historical account of the development of the metric system; and group 3, received no prior instruction and was used for control purposes only. All participants within each group were subdivided according to ability and cognitive structure. The McFee Metric Test was used both as a pre- and posttest to measure the effectiveness of the advance organizer. The pretest was followed by the study of the experimental introductory passages (advance organizer), participation in learning activities, and immediate and delayed posttesting. The analyses involved a 2 x 3 ANOVA and, when F ratios were significant, the Scheffé Test was used.

The results indicated that (1) the comparative advance organizer and historical introduction had significant effects on total gain scores, but such effects were not found for the subtests; (2) high ability students did better than lower ability students on the total test and on the subtests; (3) cognitive structure was not found to have a significant effect on learning metric system concepts; and (4) scores on the delayed posttests were significantly higher for the experimental groups over the control.

Together the studies that deal with advance organizers suggest that, appropriately developed and used, they are of value in enhancing achievement, particularly on a short-term basis.

Miscellany

A number of studies seemed to belong in the section, Instructional Methods, but they were almost impossible to categorize. Consequently, they are being reviewed under this "catchall" heading.

The first study is a review of research by Wilson and Koran (365) of mathemagenic behaviors, which are activities that promote learning. Learners engage in these activities as they are confronted with "instructional stimuli during instruction." A total of 57 references were reviewed and for purposes of discussion were dealt with in three groups: translation, segmentation, and processing. The implications of mathemagenic research for science teaching are mentioned, in particular, that active behavior on the part of the student in the learning process is essential.

The report, which is 21 pages in length, hardly does justice to the implications in 57 references, but it was included in this review because of the possible usefulness of the list of references.

Ciesla (67) developed and evaluated a self-instructional environmental study learning guide for use at the Ball State University Wildlife Preserve in Muncie, Indiana. The chief purposes of the guide were to assist the student in a study of the environment in a natural setting and to help familiarize future teachers with a method of outdoor education. Such aims could be implemented only by evaluating the materials before and after their use with students.

The first steps were to identify a number of appropriate environmental concepts and categorize them on their applicability to the nature area under study. Behavioral objectives were then written to match the concepts. The text of the learning guide was based on these concepts and objectives, and was constructed using the programmed learning format. Using this text, the student was guided along the trails at the Wildlife Preserve and performed appropriate activities. The subjects with whom the materials were used were four sections of students enrolled in a natural resources course and one section enrolled in an elementary education methods class who served as the experimental group. Two additional sections of the natural resources class served as the control. Also four sections from both courses participated by using the guide and filling out a questionnaire, but these students were not measured for cognitive gain.

Pre- and posttests were written, administered, and analyzed for differences using the t-test. In addition, a post field trip questionnaire was prepared and administered. The results of the analysis indicated that three of the experimental groups had significant cognitive gains from pre- to posttest, whereas two of the experimental, and all of the control groups, failed to show significant gains. Taken as an entire group, the experimental students did gain significantly. The responses to the questionnaire indicated that between 80 percent and 90 percent of the experimental students agreed that the trip was worthwhile, they learned new facts and concepts, and they would like to take elementary students on such a field trip. Apparently the goals of the study were met.

Allen (4) reported an investigation in which he attempted to improve the "economy and efficiency in this latter sphere [lecture method as a means of receiving and absorbing information] by means of a modification of the visual presentation of the lecture." He attempted to compare the relative effectiveness of lectures that made use of the blackboard, overhead projector or two channel slide presentation. In the latter method, two slide projectors are involved. After a slide is projected and discussed, it is transferred to a second projector and displayed with the next slide. When the third slide is displayed, the first is removed, and the second is displayed with the third, and so on.

The effectiveness of the two-channel projection was assessed by means of a questionnaire that was developed independently from the researcher. The students rated the use of the blackboard, overhead projector, and two-channel slide projector. The responses indicated that students rated the two-channel method as being more effective than the blackboard. The report was more oriented to a description of techniques rather than a research study designed to make a definitive comparison.

Fronk (106) sought to (1) determine the relationship between reading ability of students and their success with reading and listening modes of instruction; (2) find the relationship between the mode of instruction a student uses and his success with different types of material; and (3) determine the feasibility of using a reading test to predict the proper instructional mode for individual students studying different types of material.

The subjects were 48 freshman and sophomore college students, all members of three physical science classes for nonscience majors who were split into three groups - high, medium and low - by dividing the percentile range of the scores they received on the California Reading Test. Each group was then divided randomly into two subgroups. All students used two modes of instruction, reading and listening, involving printed material and cassettes. Two types of instructional material were used, presumably one with each subgroup of the three reading groups, (1) manipulative with material adapted from the A-T Moon, Planets and Stars designed for college physical science, and (2) nonmanipulative, consisting of an edited article entitled, "Tragedy of the Commons." Mastery level of achievement was defined as a perfect score on criterion measure, and the time for mastery was recorded.

The results indicated that significantly more time was required for mastery for reading than for listening in the manipulative unit. There were significant differences among the times for mastery for the three groups, the high group requiring the least time and the low group the most. With nonmanipulative materials, there was greater variation in times for mastery among the groups for reading than for listening although significant differences were not found for treatments. Significant effects were found among the reading groups similar to those found with manipulative materials. It was concluded that the California Reading Test can be used to predict the efficiency of different instructional modes.

Levenson and Brooks (197) attempted to make within and between comparisons of the ratings students give to their lecture and laboratory instructors in introductory college chemistry. Their report involved corollary studies at Texas A & M University and the University of Nebraska, Lincoln. In two studies at Texas A & M about 200 students in three lecture sessions received three lecture sessions per week and were subdivided into laboratory sections of about 25. A group of four to six sections had prelaboratory instruction in a lecture room under the supervision of a senior staff member who did not always lecture. Subsequently the sections moved to laboratories with a graduate student instructor who did not lecture. At the University of Nebraska, the activity was similar except the groups of 25 met with the graduate student laboratory instructor for one hour prerecitation. The evaluation instrument asked students to indicate the most and least appreciated features of the teaching techniques in lectures and laboratories. In the second study at Texas A & M, the students responded to a Focus Questionnaire on which they were expected to write detailed descriptions of all the activities of the lecturers and laboratory instructors during the period.

The results of the responses of the students did not indicate that there were significant distinctions on most liked activities of lecturers, but there were significant differences among least liked activities. On best liked features, all instructors received about the same ratings. Significant differences were not found between the best liked features of lecturers and laboratory instructors but they were found between the least liked features. The students seemed to be more critical of their lecturers than of their laboratory instructors. The report would have been more useful if more consequential implications had been made. The study seemed to have much potential for college teaching that could have been exploited.

Since the studies in this section were Miscellany, a synthesis of generalizations would be of little merit.

College Science Instruction

Four studies appeared that dealt with this topic without reference to specific approaches to teaching. They were grouped here because they were difficult to place in other categories.

Page (255) set out to develop a procedure that provided knowledge about the affect students may have for or against aspects of teaching and learning science as a basis for selecting teaching strategies directed toward the achievement of goals in the affective domain. He indicated that his specific problem was twofold: to (1) develop a procedure for identifying, describing, and reporting observations on the degree of pro-ness or con-ness of affective antecedents seemed to be important to science instruction, and (2) identify teaching strategies which take these antecedent conditions into account and which are directed toward science teaching outcomes in the affective domain.

Four steps were involved: (1) developing a theoretical construct of affect toward or against an object; (2) developing a theoretical presentation of a proposed procedure for implementing the purposes; (3) implementing the procedure in a classroom situation ; and (4) evaluation of the procedure. The subjects were students in Physics 110, the first year physics course at the University of British Columbia. The course rationale, final version of the course, and the techniques for evaluation were a joint effort of the investigator and the instructor. The ultimate outcome was to have students predisposed to physics as (1) being a powerful way to understand a wide range of natural phenomena; (2) a basis for working in science, technology, and to some extent, in medicine; and (3) a scientific enterprise with important implications for human welfare. Thirty-seven value scales were developed and applied to seven value objects including people, events, beliefs, actions and arguments and tested on a sample of 200 students from 419 in Section I and 213 from Section III.

At this point, the study becomes somewhat murky without a clear indication of what the tangible results were. The entry in Dissertation Abstracts International was insufficient to clarify the outcome and a review of the Microfiche copy failed to be of much help.

Koran (179) reviewed and summarized the nature of research in college science teaching as evidenced in abstracts of papers presented at the annual meetings of the National Association for Research in Science Teaching and listed in publications of the EFIC Informational Analysis Center, Ohio State University, for the years 1971-1975, as well as in other selected bibliographies.

His summary indicated that of 163 studies identified, and of 131 reviewed for 1968 and 1969, only 41 were published, whereas 82 were in dissertation form and 8 were in abstract. Of those he categorized as Descriptive, 34 were in the area of Curriculum; 21 in Teaching; and 24 in Learning. Of those he categorized as Experimental and Comparative, 40 were in the area of Curriculum; 7 in Teaching; and 6 in Learning. Informal examinations of bibliographies in later years indicated that the distributions were probably about the same. He indicated that completion of the dissertation was the zenith of the research effort of many investigators. He claimed that Curriculum studies dominate the field, with little descriptive or experimental research and most of the papers presented at meetings described materials development.

Grandits and Young (120) set out to ascertain if there are any particular trends among college non-science majors in the selection of general science courses based on the course titles. It was hypothesized that descriptive adjectives in the titles of courses for non-science majors may attract or deter enrollments. Fifteen adjectives were taken "at large" from the catalog of the State University of New York at Buffalo and were used as a basis for titles for hypothetical science courses, for example, "Modern Science," "Fundamentals of Science," and the like. From these, combinations were made such as "Fundamentals of Modern Science."

A pilot study followed in which 123 titles were developed and tested for their appeal. If a title did not receive at least 20 percent positive response from the pilot subjects, it was deleted. A total of 33 titles remained, 5 containing the word "evolutionary," and 25 others that included a total of 11 adjectives, and 3 miscellaneous. The final list was tested with 211 students in five sections of "Contemporary Topics in Science" and "Life in Geologic Times," from whom 160 usable responses were obtained. They were asked to rate the titles as (1) turns me on; (2) indifferent; or (3) turns me off.

Of the respondents, 46 percent were freshmen, 73 percent had taken at least three science courses in high school and 58 percent had checked the college catalogue before enrolling. The data showed a trend to pick course titles with specific adjectives, such as "Evolutionary Science" and "Modern Ideas in Science.". They seemed to choose courses that sounded relevant. Low scores were received on titles such as "Processes of Science" and "Methods of Modern Science." Also, students seemed attracted to titles that suggest "sampling of today's science." But, it was found that students generally enrolled in courses if recommended by a friend, if the courses fit into their schedules, or seemed pertinent to their general interest.

Anderson (10) and others, under the auspices of the American Educational Research Association Task Force on Training Educational Research and Research-Related Personnel, conducted an analysis of the tasks and competencies of personnel engaged in research and research-related activities in education. In order to implement the change, a review was made of educational research literature concerning the training of educational research personnel. The studies were judged for methodological adequacy and the findings judged to be adequate were synthesized. The study was comprehensive but the implications for science education were abstracted.

It was recommended that, with changes occurring in job qualifications because of changes in science education, the appropriate focuses of doctoral programs in science education need to be identified and programs built on these areas. Three areas of such emphasis were identified, (1) research and evaluation; (2) development; and (3) instructional leadership. A refinement of existing policies was recommended including a more careful selection of students and more cooperative arrangements with public schools.

It was difficult to suggest that anything new emerged from the study. Also, the reviewer wonders what happened to the growing need for science educators to understand energy and materials management.

The studies in this section were too few and too diverse to synthesize any generalizations.

Enrichment Activities

Seven studies were found that are best categorized as enrichment. In one of two studies aimed at the elememtary school level, Lucas (203) investigated the effect that participation in a single visitation program in meteorology at Fernbank Science Center had on the student's scientific attitudes. Seven other factors related to attitude were also considered: (1) scholastic aptitude; (2) science achievement; (3) attitude toward or about learning about science; (4) attitude toward or about the Fernbank Science Center; (5) attitude toward or about meteorology; (6) meteorology achievement; and (7) teacher's attitude toward or about science and science teaching.

The subjects consisted of eight teachers and 493 sixth graders selected from DeKalb County elementary schools that were departmentalized at this level. Each teacher had a randomly selected experimental class and control class. The design involved pretesting, posttesting, and post-posttesting during which three tests were administered; the Scientific Attitude Survey developed by Moore, and two tests developed specially for the purposes of this study. Meteorology achievement of the students was assessed by What Do You Know About Cyclones? and their attitudes toward or about learning about science, the Fernbank Science Center, and meteorology were assessed with the Inventory of Attitudes. The scores obtained from the tests were analyzed using the stepwise regression technique and product-moment coefficients of correlation.

The results of the analyses indicated that significant differences were found between gains from pre- to posttesting on the Scientific Attitude Inventory apparently in favor of the experimental group, but significant differences were not found between gains from pre- or posttest to post-posttest. It was found that scholastic aptitude, science achievement, attitude toward the Center and toward science were all positively and significantly related to the pre-, post, and post-posttest scores on the Scientific Attitude Inventory. With the control students the only significant relationship was between the gain from post- to post-posttest and student attitude toward the Center.

It was concluded that the single visit concept in programming at Fernbank Science Center does produce significant positive results.

Zehr (376) set out to compile a reliable and up-to-date descriptive list of quality books of non-fiction and fiction which could be used to enrich units in elementary school science. To accomplish his purpose, he classified books according to the Dewey Decimal System including those in the "pure sciences" with subcategories such as 530-Physics

although he did not consider those in 510-Mathematics. Where it seemed appropriate, those under 600-Technology were included. The subheadings basically followed the classification system used in Sear's List of Subject Headings: Tenth Edition.

Two or more favorable reviews were used for refining the original list of 1811. Reading difficulty was judged by comparing reading levels indicated by reviewers in at least two reviews. Where differences occurred in the indications of reading difficulty, the lower reading level was assigned.

The end product, entitled Descriptive List of Quality Books for Science, consisted of 531 books classified under 173 topical headings. A descriptive comment was included for each entry, an example being as follows:

> Pringle, Laurence, One Earth, Many People: The Challenge of Human Population Growth, Macmillan, 1971. Gr. 5-8. This book discusses the effects of expanding population and points out various scientists' proposals for dealing with growth problems.

The reviewer questions the rationale for this effort with the existence of the quarterly publication of AAAS entitled Science Books and Films that accomplishes the same thing and more. Also, research indicates that reviewers are notoriously unreliable in their judgments of reading difficulty of material if they make them intuitively and there is no indication of how the judgments were made. It seems particularly unwise, if judgments differ about reading level, to assign the lower value. It would seem to be safer to assign the higher.

McNamara and Fowler (219) investigated the difference in learning of eighth and ninth grade earth science students, one-half of whom experienced laboratory investigations in an indoor environment using prepackaged materials, and the other half in the outdoor environment using available natural resources. The study attempted to discover if there were significant differences in achievement, critical thinking, and preference between the groups on the basis of the different experiences.

The subjects were 13 groups of ninth graders and two groups of accelerated eighth graders, averaging 25 students, enrolled in East Ridge Junior High School, Ridgefield, Connecticut. They were assigned to five significantly different group levels based on IQ as measured by the Lorge-Thorndike Intelligence Quotient Test, with two groups at each group level. The teachers were randomly assigned to the groups. All subjects were pretested in September, 1970, with the ESCP Achievement Test - Unit One; the Cornell Critical Thinking Test; and McNamara Indoor-Outdoor Preference Appraisal. The instructional materials that followed were in the ESCP textbook, Unit One, with one group having indoor laboratory and the other outdoor. The McNamara Concepts Test 1 was used at the end of the first three chapters, and the McNamara Concepts Test 2, at the end of the sixth chapter.

The scores on Test 1 failed to indicate significant differences between the indoor and outdoor groups, but the outdoor method seemed to contribute to significantly greater achievement on the Cornell Critical Thinking Test and also to significantly greater gain scores on the McNamara Indoor-Outdoor Preference Approach. It was stated that significantly higher scores were not found for the outdoor group in terms of achievement on the concepts taken as a group, but they were found for five individual concepts.

Parish (258) investigated how a three-day resident field experience at Sandy Hook, New Jersey, as part of an introductory oceanography course at Jersey City State College, related to oceanography content knowledge achievement, attitude toward scientific research, and science process skill development of students. More than one day of the three-day experience was spent living at the site.

Ninety-one students finally participated from a group of 105 volunteers, 31 of whom had been randomly assigned to a field study group, 31 to a classroom simulation group, and 25 to a control group. The field study group was arbitrarily divided into work teams of three students that carried out a fluorescent racer experiment to study sediment movement by beach drift mechanisms along the beach foreshore. The students were asked to record basic coastal geological factors and wave conditions to improve their observation and measurement skills. "On the morning of the third day each student was required to complete a pre- and post-test of scientific attitude, content knowledge achievement, and a post-test of Science Process Skill Development."

The classroom simulation group was presented a simulated field study using audio visual materials, and the control group received no treatment. However, the subjects in these groups were required to complete the evaluative instruments, both pre- and post-test. The scores of all groups were compared using ANOVA to test for significant differences. The analyses failed to indicate significant differences among the scores for achievement or process skills for the three groups. However, significant differences were found among the attitude scores, with the field study group being superior to the control group.

Hickman (140) examined the extent to which field trips were used by science teachers in Oklahoma high schools accredited by the North Central Association. A questionnaire was constructed, tested, revised and mailed to 543 Oklahoma science teachers, with 202 usable returns.

The responses indicated that (1) most of the science teachers learned to use the field trip through experience; (2) factors such as places to go and acceptable student behavior encouraged the use of trips, whereas lack of transportation, funds and time, and student misbehavior discouraged the use; (3) about half of the schools discouraged field trips during school hours; (4) the competency of science teachers to use field trips effectively was evidenced by their maintaining files, preparing the students, having "Rules of the Road," conducting the tours, evaluating the trips and the students, and using follow-up activities; and (5) increased interest in class discussions and daily work was cited as concrete evidence that field trips were worthwhile.

Ridky (286) employed a pretest-posttest control group design to establish the existence of a mystique effect in using a planetarium in science teaching and to determine if an orientation session prior to instruction was effective in minimizing the effect. The study was motivated by claims that the use of the planetarium has been based on the achievement of content objectives with little understanding of the management of a planetarium facility, hence, a "mystique effect."

The subjects were two section (n=52) of eighth graders from Pine Grove Middle School, East Syracuse-Minoa, New York who were randomly assigned to one of two teams and them to one of two classes. The investigation involved the use of a Nova Planetarium with a 16-foot diameter dome. One group received an orientation sessions describing the purpose of the domed ceiling, function of the red lighting system, and components of the projection system. On the next day, both groups received a planetarium experience dealing with diurnal motion. Both groups were pre- and posttested with a 20-item multiple-choice test, referred to as the Daily Motion Concept Test, consisting of items taken from the Teacher's Guide for Investigating the Earth. The gain scores were analyzed using t-tests.

The results showed significantly greater gains in favor of the group receiving the orientation session. It was concluded that the claims for the "mystique effect" were supported, but that the effect could be controlled using an orientation session.

Dickerson (85) undertook a study to (1) assess the activities of the Public Affairs Office, Education Programs Branch, Marshall Space Flight Center, Huntsville, Alabama, to determine potentials for curricula enrichment; and (2) develop a method to ensure that technological information developed in the National Aeronautics and Space Administration (NASA) program was translated into forms suitable for educational use and disseminated effectively and economically through educational channels. The study was limited to the conduct of local, state, and regional aspects of NASA educational programs in all NASA elements. The data were gathered primarily by the observations of the researcher and those of participants in the educational programs.

The findings and conclusions that emerged from the data were that (1) the reorganization of the four branches of the Public Affairs Office into two would result in more effective planning and use of budget and more efficient use of personnel; (2) the combining of all educationally oriented offices at Marshall Space and Flight Center would be desirable; (3) there needed to be greater use of educational television; (4) additional spacemobile lecturers needed to be employed; and (5) more travel funds are needed for Public Affairs-Education so that the Chief and his staff can attend more relevant meetings. With changes in the Administration at the Federal level, the study may be only of historical interest.

In summary, the studies in this section generally support the use of enrichment activities for enhancing various types of science objectives.

However, it is obvious that the conditions under which they are effective differ greatly and that the use of enrichment activities must be "tailored to the situation," a statement that is not particularly helpful.

Television and Films

At one time, a survey of the science education research for a year would unearth numerous studies dealing with the use of films, radio, and television. The search for 1975 revealed four studies, two each in the areas of television and of films.

Grossman (127) reported a study, best described as developmental, that appraised the development and production of a children's television program on science, designed for viewing at home. Specifically, it dealt with the activities that led to the broadcasting in January, 1974, of Waves, the pilot for a proposed 13-program series, with a target audience of about 100,000 children, over WCVB-TV, Boston. The collaborators were professionals from the station and educators from the Harvard Graduate School of Education who wished to create an innovative alternative to the "show and tell" format of traditional television science.

The development involved (1) the need to look at science as a conceptual discipline; (2) the recognition that manipulative materials enhance children's understanding of science; (3) the use of visual power of television to enhance conceptual learning; and (4) the use of "creative interaction" to invite the viewer to participate intellectually. Using these as criteria, themes were developed, conceptual implications of the themes were identified, ideas were contributed to illustrate related phenomena, and appropriate activities were proposed using simple materials. Six workshops were then held during which the use of children on the programs was debated, and as a result, Waves was selected for the pilot. The usual procedures for developing educational television programs were then followed.

The report emphasized the need for intermediaries who see both the educators' and broadcasters' viewpoints, and indicated that the costs of a science series are high compared with those of typical locally produced programs. As one who has worked with locally produced TV science programs for many years, the reviewer can only ask, "So what is new?"

In another study concerning educational television, Kohlmeyer (177) tested two selected procedures for individualizing instructional television, and sought to ascertain the relationship between self-concept and learning as demonstrated by gains on a science test. The subjects were 203 students in grades four through six enrolled in a summer session of a Title I school and who had been identified as being below grade level achievement and able to benefit from a remedial instruction program. The intact groups were assigned to three treatment groups, all of which viewed a 20-minute television science lesson designed to teach the scientific method and its application in problem situations.

The control group (Cell A) had the open circuit television and prelesson and postlesson reinforcement activities presented by the classroom teacher; Cell B had open circuit television lesson and Individualized Learning Packets (ILPS) for the reinforcement of prelesson and postlesson activities; and Cell C viewed the lesson individually on videocassette tape and had ILPS for prelesson and postlesson activities. All subjects were administered field-tested pre- and posttests to establish gain scores, and two self concepts instruments developed by the Instructional Objectives Exchange.

An analysis of the test results did not indicate significant differences among the gain scores of subjects in the three cells although both groups that had experienced open circuit television did score higher on the posttest. Also, there appeared to be a "tenable relationship between positive self-concept and learning, particularly with respect to need to accommodate; courage to express opinions; willingness to participate; and the association between self and peer, family, scholastic, and "general aspects."

The two studies indicated, but not conclusively, that educational television has the potential for positively enhancing the objectives of science instruction.

Allen (5) attempted to determine whether or not viewing a silent, single concept supper [sic] 8mm film would affect the response of elementary science school children to a set of questions related to the film. The experimental film depicts a simplified biological food chain and includes the predatory acts involved in the chain. The food chain shown in the experimental film had four steps: (1) producer (grass); (2) primary consumer (grasshopper); (3) secondary consumer (pheasant); and (4) tertiary consumer (man, hawk). Another film showing the same organisms was produced but feeding and predatory acts were replaced with nonpredatory activities.

The subjects were 27 students at the second, fourth, sixth and eighth grade levels who were randomly assigned to groups that saw the predatory film, nonpredatory film and no film (control). They were all administered a six-part pre- and posttest that was used as a measure of understanding the concept of the food chain. The contents of the test are not clearly evident.

On the basis of pre- and posttest differences, using the F-test, the "predatory group" performed significantly better on the factual section than did the other two groups; at the fourth grade level, the "non-predatory group" performed better than the control group. Also, significant relationships were found between variables such as sex, pet experience, farm experience, and father's occupational status, and pretest and posttest scores. Specifically, males generally outperformed females, and those with pet experience generally outperformed those without. In general, however, significant relationships between independent and dependent variables were not found to exist.

Webb (355) attempted to evaluate the extent to which students can learn from film and to show some ways in which the learning process can be improved. The film used was Amphioxus with a running time of about 33 minutes covering about "two to three one-hour lectures" of information. The subjects of the study in Group I were second and third year undergraduates; those in Group II, last year undergraduates; and those in Group III, in school equivalent to high school. A test was constructed consisting of 20 groups of four statements, two of which were correct. Immediately before viewing the film, about half the students in each group were pretested. Two methods of scoring were used, (1) 40 correct minus incorrectly filled or unfilled boxes that should have been filled, and (2) number of "correct answers having true statements" expressed as "twice the number of boxes." Apparently before viewing, with method (1) of scoring, the three groups scored in a ratio of 3:2:1 with Group I scoring significantly better, but with method (2), the difference between Groups I and II was maintained, but the score of Group III was about equal to that of Group I.

The film was then shown to all subjects and they were tested immediately, one week later, and again three months later. Immediately after viewing, pretested Group IA scored significantly better, although the difference declined on later scores. The advantage of pretesting disappeared with method (2) of marking. The same was generally true for the other pretested groups.

It was concluded that with pretesting there is about 20 percent improvement when tested immediately after viewing the film. With both pretesting and self-marking, a 50 percent improvement was evident. After three months, the differences had declined consequentially.

The two studies on films failed to contribute consequential information and with the two studies on educational television, a synthesis of generalizations would be of little value.

Computer-Assisted Instruction

Despite the recent interest expressed in Computer-Assisted Instruction (CAI) only one investigation, that of Jones (161), dealt with the subject. His study described a computer-assisted testing program called LEVEL 3 and a study of its use in the School of Basic Medical Sciences at Urbana-Champaign (SBMS-US). The structure of LEVEL 3 emphasizes an interactive review of missed questions in the course of an examination. At the end of each clinical problem the student is given a comprehensive objective examination. An effort was made to reduce the number of items (the examination for some had as many as 300) and to give the student some tutoring depending on the responses made. However, the tutoring was minimal since it was oriented toward coaching the student to slicit the correct answer rather than to develop understanding. If the student gave an incorrect response, he was "recycled."

The subjects were 32 students in the 1972-73 class of SBMS-UC who were "divided into two equivalent groups," an experimental (N=21) and a control (N=11), and compared on three variables, (1) performance on the

Level III examinations administered by the LEVEL 3 program; (2) performance on two external, year-end examinations testing similar concepts and materials; and (3) mastery of items repeated in a number of Level III examinations. The experimental group received LEVEL 3, whereas the control received the traditional evaluation.

The program lasted ten months, covering ten basic science disciplines including anatomy, biochemistry, genetics, histology, immunology, microbiology, neurosciences, pathology, pharmacology, and physiology, all involving the self-study approach.

An analysis of the scores from the evaluations failed to indicate significant differences between the two groups on Level III examinations given early in the year, but the computer-assisted group performed significantly higher than the control group on examinations given late in the year. The latter included five of seven disciplines on the National Boards Part I examination, and on every discipline of the Freshman Comprehensive Examination. However, significant differences were not found between the two groups on their mastery of repeated items.

In conclusion, this study indicated that CAI can contribute to increments of achievement.

Student-Teacher Interaction

The phenomenon of student-teacher interaction has attracted the attention of many science educators in recent years. This is evidenced by the twelve studies available for review in this section. Obviously, the characteristics and purposes of the interactions differ greatly, as do the level of students involved. However, the general aims are similarly oriented so a discrete section dealing with these studies seems reasonable.

Two of the studies were reviews of research. Stewart (324) attempted to investigate the relations between specific forms of classroom verbal behavior and affective, as well as cognitive, process development. The data were those obtained from six investigations, those of Campbell, Amidon and Flanders, Rothkopf, Haindl, Citron and Norton, much of which was not used by them in their analyses. These data included proportion of class talk devoted to teacher questions, frequency of transition from lecture to teacher questions, and that between unsolicited student talk (student-initiated talk) and teacher questions and lectures. These were compared with affective and cognitive development.

A review and reanalysis of the findings of these studies showed that one study indicated that classes taught by teachers who devote a low proportion of classroom time to lecture will have low mean gains in affective process development and two studies indicated that such classes will also have low mean gains in cognitive process development. In the four studies of the latter that did not so indicate, the teachers had been instructed in the Flanders system and were reported to have made conscious efforts to alter their classroom behavior patterns. It was also observed in two studies that significant positive relationships were found between the

measures of cognitive process development and proportion of talk classified as teacher questions. However, data from two other studies failed to show such relationships. In one set of data, a significant negative correlation was found between the time devoted to lectures and that recorded as transitions from lecture to teacher questions. It was concluded that a balance between the use of lecture and that of questions would enhance affective and cognitive process development.

Greenwood and Renner (124) reviewed, synthesized and summarized the findings and conclusions of 33 research studies that dealt with the question, "What conclusions can be drawn from validity research on student ratings?" Some of the studies dealt directly with science whereas others did not, although they had implications for college science teaching.

They concluded from their synthesis that a college instructor can intentionally adapt his teaching technique and classroom interaction so as to get a good or bad student evaluation and consequently teaching for a "good student-faculty evaluation" may not be the best educational practice.

Evaluations by students relieve administrative personnel from making evaluations and so the student evaluations may be used as proof that something good is being done when it is not. The reliability of evaluations has been reported in a number of studies as being high, but agreement on appropriate validity criterion measures still needs to be accomplished. In fact, some studies report negative coefficients of validity between student ratings and student achievement.

There is no substantial evidence that students or administrators are satisfied with the results of faculty evaluation by students possibly because judgments cannot be made, as yet, on the validity or invalidity of such ratings.

Sherman (306) described a study related to on-task and off-task behavior of four students in a tenth grade science laboratory classroom, for a single period for four successive days during which there was low teacher control. Particular attention was given to their use of materials and science process skills. The four subjects were selected from a New York City High School on the basis of their regular attendance and willingness to participate.

Each subject was videotaped during the four-day sequence with a camera located at the rear of the classroom and each wore a lightweight wireless microphone for monitoring verbal behavior. The study used the theoretical construct in Barker's ecological psychology that suggests a useful way of observing an individual over time interacting with objects, with other people and with symbols in a setting. The setting variables selected for describing student behavior in a tenth grade classroom were pacing, group size, teacher location, and materials available. The behavior variables included material use, discourse, science process skills, movement and on task/off task. The videotapes were coded for each category every 30 seconds, and frequency counts and percentages were calculated for each.

The results indicated that (1) most of the time students were engaged in on-task behavior with or without the immediate presence of the teachers; (2) they often selected concrete materials; (3) they generally talked with peers rather than with the teacher; (4) most of the talk was related to science work; (5) they used descriptive and/or exploratory experimental science process skills; (6) they talked nearly 7 percent of the time; (7) they began and ended their own science work; (8) they integrated their social and science task work; and (9) equipment intervention was almost nil.

Three of the subjects in the low teacher controlled situation showed a high level of on-task behavior, whereas one "goofed off." The reviewer wonders, knowing that the students were aware of their "star role," whether their behavior might not have been influenced.

Bates (26) listed two objectives for his study, (1) an effort to predict measures of classroom climate from teachers, students, and the organization of the class, and (2) the identification of a general conceptual model for describing the sociopsychological domain of classrooms.

The study is based on the national radom sample of 52 physics teachers in 101 classes with 2,393 students used in the summative evaluation of Harvard Project Physics. Data were collected on a large number of characteristics of teachers, students and classes. One criterion instrument used was the Learning Environment Inventory that has 14 properties of the classroom that reflect interpersonal relationships among students and between students and teachers, relationships between materials and students, structural characteristics of the class, and social climate and learning. Other data were gathered with the Semantic Differential Academic Interest Measure, Pupil Activity Inventory, Student Questionnaire, Henmon-Nelson Test of Mental Abilities, and Allport-Vernon-Lindzey Study of Values. These were factor analyzed and produced four sets of orthogonal measures: (1) Teacher Personality Set; (2) Student Personality Set; (3) Classroom Characteristics Set; and (4) Learning Environment Set. The final regression analysis was not found to be as encompassing a model for understanding the relationships among the numerous variables involved as the factor analytic study of the 41 variables. From the analysis a three-dimensional Class Factor Space model was proposed (1) U-D ("upward-downward") dimension representing the speed, difficulty and pressure perceived by the students; (2) P-N ("positive-negative") dimension representing the perceived friendliness and intimacy of the class; and (3) F-B ("forward-backward") dimension representing the perceived goal direction or disorganization of the class.

Certainly the effort represents a basic step for predicting learning environments but much will need to be done to make it possible for those "on the firing line" to use the findings to enhance science teaching.

Philp (265) attempted to investigate the relationships among the kinetic structures of a number of verbal interaction sequences in the classroom and student perceptions of the teacher, discussion and learning material. The interaction sequences investigated were total continuous,

teacher-teacher selective continuous, teacher-student pair, and student-teacher pair analyses.

The study involved the investigators conducting one biology lesson in each of 15 high school classrooms and the coding of each lesson for the interaction sequences listed above. The mean B_1 coefficient in Anderson's system, which gives a gross measure of content structure "within explicit verbal communication," was determined after the codings were made. The analyses of the first two interaction sequences were determined from statements taken as a continuous sequence, whereas those for the latter two interaction sequences "were treated pair by pair in consecutive order." The kinetic structure levels of these variables were varied by the researcher and used to investigate the relationships mentioned above. Perceptions as dependent variables, as well as measures of evaluative, potency and activity factors, were assessed by a semantic differential test devised for this study.

The interpretations of the findings were that teachers contribute greatly to students' perceptions of the learning materials in terms of the kinetic structure of their verbal dialogue. The students of teachers with higher levels of teacher-teacher kinetic structure seem to believe that the learning materials are better organized interconnected and more natural. Thus, the higher level the kinetic structure of the verbal contributions from both teachers and students, the greater the satisfaction of students with the content.

In summary, the study indicates that a teacher who has knowledge of content and presents it in a rational, connected sequence, will do a better job than a teacher who has less command of content and who is not organized.

Vinelli (1978) investigated the effects of two teaching strategies, Student-Structural Learning in Science (SSLS) and a modified Teacher-Structural Learning in Science (mTSLS) on achievement-motivation, affiliation-motivation, and critical thinking ability of a group of ninth, tenth and eleventh graders enrolled in a special science course in the Developmental Research School, Florida State University during the first semester, 1974-75. He also investigated the relationships of these three variables to the Activity Ratios, a measure of the relative amount of time a student spends doing lesson-related activities.

In both treatments, students could choose science activities in biology, chemistry and/or physics, but with the mTSLS strategy he/she was given the objectives of that activity with specific instructions to follow, and his/her performance was measured with written tests. Under SSLS, a student, after selecting an activity, was neither given objectives or instructions to follow, nor was he/she tested. The students were pre- and posttested with the Motivational Needs Inventory (MNI) and the Watson-Glaser Critical Thinking Appraisal: Forms Ym and Zm. On the basis of the pretest scores the students were blocked in two different levels-above and below the median. The data were analyzed with ANOVA and Correlation with Transgeneration.

The results failed to indicate significant differences between the two treatment groups with respect to students' achievement-motivation, affiliation-motivation, or critical thinking ability. However, significant increases were found for males with initial low achievement-motivation to high level of motivation, but not for their female counterparts. Significant relationships were found for the whole sample between Activity Ratios and need-achievement posttest scores, and for students with Activity Ratios above the median, between the Activity Ratios and the critical thinking pre- and posttest scores. The latter findings seem to suggest the necessity of providing students with materials that will allow those with high achievement-motivation and critical thinking ability to work with such materials more extensively than other kinds of students less in need of working with the same materials at the same rate.

Landers (182) conducted a comprehensive evaluation of the Guided Design mode of instruction developed by Wales and Stagner. In Guided Design, students work in groups of four to seven without direct faculty supervision under a project leader selected by the group members. The student project leader "guides" the group through steps in the decision-making process using instructional information provided in a series of "instructions" and "feedbacks." The work a student performs is integrated by the nature of the open-ended problem serving as the basis of the assigned project.

In this study, the subjects were three consecutive classes of engineering technology students at Cleveland State University, all having the same course, instructional materials, facilities and instructor. The first class had conventional instructional techniques; the second used Guided Design; and the third a modified Guided Design including modifications to the instruction to determine if such modifications resulted in "selected improvements in the measured results." The usual tests were given at midquarter and end-of-quarter; five projects were assigned to measure job-performance skill achievement; and a four-concept (activity, evaluative, potency, and novelty) Semantic Differential type instrument consisting of 31 bipolar adjective factors was administered at the end to measure student attitudes toward the course.

An analysis of the results failed to show significant differences between the conventional and Guided Design classes on cognitive achievement and job performance skills. However, significant differences were found between the conventional and second Guided Design class in the evaluative and potency concepts of the Semantic Differential with the factors treated collectively and in more than two-thirds of the concept factors treated individually. Significant differences were not found between the attitudes of the conventional and Guided Design groups, although slight differences appeared in favor of the Guided Design group. However, a number of significant differences in concept factors were found between the first and second Guided Design groups, apparently in favor of the modified Guided Design group.

The author implies that Guided Design, with and without modification, has substantial merit.

Houston (148) dealt "with one aspect of the methodological contrast between open-ended discovery teaching and the direct instructional sequence used by the expository teacher; namely, the prevailing style of verbal interaction between teacher and students." Using the interaction analysis techniques of Flanders, the investigator identified teachers of three styles—openended, intermediate, and expository. Apparently, the identification was accomplished using an I/D ratio (I meaning indirect teacher influence, and D, direct). The indirect teacher asks many openended questions to stimulate students to think whereas the expository teacher is primarily a lecturer who uses closed questions. Six visits of 80 minutes each were made to six teachers, two representing each of the three styles. The most openended teacher had an I/D of .82 and the lowest, .27.

Objective tests were administered to their students with items based on the physics syllabus that leads to the Scottish Certificate of Education in Physics. The four categories of items on the test were similar to those of Bloom. Category A dealt with useful information in Physics; Categories B and C with applications of physics in familiar and unfamiliar situations; and Category D, almost identical with Bloom's Analysis, Synthesis and Evaluation.

The results indicated that "openended" students performed significantly better on Category D items than did students with teachers of the other two styles, but these differences were not evident with the other categories of items. It was found that with "openended" students there was less consistency in test performance among the categories of items than with "expository" students, but their performance was somewhat better.

It was concluded that the results could not justify unrestricted support of one style over the others, since the expository style apparently helps students grasp fundamentals and achieve compositional skills somewhat better than did the others.

Three studies were found that focused mainly on teachers. Beam and Horvat (28) assessed both teacher and student perceptions of science classroom behavior. Specifically, teachers indicated the types of behaviors they used in the classroom (teacher perceived behaviors) and those they would like to use (teacher ideal behaviors). Students assessed what types of behaviors were exhibited in their classrooms (student perceived behaviors), and what behavior types they would like to see exhibited (student ideal behaviors).

The subjects were 33 science teachers in grades 7, 8 and 9 in schools in the Buffalo, New York area who volunteered after department heads and administrators agreed to have their schools participate in "a study of science teaching as it currently exists in junior high schools." Audiotapes provided data on what was actually occurring in the classrooms (actual observed classroom behaviors) and these were analyzed using Flanders Interaction Analysis Scale. The teacher's conceptions of the "ideal" were measured with the Ideal Classroom Behavior Teacher Scale. The Teacher's Perceived Classroom Behaviors were measured with the same scale, but the teachers were expected to

state what they actually did. The Student Ideal Classroom Behaviors were indicated by responses to a questionnaire with items concerning what time should be spent ideally in each of the categories on the Flander's Scale, and Student Perceived Classroom Behaviors were assessed with the same questionnaire, but they were asked to indicate the percent of time they believed was actually spent. Differences among science teachers' ideal and perceived behaviors and the analyses made from audio-tapes (CRB) were evaluated with t-tests.

The results showed that actual CRB are often significantly different from both student and teacher perceptions. Indirect/direct teaching ratios and student/teacher talk ratios were generally overestimated. The only reasonable estimate of the teachers was the motivation/motivation and control ratio. What teachers said would be desirable was significantly higher than what actually happened. Science teachers want more inquiry, student talk, and activity than they believe is occurring. Students show nearly the same lack of perceptiveness as teachers. They want more than actually happens and claim that more happens than actually does.

Vargo and Schafer (347) examined the effects of role-specific pupil/science teacher interpersonal compatability (as opposed to general interpersonal compatability) on the development of students' attitudes toward science and their self-concept in science. The study involved six ninth-grade teachers using the discovery oriented New York State Syllabus in Earth Science and 205 students in twelve of their classrooms, all of whom were administered the Fundamental Interpersonal Relations Orientation Behavior, (FIRO-B). In addition, the FIRO-BT (Teacher) was administered to all teachers in order to index role-specific interpersonal tendencies. The students were pre- and posttested. Regression equations were used with dummy coded teacher variables, generated according to the Draper and Smith technique and also with first-order teacher times (x) compatability terms. The first order teacher terms used in the analysis did not contribute significantly to the regression model so they were removed from consideration.

It was concluded that as science teaching became more inquiry oriented, science teachers were interacting more frequently with individual students. With increased interaction, pupil-science teacher interpersonal compatability most likely contributes significantly to the development of student's science attitudes.

Smith (314) tried to determine the effects of small, intermediate, and large instructional groups have on the verbal behavior of junior high school teachers. In order to measure the effects of instructional group size on such behavior, groups of 8, 30 and 100 students were randomly selected from each of the seventh, eighth and ninth grades of the Ridley South Junior High School, Ridley Park, Pennsylvania. Nine teachers of the Science Department were the teacher population.

Without prior training or preparation each of these teachers developed three lesson plans from prepared outlines and presented them to the three different-sized instructional groups at the grade level of

his/her normal teaching assignment. The instructional sessions were audiotaped and coded for each three seconds of instructional time using the Flanders Interaction Category and the Campell-Rose Interaction Analysis Systems. The ratings were analyzed with Darwin Chi-Square.

The results indicated that (1) teachers exhibit the significantly greatest proportion of indirect to direct verbal behaviors in intermediate instructional groupings, and a greater proportion in small as compared with large groupings; (2) the percentages of teacher talk and student initiated interaction may vary significantly in instructional groups of different sizes, but statistically significant differences were not observed among the teachers in this study; and (3) in small instructional groups teachers employed a significantly greater percentage of divergent and evaluative questions, and significantly less cognitive-memory and convergent questions than in intermediate or large instructional groups.

The investigator concluded that the results support those of a number of other studies concerning the need for flexibility in sizes of instructional groupings, and that no one size is unrestrictedly supported by the findings. Extensive inservice training is needed by teachers to use different-sized groupings optimally.

One study dealing with adult education science classes belonged in this section but could not be grouped with others so it is considered alone. It was the study by Whitehead (360) in which the purpose was twofold, (1) to compare the relative effectiveness of expository and non-expository teaching methods for Adult Basic Education, Science, Level II as determined by student achievement on an immediate post-test and a post-posttest; and (2) to determine teacher and student behaviors in classes taught by expository and non-expository methods and the relationships of those behaviors to student achievement.

The subjects in the study included 34 Adult Basic Education (ABE) Level II science teachers and their 276 ABE students, of whom ultimately 34 teachers and 202 students completed the study. An ABE Level II unit in ecology was developed by the researcher with the usual supportive materials. Teacher workshops were held in four areas of the state to train teachers to use expository or non-expository methods. According to the researcher, the Classroom Interaction Analysis Index was used to determine the interaction patterns in the ABE classes studied. The researcher visited each classroom and evaluated teacher behaviors and student responses through the use of CIAI. "Data derived through these instruments were subjected to the multiple regression and analysis of variance statistic."

Based on the results of the analyses it appears that significant differences were not found in the achievement of the two groups as measured by the posttest and the post-posttest. Neither were significant differences found in achievement when the interactions of teaching method and age, or those of teaching method and race, were considered. However, significant differences in achievement were found between expository males and females on the post posttest although it is not indicated who was superior.

It was indicated that the group taught by expository methods exhibited eight types of behavior that were basically teacher oriented, the two most prevalent being, (1) subject centered behaviors, and (2) behaviors indicating student avoidance of learning. In the non-expository classes the two most prevalent types of behaviors were (1) learner oriented behaviors, and (2) behaviors indicating student approaches to learning.

The recommendations deal largely with the need for more research. Regrettably, there are few implications made from the findings for teaching adult education classes.

Although the data from these studies related to student-teacher interaction are not conclusive, there is sufficient evidence to indicate the desirability of increasing the amount and improving the quality of such interaction. But, it is not reasonable to suggest that these studies together "put a handle on the problem."

Textbooks and Reading

Five studies were found that were concerned with textbooks and reading, three at the elementary level, one bridging the elementary and junior high school levels, and one dealing with the junior high school.

Maxwell (211) attempted to determine the effect of science activities which use concrete objects to develop science concepts and process skills on the attainment of reading readiness in kindergarten children. The factors of visual perception, language facility and experience were examined to determine the effect of the science activities upon the attainment of these factors. The treatment involved the use of activities from the physical science unit "Material Objects" that is part of the Science Curriculum Improvement Study.

The subjects, 132 kindergarten children from two schools in the Waterford School District, Waterford Township, Michigan were administered the Metropolitan Readiness Test: Form A in January, 1970. Based on the scores, 120 children who fell in the C, D and E categories were randomly assigned to one of three groups. They were (1) a treatment group that received the science activities; (2) a placebo group that received fine and gross motor activities instead of science activities; and (3) a control group that received the normal kindergarten program. After eight weeks of instruction consisting of 20-25 minutes for five days each week, the groups were administered the Metropolitan Reading Test: Form B; the Marianne Frostig Developmental Test of Visual Perception; the Verbal Expression subtest of the Illinois Test of Psycholinguistic Abilities, and the Materials-Objects Test. The scores from the various measures were evaluated using multi-variate analyses of variance.

The results "indicated that science activities from the Science Curriculum Improvement Study's (SCIS) physical science unit Materials Objects did significantly effect [sic] kindergarten children's reading

readiness. . . "Specific factors effected [sic] in this study were language facility . . . and experience" but visual perception was not. It was concluded that the treatment group made greater gains in the attainment of reading readiness, development of language facility, and the experience factor than did those children in the other groups. The greater gains in the last two, however, were only over the "traditional group."

Yow (373) had the purpose of determining the effect of the systematic teaching of Science - A Process Approach on the reading comprehension of first grade students in two selected schools. The subjects were 48 first grade boys and 34 first grade girls who were divided into two experimental and two control groups, one of each group in each of the two schools. Together the experimental groups consisted of 24 boys and 17 girls, with the same numbers in the control groups. In October, 1974, the students were classified according to intelligence as measured by the SRA Primary Mental Abilities Test. On the basis of the scores the students were designated as average, above average, or superior. It was found that the distributions of the students in these classifications were about the same for both the experimental and control groups.

The treatment period began in September, 1974, and ended in February, 1975; the experimental groups reviewing Science - A Process Approach and the control groups, the "traditional" program. At the end of the treatment period all subjects were administered the reading section of the California Achievement Test: 1970 Edition, Level 4, Form A from which vocabulary achievement and comprehension achievement scores were obtained. The data were analyzed using Harvey's Least Squares Analysis of Data with Unequal Subclass Numbers.

The analysis of the data indicated that the experimental groups scored significantly higher than the control groups on reading comprehension scores, but when the data were analyzed for subgroups, only students in the experimental average subgroup showed a significant gain in reading comprehension. Significant differences were not found for the average and superior subgroups in comprehension achievement. A significant difference was found for the interaction of sex and method with experimental males showing significant gains over females.

Babikian (17) sought to answer the question, "To what extent do elementary science textbooks reflect the nature of science and the activities of scientists? Particularly, what do elementary school children think about the explorability of natural phenomena and answerability of science questions?" It was hypothesized that these textbooks do not impart a clear image of science or scientists and consequently many elementary school children believe that all natural phenomena are explorable and all questions related to science are answerable.

Two surveys were conducted. A content survey was made of 10 percent of the lessons chosen randomly from levels two, four and six of leading elementary science series. The questions and experiments were classified in terms of answers and outcomes being provided, withheld, or claimed unanswerable or unexplained. Also, an opinion survey was administered to

549 children in grades 2, 4 and 6 about the ability of students, teachers, scientists and textbook authors to answer all questions related to science.

The data that were gathered indicate that questions posed in textbooks have explicit answers, but most of them are withheld. Questions acknowledged to be unanswerable are not posed. Experiments have explicit outcomes but most of the outcomes are withheld. Experiments acknowledged to be unexplorable or not posed.

Most students think they cannot answer all questions related to science but that teachers, scientists and textbook authors can. The number of students holding this opinion decreased from second to fourth grade and constituted a minority in the sixth.

It was concluded that elementary-science textbooks give an aberrated image of science and scientists. It was recommended that such textbooks should contain more unanswerable questions and unexplorable experiments. This recommendation needs considerable thought in order to be implemented properly.

Wardle (353) attempted to use existing textbook illustrations in order to determine (a) the predicted and (b) actual contribution of science textbooks to reading comprehension of pupils varying in reading ability. Two separate studies were conducted, each using three written science texts of about 800 words dealing with the human heart, leaf structure, and the nervous system. Both studies also employed colored science illustrations that were obtained from elementary and junior high science textbooks.

Study One sought answers to two questions: (1) What is the agreement (a) within teacher and pupil groups and (b) between the two groups on the predicted learning value of illustrations?; and (2) What is the relationship between (a) the teacher and pupil predicted learning value and (b) the actual learning value of illustrations?

The subjects were 37 elementary school teachers and 144 seventh-grade pupils who read a science lesson and were then administered a 20-item multiple-choice test. They were then asked to rate 15 illustrations on a scale of 1-10 indicating how well the illustrations would help them answer the test items correctly. Pupil retest reliability was obtained about one week after the initial rating.

Analyses of the results indicated there was little agreement between teachers and pupils concerning the predicted value of the illustrations. Also, there was little test-retest reliability between the pupil ratings. Consequently, it was considered impossible to determine the relationship between predicted and actual learning value of illustrations.

Study Two sought to answer the question, "How is the number of test items answered by an illustration related to its value in aiding the reading comprehension of pupils of different ability?"

The subjects in Study Two were 191 seventh-grade pupils selected from a pool used in Study One on the basis of the number of test items they could answer. The 191 subjects were assigned randomly to one of five treatment conditions: (1) text accompanied by illustrations that answered a high number of test questions; (2) same as (1) but a medium number of test questions; (3) same as (1) but a low number of test questions; (4) an unillustrated text; and (5) control without text or illustration.

The subjects were presented one lesson a day in random order and were allowed to consult lesson materials when they were completing the tests. The analyses of the results failed to show that the total pupil group performed significantly better on reading comprehension tests with illustrated text lessons than with unillustrated. Since the illustrations were not found to have an effect, no further analysis based on pupil reading ability was conducted.

The report of the study is difficult to review since in Study Two there is no clear indication of what "one lesson a day in random order" implies or what the "total group" comparison was. In addition, the methods used to analyze the data are not indicated. In the opinion of the reviewer, the researcher had a good idea, but the design of the study is suspect because of the deficiencies in the report.

Allen (3) was concerned with the fact that the 1968-1969 Intermediate Science Curriculum Study (ISCS) test on Volume 1, Probing the Natural World was thought to be difficult for Handicapped (H) readers to comprehend within the time limit of the test. Consequently, he investigated whether the H group had a problem reading the ISCS test and presented an eclectic method for adapting the ISCS test so it might be more adaptable for handicapped readers.

The study was conducted in the Philadelphia Public Schools during the 1969-1970 school year and involved testing 35 seventh-grade ISCS classes of 13 teachers in seven schools. A pilot study was run with two groups, one with students whose mean reading levels were two years below the ISCS test and those with means above the fifth grade, fourth month on the 1970 Iowa Tests of Basic Skills, to determine if a revision of the ISCS test was needed. The findings of the study indicated that the readability was a problem and that reading the items to the H students did not improve their comprehension; hence, a Revised ISCS Test was designed. The revised test used 38 of the 44 items from the original. The items were reworded and eleven illustrations were added, plus an oral-demonstration presentation of half the items, all aimed at designing a parallel, but less reading dependent test. It was found that the pilot study pupils scored an average of one point higher on the oral subtest than the silent subtest.

During the 1969-1970 school year, the 1968-1969 ISCS Test was administered in September and March, and the Revised ISCS Test was administered in June. Since the two forms covered the same content, they were assumed to be parallel. A comparison of achievement over the year was made between H and NH classes to see if reading was an important factor.

Item analyses of the responses were made and the Hotelling t-Test was used to see if the Revised ISCS Test had a reduced correlation with reading as compared with the 1968-1969 test.

The results of the analyses indicated that (1) the H group mean was significantly above the chance range on the Revised ISCS Test; (2) the H classes made significant gains from September to June, but the gains from September to March on the original ISCS test were not significant; (3) a significant difference did exist between the science achievements of the H and NH groups; (4) the difference between the means of the oral and silent subtests was significant in favor of the oral; (5) there appeared to be a decrease in difficulty in ten of the items from March to June; and (6) surprisingly, the Revised ISCS Test was more significantly correlated with 1969 ITBS reading comprehension than was the 1968-69 ISCS test.

This latter point, according to the researcher, "resulted in part because of a nonsignificant correlation between the original ISCS test and reading comprehension." The reviewer wishes that the researcher had clarified this statement since it seems reasonable to conclude that the Revised ISCS Test is more reading dependent than the original.

The researcher concludes that his study indicates that a written science test can be revised so that lack of reading ability does not block the measure of science items on the Revised ISCS Test.

The studies in this section were so diverse in purpose that generalizations are not warranted.

Measurement of Attitudes

The concern with the affective domain is amply evident in that 28 studies were found in the area of attitudes, and to some extent, interests. The attention of research involved attitudes to science and scientists, courses and programs, teachers, teaching strategies, and students. Insofar as possible, the studies will be reviewed in these categories.

Four of the 28 studies were somewhat "mavericks" and did not fit well into any of the categories mentioned here. The first two considered are reviews of research.

Gardner (113) reviewed 205 studies on attitudes, placing them in nine sections: (1) Attitudes to Science: Meaning and Significance; (2) Survey of Types of Instruments; (3) Methodological Issues: Relationships with Other Variables; (4) Other Educational Variables; (5) Personality; (6) Sex; (7) Structural Variables; (8) School Variables; and (9) Curriculum and Instructional Variables.

His analysis, which includes extensive bibliography, indicates that "Attitudes" have two meanings, "Attitudes toward Science" and "Scientific Attitudes." He points out that the volume of research on attitudes is so great that it is no longer possible to produce a comprehensive and

detailed review of the literature within the confines of a journal article. Two conclusions he makes are that there is (1) no evidence that attitude instruments measure a common construct, and (2) no evidence of what classroom behaviors affect pupils favorably.

He does, however, raise some questions to which research on attitudes should be directed: (1) "Should scales have equal numbers of favorable and unfavorable statements?"; (2) "Averages are used in interpreting data, but how do individual teachers act on individual students?"; (3) "Do better students react more favorably to science?"; (4) "Is the claim true that courses that emphasize implications with other disciplines make science more attractive?"; (5) "Do open classrooms and individual study really make science more attractive?"; (6) "Do external examinations inhibit the enjoyment of science?" and (7) "Will changing concepts of sex roles be associated with attitudinal changes of girls toward science?" He recommends strongly the need for more sound research design.

Omerod and Duckworth (250) reviewed "about 500 significant studies" from literature published in the limited Kingdom and the United States dealing with pupil interests and attitudes. The studies were grouped under nine headings: (1) Attitude measurement in science education; (2) Differences between biology and the physical sciences; (3) The difficulty of the physical sciences and its causes; (4) The early age of the arousal of science interest; (5) The efficacy of various pupil-centered learning strategies; (6) Girls and science education and the effects of co-education and single-sex schooling on the attitudes of both sexes to science; (7) The critical role of the science teacher; (8) The feelings of pupils and students about the social implications of science and the activities of scientists; and (9) The effects of home and other environmental factors on attitudes to science.

Among the many conclusions are that (1) many differences between the biological and physical sciences are related to student attitudes; (2) difficulty, perceived or real, of the physical science is often based on comparisons with other subjects; (3) interest in science is aroused at an early age; (4) students like practical work and applications more than theoretical discourse; (5) girls dislike the physical sciences more than do boys; (6) the value of discovery learning as a way of developing pupil knowledge or interest is doubtful; and (7) pupils, teachers and effective teaching and learning are all diverse.

These two reviews are comprehensive and well done.

Billeh and Zakhariades (43) attempted to (a) construct a Thurstone-Chave scale to measure the scientific attitudes of secondary school pupils, university students and science teachers; (b) compare the scientific attitudes of these three groups; and (c) correlate the scientific attitudes of secondary school pupils with their achievement in science.

After a review of several types of attitude scales, the Thurstone-Chave form was chosen for developing the Scientific Attitude Scale (SAS) in this study. A total of 87 items were assembled and submitted to 45

scientists for examination, scaling and evaluation. The items were placed in 11 piles, Pile 11 being the most favorable "feelings" and Pile 1, the most unfavorable. The effort yielded 46 items that were piloted with 88 students who were to respond to each with "Agree" or "Disagree." As a result, ten items were eliminated and the final scale of 36 items was administered to two tenth and two twelfth grade classes in three randomly selected Greek public secondary schools of 47 in Cyprus, and to science teachers working in those, as well as in other, schools. In addition the scale was administered to sophomore university students who were chemistry and biology majors, and to seniors who were chemistry, biology, and physics majors at the American University in Beirut. In total, 321 secondary school students, 121 university students, and 31 science teachers responded to the 36-item scale.

The analyses of the results indicated that (1) all groups exhibited positive scientific attitudes; (2) the amount of exposure to science courses and amount of science knowledge positively affects scientific attitudes; (3) exposure to science course from the twelfth grade to the sophomore year does not seem to affect scientific attitudes positively although courses in the junior and senior years do; (4) significant differences were not found between the attitudes of university students and science teachers so teaching experience does not seem to affect scientific attitudes; and (5) there is a low positive relationship between scores on the Scientific Attitude Scale and the grades that secondary school students receive.

Cusimano (77) described a study that "was designed and conducted by high school students to analyze the effects of age, sex and family composition on student's preferences for the sex and birth order of their offspring." A questionnaire was designed by the students and administered over a two-day period to all classes in the high school. The questionnaire sought information from the subjects about age, sex, class and number and ages of brothers and sisters and then their choices for their first, second and third offspring. Nine hundred sixty-one usable replies were received, 396 from boys and 565 from girls; the data were punched in IBM cards and analyzed by Chi-square.

The analysis indicated a significant difference between the responses of boys and girls. The boys chose MMM, MMF and MFM more frequently than did girls, whereas girls chose FFF, MFF and FMF more frequently than did boys. Twenty-one percent of the girls, but only 8.1 percent of the boys, chose MFF. With girls there was little difference between their choices of FFM and FMM. Boys and girls without siblings chose MFM frequently which differed significantly from those with siblings. Family composition did not seem to be significantly related to choices. With only sisters in the family, both boys and girls showed increases in choices of FFF. It was noted that 86.7 percent of the boys and 69.2 percent of the girls chose a male for the first offspring.

Since two of the studies were reviews and the purposes of the other two were quite different, generalizations were not feasible.

Attitudes Toward Science and Scientists. Ayres and Price (16) set out to (1) develop an instrument to assess children's attitude toward science and to field test the instrument with a group of children in the Southern Appalachian Region; (2) determine how children's attitudes toward science varied; e.g., from grade level to grade level and among [sic] the sexes; and (3) provide information that might be of aid in the redesign of the science curriculum and in-service teacher training programs for a school system.

A science inventory was devised, based on an attitude questionnaire developed by Ayres to assess children's attitudes toward instructional television and on the works of Perrodin. The first portion consisted of twelve items concerning how the questions or statement applied to the respondent and to be rated as "never," "sometimes," "usually," or "always." The second portion was a modification of Perrodin's science attitude scale which was a projective-type instrument consisting of eight sentence fragments intended to stimulate students to express their feelings toward science. The subjects on whom the science inventory was tested were 455 fourth, fifth, sixth, seventh and eighth graders (232 males and 223 females), enrolled in elementary schools in Clay County, Tennessee during the spring, 1973. They represented about 95 percent of the students in these grades in Clay County, most of them in self contained classrooms.

The responses indicated that more fourth graders indicated that they liked science than did eighth graders. Over 66 percent of the students thought science would be valuable to them after graduation from high school but those who said "always" dropped from 56.6 percent in fourth grade to 13.50 percent in eighth. Few students said they liked to read about science at home. Forty-two percent said they "always" liked experiments. Only 1.7 percent said "never" in the fourth grade and 3 percent in the eighth. Fifty percent "always" wanted more experiments, 50 percent liked field trips but 38.1 percent had never been on one. Positive attitudes toward field trips declined from fourth to eighth grade. Few differences were found between the attitudes of boys and girls.

On the openended (second) portion, fourth and fifth graders had positive attitudes; sixth graders had many negative reactions, but 37 percent expressed a preference for science over other subjects.

The study supports the findings of other research studies and empirical observation that attitudes toward science are high in the elementary school but decline through junior high school.

Wilson, Mertens and Hendrix (366) assessed the value stances of both high school and college students relative to human genetic engineering. Some questions to which they sought answers were: (1) Under what conditions would these young people be willing to avail themselves of these advances? (2) How willing are they to see their tax dollars used in support of human genetic research? (3) Do they fear misuse of advances in genetics? and (4) How scientifically literate are they with respect to developments in human genetics?

A 43-item forced-choice survey instrument was designed and administered to 237 students, including 95 enrolled in general and advanced biology at Chrysler High School, New Castle, Indiana, and 142 students at Ball State University, 52 of whom were enrolled in genetics courses whereas 90 were a random sample of undergraduates. The cover sheet had five items seeking background information and asked the subjects to define six terms; genetics, genetic engineering, gene survery, cloning, amniocentesis, and artificial insemination. The remaining 32 items were scaled from 1 (strong agreement or support) to 7 (strong negative reaction or disagreement). The word "you" appeared in each item so as to personalize the responses. The mean responses to each item were then collected.

The responses indicated that university students were generally more capable than high school students of formulating technically accurate definitions with students in genetics classes doing better than randomly sampled undergraduates. But, even those who could not define the terms still seemed to "grab their significance." All groups of students indicated the value of genetic research to mankind with human genetics students most willing to invest tax dollars.

Students preferred peer monitoring of genetics research rather than government control although undergraduates favored more control than did high school students. There was no strong opposition to aborting a defective fetus but there was opposition to aborting a fetus because of its being an unwanted sex. Artificial insemination was generally favored if the husband's semen was used, but this was not true for the semen of another donor. Thus, there was not extensive opposition to the in vitro insemination of the human egg.

Serious misgivings were expressed about cloning (genetically identical individuals), but little concern was expressed that political considerations might pressure the creation of special groups. There was general endorsement for improving animal traits by gene surgery but there was less willingness to do so with humans.

The reaction to keeping genetically defective persons alive so they can reproduce was generally neutral; there was some concern expressed about interfering with the procreative abilities of the feebleminded.

The study was well reported and was most interesting.

Moore and Moore (227) undertook an investigation to answer two questions, (1) What variables influence high school students' stated (objectively identified) willingness to become personally involved with scientific activities? and (2) What variables influence high school students' stated (objectively identified) perception of the scientist?

An exploratory study was conducted to identify possible influences (predictions) on high school students Attitudes toward Involvement with Science (AIS), and Perception of the Scientist (PS) that can be controlled or manipulated by schools. The potential predictor variables included those related to curriculum and instruction, and to the personal characteristics of the students. More than 40 other hypothesized predictor variables were treated as covariates. The instrumentation included a machine scorable instrument of Likert scales, two dimensions of academic self-concept, and the more than 40 variables.

The subjects were students in schools selected by science educators in various parts of the country with the aim of maximizing the heterogeneity of cultural, socioeconomic and educational variables. Usable data were collected from 373 students.

The analysis indicated that the availability of the BSCS Yellow Version, CHEM Study, Harvard Project Physics and PSSC-1st edition helped explain the significant variance in AIS and PS scores but did not provide evidence that the availability produces higher scores. Students who were taking the "alphabet" courses had higher AIS and PS means than the general population. [Reviewer's note: These last two statements, taken from the report seem somewhat contradictory. They need clarification.] Harvard Project Physics (HPP) students had higher AIS and PS scores than students in schools without HPP, although their IQ's were below those of typical physics students. About 32 percent of the variance in the attitudinal scores could be predicted from the students' sex, their intentions to enroll in advanced chemistry, whether or not they liked the physics teacher, and the availability of Science Course Content Improvement curricula.

Newton (240) stated that "a direct assessment of pupils' attitudes to science goes a long way to answering these questions. How large is the attitude (toward science) difference between boys and girls? Does attitude vary with age and ability? The Nuffield alternative in science has been in use some time now; does it affect attitude?"

In order to gather data, a Thurstone-type attitude scale consisting of 40 statements about science was prepared. The scale was administered to over 1,000 pupils, age 11-16 with a wide range of ability, who were enrolled in "several schools," presumably in England. Each statement was rated on a scale from 0-10 with 0 being "most unfavourable" and 10, "most favourable." A modified scale was administered later to fourth form pupils, (number not indicated), who were enrolled in County Durham, half of whom were in conventional physics and half in the Nuffield variety.

In the part involving the more than 1,000 students, the group as a whole was very favorable toward science. The difference in favorable attitude, presumably in favor of the boys, increased with age. The more able students generally were more favorable than the less able, and taken as a group, the younger students had more favorable attitudes than did the older.

In the County Durham study, boys had slightly more favorable attitudes than girls with a slight decline with age. No real difference in attitude was noticed between those in conventional, and those in Nuffield Physics.

It was concluded that science should not be made easy in order to make it more attractive. The basis for the conclusion is somewhat obscure.

Spears and Hathaway (320) indicated that scientific literacy consists of an understanding and knowledge of (a) the content of science; (b) the processes and methods of science; (c) the ethics underlying science; and (d) the interrelationship of science and other aspects of society.

The research report here deals with the last item. "In particular, non-science students have been surveyed to determine their attitudes toward societal values considered necessary for the growth of science. By comparing these attitudes with those of academic physicists, the differences in value systems underlying the interrelationship of science and society held by non-science students and by academic physicists were determined."

The instrument used to gather data was the 60-item Schwirian Science Support Scale that is constructed around five basic cultural values identified by Barber as being those societal values most conducive to the growth and development of science within that society. The five values are rationality, utilitarianism, universalism, individualism, and progress and meliorism. The values are operationalized by series of statements that place values in conflict with some aspect of society. The respondent is asked to choose one of the five positions ranging from acceptance to rejection. The Scale was administered in 1971-72 to 701 students enrolled in an introductory physical science course, and to 50 faculty members and graduate students in the Department of Physics, presumably at Kansas State University. The last two items were not used.

The two populations were found to differ significantly in a number of ways. They differed little in support of universalism but differed more significantly in support of utilitarianism, individualism, rationality, and progress and meliorism. Student concerns were evident in the relationship between science and religion since they were nonsupportive of rationality in dealing with the scientific explanation of miracles. More students were undecided or in agreement with the statement that science has led man away from a commitment to religion, than were in disagreement. Also, students seemed likely to place value on a scientist's reputation rather than judging experimental procedures and results. Students were not sure whether science should be directed toward solving societal problems. They had concerns about man's being able to adjust to mechanized life.

Students did accept utilitarianism except when it engendered conflict between science and religion. They did accept progress and meliorism but were concerned about man's ability to adapt positively to the pace of progress. It was indicated that such attitudes are not likely to change in one semester.

A factor analysis revealed four factors that seemed operative: (1) universalism; (2) conflict between science and morality or between science and religion; (3) the relationship between science and politics; and (4) the impact between technology and that of science on man.

Randall (278) undertook a study that was threefold: "(1) the development of an instrument to assess perceptions and attitudes toward science as a school subject, science content, and science teaching; (2) to use the inventory to measure differences in perception and attitude toward science as a school subject, science content, and science teaching of eighth, tenth and twelfth grade junior high and senior high students; and (3) to use the inventory to measure differences in perception and attitude toward science as a school subject, science content and science teaching for science-oriented and nonscience-oriented seniors."

After pilot testing, a 60-item inventory was developed and administered to 972 students in grades 8, 10 and 12 in one high-, and three feeder junior high, schools in Gary, Indiana. Reliability was checked with the Kuder-Richardson and a factor analysis was made from which four actors were identified, Attitude and Perception Toward (1) Science Content and Science Methods; (2) Methods of Learning Science Content; (3) the Use of Specific Audio-Visual Aids, and Evaluation; and (4) Science as a School Subject.

Among the conclusions were that (1) attitudes toward studying environmental problems are more favorable at higher grade levels than at the lower; (2) twelfth grade students were more interested than eighth and tenth graders in studying meteorology topics such as weather, hurricanes, and tornadoes; (3) students at all grade levels like teachers to show enthusiasm and interest in their teaching; (4) favorable attitudes and perceptions toward discussions of research problems and career possibilities in medicine and engineering increase with grade level; (5) favorable attitudes and perceptions toward individual library reading assignments decline with increasing grade level; (6) attitudes and perceptions toward lectures from science teachers become more negative with increasing grade level; (7) the attitudes and perceptions of science- and nonscience-oriented students toward various aspects of science did not differ significantly; (8) attitudes and perceptions of males and females did not differ significantly; (9) attitudes and perceptions toward various aspects of science differed markedly from school to school; (10) students at all grade levels believed that science courses should be aimed mainly at developing scientists; and (11) the attitudes and perceptions of students at all grade levels toward science as a school subject were negative.

The reviewer believes that the last item is a "real cruncher" and should be listed first.

Gieger (117) investigated the scientific attitudes of junior college students in selected, accredited junior colleges in Mississippi and attempted to identify variables that might be related to scientific attitude. She also attempted to determine if a correlation existed [sic] among scientific attitude, attitude toward science as an academic subject, and attitude toward mathematics.

The study involved 150 students from randomly selected classes at three junior colleges in Mississippi who were administered the Scientific Attitude Inventory and The Purdue Master Attitude Scales, Form A of The Scale to Measure Attitude Toward Any School Subject.

An analysis of the scores indicated "that the mean scores for the sample and all groups tested were positive for the Total Scale, Positive Scale, Emotional Scale, Intellectual Scale, items of the Positive Attitude Position Statement Subscale, mathematics and science. On the Negative Scale, the mean scores were positive for the total sample and all groups tested except the Black females."

It was concluded that the items of the Negative Attitude Position Statement Subscale revealed rejection of these items except the ones concerning the understanding of the difference between science and

technology. The Black females revealed a lack of understanding of scientific explanations in the form of laws and theories. It was recommended that teachers place more emphasis on experiences that will remedy the deficiencies indicated.

Waugh (354) sought to learn how 26 third-year students studying science and mathematics under the Achievement Certificate in a Western Australian high school thought, felt and behaved toward science, mathematics, scientists and mathematicians. Three components of attitude were explored: (1) cognitive - perceptions and beliefs about the worthwhileness of science and mathematics; (2) affective - do they enjoy the subjects? and (3) behavioral - do they do their homework, spend extra time on their assignments and approach them with confidence?

To gather data, a modified Aiken and Dreger Scale (I do not like science) was used. The modification was based on a five-point scale first derived by Likert - strongly agree; agree; undecided; disagree; strongly disagree. The instrument was scored from +2 to -2 with a maximum value of +80 and a minimum of -80.

The instrument was administered to the subjects. The science and mathematics teachers rated the students on a three-point scale (Does he enjoy science?) for comparison. An analysis of the student responses using the Cronbach Alpha Coefficient indicated values of .95 for science and .93 for mathematics which were interpreted as indicating internal consistency. The values for the similar ratings made by the teachers were .93 for science and .63 for mathematics. All four instruments were readministered one week later and the rs were all above .90. When the various scores were compared by computings rs between the Likert instrument ratings and teachers' ratings, it was found that Likert mathematics vs science teacher yielded .44; between science teacher and mathematics teacher, .48; between Likert science vs science teacher, .85; and between Likert mathematics and mathematics teacher, .63.

The researcher concluded that "from these results the math and science department can have considerable faith in the reliability and validity of attitudes of students in this class." The reviewer questions the conclusion on the basis of the small sample of students and the number of teachers. Also, he is aware that the reliability and validity of measurements of attitudes can be computed, but can the attitudes themselves be reliable and valid? Further, can the Scale measure all three components of attitude?

Bohardt (46) attempted to asses's the attitudes of children toward the new process-based instructional program in science, to (1) note changes, if any, from the fourth to the eighth grade level; (2) note trends in the attitudes of children; (3) compare the attitudes of boys and girls toward process-based science. Eight basic questions were addressed for the children, and five for the teachers. They were respectively, "Do children in grades four through eight feel that process-based science is (1) dull and boring; (2) an interesting subject; (3) a subject they would take if they didn't have to; (4) the best subject in school: (5) something they sometimes just do for fun; (6) a subject they wish they

had more often; (7) a subject that is useful to them in their daily lives; and (8) a subject they really enjoy?" For the teachers they were, Do they feel that process-based science is "(1) a subject they will always try to fit into their teaching day; (2) an enjoyable subject to teach; (3) markedly changed from traditional content based science; (4) a subject which requires additional training or reading to teach successfully; and (5) a subject of great value to students?"

The subjects were all the students enrolled in grades four through eight in the Catalina Foothills School District and their teachers who began the process-based science program in 1968-69. They were of middle to high socioeconomic status. They were administered a Duttons Arithmetic Attitude Scale modified for use with science and referred to as Attitude Scale for Process-Based Science, in December, 1972. Form I was designed for the students and Form II for the teachers. Both forms had 35 items to which they were asked to "agree" or "disagree."

The analysis of the responses indicated that the attitudes of fourth and fifth graders were positive but they deteriorated markedly with grade level. Yet, there were more positive responses than negative at all grade levels. Sixty-nine percent of the total sample said they would take science even if it were not required. Half of the fourth and fifth graders said they sought science activities for fun, but this feeling systematically declined beginning with the sixth grade. With the exception of fifth grade boys, the students felt that science was not the best subject in school. Sex was not found to be a significant factor in attitude.

The teachers did not always try to fit science into the daily schedule but did indicate they enjoyed the teaching of process-based materials once they started. They thought that process-based science was a major departure from traditional programs and that they needed to stay abreast of developments to be a "good teacher," but the majority of them had not taken any training or read appropriate literature.

This study as with many others, without regard for programs being process-based or traditional, shows a deterioration of positive attitudes toward science classes beginning at the sixth grade level and extending through the junior high.

Attitudes Toward Courses. Three studies were found in this "arena" all dealing with biology. Anderson (6) set out to determine the effectiveness of a student-centered modular course of study in general college biology for improving student attitude toward biology. The chief questions to which he sought answers were (1) "Are there any significant changes in student attitudes as a result of being exposed to a modular course of study?" (2) "Can the same degree of achievement be attained by students using such a course as by students having a traditional lecture course?" and (3) "Are there any significant differences when students are grouped by sex?"

A modular course was developed and used for two academic quarters at Blue Ridge Community College, Virginia beginning in January, 1973. Experimental and control groups were established and were administered a

Semantic Differential, designed to be congruent with the modules, as a pretest of attitudes. The experimental group used the modular course and the control group had the traditional program. Both groups completed the same achievement tests and were posttested with the Semantic Differential. Eighty-one students completed the modular program. The statistical analysis involved regression analysis and the computation of Pearson r's.

The results indicated that (1) the gain scores in positive attitudes were significantly greater for the modular group than for the conventional; (2) the modular group had significantly higher achievement scores than the conventional; (3) sex was not found to be significantly related to changes in achievement; and (4) a significant interaction between student sex and method was evident in the attitudinal gain scores.

Barman (21) tested the effectiveness of value clarification techniques with respect to attitudes toward science, biology, affective behavior and achievement in BSCS Yellow version biology classes. The subjects were 155 students including sophomores, juniors and seniors who were selected from students enrolled in Biology 400, a BSCS Yellow version biology course at Nathan Hale Senior High School, West Allis, Wisconsin in 1973-74. Three instructors were involved: the investigator and two colleagues.

Experimental (N=78) and control (N=77) groups were established with each instructor working with one of each group, selected at random from the students assigned to him. The control groups participated in the regularly scheduled biology program whereas the experimental groups attended the regularly scheduled classes and were taught value clarification lessons once a week for eighteen weeks.

Data were gathered using a pre-test, post-test control design with the Schwirian Science Support Scale (Tri-S Scale); the Affective Domain Measuring Scale (ADMS); and the BSCS Yellow Version Comprehensive Final Examination. In addition, during the last week of the study, the students were administered a self-evaluation inventory (SEI). The analysis of the data involved analyses of covariance and t-tests.

The results failed to indicate significant differences for changes in attitude toward science between the experimental or control groups; nor did they indicate significant differences with respect to (1) attitude toward biology or (2) affective behavior. However, the gains in biology achievement were significantly greater for the experimental group than for the control.

Value clarification lessons did not seem to do much for improving attitudes and values but, in terms of this study, seemed to enhance cognitive achievement.

Popowicz (270) attempted to determine whether an interdisciplinary approach, involving the integration of art with high school biology would have a positive effect on student's attitudes toward science. In this study "art" referred to the "applied work of representation, to decoration on surfaces together with the techniques and crafts accociated with them."

School A was designated as the experimental school in which a treatment and control group design was used with 235 students. In School A, the study involved two teachers and eight "college-bound" tenth grade biology classes. Each teacher taught two experimental and two control classes. Each student in the experimental groups was required to complete an art activity at the end of each biology unit and was expected to devote additional time to the art activities independent from the class time. The biology teachers involved had successfully completed a number of formal art courses "designed for educators in that discipline." Modern Biology by Otto and Towle was used for the instructional materials. The control groups used the instructional materials. The control groups used the instructional materials without the art experiences.

School B with 120 students was used only as a control in order to test for a possible "spillover" effect. The 120 students were randomly selected from a total of 12 "college bound" classes using the same instructional materials.

Achievement of the students was measured with the Cooperative Science Test in Biology and attitudes with The Scientific Attitude Inventory. Three other variables were also investigated: intelligence, teacher and sex.

The analysis of the scores indicated that boys who were involved with art activities along with the biology experiences developed significantly more positive attitudes toward science than boys and girls without the integrated art experiences. This was true for all teachers and across all IQ levels. For girls, the treatment effect on attitude interacted significantly with the teacher. A more positive change in attitude was found for the girls in the treatment classes for only one teacher.

The researcher also concluded that the interdisciplinary approach to teaching "biology integrated with art" did not have a negative effect on achievement, which is a "backhand" way of saying that it didn't have a positive effect either.

Attitudes Toward Teachers. Three studies dealt specially with attitudes toward teachers: one involving elementary school children; one, high school physics students; and one, preservice elementary school teachers.

Hagerman (130) sought to determine (1) teacher attitude as influenced by participation in a Cooperative-College School Science Program (CCSSP) and by the use of SCIS materials; (2) the children's attitudes and perceptions of their science classes as influenced by teacher participation in the "workshop" and by the use of SCIS materials; and (3) the influence of teacher attitudes, regardless of special experiences, on the children's attitudes and perceptions of their science classes.

Ninety teachers in grades one through six were placed in three groups, (1) 30 who had attended a three-week summer workshop designed to acquaint them with SCIS and had SCIS materials in their classrooms; (2) 30 who participated in the three-week workshop but did not have SCIS materials in their classrooms; and (3) 30 who had not participated and didn't have

SCIS materials. All 90 were administered What is Your Attitude Toward Science and Science Teaching? that provided three attitude scores toward science, science teaching, and a composite of both. The pupils of the 90 teachers were surveyed to get measures of their (1) attitudes toward science; (2) perceptions of science classroom activity; and (3) preferences for type of science activity. The assessment of attitudes was made by their responses to diagrams of four different facial expressions.

Analyses of the scores failed to indicate that participation in the workshop had a significant effect on teachers' attitudes toward science teaching, or on their students' attitudes toward, and perceptions of, their science classes, but it did have a significant effect on the teachers' attitudes toward science teaching. Children using SCIS materials were claimed to view their science experiences as happy ones, although children taught by teachers with negative attitudes toward science held more positive attitudes toward science than children taught by teachers with positive attitudes. Also, children taught by teachers with positive attitudes toward science perceived reading as their most frequent science activity and experimenting as their least frequent science activity, with almost the opposite being true for teachers with negative attitudes. However, children taught by teachers with positive attitudes toward science teaching, exhibited more positive attitudes toward their science classes than children taught by teachers with negative attitudes toward science teaching. Regardless of the teachers attitudes and experiences, children preferred experimenting to other types of classroom activities.

Frankly, the reviewer is of the opinion that the findings are so full of anomalies, that an intensive analysis of the entire design needs to be made before any credence can be given to the results.

Odom (244) sought to determine if exposure to a Project Physics Institute, its methods and materials, would in any way alter (1) teacher attitudes about the teaching process and teaching profession and (2) teaching techniques employed by the participating teachers. In addition, the study was used to determine if there were any correlations [sic] between (1) teaching experience and changes in teaching strategies, and (2) training physics [sic] and changes in teaching strategies.

The population of the study consisted of 21 teachers of high school physics, all of whom had participated in a Project Physics Institute during the summer 1973 at the University of Northern Colorado. Measurements were made of changes in attitudes and teaching strategies with a pre- and posttest design by administering (1) the Teacher Attitude Questionnaire (TAQ) and (2) the Student Science Classroom Activity Checklist (SSCAC) in April, 1973, prior to the Institute and again in November, 1973, after completion. At each period of evaluation the participants were sent packets including the two instruments, answer sheets and instructions. Other variables considered were physics teaching experience, general teaching experience, and college credit in physics. Gain scores were analyzed using Chi-square, t-tests and r.

The analyses failed to indicate that significant changes occurred in the attitudes of the participants about the teaching process or

profession, although significant changes did take place in the classroom teaching strategies of the participants with their becoming more humanistic. A negative relationship was found between changes in teaching strategies and teaching experience, with a small positive relationship between changes in teaching strategies and previous training in physics.

It was concluded that teaching strategies, but not attitudes, changed as a result of the experience and that training in physics was apparently not a factor in changing teaching strategies.

Bogut (44) had several purposes in his study: (1) to explore the attitudinal changes of preservice elementary science teachers resulting from exposure to structured and unstructured instructional strategies and to determine whether or not (a) the sequencing of these instructional strategies or (b) the initial degree of open- or closedmindedness of the preservice teachers has any relationship to these attitudinal changes, and (2) to determine whether the degree of openmindedness existing in students can be increased through the use of either of the two instructional strategies.

The subjects were 20 preservice elementary education students, all of whom were enrolled in the Encore Program at Indiana University, and most of whom were first semester seniors. Two groups, each consisting of ten randomly selected students, were exposed to different treatments: one highly structured and the other unstructured. The Semantic Differential Attitude Inventory was used to measure attitudinal changes and the Rokeach Dogmatism Scale: Form E was used to determine the degree of open- or closedmindedness. The instruments were administered after four weeks of treatment. The treatments were then reversed, and the same instruments were administered four weeks later. The final eight weeks involved independent exploration of various science topics of interest. The data were analyzed with multi-variate analysis of covariance.

The results failed to show that sequencing of instructional strategies produced significant changes in attitude. Openminded students after exposure to unstructured strategies seemed to remain openminded and closedminded students after such exposure seemed to become more openminded. When openminded students were exposed to structured strategies they became more closedminded, whereas the opposite seemed to occur with closedminded students. It was concluded that the degree of openmindedness seemed to be the single most important factor in producing attitudinal changes.

The three studies with three different populations make generalizations irrelevant.

Attitudes Toward Teaching Strategies. Four studies were found that were associated mainly with teaching strategies. Noeske (242) compared the attitudes of fifth graders in the Milwaukee Public Schools toward the urban environment of today and of the future as a result of their involvement with real instructional experiences, simulated instructional experiences, and their geographic proximity to the urban environment. The subjects were students from 72 classes randomly selected from central city, midsection of the city and suburban settings. The classes were assigned randomly to treatments that were classified as real or simulated.

Real treatment consisted of an urban field trip experience of an Environmental Education Program designed to generate realistic and positive attitudes toward the city. Simulated treatment involved viewing a slide/tape presentation of this field trip.

Attitudes toward the city of today and of the future were measured by two parts of a semantic differential administered immediately after treatment. The instrument was one dependent variable and the other dependent variable was "future optimism," namely, the difference between the mean scores of attitudes toward the city of today and of the future. The data were analyzed using analysis of variance and t-tests.

The results of the analyses failed to indicate significant main or interaction effects of real treatment, simulated treatment or geographic area on fifth graders' attitudes toward the city of today. However, field trips had a greater positive effect on attitude scores than did other variables. Central city subjects participating on field trips had a more positive attitude toward the city of the future. Also significant differences were found to exist between the grand mean scores of attitudes of the city of today and the city of the future among participants in all schools.

Lawrenz (185) carried out an investigation of possible differences among student perceptions of their biology, chemistry and physics classes, with a view toward answering these questions: (1) Are there any overall perceptual differences among the science courses? (2) What specific components of the environment are perceived differently? (3) Do these specific components differentiate between each pair of courses? and (4) Can the specific components considered as a group be ordered on the basis of their ability to discriminate among the courses?

The population consisted of a random sample of classes on all levels of population from 12 states in the regions of Mississippi, South Dakota, and Wyoming, regions that were experimental and control for three National Science Foundation Comprehensive Projects. The students completed the Learning Environment Inventory (LEI) consisting of ten scales related to classroom social situations and the Test of Achievement in Science (TAS) that contained 45 items released for public use from the National Assessment Test for Science. The data were analyzed mainly with univariate and multivariate analyses of variance.

The results revealed that Mississippi region chemistry courses were viewed as high on the Friction, Favoritism and Cliqueness scales and that the biology courses in the region were viewed as high on the Formality scale. Biology classes generally were rated highest, followed by chemistry and physics on the Diversity, Formality, Friction, Favoritism and Cliqueness scales. The reverse order was true for the Democratic and Satisfaction scales. Chemistry classes, followed by physics and biology, were rated highest on the Difficulty scale and lowest on the Disorganization scale. Friction and Cliqueness scales discriminated significantly among all three courses. On the basis of discriminant function analysis, the scales that discriminated best among the three courses were, in order, Difficulty, Friction and Formality.

In brief, students perceive the learning environments in these courses quite differently.

Alexander, Allison, Ongiri, Smith and Starkey (2) undertook a study with implications for, but little reference to, science education that was an effort to assess the attitudes of inservice and preservice teachers toward the open classroom. Three instruments were used as pre- and posttests of participants in a one-week Open Education Workshop. They were (1) a 52-item Likert-type attitude scale dealing with formal/informal and teacher centered/child centered attitudes; (2) an adaptation of the Rokeach Value Survey on which 18 terms dealing with values are ranked; and (3) a semantic differential task that required ten responses to each of 12 items.

According to the five investigators the data clearly support the conclusion that it is possible to change attitudes in a positive direction in a one-week workshop as measured by the AOA Attitude Scale. Pre- to posttest changes seemed to be reasonably stable. However, the last instrument, presumably the AOA Attitude Scale, indicated short-term changes in the perceptions of the participants toward open education; the long-term effects were shown to be less consistent.

Smith, Allison, Ongiri, Alexander and Starkey (315) reported another study, that seems to be somewhat of a repeat performance of the theme of the one just preceding, in which they conducted a workshop to train teachers in methods of open education for future implementation in their classrooms. The format was to allow participants to experience an open classroom in action by actually "living the experience."

Prior to the one-week (48-hour) workshop, attended by 150 teachers, the participants were asked to read five books to acquire background information about open education. Four research instruments were administered as a pretest and three were readministered at the end. Six months later all participants were mailed the four instruments for completion and return; 35 percent returned the instrument. One instrument is described in the report, "Sketch Your Classroom," and the data included represent only the 46 who completed the Attitude Inventory and "Sketch Your Classroom."

The authors concluded there was some evidence of positive attitudinal change but it was indicated that a one-week workshop cannot serve to achieve significant gains. This is exactly opposite to what the same five authors concluded in the study just preceding.

Attitudes of Students. Five studies dealing directly with student attitudes appear in this section. In the first, Hason (132) examined the influence of some selected variables including instruction, family background, sex, and social factors on the development of student interest in science. The subjects were 340 eleventh graders, 166 of whom were boys and 174 of whom were girls, ranging from 16-19 years of age, randomly selected from four major secondary schools in Jordan.

The science interests of the students were measured with a scale of 40 triad statements similar to those on the Kuder Preference Record. The split-half r was claimed to be .88 and .98 for representative samples of science students. Data on other variables were collected with questionnaires, checklists and rating scales. The science interest scale and questionnaire were administered to the selected sample in two settings in 1971-72. The subjects were then divided into three groups based on their scores on the science interest scale: high, middle, and low. t-tests were used to measure differences between the highest 27 percent and lowest 27 percent of the students.

The results indicated that variables of instruction, Outer Motivation and Inner Motivation differentiated significantly between the high and low interest males, whereas Outer Motivation and Inner Motivation differentiated between high and low interest females. Motivation of science teachers and participation in extracurricular activities differentiated significantly between high and low interest students. Also, career desired by parents, career desired by students, and student ability in science differentiated between high and low interest females.

It was indicated that high interest males participated in more science activities than did low interest males, had a better image of their science capabilities, rated their science teachers as better motivators, and had a greater desire to follow science careers. The findings for high interest females over low interest females were similar.

Surprisingly, the educational level of the family did not seem to be related to science interest.

Brown, Tweeten and Pacheco (54) attempted to discover the relationship between [sic] adolescent, teacher and parent attitudes on topics of current societal interest. The study was adapted from an article in the Biological Sciences Curriculum Study Newsletter of February, 1973, and was based on the experimental activity, "What Do You Think of That?" which is part of the Human-Self Module in the Biological Science Curriculum Study's New Human Science Program.

Among those involved were 60 students in two seventh grade Life Science classes in a predominantly upper middle-class white junior high school in Albuquerque. The students in pairs were given ten picture cards depicting an item of societal importance - marijuana, police, school, baby, atom bomb, smog, whiskey, teacher, army, and cigarettes together with an instruction sheet and information form. Each pair interviewed three groups of people including three male and three female junior high school students, two teachers - a male and a female, and four parents - two mothers and two fathers. Those interviewed were shown each picture card independently and asked for a response, very good, somewhat good, so-so, somewhat bad, and very bad. A total of 125 persons were interviewed and analyses of variance were used to detect differences.

The results indicated that for marijuana and cigarettes, the students were significantly more positive than the parents; for police, school and baby, the parents and teachers were significantly more positive than the students; and for teacher, the teachers were significantly more positive than the students or the parents.

Significant differences were not found between males and females. Murray (232) assumed that the development of positive attitudes was an objective of higher priority in teaching biology than cognitive learning. In order to assess attitude development, a pre-posttest designed for measuring attitudinal change was implemented.

A teacher assessment form was administered to students during the first and last weeks of class of the 1971-72 and 1972-73 academic years. The form was adapted from one used at the University of Kansas and was called "Student Opinion of Science." It contained 21 items to be rated from 1 (poor) to 5 (outstanding). Sixteen items dealt with various teacher characteristics and five with reactions to the course and its organization. One hundred forty-five students participated.

According to the researcher, from 1971-72 to 1972-73, the mean of all items improved significantly from 3.26 to 3.74. He expressed the opinion that his teaching had improved, possibly as a result of becoming involved in the study.

The details of the effort were much too sketchy to make any judgments about the study or its findings.

Gardner (112) stated that the "PQRS (Physics Questionnaire Research Study) project set out to investigate between [sic] pupil personality, teacher behavior, and pupils attitudes to physics." The study was conducted in Victoria, Australia on Grade 11 pupils taking the first year of a two-year course based on the PSSC materials and was restricted to pupils in coeducational state high schools situated in regions of above-median socioeconomic status in the Melbourne Metropolitan area.

The subjects, (1,014 students including 798 boys and 216 girls in 58 classes in 34 schools), were administered three instruments. These were the Physics Attitude Index (PAI) that was administered pre and post eight months apart; the Personal Preference Index (PPI); and the Physics Classroom Index, the latter two being administered as midtests, the PAI is a Likert-type scale dealing with attitudes toward non-authoritarian modes of learning, toward physics as an open flexible, dynamic discipline; toward scientists; and toward personal enjoyment of physics. The PPI has eight "need" scales based on Stern's Activities Index; and the PCI has eight "press" scales corresponding to needs.

An analysis of the test results indicated that (1) teacher behavior had little effect on pupils' attitudes to non-authoritarian modes of behavior; (2) achievement motivated, serious, intellectual students displayed more favorable attitudes and were more open-viewed; (3) students who were warm and friendly, and also those who were submissive and conformist, looked at the scientist with affection and tolerance, the girls more than the boys; (4) achievers, and serious intellectual pupils who were warm and deferent tended to be more associated with enjoyment; and (5) achievement pressing teachers had opposing effects on the enjoyment of serious as well as of playful students.

It was noted that pupil enjoyment depended more on teacher education than on the development of materials.

Humphries (151) wanted to test in practice the theory that Biological Science: Patterns and Processes was more effective than traditional programs in developing a better attitude toward biology, in improving achievement, and in developing knowledge of scientific methods of inquiry in slow learner high school biology students.

Sample groups were selected from the slow learner populations of Airline and Bossier high schools in Bossier Parish, Lousiana, one sample group in each was given the experimental treatment with Biological Science: Patterns and Processes, and the other smaple group given the control treatment with the "traditional" program. The investigation was carried out in 1973-74, with all subjects being administered A Scale to Measure Attitude Toward any School Subject to measure attitude; the Nelson Biology Test to measure achievement; and the Processes of Science Test to measure knowledge of scientific methods of inquiry.

Ninety other students were selected from slow learner populations of five other high schools in Bossier Parish and compared on various characteristics with the experimental and control groups in the hopes of being able to generalize results.

The scores from the tests were analyzed with Chi-square, F and t. From the results it was concluded that Biological Science: Patterns and Processes resulted in significantly more positive attitudes in the slow learners than the traditional program, but the significant differences were not evident for achievement or for knowledge of scientific methods of inquiry.

The reviewer wonders, when he examines the obvious bias of the investigator in the statement of purpose, whether the "halo effect" is operative in the improvement of attitudes rather than Biological Science: Patterns and Processes.

A retrospective examination of the reviews of the studies on attitudes leads to frustration. Obviously, the affective domain of objectives is currently receiving considerable emphasis, whereas formerly the cognitive domain received practically all the attention. The frustration comes from the inconclusive, and in many cases contradictory, findings of the studies. It is reasonably obvious, as indicated in one of the reviews of research at the beginning of this section that no one has yet "gotten a handle" on the issue. The enhancement of positive attitudes does not seem to be a function of the material that is used, or the way it is used. It seems more likely to be a parochial function of the investigator or other person who interfaces with the subject who is the target of the effort for attitudinal change.

The studies commonly involve a treatment group on whom some attention is lavished, and a control group that participates in a traditional program, which in many cases, from the narrative in the study, is more or

less a "laissez-faire" situation. Here one can easily postulate the "Hawthorne Effect." Further, many of the attitude inventories are "home-made" with little evidence of their reliability or validity. Even the standardized tests that are used are somewhat suspect as evidenced by reviews in the Mental Measurements Yearbooks.

It may be very simply that attitudinal change is a function of the teacher, who is seldom the primary target of the investigation, and probably should be.

Mastery of Process Skills

With all the emphasis on process, it was obvious that a number of studies would be focused directly on that phenomenon. Eleven studies were believed to fit that category.

Van Bever (345) set out to answer six questions, (1) "How well have Detroit seventh graders mastered selected process skills as compared with the norm group?"; (2) "How does mastery of process skills vary with sex and age in Detroit's seventh graders?"; (3) "Is there a relationship between the mastery of process skills and the verbal and quantitative skills of Detroit's seventh grade students?"; (4) "Can analysis of the responses to test items give information useful in determining the emphasis to be given particular process skills in the elementary schools of Detroit in the future?"; (5) "What selected process skills identified as minimal science objectives for the State of Michigan are measurable by the Test of Science Processes?" and (6) "What effect, if any, does a test instrument presented both visually and orally (as opposed to having it presented only visually) have on achievement scores?"

The subjects were selected randomly from seventh grade students in the Detroit Public Schools, 427 in what was referred to as a Detroit control group and 219 in a Detroit experimental group. The Test of Science Processes was administered to the entire population in October, 1973. The entry in Dissertation Abstracts International indicated that the Detroit sample/control [sic] group read and responded to test items without assistance, whereas the control group was assisted by having the test items presented orally on a tape recording as they read them. Personal data were also obtained, apparently from school records, and were analyzed together with the scores on the Test of Science Processes using z, t, r, and F.

It was indicated that the scores for the sample/control group for the Test of Science Processes and its subtests were found to be significantly lower than those of the total norms group and its urban and suburban components. Also, scores for the sample/control group were significantly in favor of females for the total test and four subtest. Significant differences were not found on the basis of age. Also, it was stated that the Test of Science Processes was found to be inappropriate for assessing mastery of the Minimal Performance Objectives for Science Education in Michigan (Grades 1-6) since less than 50 percent of these objectives could be matched with those for the process skill test.

Bergman (35) developed, field tested and evaluated a preschool science program, dealing with the five senses and designed to promote the young child's development of such perceptual processes as observation, discrimination and classification. The program, intended for use with four and five year olds, consisted of materials and instructions for identifying and describing properties of materials, and the senses used in examining objects; distinguishing between similarities and differences in materials and between two stimuli on the extent to which they exhibit a particular property; and sorting objects according to binary criteria and qualitative distinction. Each of the above was explored with all five senses, and together constituted 30 units. Each unit was designed for three 20-minute sessions; the first, free exploration of the materials; the second involving specific instruction; and the third, again free exploration. The units were developed using literature search, pre-planning, small-scale try-out, field testing and analysis. The field testing was implemented with 24 prekindergarten and 22 kindergarten children; predominantly from middle-class females.

The investigator concluded, without much objective documentation, that the program was successful in terms of the criteria for pupil achievement determined at the outset of the study. The children were described as interested and enthusiastic, and innovative with the use of the materials. It was also indicated that "successful strategies for pupil language development were uncovered as well as specific patterns of how pupils incorporated demonstrated operations into their own spontaneous activities." This latter point needs considerable rereading.

Gabally (109) attempted to determine the effectiveness of science inquiry lessons on the development of the skill of classification in inner city kindergarten children. Answers were sought to two major questions: (1) "Do the science inquiry lessons affect the classification behavior of the children?" and (2) "Will the children involved in the science inquiry lessons retain any increased ability to classify three months after the termination of the lessons?"

The subjects of the study consisted of 82 kindergarten children from an inner city school who were randomly assigned to an experimental or a control group. The experimental group participated in 20 lessons emphasizing science inquiry. Each lesson was 20 minutes long, and the treatment covered 6 weeks.

The Sigel Object Categorization Test was used to measure the classification development of the children. The test, administered individually and consisting of 12 items, assesses three modes of classification, (1) descriptive; (2) relational-contextual; and (3) categorical. The homogeneity of the population, presumably both experimental and control, was tested with the George-Dietz Test of Eight Basic Skills. The test for retention was administered only to those children who entered first grade. The post- and post-posttest results were analyzed with multivariate analysis of variance.

It was indicated that the analysis showed that classification development of inner city kindergarten children can be altered by lessons that emphasize concrete experiences with objects. However, that increased ability to classify was not found to be retained three months after the study terminated.

Bethel (40) undertook a study whose purpose was similar to that of Gabally's study, namely, to determine the effectiveness of science inquiry lessons on the development of two basic skills in inner city elementary pupils: abstract categorization and oral communication skills. The subjects consisted of 56 randomly selected third graders, 30 of whom were assigned to an experimental group and 26 to a control. The experimental group received 30 sequential inquiry lessons, 45 minutes in length, in which they used their senses making observations and comparisons of items such as rocks, shells and pieces of metal, and were then expected to group them. The subjects worked individually and also in small groups. The control group was treated with a "read and look" textbook oriented program. One-half of each group was individually pretested and all were posttested individually using the Goldstein-Sheerer Object Sorting Test (GSOST) and the Test of Oral Communication Skills. The data were analyzed with multivariate analysis of variance in which the factors of test sequence, treatment and sex were considered.

The analyses indicated that there were significant improvements in the abstract categorization and oral communication skills of the experimental group. Significant improvements in the two skills were not found for the control group nor were differences found on the basis of sex.

Jacknicke (155) compared student outcomes on science content, process skills, attitude towards science, and anxiety about science class, and teacher outcomes of process skill utilization, attitude towards science, and attitude toward the teaching of science, after having used Science - A Process Approach (SAPA) or an alternative program at the grade two level. The subjects were 42 teachers (21 SAPA and 21 non-SAPA) and 240 students (120 SAPA and 120 non SAPA) selected from grade two classrooms in the Edmonton Public Schools, Alberta, Canada.

The teachers were pretested and, after teaching one of the two programs for six months, were posttested on the same measures. The two groups of students were tested on the criterion measures after eight months of treatment. The scores were analyzed with analysis of covariance with the pretest score as the covariate for the teachers, and a subscore on the Stanford Early School Achievement test as the covariate for the students. Other analyses were made including sex-treatment interaction.

The results failed to indicate significant differences between the two groups of teachers on any of the criterion measures. The SAPA students were found to be significantly better than the non-SAPA on process skills, but inferior in knowledge of science content. Other significant interactions were not found.

Chiappetta and Collette (65) sought to determine (1) which of two types of verbal label training - attribute or value - would better aid second graders to transfer their classification skill, and (2) what type

of verbal labels the pupils in the attribute and verbal training groups would use when classifying on the transfer tests. Verbal labels were considered to be more specific and concrete than attribute, for example, color is an attribute, whereas red, green, and blue are values.

The subjects of the study, 43 white second graders in Nichols Elementary School, Syracuse, New York in May 1971, were assigned to one of four treatment groups, each with an equal number of boys and girls. The treatment groups were as follows: (1) Identifying - pointed to object when value or attribute label given; (2) Practice - came as group one, but named figures and described either attribute or value labels when pointed to by experimenter; (3) Value - taught to use the word value with value labels to describe; and (4) Attribute - when looking at dots would say all are colored.

The training materials were three dimensional objects, several of which were put in 13 training boxes. With boxes 1-6, pupils in Practice, Value and Attribute groups classified objects in as many ways as possible. Using training boxes 7-13, the experimenter grouped the objects and the pupils explained the groupings. Near and transfer tasks were used as dependent measures to assess effects of verbal and label training. These tests included People, Pieces and Creature cards from ESS and Raven Colored Progressive Matrices (Raven CPM). A standardized test was used to measure the IQs of the subjects.

The analysis indicated that the groups were not equal in academic achievement so mathematics achievement was used as the covariate. It was found that second graders automatically used value labels to classify, but not attribute labels. They had to be prompted to use attribute labels. Added practice enhanced the use of attribute labels. If they were trained in the value labelling system, their classificatory skills improved, but they used value labelling without regard for type of verbal label training. The investigators did not find that attribute label training improved classifactory skills.

It doesn't surprise the reviewer that a second grader would call a red object "red" rather than saying "it's colored."

Dietz and Barufaldi (89) sought answers to the question, "Does the familiarity of the object observed by the individual influence his responses on observation and comparison tasks?" The subquestions dealt specifically with ordinary and unfamiliar objects; observing two objects simultaneously or in sequence; and relative skill in recognizing differences and similarities.

The subjects were 66 randomly selected students in grades 1-6 from randomly selected classes in one elementary school in a large eastern city. The average income of 56 percent of their families, based on responses to a questionnaire, was less than $5,000 per year. Each child was interviewed individually and shown four objects: a ball, a cube, a kaleidoscope and a gyroscope, the first two objects were considered ordinary and the second two, novel. The objects were shown in pairs, one

ordinary and one novel. The subject was asked to name the object, describe it, indicate its sound, and smell, and how it felt. After examining the four objects, the subject was allowed to manipulate them and indicate how they were alike and different. The responses of the subjects were tape recorded, scored using a modified procedure of the Inquiry Skills Measures, and analyzed with ANOVA.

The findings indicated that children in upper grades make more observations of ordinary and novel objects than those in lower grades but the difference was not found to be significant. However, first graders were found to be more skillful in observing ordinary objects than were second graders, and made more observations of novel objects than did second, third, and fourth graders. Significant differences were not found generally between the numbers of observations of ordinary and novel objects, but there was greater skill in recognizing differences than similarities.

In general, in that school, the general trend in observation skills seems downhill.

Stevens (323) had the purpose of determining the effects of the Introductory Physical Science (IPS) program on eight selected process skills. Three ability groups were chosen from 1974-75 IPS classes at Coronado High School, Scottsdale, Arizona. The groupings were made on the scores the subjects obtained on the Primary Mental Abilities (PMA) test, with those in the lowest ability group falling in stanines 1-3; the middle in 4-6; and the highest in 7-9. The sampling was, in effect, on a stratified random basis.

All students received the Test of Science Processes (TSP) as a pre- and posttest with the treatment being the completion of experiments 1-1 through 5-10 of IPS. These experimental groups were compared with similar non-IPS groups. The process skills measured were observing, comparing, classifying, quantifying, measuring, experimenting, inferring, and predicting. The statistical procedures involved multivariate analysis of variance, univariate analysis of variance, the univariate F test, and Chi-square.

The analyses indicated that those in IPS did not make general gains in process over non-IPS, but did make gains in inferring, measuring and experimenting. Significant differences were not found between the low and middle groups or the middle and low groups, although significant differences were found between the high and low groups in observing, comparing, inferring, measuring, quantifying and experimenting. Further, significant improvements were not found for IPS over non-IPS or vice versa in subsequent courses.

Any differences found seem generally to be a function of "intelligence" as measured by PMA rather than of the program.

Walding (352) investigated the acquisition and transfer abilities of junior high school students in performing the scientific process of classification and certain variables that impinge upon that cognitive process. The hypotheses indicate generally that training in the process will enhance the ability of the trainees in that process and that ability will transfer itself to related classificatory tasks. Subjects for the investigation were 170 junior high school students in five seventh grade classes at Lincoln Junior High School, Carbondale, Illinois, during May, 1973. Two experimental groups of 65 each and one control group of 40 were formed.

All students were administered the Twig Classification Test ("twig" as in "plant") as a pretest. The following day the subjects in the control group took the Algae Classification Test. Apparently these were "homemade" tests. The experimental groups received training on a set of three-dimensional botanical models and then were administered the Algae Classification Test without having been trained in Algae classification. Another variable was that a number of the experimental subjects were informed that they would be graded on their performance on classification, whereas the remainder were not. An analysis of the results indicated that the experimental groups did better on twig classification and on algae classification despite no training in the latter than did the control groups. Also, those that were aware that they were being graded performed significantly better than those that were not. Again, this study shows that students who receive training will probably do better than those that do not.

Hillis (142) investigated the relationship between teacher attitudes toward inquiry teaching strategies, the degree to which the science classroom activities are inquiry oriented, student's critical thinking skills, attitudes [sic] toward the science curriculum, and views [sic] of the tentativeness of science. School districts were apparently polled about their interest to participate in the study. Each physical science teacher who was allowed to participate selected one class considered to be representative of his/her students. Thirty teachers in 16 secondary schools in 10 school districts in Texas and 671 of their students were the subjects.

The participating teachers were sent the Inquiry Science Teaching Strategy (ISTS) instrument and information concerning the testing of their students. The students were administered the Watson-Glaser Critical Thinking Appraisal, Osgood's Semantic Differential, the Science Classroom Activity Checklist (SCAC) and the Views of Science (VS). The latter instrument was developed for this study to serve as an indicator of a subject's view of the tentativeness of science and is a Likert-type summated rating scale consisting of 40 statements.

An analysis of the scores indicated that a teacher's attitude toward inquiry teaching strategies is a poor predictor of students' critical thinking skills, attitudes toward the science curriculum, and views of the tentativeness of science. However, the Science Classroom Activity Checklist appeared to be a good predictor of these student variables. Students in the more inquiry oriented science classrooms showed higher

critical thinking skills, viewed science as being more tentative and held more favorable views toward science teachers and science classrooms than did students in the less inquiry oriented physical science classes.

Dawson (80) tested the hypothesis that college students who participate in a one-quarter biology laboratory course with a guided decision-making approach will have greater critical thinking ability and knowledge of the processes of science than students in the same biology laboratory course with a conventional direction-following approach. In the former, students were taught how to solve problems and then were given help in designing experiments to answer general problems. In the latter, the students were given detailed instructions for all the exercises they did.

Data were gathered from 329 of 372 students in 16 different laboratory sections in a college biology course. Prior to instruction by 14 graduates and two upperclassmen, the instructors were divided into two nearly equivalent groups. During the study the instructor's behavior was coded using the Science Classroom Assessment System and the questions they asked were classified to test whether the instructors in the two approaches acted the same. Their students were administered the Watson-Glaser Critical Thinking Appraisal and the Science Process Inventory at the beginning and end of the quarter.

An analysis of the results did not indicate significant differences between the two groups of students in critical thinking, knowledge of science processes, or final grades in the lecture portion of the course; or classroom behavior and the number of kinds of questions the instructors asked. In brief, the study did not indicate that one approach was better than the other.

As with the studies on attitudes, these dealing with mastery of science processes yielded inconclusive results. Parenthetically, use of science processes, critical thinking and inquiry strategies as well as other terms are used interchangebly. A few studies indicate that when direct efforts are made to teach process skills, increments are found in the ability to use them but there is a corollary loss in content knowledge. In other cases, significant differences were not found between the experimental (process) and the control (non-process) groups. The reviewer is also concerned, as with studies in other sections, about the "stacked deck" against the control subjects with whom little, in many studies, seems to be one. Also, "process groups" are compared glibly with "traditional textbook approaches" on the assumption that being a member of a process group ensures the epitome of learning experiences whereas "traditional textbook" implies the very worst in learning experiences because in a classroom in which a textbook is used, inquiry activities are automatically stifled Empirical observations do not support such assumptions.

Again, the key factor lurking in the background seems to be the teacher, not the material or the system.

Prediction of Success

Only one study was found in this important area, namely, that of Chesson (63) who attempted to develop a procedure for predicting success

in freshman-level general biology based on a combination of prediction variables including the test grade on a micro-learning unit (MLU), dealing with osmosis and diffusion, six Comparative Guidance and Placement (CGP) measures of reading, mathematics, biology interest, year 2000 (sic), mosaic comparison, and academic motivation; high school biology grade; numbers of semesters of high school biology and of chemistry; rank in high school class; and high school size. The criterion variable was the final grade in college biology.

The subjects were general biology students at College of The Albemarle (N=63); Sandhills Community College (N=67); and Southeastern Community College (N-87) during the fall quarter 1973. Simple r's were computed between the prediction variables and criterion variable for each participating college and for all students referred to as the Composite group (CGP). The prediction variables that bore the highest relationship were MLU test grade, CGP mathematics score, CGP reading score, CGP YEAR 2000 score, and semesters of high school chemistry.

The development of multiple regression equations indicated that the combinations of prediction variables that were significant were for College of The Albemarle - none; Sandhills Community College - MLU test grade, CGP - Reading Score, CGP mathematics score and high school rank; and for Southeastern Community College - MLU test grade, CGP mathematics score and high school rank.

It was concluded under the conditions of this study, the grade on a micro-learning unit can serve as a significant predictor of academic performance in the total course.

Testing and Evaluation

Fifteen studies were found in this category, five dealing mainly with the tests themselves; three oriented toward their use with junior high school students; three focused on high school science; two related to college science courses; and two with implications for elementary science teachers.

In the first group Goodyear and Renner (119) undertook a preliminary study to answer the question, "What degree exists that he (the student) is basing that choice (on a multiple-choice test item) upon an understanding of the concept." They hypothesized that choice is often based on the degree to which a concept is misunderstood. Four tests, two each in chemistry and physics, each with 15 items based on typical concepts in the two courses were constructed. The concepts included Newton's laws, velocity and acceleration, and the mole. An item might stress general knowledge about a specific relationship such as that between momentum and gravitation with an orbiting satellite. However, teachers were to omit items in which the content had not been studied. The subjects were 68 students enrolled in physics and 111 enrolled in chemistry in four high schools. Each subject was expected to make a response and then justify why he selected that response. The justifications were put in five categories: (1) could justify response even if incorrect; (2) reasons for eliminating choices; (3) guessing; (4) cheating or copying; and (5) responses with no justification.

An analysis of the results indicated that there was great variation among schools with respect to responses because in some, students had studied materials more thoroughly than in others; reasons for responses did not differ greatly between students in physics and chemistry. On justification in category one, 37.5 percent had correct answers and 21 percent had wrong answers. From this it was concluded that many students leave classrooms with erroneous information. Also, the technique of elimination of incorrect responses was used less than expected. It was also found that 12 percent of the responses were correct but the justifications fell into the categories three, four, or five.

It was concluded from the results that the examinations needed improvement and that 15 items were probably too many for the time allotted.

Swigart (331) undertook a pilot study to formulate a classroom observation instrument for the assessment of the inquiry mode of instruction for elementary science education. A literature search was made to identify the "commonly specified attributes of the inquiry mode" and these catalogued into three major Critical Elements of Inquiry. Classroom behaviors that were illustrative of each of these three Elements were prepared. These behaviors were written in pairs, one illustrative, and one non-illustrative of inquiry behavior.

The instrument was used in a pilot study in a live classroom or in the viewing of a videotape of a live classroom in the Summer, 1973, with trained graduate students serving as coders. The live, or videotaped lessons, were in elementary science. An analysis of the ratings indicated a rater reliability of about .63 which was deemed insufficient to warrant using the instrument without further refinement.

The entry in Dissertation Abstracts International was clearly, if not definitively, written. The investigator deserves commendation for not apologizing for, or camouflaging, the results.

McLeod, Berkheimer, Fyffe and Robison (217) focused their research on four of the integrated processes as defined by the Commission on Science Education of the AAAS: controlling variables; interpreting data; defining operationally; and formulating hypotheses. The external criterion was "the child's ability to perform selected appropriate competency measure tasks in an experimental setting."

The setting was undertaken with a sample of seventh graders who had studied Science - A Process Approach in sixth grade, each of whom was given individually some competency measures for the four processes and scored on his responses. Meanwhile, the investigators collected objective test items that had face validity and administered them to the same children. The child's ability to perform the process was the criterion of accepting or rejecting an item. The effort resulted in the acceptance of 79 items, 42 of which were sufficiently complex to modify and augment with slides and oral script to produce A Group Test of Four Processes. The final test of 79 items, multiple choice or numerical fill-in, had 18 on formulating hypotheses and 18 on defining operationally. The test was administered to the same subjects who had been tested individually earlier and who agreed to participate (N-59).

The results showed that the r's between the individual competency measures and the group test that was developed ranged from .561 to .786, all of them significant but two. However, if integrated processes are based on the basic processes the r's should be higher since they are exceeded by the coefficients of alienation. The test probably measures factors other than integrated processes.

Ludeman (205) was involved in developing "a test of science processes using a method of item selection which replaced the customary panel of judges who pass on the items' validity with an objective method of item selection based on an external criterion." The item improvement involved addition to, and revision of, the items developed by Fyffe and Robison using the item analysis data from their study. The items had to be tested and revised twice before 61 were judged to be of "adequate quality." The product was referred to as The Science Processes Test (TSPT) form C.

The procedure for validation consisted of the administration of three tests (1) four subtests of the Individual Competency Measures from Science - A Process Approach; (2) TSPT form C; and (3) the Science Research Associates (SRA) test, to 52 sixth graders. The relationships between the scores on each item on form C and those on the four subtests of the Individual Competency Measures were determined by computing r's between the respective scores. The latter served as the external criterion measure for the upper and lower 27 percent groups used to calculate item discrimination indices. Thirty-six items from form C met the external criterion references discrimination value of at least 20 and so were included in TSPT from D.

It was concluded from the effort that external criterion referenced method of test development is an appropriate approach to test construction. However, it was pointed out that the high correlation between the Individual Competency Measures of SAPA, allegedly process based, and the SRA Science Test which is factual-knowledge based indicates that the two may measure the same thing. If so, TSPT form D would become a third partner.

Mitias (225) evaluated four standardized tests in high school physics to answer three questions, (1) "What behavioral/specific objectives does a sample of current standardized physics achievement tests measure?"; (2) "How do these tests compare with one another with regard to the emphasis they give to an identified list of science teaching objectives?"; and (3) "How does this sample of current standardized physics achievement tests compare, generally, with the findings of an earlier study reported by the author, regarding measurement of various objectives of science teaching?" The four tests examined were the Dunning-Abeles Physics Test; Form E; Tests of the Physical Science Study Committee (PSSC); Every Pupil Scholarship Test; and the Minnesota High School Achievement Examination: Form EH (revised).

A search of the literature produced a list of 11 general objectives of science teaching that were stated in "behavioral terms." These were: (1) knowledge of factual information; (2) application of physics principles; (3) ability to identify problems; (4) ability to analyze problems; (5)

ability to collect information; (6) ability to test hypotheses; (7) ability to interpret graphs and data; (8) attitude toward superstitions; (9) attitude to suspend judgment; (10) ability to draw conclusions; and (11) ability to differentiate between various components in thought processes.

Comparisons of the tests with the objectives indicate that knowledge of factual information is emphasized heavily followed by application of physics principles. The ability to identify problems seemed to be emphasized only by the Physical Science Study Committee (PSSC) and to a much lesser extent by the Minnesota test. The ability to analyze problems received little attention except by PSSC and the ability to collect information did not seem to be dealt with by any test. The ability to test hypotheses was dealt with by PSSC to a small degree, and the ability to interpret graphs and data were fairly well measured except by the Minnesota test. Objectives 8-11 were apparently not measured by any of the tests.

One may suggest that generally, evaluation instruments are behind, what is professed to be, "the times."

Palmer and Pella (256) investigated the relative consistency and concordance of inventory responses as indicated by the rank order given to science categories on the basis of the attribute "interest" by eighth graders in Wisconsin middle and junior high schools. The subjects consisted of nine classes selected randomly from an approximate population of 1,819 eighth grade classes in Wisconsin middle and junior high schools. The classes selected ranged in size from 18-35, in five of which there was homogeneous grouping, but none were reported to be slow or accelerated.

The stimulus comparison categories used in the investigation covered 15 areas of science with about equal emphasis for the biological, earth and physical sciences. Two triad inventories, similar to the Kuder style, were developed, Form I involving manipulation and From II, non-manipulation. A paired comparison inventory was developed by using two statements taken verbatim from the triads and administered to students for a check on interval consistency. The consistency between the pairs and triads was not found to be great with 67.8 to 88.3 inconsistencies out of a possible 126. The final instrument had 35 triad items. Each paired comparison contained 3 x 35 or 105 items.

Three measures were used, consistency of responses; concordance 1, concordance between triad comparisons and derived pairs; and concordance 2, basically an indication of reliability between triad comparisons. The findings indicated that class levels of consistency within response sets did not come from random assignment; there was positive concordance of .422 between rankings from the same form of triad and paired comparison inventory, there was positive concordance of .287 between rankings from triad inventories dealing with manipulation and non-manipulation. And there appeared to be some relationship between science experience and interest in science categories.

This study basically had much "meat" to it, but to exploit the implications so that they can be applied in classroom situations, a more extensive and detailed report would be useful.

Orpaz (251) investigated the accuracy of Academic Self-Evaluation (SE) reports and motivational effects of SE in seventh grade Intermediate Science Curriculum Study (ISCS) by employing the ISCS Performance Checks (PC's) and Performance Assessment Resources in two treatments: Academic Self-Evaluation (SE) and Teacher Evaluation (TE). With both treatments, students were free to choose the PC's they were going to answer.

The five teacher participants with 20 classes were assigned randomly to treatments, with 280 students in the SE group and 171 in the TE. Progress reports were collected during seven months of instruction with the first five ISCS units. Individualized achievement tests were administered to 123 of the SE students to check the accuracy of the SE reports. In addition, all students responded to the Intellectual Achievement Responsibility (IAR) Questionnaire. Their Progress Reports were analyzed for preparing Profile Analyses on eight dependent variables: Perceived Achievement, Level of Aspiration, Number of Attempted PC's, Average Confidence, Goal Discrepancy, Success Ratio, Risk Taking, and Chance Conformity.

The results indicated that students of low reading level were significantly less accurate in their SE reports than average or high reading level students. Black girls were found to be significantly less accurate than white girls or black boys. Significant differences were not found between entire reading groups in the analysis of covariance of IAR, but SE boys and SE black students showed a significant decrease in IAR scores. In the Profile Analysis of the dependent variables, SE students were significantly higher than TE students in achievement and success ratios and significantly lower in goal discrepancies. The SE students were significantly higher than TE's in achievement and success ratio when groups of equal six, equal race and equal socioeconomic status were compared.

It was concluded that a shift from TE to SE in seventh grade ISCS instruction "would be concomitant with an approximate 20 percent increase in reported perceived achievement."

Cohen (69) examined the effect of content material chosen from textbooks used at the seventh grade level in literature, social studies, and science on Cloze test performance of seventh grade students. Cloze tests are constructed using "a method of systematically deleting words from a prose selection and then evaluating the success a reader has in actually supplying the words deleted...In this study, Cloze tests were constructed by the deletion of every fifth word."

The subjects in this study were 63 seventh graders who were administered a battery of six Cloze tests, three multiple-choice tests derived from the text material, and three subject-area questionnaires.

The scores recieved by the subjects on the Cloze tests revealed significant differences in difficulty among the subject areas with the mean percentages scores for literature being 31 percent; for social studies, 40 percent; and for science, 37 percent. The Cloze and multiple-choice tests differentiated among passage difficulty within subject areas, whereas the Dale-Chall readability formula did not. The Dale-Chall formula and the Cloze tests ranked the passages in the same order of difficulty, but there were conflicting results in similar passage ranking based on multiple-choice test performance. The r's between the Cloze and multiple-choice tests were for literature, .55; for social studies, .35; and for science, .40. This seems to suggest that Cloze tests may not be appropriate for content material at this level.

Students' preferences for text material did not seem to affect their level of comprehension of Cloze and multiple-choice tests. However, a large proportion reported difficulties in reading content texts. The difficulties were listed as poor comprehension, problems with studying, density of facts, vocabulary load, and uninteresting material.

Grayson (123) attempted to (1) develop an effective grading model for a science course that employed individualized instructional techniques; (2) evaluate the model in terms of students abilities to predict their own achievement and effectiveness in meeting the course requirements; and (3) analyze relationships among certain pupil characteristics and the use of the grading model. The subjects were the students enrolled in the Chemistry classes of a private, coeducational, boarding-day, secondary school from September, 1971 to May, 1974. The instruments used in the study were the ACS-NSTA High School Chemistry Examination: Form 1971 and the California Psychological Inventory (CPI).

The grading model, designed for use with individualized instructional techniques, was criterion- rather than norm-referenced and had four grade categories, Honors; High Pass; Pass; and Unsatisfactory. The model required the subjects to select one of the three achievement levels at the beginning of the course and then attempt to fulfill the requirements. The objectives and skills and their proficiency levels differed among the grade categories or achievement levels.

An analysis of the data that were collected showed that fewer than half the students could successfully complete the requirements of the grade level they selected. However, a Chi-square analysis showed that students receiving an Honors grade ranked in the upper 10th percentile (sic) [Reviewer's note: the researcher should have stated "at or above the 90th percentile (or in the upper 10 percent)" since a percentile is a point and one can't by in it]; those receiving High Pass grades ranked between [not in] the 65th and the 89th percentiles; and those receiving Pass, ranked between [not in] the 10th and the 64th percentiles. The pupil characteristics found to discriminate between the accurate and overestimators were years in attendance at a particular school, mathematical aptitude and CPI characteristic of socialization.

It was concluded that because of the inaccuracies in estimation, predictors that discriminate each level of achievement or grade category need to be identified.

Finstad (102) conducted a study to compare the test performances of sample populations of students enrolled in biology in three secondary schools, two located in rural northwestern Wisconsin and one in suburban St. Paul, Minnesota. Their test scores were compared on the basis of (1) pre- and post-test differences; (2) differences in alternative scoring procedures, graded response and traditional; and (3) differences in student performances by school designation - small, medium or large.

A test instrument of 100 multiple choice items in general biology was prepared and then reduced to 85 items by item analysis and judgments of biology professors. Fifty-four percent of the items were lower cognitive (knowledge, comprehension, and application); and 46 percent, upper cognitive (analysis, synthesis, and evaluation). The content of the items was about equally distributed between traditional and contemporary biology. The test was administered pre- and post to students, number not indicated in Dissertation Abstracts International, during 1972-73 school year. The responses were scored in two ways, a "traditional" grade of three for one correct answer, and "graded responses" of three, two, or one based on answers of varying degrees of correctness. The results were analyzed using F and t.

The analysis indicated that (1) significant degrees of learning, based on pre- and post-test differences, were accomplished by the students; (2) student scores were significantly higher with graded-response scoring than with traditional scoring; and (3) students from the medium and large schools had significantly greater gains in achievement than those from small.

Grant (121) undertook a study to determine if a student's responses on multiple-choice items reflected understanding of formal and concrete concepts and if that understanding was commensurate with his level of mental development.

The subjects were 89 biology students enrolled in three sections randomly selected from 15, and 59 physics students in three sections, in high schools in the Oklahoma City area. They were measured with subject-matter examinations and four Piagetian tasks - conservation of volume; separation of variables; equilibrium in the balance; and operations of exclusion. The subject-matter tests in biology covered populations and adaptation; and in physics, measurement and rectilinear motion, each of which had ten concrete and ten formal items.

The data that were gathered indicated that the operational levels of the biology students were 37 percent formal and 63 percent concrete and those of the physics students, 68 percent formal and 32 percent concrete. Positive correlations were found between formal and concrete test scores and reasons given on Piagetian tasks by formal operational biology and physics subjects; and between concrete test scores and reasons given by concrete operational students in both biology and physics. However, no correlation [sic] was found to exist between formal test scores and reasons given by concrete operational subjects in either biology or physics.

It was concluded that objective tests provide a valid measure of understanding formal and concrete concepts only when the operational level of each student is known.

Monk and Stallings (226) designed a study to determine what effects testing might have in stimulating the learning of problem-solving abilities. The subjects of the study, 200 students in a course in physical geography at the University of Illinois, were assigned to one of two treatment groups that were "generally taught in the same manner" except for different treatment on quizzes. Group I, consisting of about 80 students, received factually-oriented quizzes, whereas Group II, consisting of about 120 students received quizzes that stressed higher level behaviors such as application and analysis with an orientation toward problem solving. The groups were taught by the same instructor with two lectures per week in addition to three one-hour quiz sessions that were handled by six graduate assistants. There were five quiz sections for each group with seven 15-minute quizzes during the semester with a fact to problem solving ratio for the items of 3:1 for Group I and the reverse for Group II. The final examination was the criterion measure for comparing the two groups.

Two-tailed t-tests were used to measure any differences and r's were calculated to measure the relationships between students scores on factual and problem solving items. The results failed to yield any significant t's or r's. One can only conclude that the type of test failed to influence the learning of problem solving abilities.

Lowry (202) undertook a study to (1) display functional relationships between misinformation scores and discrepancies between true and legitimate ability and raw and corrected-for-guessing scores; (2) display functional relationships between luck scores and discrepancies between true and legitimate ability and raw and corrected-for-guessing scores; (3) determine the extent to which corrected-for-guessing scores or raw scores are better estimates of legitimate ability; and (4) determine the extent to which corrected-for-guessing scores or raw scores are better estimates of true ability.

The subjects were about 220 students in three sections in the second quarter of a three-quarter Biology I laboratory sequence during the winter 1974-75 at Virginia Polytechnic Institute and State University. During the quarter the subjects were administered six tests each consisting apparently of 23-25 items. Their abilities were defined in two dimensions, true ability which was the number of items from which all the wrong choices were confidently eliminated, plus expected gain from guessing on items from which one or more wrong choices could be eliminated, leaving the correct choice; and legitimate ability, which was the actual number of correct items from which at least one wrong choice could be eliminated leaving the correct choice. Misinformation was defined as confidently eliminating the correct choice and luck was defined as the discrepancy between expected guessing success and actual guessing success.

The tests were scored using these definitions as criteria for assigning values to responses, with students indicating the way they addressed themselves to the items.

The analysis failed to indicate that misinformation had an effect on the ability of raw scores to estimate legitimate (true) [sic] ability; although misinformation appeared to have a substantial effect on ability of corrected-for-guessing scores to estimate legitimate (true) [sic] ability, the latter being more pronounced on tests with fewer choices per item. Luck was shown to be influential on ability of both raw and corrected-for-guessing scores to estimate true or legitimate ability, although the influence was more pronounced for raw scores. It was concluded that raw scores were better estimates than corrected-for-guessing scores of legitimate ability but neither seemed superior for estimating true ability.

The study was difficult to follow because of complicated explanations although the reviewer believes it was basically well designed and has many important implications for test design. An anomaly is that legitimate ability and true ability have different definitions, yet in two of the conclusions the term "legitimate (true)" is used and there is no clear indication of the implication.

Butzow and Davis (56) attempted to create an open-ended type program such as Elementary Science Study (ESS). It was hoped that the instrument would allow predictions to be made as to the relative level of success teachers would have using a student centered program. In this study, the development of the instrument is described, and in a related study, its validation.

The development was based on three conceptual phrases relevant to teaching elementary science, For me, doing science; For me, teaching science; and For me, science concepts. Concepts in these phrases were rated on a five-point scale in the preliminary effort by 104 elementary science methods students at the University of Maine-Orono using 46 adjectival pairs such as Valuing; Important-Trivial; Enjoying; Enjoyable-Unenjoyable; Striving; Powerful-Powerless; and Difficulty; Easy-Difficult. The adjectival pair having the largest loading on these four factors was selected to stand for that factor in the final instrument. It is completely unclear in the final report how this effort was related to the development of the attitude instrument, except one may assume that it had a criterion value. But, nevertheless, the attitude instrument that emerged and referred to as the Semantic Differential Test of Teacher Attitudes was constructed by selecting 21 teacher-behaviors from the works of authors involved with ESS.

The trial was conducted with 29 elementary classroom teachers who were members of an ESS inservice institute and were administered the test prior to implementing ESS in the classroom. After several months of implementation, the participants were videotaped on a prearranged basis while teaching science. The videotapes were evaluated by three professional science educators trained to use the Science Curriculum Assessment System-Teacher. Two subgroups were formed (a student-directed group and a teacher-directed group) and they were compared.

An analysis indicated that six of the 21 items (teacher behaviors) were significant on the Enjoyable/Unenjoyable axis. These were for Teacher orientation, For me; allowing students to mess around with water; and for the Student orientation, (1) For me, keep live plants and animals in the classroom for use in experiments; (2) For me, being able to correctly answer questions in science; (3) For me, allowing children to work in groups to discuss different views and findings; (4) For me, teaching science; and (5) For me, having a strong background in conceptual and factual science.

The validation of the Semantic Differential Test of Teacher Attitudes was undertaken by Davis (79), using two groups of elementary school teachers who had been exposed to the materials and philosophy of the ESS program in two in-service institutes. Both groups were administered the Semantic Differential after exposure to the ESS program but before any formal implementation of ESS in their schools. One group of the study was divided into two subgroups on the basis of scores on the classroom observation instrument and designated as (1) a group in which teachers allowed the students to direct their own activities (SDG) and (2) a group in which the teacher directed the student's activities (TDG).

Average scale scores for the evaluative, activity and potency scales of the semantic differential were used to determine which concepts showed a significant difference between the two subgroups. Using the Chi-square test, a significant difference was evident between the two subgroups on certain concepts. Analyses of these significant concepts indicated that the SDG group viewed science teaching as being closely related to allowing children to explore natural phenonema actively for themselves and also recognized the need for having a strong background in conceptual and factual science. The same was true for the TDG group but to a lesser degree.

A reexamination of these reviews of studies dealing with testing and evaluation does not indicate that much optimism can be expressed with the results. The reporting of the studies, in general, is mediocre, and in some cases, almost incomprehensible. Conclusions are drawn in some without tangible support. Many of the instruments, despite being assigned flamboyant titles, are "homemade" and the reliability and validity are suspect. There is much question as to how sensitive the instruments are in measuring differences among groups. The reviewer believes that the studies in this section are generally "weaker" than those in any of the previous sections.

Use of Computers

Three studies were categorized under this heading. They are focused more or less directly on the computers themselves rather than on CAI, and so a separate category was established.

Dorn (90) described a number of examples of computer-based experiments that could be used to develop intuition, act as a catalyst for student-generated conjectures, and motivate further study. Some of the

experiments were designed to give rise to inductive reasoning, and others were aimed at deductive reasoning. He indicated that a case could be made for the principle that the manner in which the computer was "used should be governed more by whether the student is expected to use induction or deduction than by any similar thing."

In his development, a computer simulation was suggested for population growth with conditions and constraints affecting the numbers. An examination was then made of computer capabilities for graphing the population trends. The student was required to reason inductively to provide variables affecting growth. Computer modeling, however, involved guesses as to how the population would behave. Then the computer was used to determine the consequences of the guesses. Examples are given for handling the data.

An analysis of the effort led to the conclusion that computer simulation is considered to be a "black box operation" in which students have little insight into the operation of the program, whereas in modeling the student must "see inside the program." This suggested that simulation seems most appropriate for inductive processes and modeling more appropriate for deductive. However, in both induction and deduction, the objectives are to (1) develop student intuition in the particular subject under study: (2) increase students abilities to make educated guesses or conjectures; and (3) increase the student's motivation to delve deeper into the subject.

The investigator concluded that both simulation and modeling should be used. The study would have been more helpful had the differences between simulation and modeling been explained more precisely.

Bennett (31) examined certain aspects of computer-assisted problem-solving behavior among secondary school students with the aim of aiding teachers and administrators to provide the optimum computer environment for the education of their students. In particular, answers were sought to two questions: (1) "Is there a difference in performance and product under the two modes of computer operation, batch processing and time sharing?" and (2) "Is this difference a function of the type of problem under consideration?"

A sample of 12 of 48 students enrolled in a course in computer science at Teaneck High School, Teaneck, New Jersey in 1971-72 were selected on the basis of responses to a questionnaire concerning the computer system with which they liked to work. All were superior students but none had previous computer experience. Six were assigned to the batch-processing computer mode using an IBM 1130 and six to the time-sharing mode using a Hewlett-Packard 3000 with two online terminals. Each was given six problems, three closed-ended and three open-ended. The subjects worked one problem at a time and kept records of time spent analyzing and coding. For those in batch processing, time ended when they were ready to key punch; for those in time sharing, when they were ready to punch paper tape. Debugging time was the second variable.

Analyses of the data indicated that ahead of time 50 percent of the 12 preferred each of the two modes. On completion, apparently 51 percent of batch group preferred batch with 12 percent undecided; 64 percent of time sharing preferred that with 22 percent undecided. The time sharing seemed preferable for effective debugging but significant differences were not found between the debugging times of the two groups. The time-sharing students produced significantly longer programs, but apparently spent significantly less time in writing and debugging. More preparation time was required with batch processing. Basically, differences were not found between the qualities of programs, although they had different styles.

Brumbaugh (55) investigated factors that might affect the extent to which science teachers use computers in the teaching of secondary school science, and evaluated the effectiveness of an intensive in-service program for science teachers that dealt with computers and their application in the teaching of science.

The subjects of the study were 37 secondary school teachers from the Macomb Intermediate School District, Mt. Clemen, Michigan who were participants in a combined summer and inservice institute. Twenty-seven percent of the participants were women, 73 percent men, 37.8 percent, junior-high, and 62.2 percent, senior-high school science teachers. Four variables related to computer usage were studied: (1) cognitive and affective characteristics of the participants; (2) personal data concerning the participants; (3) availability of computer equipment; and (4) effectiveness of inservice instruction. Information collected on these variables included the teacher's level of knowledge of a programming system and of a computer being used; teaching experience, science background, mathematics background and access to a terminal. It was indicated that those "who have access to computer facilities will use computer technology to supplement their instruction if they have had training in relation to available computer hardware and software." In other words, if they are trained to use the computer on hand, they will use it; if not, they won't.

The findings of the three studies are not sufficiently extensive or related to warrant generalizations.

Talent and Creativity

Only one report was found in this area although in the late 1950's and early 1960's talent and creativity were the subjects of much research. The major purpose of Smithwick's (317) effort was to prepare a monograph designed to (1) identify talent areas and their criteria in the classroom; (2) suggest methods and strategies for identifying student's talent strengths and weaknesses; (3) identify methods and strategies for implementing a Multiple Talent Approach in the science classroom; and (4) identify methods and strategies for evaluating the Multiple Talent Approach in the science classroom.

The Multiple Talent Approach to teaching emerged from Taylor's research on creativity and higher level talents but its use and implementation in the classroom were claimed to be minimal. Therefore, the monograph defined talent as a learnable set of intellectual abilities encompassing creative talent, forecasting talent, planning talent, decision-making talent, academic talent, science process talent, and group relations talent.

Means for identifying talent were indicated as being human judgment, the ALPHA Biographical Inventory, and Guilford's Structure of Intellect Model. Means for implementing the Multiple Talent Approach included program sequencing, talent centers, the Inquiry Role Approach, the morphological analysis technique, and the use of talent processes.

In retrospect, this effort was mainly a literature review.

Accountability and Competency-Based Programs

This section deals with a field that is receiving increasingly greater attention from researchers.

Saltinski (298) undertook a study to determine the concensus (majority) opinion of junior high school teachers on the issue of accountability and the minimal performance objectives for science education in Michigan (developed by the Michigan State Department of Education). The Delphi technique, described earlier in this review, was used to determine if teachers could arrive at a concensus (majority) of opinions to the 50 items on a Delphi I questionnaire that was sent to an initial sample of 170 teachers. The teachers were expected to respond to the items on a five-point scale ranging from strongly disagree to strongly agree. The reactions of 127 respondents were tabulated, the results were returned to the respondents on a Delphi II questionnaire; and they were asked to reconsider their reactions and make any changes if they chose to do so. A total of 103 teachers responded to the Delphi II.

The results showed that teachers have strongly polarized opinions on most aspects of accountability, particularly with respect to assessment and teacher responsibility for student learning. Most of the teachers, however, did report agreement with many aspects of the minimal performance objectives for science education in Michigan.

The responses were also studied in relation to ten variables including demographic area, type of school, grade level, science courses, sex, race; teaching experience, science organizations, undergraduate school and credits in science. However, for any one variable there were only a few survey items for which any significant differences of opinion were detected. In most of these cases, differences of opinion were only in degree of strong agreement-agreement or strong disagreement-disagreement. Black science teachers did appear to differ from white science teachers on a few aspects of accountability. Without regard for area, white teachers disagreed with taking responsibility for student learning, whereas black teachers agreed to take such responsibility without regard for area, urban or suburban.

The Delphi technique did not result in any consequential shift of teacher opinion.

Kreuzer (181) dealt with the problem of biology teacher preparation specifically in the area of competencies, defined primarily as techniques, in the teaching of biology. Two subproblems involved the degree to which the preservice teachers who were subjects attained the competencies under consideration and comparisons of groups of preservice teachers, or students as to their attainment of each competency.

A biology teacher's checklist of 75 competencies was developed from an analysis of five modern biology textbooks and teachers' manuals and were evaluated by 125 secondary school biology teachers who had received the Outstanding Biology Teacher Award (OBTA). Those competencies that more than 50 percent of the teachers listed as either highly essential or essential were used in the preparation of a final checklist of 60 competencies. The checklist was then evaluated by 155 senior biology major preservice teachers from 16 colleges and universities in terms of the degree to which they thought they had attained the competency.

The responses indicated that (1) the checklist could serve a useful function; (2) the 15 most highly rated competencies are in the categories of biochemistry, microbiology, plant growth and function, ecology, quantitative activities and classification; (3) preservice teachers do not have the maximal level of attainment of the competencies judged to be of greatest value by outstanding biology teachers; (4) students who had completed student teaching or were in the process showed only a slightly higher degree of attainment than those who had not student taught, thus indicating the importance of prior preparation; and (5) neither students in private nor public college showed superior overall attainment of the competencies over the other group.

Berger and Roderick (34), in cooperation with four teams of four to five teachers from the Ann Arbor, Michigan, area, developed lists of "characteristics a competent elementary teacher should have in order to teach science." The lists, comprising 230 characteristics, were then edited and evaluated on a scale of 1-7 as to their importance for elementary science teaching and then ranked on a scale of 1-4 with respect to the extent of involvement the University of Michigan should have in developing each competency. The ratings of 14 teachers and four teacher educators were then analyzed. A competency was removed from the list if it was rated less than average in importance or if University of Michigan involvement was rated in the lower quartile [sic]. The Mann-Whitney U Test was used to test the significance of the difference between ratings of teachers and teacher educators. The 143 competencies that emerged were then evaluated by another 22 teachers and 18 teacher educators, none from the Ann Arbor area. The teacher educators were involved in science education.

In the last evaluation significant differences were found, using the F test, between teachers and science educators on 66 categorizations. Twenty-five of 33 were rated as being more important, or should be

attained earlier, by the teacher educators. Teacher educators were found to place less importance on classroom discipline and record keeping, and more importance on working with students, than did teachers.

Zigler, Hendrix and Mertens (377) reported on a combined summer/inservice institute held during the summer 1973 and academic year 1973-74 designed to enhance science education accountability and how a school visitation program by the Coordinator of the School Science Visitation Program in working with teachers and administrators enhanced spinoff.

The participants in the study were 39 teachers who attended at least part of the combined institute in 1973-74 at Ball State University. The eight-quarter hour course during the summer emphasized modern biology and laboratory investigations. The inservice follow-up, involving 14 participants who lived within a 75 mile radius of the university, was concerned with applying the knowledges and skills attained during the summer and then reporting the results. The participants developed model instructional units with specific performance objectives, and teaching strategies. In addition, they were administered pre- and posttest, the results of which were analyzed with the t test.

The results indicated that statistically significant learning had taken place during the experience and that the participants had many complimentary things to say about the Coordinator. Unfortunately, the report did not come specifically to grips with what happened to the accountability issue.

Reineke and Welch (281) sought to examine the degree of heterophily [differences between individuals or groups of individuals] which is indicated between principals and teachers regarding the perceived adequacy of school conditions. Dealing with the perceptual mismatches between teachers and principals would appear to be an important first step in improving the educational environment in schools.

As part of the NSF Comprehensive Program for Teacher Education, questionnaires concerning various issues in secondary schools were administered to principals and teachers. The questionnaires contained 27 Likert-type items that sought evaluations of the instructional setting. The items on the questionnaires to principals and teachers were identical except principals were asked to respond in terms of how conditions affected science teachers, whereas teachers were asked to respond in terms of how the conditions affected themselves.

1,074 questionnaires were received from the subjects in five NSF Project impact and control regions. Three of the regions focused on science teachers and two on mathematics. The number analyzed was reduced to 984 since the only ones used were where both principal and teacher responded. Multivariate ANOVA was used to compare the perceptions of the principals and teachers on five scales, Effectiveness, Curriculum, Load, Facilities, and Support.

The results indicated that principals tended to rate teaching conditions as satifactory or above except for staff support (secretaries,

laboratory assistants and paraprofessionals) whereas teachers rated three areas as being less than satisfactory—Load; Facilities; and Support. However, the order of perceived adequacy was the same for both principals and teachers.

Berliner (36) prepared a report of a project of the California Commission on Teacher Preparation and licensing in which an effort was made to isolate issues concerning the evaluation of teacher effectiveness. There is some question as to whether the effort could be designated as research but, because of growing concern with these issues, it was included. Three major difficulties with research on the issues were indicated as being associated with instrumentation, methodology and statistics. Specific problem areas include the inadequacy of standardized tests, the unknown predictive ability of tests from special teaching units, the problem of building multivariate outcome measures, the difficulty with identifying appropriate teacher behaviors and the lack of stability of many teacher behaviors.

Research is recommended in a number of areas, particularly with the way student backgrounds affect teacher effectiveness, what subject matters should be examined, and the validity and generalizability of measures of teacher effectiveness.

The studies on accountability indicate the rudimentary state of the art in this area. Many so-called studies are discursive or expository reports rather than research. There is evidence that teachers are extremely wary of the assessment of teaching and accountability for student learning. Also, perceptions of the existence of appropriate learning environments differ between administrators and teachers. Probably most vexing is the difficulty of identifying what constitutes the ingredients of the matrix, or matrices, of desirable teacher behavior.

Science Achievement

Twelve somewhat "maverick" studies were found that could best be categorized under the nebulous title "Science Achievement."

Young (372) surveyed the material published in the Journal of Research in Science Teaching, College Science Teaching, Science Education, and School Science and Mathematics from 1960-1974 in order to determine the number of retention studies that had been performed during that period. Of the 3,451 papers published, 1,086 were identified as being research, with about two out of three being descriptive. Junior high school and college students were the favorite "targets" for study. Of the research studies, 41 dealt with retention with three listed as being "unsuccessful." The testing in 18 of the retention studies was done six weeks or less after completion of the treatment. The results indicate that few studies are performed that attempt to continue work beyond the experiment although the percentage seems to be increasing.

Brooks and Hounshell (52) studied the vertical organization of the elementary school locus of control and its relationship to science achievement. Locus of control was identified as being either internal or external.

In the former, the student perceives positive and/or negative events as being a consequence of one's own actions and hence, under personal control. In the latter, positive and/or negative events are perceived as being unrelated to one's own behavior and so are beyond one's own control.

The subjects were students in selected elementary schools who had entered first grade and were in the third year of attendance. There were three pairs of schools involved, one school in each being graded and the other non-graded. The schools in the pairs were similar on the basis of science curriculum, socioeconomic level and racial composition. The superintendent, elementary supervisor and principal of the ungraded school had to reach concensus of similarity with the principal of the graded school agreeing. [Reviewer's note: How valid this procedure for concensus is may be questioned.] Within a two-week period the subjects were administered the Childrens' Locus of Control Scale orally and the Stanford Achievement Test in Science. T-scores from the tests were analyzed with the z test.

The results failed to indicate a significant difference in science achievement between students in graded or ungraded schools who scored high or midmost on the Locus of Control Scale, although students in graded schools who scored low had significantly higher science achievement than their counterparts in ungraded schools. A significant difference in science achievement was also found between high and low students in non-graded schools, presumably a function of more personal responsibility.

In summary, students in non-graded schools with external (low) locus of control scored significantly lower on science achievement than did students in the same school with internal locus of control and also lower than counterpart students with external control in graded schools.

Garigliano (113) undertook a study in which the purpose was not stated specifically although one may infer that it was to describe the Evaluation Supplements used to assist the teacher with the evaluation of three areas with which SCIS was concerned, process, content and skills. In particular, the study describes an evaluative technique within SCIS that is described in the Final Edition of Interactions and Systems, and in the Preliminary, and Final, Edition of Systems and Subsystems.

The data were gathered using the results on the Systems Test, of children in two schools in which SCIS had been used two years, in a formal evaluation effort. The 125 third graders who had exposure to prior SCIS units also took part in the review activities. They responded to a systems test with wrinkled, folded and smooth sheets of paper with a "Yes" or "No."

The analysis of the results failed to indicate significant differences in the mean scores of the groups, although the mean scores, considering the emphasis on the systems idea, seem low. It was expected that they would be higher. Students at the level of this group do not seem able to handle more than one property at a time, for example, number or kind. Only about half of the third graders seemed able to handle more than one property.

Mays (213) examined the possible relationships between moral and cognitive development of second and fifth graders. The subjects were 60 children, male and female, from the grades indicated in an elementary school in Iowa City, Iowa. Their levels of cognitive development were assessed with four tasks, (1) conservation of liquid amount; (2) addition of classes; (3) attribute multiplicative classification; and (4) complementary perspectives. Their levels of moral development were assessed by presenting four conflict situations, (1) reciprocity concerned with value of life and punishment; (2) conservation of values involving promise to peers and response to authority; (3) perspective of viewpoint analyzing peer needs and rules; and (4) reciprocity questioning the roles of a citizen and humantarian.

For analysis, the responses to cognitive tasks were classified as preoperational or concrete operational, and those to moral development as preconventional level or conventional level. The level of performance on the coghitive tasks and to three of four of the moral judgment tasks was not found to be related to sex, whereas the grade level of the subject was related directly to the level of performance on the cognitive tasks. But, the relationships between the cognitive tasks and moral judgments were not established in 15 of the 16 possibilities examined. It was concluded that moral development lagged behind cognitive development.

Linn and Thier (200) gathered evidence about the effect of SCIS on the development of logical thinking in children by comparing fifth graders who had studied at least the Energy Sources unit from SCIS with fifth and eighth graders who had not studied SCIS. The subjects were selected from school districts where SCIS had been used for several years as well as from those presumably not involved with SCIS. Intact classes of fifth graders were used in addition to one or two eighth grade classes similar to the fifth grade classes. Seventeen school districts in seven states across the country with 92 classes and 2,290 subjects were among those that participated.

The treatment involved the Cart Experiment in the unit "Energy Sources" that was available in final edition in 1971-72. The administrator used the Experiment as a group test presented on silent 16mm film since the presentation would be identical when replicated and could be used economically. Those involved had standard instructions for administering the treatment and, in addition, collected demographic and personal data on the student subjects. Two variables were considered with the Cart Experiment: height and surface texture. The subjects were expected to figure out the relationships involved in how far the cart would roll. The scoring had two parts, A and B, based on whether they marked the effect correctly and explained it correctly.

It was concluded from an analysis of the results that evidence of logical thinking as measured by the ability to explain compensating variables was more identifiable by fifth grade students who had studied Energy Sources than by those who had not. They also did about as well as eighth graders who had not. It was noted that eighth graders were more likely to explain "compensation" adequately than were fifth graders, but many eighth graders could not perform at Piaget's formal level.

Despite the fact that the study was extensive, there was little evidence presented to lead to conclusive recommendations. One wonders also about the treatment of students who did not experience "Energy Sources."

Voelker (349) attempted to determine the relative effectiveness of two methods of instruction in teaching physical and chemical change to elementary school children and also to determine whether the maturity of the children represented by grade level, was related to the children's level of understanding of selected concepts. Method 1 consisted of an instructional sequence in which the learner was responsible for formulating the generalization that "a reliable criterion for classifying changes as examples of physical changes or chemical changes is whether or not a new material results from the change." Method 2 involved the teacher's formulating and stating the generalization.

All children in grades four through six in a single elementary school (four classes at each grade level) served as the source of the subjects. Two classes were selected randomly at each grade level, one class being treated with Method 1 and the other, with Method 2. The investigation covered four weeks with Treatment group 1 being taught the first week and tested the second, and Treatment group 2 being taught the third week and tested the fourth. After instruction, ten children from each of six classes were randomly selected for testing. All children had five 30-minute lessons on consecutive days with Lesson 1 being the same for all subjects covering background material. Lessons 2, 3 and 4 involved observation, description and discussion. Lesson 5 involved review.

During the testing week, three verbal questions and 14 demonstrated and six described phenomena were administered. They were divided between physical and chemical changes that children were expected to classify. The results were analyzed with ANOVA.

Significant differences were not found on the verbal questions between the mean scores of the Method 1 groups and Method 2 groups for the fourth, fifth or sixth graders. On the demonstrated phenomena, the classification scores of fourth graders were significantly greater for the Method 1 group, and at all grade levels for the described phenomena. Also, it was found that the mean differences increased in significance with grade level.

It was concluded that it did not seem appropriate to teach physical and chemical change before grade six if large-group instruction was used since maturation is a factor in understanding this concept. The rationale for this conclusion is not completely clear.

Keeves (167) examined the ways in which the educational environment of the home, the school and the peer group accounted for change in performance in science and mathematics at school over the period of a year during which the subjects progressed from the elementary school to the high school. The investigation was restricted to children in Australia who came from homes in which English was the language normally spoken. A simple random sample of 242 children was drawn from those who were in the final elementary school year in 1968. All subjects were administered

specially prepared tests in mechanical arithmetic and mathematics, a general ability test, and an attitude questionnaire at the end of the 1968 school year. At the beginning of the high school year the subjects were administered a science test and, at the end, science and mathematics tests and an attitude questionnaire. In addition, data were collected on the structural and attitudinal dimensions of the home; structural characteristics of the classroom; and structural, attitudinal and process dimensions of the peer group.

An analysis of the results indicated that the initial achievement and sex of the student influenced attitudes and practices toward education in the home. However, parents attitudes toward, and ambitions for their children, although dependent on past performance, contributed to the students' final achievement levels. If parental attitudes and ambitions were low, students were adversely affected. Also, teachers who took refresher courses and who were specialists in the subject, positively influenced the achievement of students. A high level of personal affiliation with the teacher lead to higher levels of performance. Science activities seemed to contribute to positive attitudes toward science and mathematics, but not to achievement.

It was indicated that students in "larger" (10-44) classes seemed to perform better than those in smaller ones, and "engagement" by their three best friends in science and mathematics activities were found to contribute to positive attitudes towards science and mathematics but not to achievement.

Again, one sees the important influence of the teacher.

Johnson and Sherman (159) attempted to determine if preknowledge of behavioral objectives affected students' achievement in the Intermediate Science Curriculum Study (ISCS) course. In gathering the data, 180 students in the Level II ISCS course were placed in matched experimental and control groups based on scores from the Iowa Tests of Basic Skills, Stanford Science Test, and ISCS Pretest for Level II students. An ANOVA did not show differences between the two groups. In the experimental group, students were apprised of the behavioral objectives for the first five chapters, whereas the control group was not so apprised. Then, both groups were administered the same instructor-prepared test.

An analysis of the results failed to indicate a significant difference between the high achieving experimental and control groups on achievement. However, the low achieving control group performed significantly better on the achievement test than did the matched control group. Thus, knowledge of the behavioral objectives seemed to function positively for the low achievers but not for the high achievers.

Bombery (47) conducted a longitudinal follow-up study of ninth grade students who were placed in an Introductory Physical Science (IPS), non-college preparatory, group and of students who were placed in a language course, college preparatory. The study was aimed at comparing their cognitive development, their further selection of science courses in high school, and the extent to which students in the two groups went on to post

secondary education. Data were collected from their Form 80-C personal record cards and analyzed by (1) Chi-square to determine group comparisons on categorical variables; (2) t-tests to compare the means obtained by each group for categorical and analytical variables; and (3) correlation coefficients to assess the degree of relationship between tests taken before the ninth grade and tests taken during and after the ninth grade.

The results indicated that (1) the IPS group made greater achievement gains from grades nine through twelve than did the language group, but still had lower achievement at the twelfth grade level than did the language group; (2) IPS group members enrolled in greater numbers in advanced science courses in high school than would be predicted; and (3) 45 percent of the IPS group indicated an active interest in post secondary education, although few were expected to continue studies after the twelfth grade when they enrolled in the IPS course.

It seems appropriate to examine the bases on which students are categorized college preparatory or non-college preparatory in their early years of high school.

Newberry (239) attempted to determine (1) if second semester seniors in elective social studies and science programs would evidence greater achievement on the Stanford Achievement Test: High School Battery (HSB) than their counterparts in a traditional program; (2) which group would demonstrate greater achievement when HSB scores were compared with those from the Differential Aptitude Test: Verbal Reasoning (VR) plus Numerical Ability (VA); (3) if the elective group would show more positive attitudes toward the curriculum than those in the traditional group; (4) if those in the elective group achieved significantly higher grade-point averages than their counterparts; and (5) which category of students, based on the curriculum in which they were enrolled achieved higher standardized test scores, higher grade-point averages, and showed more positive attitudes toward the curriculum.

The non-equivalent control group design was used with DAT VR + NA scores serving as pretest baseline data. The other instruments administered were the HSB Subtests in Science A and Social Studies; Purdue Master Attitude Scale: Any School Subject; and a socioeconomic questionnaire. The data were analyzed with t, r and Chi-square.

The results of the analyses indicated that (1) with students of comparable socioeconomic status and ability level, the scores on standardized tests of students in elective programs will be as high as those of students in traditional programs; (2) attitudes of those students in elective programs are not found to differ significantly from those of students in traditional; (3) with students of comparable socioeconomic status and ability levels, those in elective college preparatory programs will score as well on achievement tests and show attitudes as positive toward the curriculum as those of their counterparts in traditional programs; and (4) differences in scores on standardized tests favor males whereas grade point averages are higher for females.

If any specific conclusion could be made it is that "bright students will perform better than those less endowed."

Lawson (186) assessed the Piagetian level of performance of males and females on two manipulative tasks and on a pencil and paper examination of concrete and formal reasoning abilities with a view to answering four questions: (1) Do males perform at a significantly higher (more formal) level than females on manipulative tasks of concrete and formal reasoning? (2) Do females perform at a significantly higher (more formal) level than males on a written examination of concrete and formal reasoning? (3) Overall, do males and females demonstrate significant differences in their ability to reason formally? and (4) Do the manipulative tasks and pencil and paper examinations seem to be measuring different psychological parameters dependent on the sex of the examinee?

The subjects were 62 high school students, 31 males and 31 females, randomly selected from Delphi High School, Indiana, who were enrolled in a required second semester biology course. The manipulative tasks administered by classroom instructors consisted of 14 items in three categories: (1) proportionality: early formal; (2) propositional logic: fully formal; and (3) combinational analysis: fully formal. They were also given additional measures in which materials were handled including the conservation of weight task with clay and volume displacement with metal cylinders. Significant differences between males and females were measured with the Mann-Whitney U Test.

It was found that for all measures, the mean levels of males were higher than those of the females. Significant differences were found at the .02 level for manipulative tasks, but the difference was significant only on the propositional logic section of the pencil and paper examinations.

Bennett (32) indicated that one of the primary proposes of his investigation was to determine what influence particular high school programs have on achievement in college biology, with achievement defined as the "final grade a student received in his first college biology course." The subjects were 857 Iowa State University students selected from all freshman enrolled in beginning biology during one semester. The subjects were distinguished by five factors, (1) the one of the six biology groups to which "they belonged;" (2) the college in which they were enrolled; (3) type of college laboratory; (4) whether they had taken high school chemistry; and (5) sex. The term "biology groups" refers to the text materials used in high school biology. Four variables were used in a regression analysis, scores on the (1) Minnesota Scholastic Aptitude Test (MSAT); (2) Minnesota Placement Test (MATH); and (3) English Placement Test; and (4) high school rank.

The analyses indicated that, subjectively, college biology instructors believed that BSCS programs at the high school level provide a better preparation for beginning college biology although the better students took other programs. Also, those who had taken high school chemistry did significantly better in college biology although the high school laboratory program did not seem to affect achievement. Scores on the MSAT and MATH were found to be better predictors of success in college biology than was high school rank. Sex was also found to be a predictor with males performing better than females.

Several statemants were difficult to analyze: "Two significnat interactions were found" in "biology by laboratory" and "chemistry by sex"; "The laboratory for majors seemed to be a contributing factor"; "Then in turn, males who had high school chemistry were significantly different." Also, "there were no differences found between colleges, nor between students who took a laboratory, based on high school background."

As with attitudes and processes, the influences on achievement are elusive. Interactions among influencing factors obviously exist, but their identities are difficult to ascertain. The only identifiable factor that continually shows influence is the teacher.

Special Problems

A number of studies could have been placed in some of the categories already covered. However, the studies deal with unique facets of those categories and so a section entitled SPECIAL PROBLEMS was established, with a number of subsections under which the studies were reviewed.

Early-Childhood Instruction

Seven reports were classified in this category, one of which seems to be quite similar to another that was reviewed earlier with the same two authors listed.

One by Reisdorf (282), which seems to be more of a philosophical essay than a research study had five objectives to: (1) analyze and integrate in a historical context the various theories and concepts of play; (2) postulate a descriptive construct called "playfulness," (3) examine the historical distinctions and relationships between work and play, and postulate a synergetic relationship between playfulness and work; (4) investigate the elementary science curriculum to determine how the synergetic relationship between playfulness and work can be nurtured; and (5) explore the potential of SCIS for nurturing the synergetic relationship.

The researcher indicated that many individuals believe that the unification of work and play are vital; that if such a synergetic relationship is nurtured, a student is encouraged to open himself in playfulness and sustain progressive action in work and integrate and fulfull himself in the interplay and interaction of playfulness and work. SCIS professes to be consistent with the developmental psychology of Piaget and so it does have a conceptual framework for nurturing a synergetic relationship between playfulness and work.

Powell (273) attempted "to ascertain young children's concepts related to the following areas of time and change: (1) General Divisions of Time, (2) Historical Time, and (3) Time and the Life Cycle." The data were gathered with a specially developed instrument called the Time Understanding Test (TUT) that required the sorting of stacks of colored photographs in fifteen different tasks with a minimum of verbal responses. A reliability study indicated that the instrument was suitable for use with preschool children. The subjects consisted of 90 children (three, four and five

years old) who were randomly selected form eleven preschool programs in Stillwater, Oklahoma. The investigator interviewed the subjects at their schools. The responses were analyzed using ANOVA.

The results of the analyses indicated that there were significant differences among the children in all three areas of time and change based on age. Significant differences were not generally found on the basis of sex, except males scored significantly higher in identifying ages of automobiles and females significantly higher in identifying ages of women. Also, it was found that the concepts of Historical Time and Time and the Life Cycle were more closely related than either was to the concept of General Divisions of Time (weeks, months and years) in the curriculum for three and four year olds but it may be appropriate for five year olds. It was found that preschool children are interested in history and life cycles of plants, animals and people and have an impressive amount of knowledge in these areas. It was found, however, that as children grow older and learn more about life cycles of people, they become more negative in their attitudes toward elderly people and growing old.

The study was unique and yielded much valuable information for curricula for preschool children.

Judge (163) compared preschool children using the Montessori Method with those using SAPA on the skill of observation. The study had two parts. In the first part, in order to ensure that the two programs had common objectives, they were compared with respect to (1) the sequential presentation; (2) the use of materials to provide sensory training; (3) practice acquired through activities; and (4) the role of the teacher. In the second part, the competence on observational tasks of three groups of children was investigated, the first group receiving Montessori training for two years in preschool; the second using SAPA for one year with a background of another in preschool; and the third group had neither Montessori or SAPA in preschool. The instrument used for comparison was a set of observational tasks from the test, The Science Process Instrument (SPI).

The analysis in the first part of the study indicated that the similarities between, and common elements in, the two programs "were evidence of congruence." The subjects in the second part were 75 upper-middle class preschool children (5-6 year of age) 25 of whom were enrolled in a Montessori School in Dallas; 25 in a private kindergarten in San Antonio where apparently SAPA was used; and 25 in a private kindergarten in which neither the Montessori Method nor SAPA was used - this group being the control. The selection of subjects was based on socioeconomic level, years in school, and age. The SPI was administered individually by the investigator to all subjects. The test included 68 tasks with the administration taking 10-40 minutes since after three incorrect responses testing was terminated.

Significant differences were not found between the Montessori and SAPA groups on the observational tasks although it was claimed that SAPA children acquired the skills in a shorter time. It was indicated that apparently neither group needed to be taught the process of observation. At best, the findings were inconclusive.

Miller (223) investigated the relationships between perceptual-motor and conceptual growth, with two hypotheses in mind, (1) children who are delayed in perceptual-motor development will also be delayed in concepts of space, time and quantity; and (2) perceptual-motor intervention will effect changes in the development of these concepts. The subjects were 359 children in kindergarten and first grade who were initially screened on measures of gross motor development with the Martin Screening Test (MST) and the Berry Test of Visual Motor Integration (VMI). Groups as defined by low scores on the MST, VMI and both tests were randomly assigned by grade level to three intervention programs, (1) Individualized perceptual-motor; (2) Group perceptual-motor; and (3) Distar. A fourth group remained in the classroom and did not receive intervention.

Prior to treatment, all kindergartners were administered the Boehm Test of Basic Concepts (BTBC) and those assessed as having delayed perceptual-motor development were compared on the basis of BTBC with the remainder using a one-way ANOVA. A significantly lower conceptual level in space, time and distance was found for those children with delayed perceptual-motor development.

After three 30-minute treatment sessions per week for 11 weeks, the four groups were again administered the MST, VMI and BTBC, and in addition the kindergartners were administered the Metropolitan Readiness Test (MRT). The main effects and interactions among programs, groups, sex and grade levels were assessed with ANOVA. The results failed to indicate significant differences among the means of the program and classroom groups. Consequently, it appeared the intervention did not effect changes. It was concluded that increases in MST and BTBC scores are probably more affected by school and maturational factors than by specific short term interventions. In brief, children mature at different rates and "they can't be pushed."

Holliday and Partridge (145) evaluated "a rather practical procedure for determining the optimum sequencing of pictorial classification tasks using mean difficulty." The effects of three presentation sequences of the science tasks were experimentally evaluated in terms of student performance. The subjects in the "standard sample" (control) were 51 second graders and in the experimental sample, 134 second graders all from the same Calgary Alberta elementary school ranging in age from seven through eight years.

Fifty-six multiple-choice classification tasks were developed, each requiring the subjects to sort pictures of domestic animals, familiar to North Americans, on characteristics such as position and size, or shading and size. The experimental students were assigned randomly to one of three groups, ascending treatment, random treatment, and descending treatment. Three animals at the top of a sheet of paper had the same characteristics whereas of four at the bottom, only one had the characteristics. The subjects had to mark the one at the bottom that "fit the top." In a trial run, each subject received 56 randomized tasks in an individually sequenced order to determine task difficulty. In the final test, 17 were used for the experimental treatment. The results indicated that a highly consistant series of pictorial classification tasks sequenced in an ascending order of difficulty resulted in better classification performance than did a random order, and a random order was more effective than was a descending order of difficulty.

Barufaldi and Dietz (25), in a study similar to Barufaldi and Dietz (24) and Dietz and Barufaldi (89), investigated "the effects of different types of visual stimuli (solid objects, photographs, and drawings of the objects), grade level (mean age) and sex of the subjects and the interrelationships of these factors on the performance of children on visual observation and comparison tasks focusing upon the four physical attributes of color, size, form, and form detail."

The subjects were 240 students selected randomly from grades one, two, four, and six from two elementary schools that were 99 percent black and 1 percent Oriental. Two solid objects, a cube and a cylinder, were constructed and then photographs and drawings were made of them. Fourteen visual and comparison tasks were prepared, three focusing on color, two on size, five on form, and four on form detail. At each grade level, three random groups were formed, one of each of the groups doing the tasks on the objects, photographs or drawings. A correct response was graded as one, an incorrect as zero.

The results failed to indicate significant differences among the groups in terms of color, or significant differences within grade levels on size insofar as treatment (object, photograph or drawing) was concerned but there were significantly more responses as the grade level increased. With form there were significantly more responses with objects than with photographs and with photographs than with drawings. Also, sixth graders had significantly more correct responses than younger children, and the same was true with form detail. It was noted that females made more correct color responses than did males.

The study apparently supported the fact that the more real materials are, rather than simulated, the greater is learning, and that, as is well known, maturation produces better performance.

Peterson (264) investigated the curiosity behavior of groups of children, varying in age, race, and sex, as they waited alone or with a strange adult in a room filled with curiosity-arousing objects. It was predicted that the adult's presence would have a differential effect on the amount of curiosity behavior the children expressed through sensory-motor responses depending on the variables of age, race, and sex. The subjects were 245 students, 53 percent boys and 47 percent girls, from four grade levels in elementary schools in Berkeley, California. These included 60 kindergartners, and 61, 61 and 63 from grades two, four and six, respectively. The sample consisted of 50 percent Black, 41 percent Anglo, 1 percent Chicano, and 8 percent Oriental. The classes at each grade level were self contained and racially integrated, and supplemented randomly from other classes to maintain 30 subjects in each class with one experimental and one control group at each level.

The children were invited to be interviewed but on arrival there was a planned delay. They could do as they wished in the "curiosity-arousing" room, with experimental group children left alone with an adult outside the room to answer questions. With the control group children, an adult was seated at a desk in the room and appeared busy. The curiosity-arousing

materials were both living and "dead," half being familiar and half novel. The activities of the subjects were monitored by concealed video cameras and classified as "approached and touched object," "approached and manipulated object," and "approached, manipulated and reorganized materials." The responses were tallied and analyzed with F and multiple t's.

The results indicated that (1) with the experimental group and the adult absent, older subjects showed more curiosity, but with adults present there was about the same curiosity with all groups; (2) blacks in both the experimental and control groups showed more curiosity than whites; (3) generally there was more curiosity when the subjects were left alone but this varied with groups; (4) children between seven through twelve years of age were more curious when left alone, with the opposite being true for those of ages five through six; (5) black experimental children showed more curiosity than black control; and (6) the presence of white adults curtailed black curiosity, but the expressed curiosity of white children differed little from that of black children when a white adult was present.

Other than the study by Powell (273), little that was novel was revealed by the studies in this section. Achievement was not found to be a function of the type of learning material; as students matured, their knowledges and skills matured; and, in general, without the presence of a "strange" adult children are likely to do more "messing around."

Career Education

In one area that has received much attention recently, it was surprising to find only two studies. The first by Lee (194) was a study of career choices and career patterns of men and women who chose the fields of science, mathematics, or teaching as an occupation. The data for the study was [sic] collected from the Project TALENT Data Bank and included those from students in grades nine, ten, eleven, and twelve during the 1960 school year when the initial data were collected. Twenty-two predictor variables were considered and their relationships to occupational groupings were examined. Followup studies for career decisions were made on one-year, 11-year and 14-year bases with intentions for a 20-year followup. The report of the study was extremely difficult to follow. A number of "holes" in the data seemed evident to the reviewer and his opinions were supported by several peers. However, some findings and conclusions appear below.

It appeared that choices in some career fields exhibited much greater stability than others but nearly all showed a big dropout from career choice "five years later." Apparently, about 50 percent of those who chose mathematics, physical science, and biology as careers when in high school and were involved in training for those fields one year later were still involved five years later, with apparently 90 percent stability in engineering. The factors that seem to supply the greatest discrimination in stability among career groups are sex, mathematics interest, sociability, and verbal knowledge. But, it appeared obvious that intentions expressed in high school are a poor criterion of what actually happens.

The study, at least in purpose, had much to commend it but the inadequate, and in some cases incomprehensible, reporting plus the lack of consecutive pagination in Chapter Two, suggest that it might have more merit if it were rewritten. The only point that stands out is that the career choices of girls are more likely to be consummated than those of boys.

Klatt (173) set out to determine the extent to which the science curricula in the public schools of Arizona were providing the science foundations required in selected occupations. The data were collected by means of two questionnaires developed by an analysis of 55 science textbooks to determine what science topics were usually taught in grades 7-12. The topics were used to devise a questionnaire (curricular survey) concerning the consolidated seven through nine science curriculum and the curricula in biology, chemistry and physics. The questionnaire was sent to science teachers in randomly selected Arizona schools to ascertain what topics were being taught and the degree of emphasis on each topic. The topics from the textbook analysis were also used to devise an occupational questionnaire that was mailed to agencies that represent the occupations under investigation. The agencies included labor unions, business and trade associations, government bureaus, and businesses. The responses to the items on the questionnaire indicated science-knowledge requirements on 24 skilled and 24 professional occupations. Among the 24 skilled occupations were air conditioning mechanic, carpenter, photoengraver and truck driver, and among the 24 professional were accountant, dentist, musician, physician and reporter.

Klatt used t test "to determine the relationship [sic] between the curricula and requirements" by means of pairing the "science-topic mean ratings for each occupation...with the corresponding mean curricular-ratings." The results indicated that (1) the minimum-required level of instruction suffices for ten skilled and three professional occupations; (2) continuation beyond the minimum level suffices for an additional 11 skilled and four professional occupations; (3) earth science and biology have little utilitarian value for the skilled occupations; (4) three skilled and 17 professional occupations require science experiences beyond those offered at the high-school level; and (5) skilled occupations require less science knowledge than the professional.

It was concluded that "public-school science curricula were found to be adequate in scope and depth of coverage."

It is difficult to generalize about career education from two studies, one of which dealt with the situation in only one state.

Science for the Handicapped

In an area in which greater attention is now being paid, only two studies were found; one a review of reports, some of which were not research. In the first study Rowe (291) "reviewed" 19 research studies related to the provision and adaptation of science programs with children with various types of handicaps. The term "handicapped" covers the gamut of the poor,

the reluctant readers and the physically handicapped from whom science programs are withheld because of the need for other learning activities. Some of the studies could be construed as research whereas others were not.

The findings were basically an impassioned plea to provide more science for the disadvantaged, since low socioeconomic groups, the handicapped and the poor readers need more science to overcome the deficits they already have.

The reviewer would not challenge the need to do more, but the investigator apparently was not aware of published materials describing many things that have been done since these were not mentioned among the 19 studies reviewed.

Linn and Thier (200), according to the published materials, discussed the conceptual framework of the Science Curriculum Improvement Study (SCIS), explained how SCIS was adapted for the visually impaired, discussed the aspects of the program that make it relevant for visually-impaired children, and presented data showing how the program affects children who differ in age, intellectual ability, and manipulative skill. The project was referred to as "Adapting Science Materials for the Blind" (ASMB).

A number of SCIS activities were adapted for use with visually-impaired children and were tested by classroom teachers of the visually impaired with small groups of four to six in a residential school. Three types of evaluation were used, (1) manipulative measures (pouring, filtering, and keeping track of objects); (2) concrete measures (describing the environment of an organism, constructing a histogram); and (3) process measures (interpreting experiments). The materials were tested with sighted children.

It was noted that (1) visually-impaired children spent more time exploring than did sighted children, (2) low-ability students had lower scores than above-average ability students on pretests, and (3) both low-ability and above-average students made significant gains in manipulative and concrete measures. The greatest gains occurred for above average students when they studied the second ASMB unit.

The reviewer had the opportunity to examine the ASMB materials at the American Printing House for the Blind, Louisville, Kentucky, and it was his opinion that they exemplified "show and tell" rather than inquiry. Also, it is his opinion that the "units" were considerably less sophisticated than those developed more than a decade ago at the Colorado School for the Deaf and Blind, Colorado Springs, Colorado, and at the Florida School for the Deaf and the Blind, St. Augustine, Florida. Also, the ASMB materials are expensive.

Both of the studies in this section were more discursive than research oriented and neither contributed greatly to the literature concerning science for the handicapped.

Bilingual Instruction

Juarez (162), in the one study in this area, attempted to determine if single language instruction was "more efficacious than bilingual instruction in a science context" and to investigate the transfer of learning science content and process skills from one language to another. The subjects were 104 fifth graders from two schools in each of Las Vegas and Las Cruces, New Mexico, who had bilingual education for at least four years. They were randomly assigned to one of four treatment groups in each of the four schools and were instructed in subordinate and superordinate units of science. One group received both forms of instruction in English; one, both in Spanish; and the other two had one in English and one in Spanish. Subordinate knowledge was conceived as building or depending on other subordinate skills in sequence, whereas superordinate refers to "more complex skills," but the latter is not clarified by the investigator.

Three measures were administered, two of which sampled student performance in science activities, one after initial science instruction and one at the end. The third measure was administered for student language preference and attitude toward science instruction.

The major finding was that there were no significant differences among treatment groups receiving instruction bilingually and those having single language instruction. The students receiving total instruction in English were not found to perform better on the dependent measures than those receiving instruction in Spanish, and students receiving instruction in both Spanish and English performed just as well as those instructed in a single language. The students did express a preference for a bilingual environment as opposed to a monolingual.

Ethnic-Based Instruction

Snow (318) attempted to determine whether the use of ethno-science exemplars in science concept development would increase the academic achievement of Navajo students at the Many Farms High School in Many Farms, Arizona. "The ethno-science of the Navajo refers to materials, topics, and ideas from Navajo technology. The technology and subsequent ethno-science exemplars were derived from the past and present cultural traditions of the Navajo which in turn evolved from myths and religious beliefs, as well as from the ongoing acculturation process."

Six conservation units were used to test the effectiveness of the ethno-science exemplars, namely "Overgrazing," "Water Pollution No. 1," "Water Pollution No.2," "Air Pollution," "Wildlife" and "Timber and Wildlife." During the instruction, local plant samples and the Navajo names for plants were used for the ethno-science classes, and slides of erosion were from the reservation.

The subjects were 115 secondary-school students attending the on-reservation boarding school for American Indians operated by the Bureau of Indian Affairs in Many Farms, Arizona. When they arrived, they were assigned on a non-bias basis to six biology classes taught by two teachers.

Apparently, the three classes of one teacher used ethno-science exemplars, whereas the other three classes did not. Each unit was followed by a short multiple choice examination and at the end of the study the student's attitudes toward science was measured.

A comparison of the results of the two groups on the teacher-made examinations failed to indicate any general significant differences between them. However, for one unit, "Water Pollution No. 1," the ethno-science group performed significantly better than did the non-ethno-science group. This was the unit with the greatest number of ethno-science exemplars and hence, it was concluded that such exemplars should continue to be used. It was noted that attitudes toward science were positive and, consequently, the use of such exemplars did not have a negative effect.

In the second study dealing with ethnic instruction, Kleinpeter (174) listed four purposes, to (1) determine how teachers perceive the use of multi-ethnic instructional materials in secondary-school science; (2) discover the extent to which instructional materials reflecting multi-ethnic identity were used by secondary science teachers; (3) discover teachers' reaction to the use of science materials reflecting multi-ethnic identity; and (4) identify science instructional materials which reflected the multi-ethnic emphasis in their content, form and substance. The subjects from whom data were collected were 200 secondary science teachers from randomly selected school districts in Kansas, Louisiana, and Michigan, all of whom were teaching at least one science course at the time of the study. The data-gathering instrument that was administered contained 14 items in the categories: "Basic Data;" "Perception and Usage of Multi-Ethnic Content" and "Open-End Opinions." The responses to the instrument were analyzed using Chi-square.

The results of the analysis indicated that (1) science teachers in predominantly white schools used multi-ethnic materials less than did those in schools with predominantly non-white populations; (2) the teachers generally realized their responsibilities to a multi-ethnic society; (3) multi-ethnic materials were used to a greater extent in large than small schools; (4) female teachers were more familiar with multi-ethnic materials than were males; (5) teachers in large schools had greater insight concerning the roles of instructional materials in science teaching and into human values; (6) teaching experience was not related to teacher perception of the need for more multi-ethnic instructional material; and (7) secondary science teachers did not make much use of multi-ethnic material and what they did use was chiefly supplementary and from magazines, newspapers and pamphlets.

Obviously, two studies can provide only minimal data but they do not indicate extensive use of multi-ethnic content by secondary science teachers and where it is used, as with the Navajo's, the effect on achievement is not marked.

Minority Group Instruction

Four studies were found that dealt with minority-group instruction, one at the secondary level and three at the post-secondary level.

With high school students, Lawson, Nordland and Kahle (189) examined the relationship among scores on ten Piagetian tasks used to assess levels of concrete and formal reasoning and problem solving abilities, and scores on a standardized reading examination. The subjects were 35 students, 18 males and 17 females, selected from an urban high school in which enrollees were predominantly Black and Spanish American.

The subjects were administered the Sequential Tests of Educational Progress (STEP) - Reading Form 3A with the subscales Reproduce Ideas, Translate, Make Inferences, Analyze Motivation, Analyze Presentation and Criticize. The ten Piagetian tasks were in the levels Preoperational I; Early Concrete Operational II A (conservation of number, substance, length and continuous quantity); Concrete Operational II B (conservation of area and weight); Early Formal Operational III B (separation of variables and exclusion of irrelevant variables).

When r's were computed between the scores on the reading test and those on the Piagetian tasks, it was found that those who scored highest on the Piagetian tasks also scored significantly higher on the reading examination (which was not surprising). It was concluded that the relationship between Piagetian total scores and STEP Reading Total Scores was linear and highly significant. These relationships were also evident between scores on the separate Piagetian tasks and the reading subscales.

Kinnebrew (172) indicated a three-fold purpose in his study, to determine: (1) the number and description of programs designed to eliminate obstacles facing minority students enrolled in courses in mathematics, science, technology and the allied health fields in community and junior college; (2) the stated position of selected community-junior colleges governing personal efforts designed to eliminate obstacles facing minority students to matriculate in the fields listed above; and (3) the extent to which minority students have programs available that encourage them to enroll in courses leading to the completion or majors or certificates in the fields listed above. The emphasis of the study focused on three minority groups, the American-Indian, the Black and the Mexican American. Questionnaires were sent to 100 selected community-junior colleges on September 1, 1974, with a followup to non-respondents on October 3, 1974. A total of 76 questionnaires were returned.

The responses indicated that 60 percent of the minority students in the community-junior colleges were Black, 30 percent were about equally divided between Mexican American and Puerto Rican, and about 10 percent were American Indian. The latter percentage may not be representative since responses were not received from states with large populations of American Indians namely, Nevada, Arizona and Oklahoma. Courses were offered by the community-junior colleges in the areas of biology, allied health, chemistry, nursing and technology but only three community-junior colleges offered courses in all fields. Three community-junior colleges offered remedial courses for strengthening the backgrounds of minority students but not in all fields. In about half of the community colleges the "Boards of Trustees" had deliberated about the problems of minority students and about two-third of the responses indicated that science departments were aware of the problems. About one-fifth of the colleges responding indicated

that they were conducting programs for the expressed purpose of recruiting minority students and about 60 percent had tutorial programs. But, in general, Boards of Trustees apparently gave low priority to the importance of implementing programs for minorities in the fields with which this study was concerned.

Haywood (134) examined the academic performance and attitudes toward science of students and teachers participating in an experimental freshman science program. The study was limited to 100 selected freshman science students participating in St. Augustine's College Five College Consortium Innovative Thrust Program (FCCIT), and 100 selected non-participating science students, along with the teachers of both groups. The FCCIT was a federally-funded Freshman Studies program designed to help inadequately prepared blacks to remain in college. It was supposed to develop active, relevant and workable programs for students in black colleges. The five colleges in the consortium were not identified.

Data were collected on instruction using the Student Instructor Report and the Instructor Self-Report; on student demographic data using The College Student Questionnaire (Part I); and on other student characteristics using The Cooperative Science Test, the Test on Understanding Science, the Watson-Glaser Critical Thinking Appraisal, and the Purdue Silance Attitude Scale. The data for the participating and non-participating students were compared using Chi-square and multivariate analysis. These statistical analyses failed to show a significant difference between the gains in science achievement of the two groups. Neither was there a significant difference between the two groups in understanding of science, although the FCCIT students showed significantly greater gains in critical thinking ability. Also, it was noted that FCCIT teachers "are more interested in the students and that there is a difference in the observable attitude of the teachers using the FCCIT concept." Also, it was stated that students expressed more positive attitude toward the FCCIT approach because it gave them more freedom in the laboratory and was more interesting, enjoyable and stimulating than was the traditional approach. The basis for the latter viewpoints is unclear and seems to be "armchair philosophizing."

Pickering (266) described a method of identifying those students [high risk] based on SAT scores and "an experimental course [in chemistry] at Columbia College used successfully to ameliorate the performance of these students." The course was supplemental to the standard course. Chemistry grades and mathematics scholastic aptitude scores were obtained for Columbia College students entering in the fall, 1972. These were used to sort students in A, B, C and D categories and the average of the SAT scores in each category was computed. Since it was found that the SAT Mathematics score had an almost linear relationship to chemistry grade, there was concern about doing anything about students with low SAT scores.

The amelioration course involved about 60 students with SAT Mathematics scores of 610 or lower who were put in two classes. Most of the time was devoted to lectures but mainly to the solution of problems that were analyzed step by step. Achievement in the course was graded Pass/Fail. A control group of regular students with comparable SAT scores was matched against those in the special class.

The results indicated that "attendance was very good in the amelioration course with some rashes of lateness", but there was a generally positive reaction on questionnaire administered at the end of the year. The dropout rate for the experimental group was indicated as being 16 percent and for the control group, 25 percent, but the report did not indicate "from what the students dropped out." It was indicated that grades of the experimental students in the regular course did improve and that "a supplementary effort works."

The studies in this section do not yield optimistic results. The merits of providing amelioration are laudatory but the increment of learning achieved from such efforts is not clearly evident.

Slow Learners — Low Achievers

Three studies dealing with slow learners - low achievers were reported in the literature, one each at the elementary, secondary and college levels.

DeTure and Koran (83) tested observational learning as a means of teaching experimental procedure using a peer group as a model of appropriate experimental behavior. Members of the subject group after observing the model were expected to be able to perform the experimental technique as it was modeled. The subjects were 22 fourth graders, seven white and six black girls, and four white and five black boys. The general socio-economic level of the group was low. The students had used Science - A Process Approach (SAPA) but often misunderstood directions.

In carrying out the investigation, four students were chosen by sociometric techniques to serve as microteaching models. The model group was instructed in the experimental procedure by the teacher and videotaped by the experimenter. The model group verbalized all their behaviors as they performed the experiment in the lesson "Formulating Hypotheses; 2. Conductors and Non Conductor." The remaining 18 subjects were divided into control and treatment groups of nine each, both getting 15 minutes of verbal instruction and complete procedures equivalent to the videotape procedures. Both then did the experiment in small groups but the treatment group recieved the 15-minute videotape procedure first. An observation instrument of 32 discrete behaviors was used by raters to rate the treatment and control groups. The data were then analyzed with Chi-square.

The results indicated that the treatment group generated 22 more positive behaviors and 22 less negative. It was concluded that live modeling or videotaped modeling has merit. One can question the design if the treatment group got the lecture and videotape before doing the experiment and the control got only the lecture. If so, the treatment group could hardly help but achieve more with two exposures to learning, with the control group getting only one.

Michel (222) developed, tested and evaluated a unit of study for slow learning secondary-school students covering the topic of structure and function of living things with special emphasis on the human body. A group-paced teacher-directed approach was selected as the method of instruction and the effectiveness of the unit was measured by gains between scores

on pre- and posttests by the students involved. The study was conducted during 1972-73 with five classes of ninth graders in two schools in the Muncie Community Schools, Muncie, Indiana. The subjects had previously been grouped homogeneously on the basis of poor reading ability and/or low achievement record.

Behavioral objectives were written for the unit of study and student activities and teaching strategies were prepared and pilot tested. Data on student characteristics were obtained from verbal and nonverbal IQ scores on the Lorge-Thorndike Intelligence Tests, the Verbal Reasoning and Numerical Ability scores on the Differential Aptitude Tests, and the Vocabulary and Comprehension subtests of the Gates-MacGinitie Reading Tests. Students from each of the five classes were randomly grouped into a pretest and posttest population. "The two populations were found to be equivalent" on the bases of IQ, aptitude and reading test scores.

After instruction "the means of the achievement test scores from students in the pretest populations were compared with those from students in the posttest population and a significant difference was found to exist between the mean scores. This was interpreted as evidence that the instruction materials were effective in facilitating learning."

Lee (193) described a 10-week curricular unit designed to improve the basic mathematical skills of open-admission students through the study of elementary probability and statistics. It was hoped that the unit would provide the background in mathematics needed for enhancing achievement in later courses in science and mathematics. A draft curricular unit was taught and formatively evaluated at a community college in the Fall Quarter, 1973. The evaluation involved 170 students taught by two teachers. The unit was then revised and taught and summatively evaluated during the Winter Quarter, 1973, with 191 students in 11 classes taught by seven teachers.

Pre- and posttest scores were obtained by administering the Basic Mathematical Skills (BMS) tests, a Probability and Statistics (PAS) test, and an Aiken Attitude Scale (AAS). Data from 116 students who attended at least 80 percent of the class sessions were analyzed.

The results failed to indicate that the unit significantly enhanced the mastery of basic mathematics skills of the subjects, although more than 60 percent of them expressed more confidence in their mastery of those skills. On the average, the classes attained about 66 percent mastery of the statistical content of the curricular unit. It was indicated that there was little change in student attitude toward mathematics.

The three studies in this section failed to indicate generally, that the efforts to provide supplemental experiences for slow learners - low achievers did not yield results in which much confidence could be placed.

Humanistic Science

Knecht (175) attempted to develop a sound philosophical basis from which to derive...characteristics [of scientific literacy], and to build a model on them for comparing the quality of elementary science education programs against thie stated goal for science education. Some of his basic assumptions were that meaning is derived from sensory experience and not from words, that scientific knowledge and scientific literacy are attained only when distinctions between physical objects and "other things" are understood, science education can be evaluated by examining the instructional materials, assessment of epistomological quality [nature of knowledge and its validity] must be "made at the level of specific knowledge claims intended for student instruction," and children do seek meaning and have the capacity for independent reasoning.

The investigation was carried out by (1) identifying the epistomological character of the goals in the NSTA Position Statement on "School Science Education for the '70s;" (2) empirically developing procedures for identifying elements in a referent program [Concepts in Science (CIS) was selected]; and (3) testing the procedures with a contrasting program [Science Curriculum Improvement Study (SCIS) was selected.]

It was claimed that the analyses of the two programs showed that 20 percent CIS consisted of theoretic statements and that the basis of knowing in the program is theory with a deductive approach. However, it was claimed that SCIS is epistomologically sound with concepts being developed from experience.

The reviewer has some questions in that the model for the program was developed using the Teachers Guide of CIS, and taking single pages from each unit at random and then selecting ten pages using a table of random numbers. Yet, this same model was applied to a non-textbook program.

Morris (229) attempted to determine the relative effectiveness of humanistically-oriented secondary school science curriculum materials which dealt with the same laboratory activities as did the National Science Foundation sponsored [sic] Introductory Physical Science (IPS) course. However, unlike IPS, the humanistically-oriented curriculum materials that were developed for this study were designed to illustrate the value of these activities to civilization. The assessment of the relative effectiveness was made with the VOS Opinion Poll that was constructed to determine the relative value students attached to the laboratory activities common to IPS and to the humanistically-oriented materials.

The VOS Opinion Poll was administered on a pre- and posttest basis to five treatment classes who experienced the humanistically-oriented materials and to nineteen classes who had IPS or Chemical Education Study (CHEMS) materials, the latter presumably having the same orietation as IPS.

The investigator indicated that although the groups were comparable prior to treatment, a significant difference was found for the treatment group on the posttest. Consequently, he concluded that (1) temporary changes can be effected in the relative values students attach to specific

laboratory activities when the materials are designed to effect such changes; (2) it is unlikely that exposure to scientific information and laboratory activities themselves will cause students to attach greater value to science; and (3) changes in attitudes and values may not be so difficult as is generally thought.

The two studies in this section were so different that generalizations could not be drawn.

Nature of Science

Durkee (94) attempted to (1) identify the views, beliefs and opinions of university/college natural science faculty in the United States on the nature of science; (2) indicate on what issues there is concensus; (3) specify differences in viewpoint or perspective between academic scientists and a group of philosophers of science; and (4) investigate the relationships between scientist's views on the nature of science and various demographic variables. The variables included vocation, area of science, type of educational institution, highest academic degree held, exposure to literature on the nature of science, extent of previous thought about issues in the criterion instrument, age, and geographical region.

An Inventory of Views on the Nature of Science (IVNS) consisting of 44 items in a multiple-choice format and grouped into 15 scales, was constructed and administered to 318 randomly selected science faculty in the biological physical and earth sciences and to 23 prominent philosophers of science. The responses indicated that both groups (1) viewed science as the process and product of dynamic man-world interaction rather than a description of natural phenomena; and (2) affirmed that the chief aim of science is to search for pattern and coherence in nature. Scientists favored the view that scientific laws are empirical generalizations, and that although philosophers of science generally reject the "instrumentalist" position with respect to scientific theories, scientists generally accept it. The findings indicated also that understandings and views on the nature of science is an extensive, complex domain to which one's vocation as a scientist or philosopher of science is related.

The entire section on special problems indicated the vastness of the realms of research to which science education could be directed. The research studies were extremely diverse and reflected the varied interests of researchers. Yet, this review indicated that the lack of unified direction in science education research resulted in fragmentary studies from which valid generalizations were difficult to make.

Foreign Science Programs — How Others Do It

The last major section of this report deals with research in science education related to programs outside the United States. The studies are grouped generally according to geographical region except where the research in one country was extensive. In the latter case, and with countries relatively isolated from others, the studies were dealt with separately.

Central and South America

Berty (38) investigated the relationships between the (1) classroom activities used and the science teacher's views of the classroom activities that should be used during science instruction; (2) student-teacher relationships that prevail and should prevail in the science classroom; (3) objectives of science education emphasized by the science teachers; (4) knowledge of the nature of science held [sic] by the science teachers; and (5) teacher characteristics, student characteristics, and situation variables. The instruments used for gathering data included the Science Classroom Activity Checklist: Student's and Teacher's Perceptions (SCACL); Checklist of Student-Teacher Relationships; Student's and Teacher's Perceptions: (CTR); Rating Scale of Objectives of Science Education (FSOSE); and Wisconsin Inventory of Science Processes (WISP).

The subjects to which the instruments were administered were a stratified random sample of 221 Costa Rican inservice secondary school science teachers with a 47 percent average response rate. The relationships among variables were established by the use of correlation and regression analysis with the scores. The analyses showed that the (1) integration of laboratory activities with science content was related positively to the amount of time spent in the laboratory; (2) use of textbook and reference materials was positively related to student-teacher relationships in the classroom; (3) student-teacher relationships were positively related to student attitudes; (4) teacher directed classroom control was positively related to student attitude toward the course; (5) objectives of science education emphasized by the teacher were positively related to the teacher's attitudes toward science teaching and the number of inservice courses the teacher attended; (6) teacher's views of appropriate activities in the classroom were positively related to the teacher's knowledge of the nature of science and of the relationships that should prevail in the classroom; and (7) teacher's views of relationships that should prevail were positively related to the teacher's knowledge of the nature of science.

The reviewer fails to find anything in the results that has not been common knowledge for years.

Ferreyra (101) described the UNESCO Pilot Project that was demonstrated as a possible model for developing physics teaching methods and materials in Central and South America. Materials that were developed were presented to a Regional Seminar in São Paulo, Brasil in 1964. These materials were tested and revised and discussed in six subsequent dissemination Seminars sponsored by UNESCO at various sites in Central and South America. The report is mentioned here, not because it appears to be research, but because it does represent an extensive effort.

De Zulberti (84) sought to determine whether (1) an inservice seminar is an effective way to change elementary school teachers' attitudes towards a teaching technique in Argentina; and (2) any changes in teachers' attitudes are affected by such factors as age, sex, position, teaching experience, and inservice experience. The subjects consisted of 71 elementary teachers in grades one through seven from 15 Argentine provinces who enrolled voluntarily in a one-week seminar that was held at three different sites. Data concerning the teachers' personal and professional characteristics.

were collected with a self-report instrument that was administered to the teachers who were assigned randomly to either a pre- or posttest treatment group. Non-parametric statistics were used to test the significances of any differences between the scores on the two groups on the instrument.

The results of the analyses indicated that the teachers' attitudes, after the inservice seminar, improved significantly with respect to the use of the inquiry approach and the use of inexpensive and readily available materials. However, differences in attitudes were not found to be related to sex, position or inservice experience. It was concluded that inservice training has merits.

Africa

Robins (289) described an effort referred to as the African Primary Science Program (APSP) that began in 1965 with collaboration of African, British and American scientists and educators. The purpose of his report was to present what he claimed to be useful generalizations about technical assistance in science education through a critical analysis of APSP.

Three generalizations were made, (1) an approach in science education which emphasizes inquiry and student involvement is educationally valid in the African context; (2) it is possible to introduce successfully in African primary schools, methods and materials for science education which differ significantly from those in conventional use; and (3) a Pan-African approach to improve science education in which countries cooperate through sharing experiences and scarce resources is workable and of continuing value.

Taiwo (332) designed and executed a study to (1) examine the nature and the amount of physical science possessed by fourth, fifth and sixth graders in the Western State of Nigeria; and (2) determine the relationship that might exist between the amount of such knowledge and the pupils' performance on Piagetian-type tasks. A 40 item Physical Science Knowledge Test and a 20-item Interview Guide for Piagetian-type tasks were prepared by the investigator to fit the cognitive level of the subjects and the cultural milieu of Nigeria. The Physical Science Knowledge Test included items on physical phenomena, natural phenomena, and domestic utilities. A total of 979 subjects were chosen for the study, 525 from six urban schools, and 454, from six rural schools. The responses of the students were item analyzed and evaluated with t, F and r.

The analyses indicated that (1) there appeared to be widespread unscientific beliefs among the subjects concerning natural and physical phenomena; (2) the subjects seemed to have a better-than-chance knowledge of incidental science content; (3) a significantly greater amount of incidental science knowledge was possessed by urban than by rural children; (4) performance on Piagetian-type tasks was age dependent in favor of the older children; (5) there was significant relationship between incidental science knowledge and performance on Piagetian-type tasks; and (6) the subjects were better informed about science related to domestic issues than to natural phenomena.

The objectives of the investigation by Awuku (15) were to (1) relate the possible factors that can affect the nature of science teacher education programs in the future; (2) account for the current preparation of science teachers in teacher training colleges and the University of Cape Coast, Ghana; (3) delineate the aspirations of professionals for improvements in science teacher education programs in the future; and (4) offer alternative suggestions for the education of Ghanian science teachers in the future. The data were gathered through an analysis of the professional literature dealing with Ghana, "oral tradition" where the written records were sparse, and structured interviews and conferences with resource persons in Ghana. These data were then synthesized.

It was indicated that the real problems of science education in Ghana are subject to economic, social, political and cultural constraints, bureaucratic and social conservatism, and a lack of viable knowledge about viable alternatives. However, it was indicated that outside assistance alone would not solve the situation, but that action would have to come internally. Guidelines that were prepared for elementary and secondary science education in Ghana were based on three principles: (1) science is a main force in economic and manpower development; (2) science plays a role in social development; and (3) science contributes to individual development. The recommendations made were in the usual areas of improving instructional efficiency, increasing teacher qualifications, developing adequate programs of evaluation, and instituting inservice and leadership programs for science educators.

Coyne (74) investigated the efficacy of microteaching as a preservice teacher training technique in a Ghanian university with emphasis on effect of providing lesson outlines to the trainees on their acquisition of four questioning skills. As part of a methods course 16 preservice mathematics and physics teachers microtaught five times. The first three lessons followed the same lesson plan, with the first emphasizing the fluency of questions whereas the second and third emphasized both fluency and the use of probing questions. Different plans were used with the fourth and fifth lessons in which the trainees practiced higher order and divergent questions. However, half were assigned to a treatment group that received lesson outlines for use when they microtaught, whereas the other half chose and prepared their own lessons. A control group of eight randomly assigned trainees did not microteach but were tuaght questioning skills through a traditional lecture-discussion approach.

The members of the three groups were audiotaped during two ten-minute segments of student teaching. The tapes were evaluated by two judges for questioning skills. All group members were also administered an attitude survey. The results of the assessments were then compared and they failed to indicate a significant difference between the two treatment groups during microteaching on fluency and probing questions although those who received the outlines for lessons four and five demonstrated superior performance on higher-order and divergent questions. It was also found that the microteaching group that received lesson outlines had significantly more favorable attitudes than the microteaching group that was "on its own."

The judges' ratings for student teaching were significantly higher for the microteaching groups than for the control groups, and the microteaching groups had significantly higher attitude scores than did the control groups.

Onwere (247) attempted to identify (1) factors that students from five English-speaking countries in West Africa - The Gambia, Ghana, Liberia, Nigeria and Sierra Leone - associated with pre-college interest in science; and (2) those factors which influenced or contributed to the choice of a science major field or dissuaded students from entering a field of science. The population for the study was the undergraduate and graduate students from the countries listed above who were enrolled in the spring, 1974, at American University, Catholic University of America, Georgetown University, George Washington University, and Howard University, a consortium in Washington, D.C.

A 33-item questionnaire, seeking personal information, as well as that for education background, attitude toward teachers, support received, and home government manpower needs was administered to 150 randomly selected students of the population, 139 of whom responded. Analyses were made of the responses of science and non-science students using Chi-square, t, means and standard deviations.

The results of the analyses indicated that the students, 74 percent male and 26 percent female, were about equally distributed in science and non-science fields of study, and were widely distributed in programs within these fields. About 52 percent were self supporting, 22 percent depended on family support, and only six percent depended on their home governments. Significant differences were found between science and non-science students in participation in hobbies, membership in school clubs, instructional methods, laboratory as an instrument of learning, and guidance received. Many of the variables studied were not found to differ significantly between the science and non-science students.

The Middle East

Four studies were found that dealt with science education in the Middle East. In one, Rahimi-Naini (276) constructed a model for the development and implementation of a science curriculum in the elementary schools of Iran. The model represented a theoretical scheme constructed from hypothetical reasoning and empirical information. The component parts of the model were objectives and content, teaching procedures, instructional materials, audiovisual aids, pupil evaluation, teacher training, and model evaluation. In addition, the model included recommendations as to organizational patterns of operation, administrative responsibilities, and implementation of the curriculum.

The establishment of a Curriculum Development Committee as an integral body under the Ministry of Education was the basic unit of the model and was to be broadly representative of the various relevant levels and areas of education. It was recommended that the Committee emphasize the inquiry approach to science teaching and the development of teacher manuals for all areas at all grade levels for the effective implementation of the science curriculum.

Za'rour (375) attempted to identify erroneous notions about some scientific facts and concepts and to determine the extent to which they are prevalent among groups of students in the Beirut, Lebanon area. The erroneous notions which occur with relatively high frequency are referred to as "science misconceptions." The 1,444 subjects were freshman and junior students from 11 high schools and students (nearly all sophomores) from the University of Beirut. Except for 130 students from the American Community School, all were, or had been before enrolling in the University, part of the Lebanese system of education.

A test of science misconceptions consisting of 40 multiple-choice items was developed from two 64-item pilot tests that had been constructed from other sources and experience. About 20 items were in physics and the rest in biology, earth and space science, and chemistry. The tests were administered by the researcher or his assistant to all subjects, with the responses of the 130 from the American Community School being treated separately. Distractors were selected by percentages greater than chance score and were labelled as "misconceptions." t was used to test for significant differences among percentages of popularity of misconceptions, and r was used to measure relationships between test scores of correct responses on the misconception test and science grades of students and V and Q scores on the SAT from eleventh graders of American Community School.

The results indicated that 30 of 108 distractors or potential misconceptions were selected by 30 percent of the respondents although there was no definite pattern of proneness to misconceptions at the different educational levels. Fewer males at the eleventh grade level held misconceptions than did females, with the difference being less pronounced above and below. Significant differences were not found between American students and the high socioeconomic level Lebanese. As might be expected, the more science courses in a student's background, the fewer the misconceptions.

Billeh and Hasan (42) sought to determine whether science teachers' understanding of science could be increased by special instruction and training in secondary school science teaching and to identify variables that might contribute to such an increase. The population included all of the 186 secondary science teachers in Jordan who were asked by the Ministry of Education to attend a four-week summer training course in science teaching funded by the Ford Foundation. The 92 percent that participated were divided into four groups - Biology, Chemistry, Physical Science and Physics. The training program involved lectures and demonstrations of science methods and concepts relevant to the secondary school, laboratory investigations emphasizing the inquiry approach, plus readings, films and lectures on the nature of science. The Biology group did not have the nature of science lectures.

Teacher understanding of the nature of science was measured with a 60-item multiple-choice Nature of Science Test (NOST) that was administered pre and post. At the beginning significant differences were not found among the groups on NOST, but significant differences were found at the end, with the Chemistry and Physical Science groups performing better than the Biology or Physics. However, all groups except the Biology group improved significantly. It was found that teachers with less than four years of college education grained more on NOST than those with four or more, although

significant differences were not found between university and non-university graduates. Also, science teaching was not found to be related significantly to gain scores on NOST, nor was previous inservice professional training. The latter point was used as justification to state that earlier inservice education did not deal with understanding the nature of science.

Hasan and Billeh (133) in a study corollary to the one just preceding, attempted to evaluate the effect of the four-week workshop described above, on the development of attitudes toward science in secondary school teachers and identify the variables that affect changes in those attitudes. One hundred twenty-nine from the workshop group, representing 70 percent of the secondary-school science teachers in Jordan, agreed to participate in this phase.

A 32-item Thurstone-Chave type attitude scale was developed by the author from a pool of 120 items with the assistance of 46 science professors from the American University of Beirut and the University of Jordan. Two parallel halves were used in the investigation. The pre- and posttest means on the scale, together with data collected on relevant variables at the beginning of the workshop, were used in the analysis.

A t-test analysis failed to indicate a significant change in attitudes over the four-week session. However, a multiple regression analysis indicated a significant positive relationship between attitude gain scores that were not significant and previous professional inservice training, but a negative relationship with level of education.

Israel

Four studies involved Israel, all dealing with facets of the Biological Sciences Curriculum Study (BSCS).

Tamir (333) attempted to determine the effects of interaction between certain aspects of the Biological Science Curriculum Study (BSCS) and variables such as "teachers' bias, type of school, sex of student, and specific subject matter taught as related to achievement." The subjects were 408 twelfth graders who were using the Israeli-adapted Yellow Version of BSCS and 581 students not using the Yellow Version who had participated in the curricula extending over a period of four years. Fifty different teachers were used and divided into two groups based on responses from the Blankenship Attitude Inventory, the BSCS supporters and the non-supporters. A multiple choice test was used to measure achievement and the statistical analyses involved various analyses of variance and t- tests.

The results of the analyses indicated that there were significant differences among the achievements of students in the different types of schools, with students in rural agricultural schools scoring much lower. Males were found to score higher than females in total achievement and in botany and zoology, but significant differences were not found between males and females in heredity and human biology. BSCS students scored better than non-BSCS without regard for whether their teachers were supporters of non-supporters. It was concluded that the nature of the curriculum was a more decisive factor in student achievement than was teacher attitude.

Tamir and Jungwirth (335) undertook a study with a three-fold purpose: (1) to provide an overview of students' growth during four years of studying the Israeli-adaptation of BSCS; (2) to identify, in the development of the project from its implementation in 1965, trends in various aspects of student achievement which may have at least some generalizable attributes; and (3) to assess the feasibility of the BSCS adaptation in Israel by comparing BSCS and non-BSCS students regarding their achievement, their acquisition of inquiry skills and their attitudes toward science and nature.

The subjects were samples from three class populations that entered the ninth grade in 1965, 1966, and 1967 and graduated in 1969, 1970, and 1971 respectively. The BSCS classes were trial classes that were first to adopt the program. Non-BSCS students were selected for a control group and were matched in terms of types of students, teachers and schools. The instruments administered were a locally-designed intelligence test, a 40-item General Biological Information Test, and Biology tests one through five that were adaptations of the BSCS quarterly tests. In addition they were administered the Test on Understanding Science (TOUS), a Hebrew translation of the Welch Science Process Test, the Biology Attitude Inventory, the Biology Process Test, the Practical Matriculation Test and the Written Matriculation Test.

The results of the measurements indicated that (1) BSCS was more widely accepted than was either PSSC or CHEM Study; (2) BSCS students were considerably superior in inquiry skills in practical laboratory problems to twelfth grade non-BSCS students who had CHEM Study; (3) when multiple regression analysis was used to study differential effects of BSCS, CHEM Study and PSSC, the only effect found was that of BSCS; (4) generally, the results of the three classes replicated one another; (5) post-hoc analysis failed to show significant differences between biology majors and non-majors on the matriculation examination; (6) significant differences in achievement were not found between boys and girls at the end of the 10th grade; (7) significant differences in achievement were found in favor of BSCS students of European parentage over those of non-European, and (8) BSCS students significantly outperformed non-BSCS in achievement.

Jungwirth and Dreyfus (164) sought answers to two questions, "First, at what level should 'understanding' be evaluated, i.e., What can be taken as symptomatic of such understanding?" "Second, how is understanding to be evaluated, i.e., What kinds of items or test (paper and pencil or practical, open or closed items) are appropriate?" The paper was based on a detailed analysis of the 1971 written examination [Israeli BSCS - Matriculation Examination] Part III only, i.e., that part of the examination dealing with the assessment of UNSE [Understanding of the Nature of Scientific Enquiry.]

The report deals mainly with an analysis of an item concerning a biological experiment, "Oxygen Poisoning in "Insects" followed by interpretation questions. The responses of about 750 students who took the examination in 1970-71 were used for the analysis. The overall results on UNSE left much to be desired except for "knowledge of conventions." The responses to the question asking for nitrogen controls were disappointing with more than half failing to make associations between "oxygen consumption" and "organisms still alive." This was judged to be a failure in biological, not enquiry, concepts.

Possession of knowledge of experimental procedures was not found to be a sufficient condition for success in applying such knowledge. Also, only one-third could respond correctly on the basis of given data. The students used "enquiry concepts" as "magic words" to explain phenomena in a manner contrary to the data supplied.

Kaplan (166) developed and tested a model for seventh grade biology consisting of five-multiple five-period sequences of lessons in six classes in four schools in 1969. The "child-centered approach" curriculum aimed at maximizing the performance of moderately disadvantaged students was later revised and tested in six experimental classes in comprehensive schools in 1970-71 and in five control classes in 1971-72. The emphasis was to move away from authoritarian teaching by means of units divided into five periods, four lessons and one assessment phase. The introductory lessons that had the verbal dissemination component consisted of three modes, (1) verbal presentation including discussion; (2) visual (reading); and (3) rote memorization of concept list. [Reviewer's note: This hardly seems an escape from traditional authoritarian teaching.] The laboratory period involved openended activities with mental operations required to solve problems. The analysis involved competency measures for students to assess their own comprehension and programmed lessons of about 50 frames that required from 10-100 minutes to complete. A "dry lab" was provided for enrichment with advantaged students. The units covered included "Water as a Habitat" and "The Organism and Its Environment." Inservice training was provided to enable teachers to use the new approach. The experimental students (n=154) were in the six classes in the comprehensive school and the control (n=151) were in the five classes in four schools. It is assumed that the control classes had the traditional program. Students were pre- and posttested on achievement and the Attitudes Towards Biology Test.

The results indicated that only by intensive efforts could teachers be "broken from" lecture-oriented content-centered didactic teaching. The differences in time to complete the programmed lessons were found to be significant, presumably a function of intelligence. Significant differences were found between the experimental and control groups in favor of the experimental in comprehension, positive attitudes toward biology, and in three of twelve interest areas.

The Philippines

Somers and Lagdamen (319) attempted to determine the intellectual differences between third and fourth grade Filipino children who had studies Science - A Process Approach (SAPA) for five months, and others who had been taught for an equal amount of time by traditional lecture and textbook methods. Of specific interest were the mental processes of observation, comparison and classification. An evaluation instrument was desired which (1) could be administered simultaneously to a group of children, and (2) did not depend on reading skill or the ability of a student to verbalize his understanding of certain concepts.

Tests for fourth and fifth graders were constructed consisting of a series of observations, comparisons and classifications of simple geometric

forms cut from colored paper. Circles, squares, triangles, trapezoids and isoceles triangles were used, either dark blue, yellow, light blue or red with each being made in three sizes. The subjects tested were 94 children from six classes of third graders, 54 assigned to an experimental group and 40 to a control group. In addition, six sections of fourth graders were subjects, 52 in the experimental and 45 in the control. All teachers received training in SAPA. The children were tested in small randomly selected groups. In the test, the geometric figures were presented to the children who responded in terms of the target mental processes.

T-tests were used to determine significant differences, and it was found that the SAPA students scored significantly higher than those in the traditional classes. Non-SAPA students seemed to have more difficulty in combinations of color and size variations. But, analysis of variance failed to show that brighter students did better than did slower students with similar science training. So internally, differences were not found within the experimental and control groups. One may question, therefore, as to whether the brighter students got SAPA.

Cruz (76) undertook an investigation to (1) design, develop, and field test a set of self-instructional materials on the basic science processes indigenous to Philippine resources and situations, and (2) evaluate the effects of this set of self-instructional materials on the achievement and attitude of preservice teachers.

The subjects were 114 third year undergraduate students in a one-semester course, Science for Elementary Teachers, at the Philippine Normal College, Manila, Philippines. The non-randomized control group pre-test and post-test design was used with two classes in each of the experimental groups one and two, and two in the control.

Prior to treatment all subjects were pretested for achievement for basic science process skills and on attitude using the semantic differential. However, only the experimental group was exposed to the self-instructional materials. Then, both groups were administered posttests on achievement on process skills and attitudes. F was used to test for significant differences.

The analyses led to the conclusions that (1) self-instructional materials were not found to significantly affect achievement on basic science process skills; (2) the materials were not found to have a significant influence on attitudes; and (3) significant differences attributed to different classes and different teachers were not found with respect to attitudes. There were, however, some interaction effects, the implications of which were not identified in the entry in Dissertation Abstracts International.

Australia

Owen (253) sought to identify factors based in schools that affected the sixth form science students in the schools of Victoria, Australia. The data were collected during study of science achievement by the International Association for the Evaluation of Educational Achievement. Data from a

sample of 37 schools were used, the probability of selection of the school being proportional to its enrollment. Within each school a random sampling of students in the sixth form was used for selecting those to be tested.

The students were tested during the latter part of 1970 in the final year of secondary school on performance in chemistry, biology, and physics and also were administered a pencil-and-paper test of practical skills. The test items were classified into four cognitive categories: functional information, understanding, application, and higher processes. Data were also collected on attitudes and family backgrounds.

The results of the analysis indicated that (1) many factors that had nothing to do with the school contributed to student performance, particularly the nature of the community, with the school possibly having a 30 percent influence; (2) males generally outperformed females; (3) in the better schools, there was greater concern with logical sequencing and control of science courses and standardized assessment; (4) in the "lower group," the academic training of science teachers was heavily weighted toward biology, and teachers taught more in other areas; (5) real differences were not found between students in better and "lower group" schools although more students in the better schools enrolled in science courses; and (5) students in the better schools had more external motivation.

India

Three studies were concerned with science education in India, one with science education in primary and middle schools, the second with students in medium schools, and the third with students in a university.

Duraiswamy (93) investigated the process of innovation diffusion among the primary and middle school teachers in Tamil Nadu, India. A major problem that faced educators and innovators seeking to improve the quality of science education in the region was that of widely disseminating and installing various innovations throughout the educational system.

Introductory material about the Discovery Method of teaching science was distributed to 500 of the target teachers who perceived the method as an innovation. By means of questionnaires, data were obtained concerning their personal and educational backgrounds and their reactions to the Discovery Method. The responses to the questionnaires were then analyzed.

The results indicated that teachers who perceive inservice programs as not being interesting or useful may constitute a resistance group. Although about 58 percent of all teachers thought such programs were interesting and useful, only 38 percent of those with six through ten years experience shared the view. Over 90 percent of the teachers indicated they were impressed with the Discovery Method but the analysis of responses to other questions revealed, that despite their favorable attitudes, they may be reluctant to use the Method in their classrooms.

The study supports the fact that innovations are difficult to implement, and the longer one teaches, the more resistant one usually becomes to using innovations.

Roy (295) compared the relative effectiveness of pictorial presentations and written passages on three classificational concepts in biology by Indians taught in English and Bengali. The subjects were 102 students from Bengali and English medium schools who were randomly assigned to two treatments and a control, with two groups each.

Written passages about three classificational concepts, geotropism, phyllotaxy and feathers, were described in a small booklet and single line drawings of the same three concepts with appropriate labels were included in another booklet. The two booklets, which served as independent variables, were used with the subjects who were all science students entering the tenth grade in Indian high schools in Calcutta. The materials on the concepts were taken from standard biology textbooks, some in English and some in Bengali. The treatment groups received the written and pictorial booklets and the control groups the standard material for a period of 40 minutes. Students were posttested, and then were administered a retention test seven days later. The tests included the Letter Sets Test, First and Last Names Test, Vocabulary Test and Auditory Number Span Test.

Analyses of the data failed to indicate that students taught in Bengali medium schools differed significantly from those taught in English medium schools; the means for subjects in Bengali schools on the posttests and retention tests were not found to differ significantly between written and pictorial material; both treatment groups performed significantly better than did the control; and treatment groups showed greater behavioral change in terms of concept acquisition than did the control.

The reviewer questions how any 40-minute experience, if he interprets the report correctly, can be used as a basis for research findings in a study of this type. Also, there is little evidence as to what was done with the control group.

Khedekar (170) reported the results of using, under Indian conditions, the testing materials that are available from the ACS-Examinations Committee. He administered a test to 159 students who passed the B.Sc. examination at the University of Poona and who were admitted to the M.Sc. Semester one. The test consisted of items from the ACS-NSTA High School Chemistry: Form 1963. The adaptation consisted of 68 multiple-choice items, 36 and 32 in Parts I and II respectively, that were approved by senior university teachers who were experienced as examiners.

An analysis of the test results indicated that that test does discriminate between good and poor students and that it could be considered of "average" difficulty and appropriate for the level of students sampled. It was indicated that the levels at which the test is appropriate in the two countries are different.

Basically, the reviewer questions the value of the study since practically any test will discriminate between good and poor students. Also, this was a high-school level test used with B.Sc. graduates.

None of the three studies in this section yielded consequential findings.

Southeast Asia

Vongchusiri (350) attempted to discover some of the effects of four alternative combinations of teaching strategies and teaching modes employed in teaching science concepts and rules to elementary school students. The combinations were (1) discovery strategy with object mode (D-O); (2) discovery strategy with graphic mode (D-G); (3) reception strategy with object mode (R-O); and (4) reception strategy with graphic mode (R-G). In discovery strategy the first two elements (definition and example) are developed by the teacher and the third rule is developed by the student. In reception strategy, all three are developed by the teacher. In graphic mode the thinking of students is guided by answering questions that the student has formulated from his reading. In object mode, materials can be physically manipulated.

The subjects were 810 students from three elementary schools in Thailand, 90 from each of the fourth, fifth, and sixth grades in the three schools. The students were pretested and on the basis of the scores were assigned to six equated experimental groups of 15 each. The students in each group performed tasks described on the worksheets under the strategy and mode to which they were assigned for one period. The study units on the worksheets dealt with movements of bones, the strength of electromagnets, and porosity of rock material. The amount of time required to complete each worksheet was recorded and the students were then administered a ten-item multiple-choice test that was readministered three weeks later to measure retention. F was used to analyze the scores.

The results of the analysis failed to indicate consequential differences among the combinations of teaching strategy and teaching mode. Differences in scores on retention tests could not be attributed to R-G, although D-O produced significantly higher scores on immediate achievement and retention tests, and R-G appeared to produce significantly lower completion times.

As with the previous study, the time for treatment seems much too brief to yield valid results.

Maddock (206) developed an attitude scale based on five objectives to measure the attitudinal components of the five stated aims of the Papua New Guinea Science Syllabus. The five objectives were related to (1) the study of natural phenomena by the use of investigation or experiment, (2) the use of the results of experiments and observation, (3) technologies being manmade developments, (4) the necessity of putting cultural models to the test of investigation if challenged, and (5) the need for modification of such models when investigations "show them wanting."

The scale, known as the Environmental Phenomena Attitude Scale, was developed through field trials with teachers in colleges and high schools, Pidgin speaking illiterate laborers, and others. The 26-item scale that emerged was administered in an interview format. Interviewed persons were 1,110 ranging in age from 14-35, including high school students in Form three and four, and people about the same age who spoke the same language but had little formal training. The sample interviewed had highland-coastal,

urban-rural and well-educated-illiterate dimensions. The interviewing was done by more than 100 interviewers who were trained in four languages, English, Pidgin, Hiri-Motu, Enga (Raiapo dialect).

The scores obtained from the administration of the scale indicated a big difference between those with schooling and those without, although the differences between persons living in the highlands and in the coastal regions, and those in urban and rural were not significant. The latter was thought to be surprising since the rural areas have low technology. Differences based on sex and those on ethnic background were not found to be significant.

The major conclusion was that the "well educated" have a more positive attitude toward investigation, manipulation and control of natural phenomena than the "less well educated" and so believe in the suceptibility of the universe to human ordering and understanding.

Maddock (207) used the Environmental Phenomena Attitude Scale (EPAS) whose development was described in the preceding study, to compare the responses of uneducated villagers in Papua, New Guinea with the responses that high school students predicted that the villagers would make. The EPAS was administered to both students and villagers and the students were asked to give reasons for their predictions. The differences between the predicted and actual responses were tested with t.

The analysis with t between actual and predicted responses was found to be significant, but the minimally educated villagers scoring much higher than predicted. Students who scored high on the EPAS predicted much lower scores for the villagers than students who scored low. The students apparently had contempt about the ability of the uneducated to handle modern technology but thought anyone could handle village technology. It was concluded that the attitude gap between students and uneducated villagers was widening.

Chao (62) attempted to ascertain whether or not the elements perceived in the physics concepts of mass and weight differed for students of different cultural backgrounds. Specifically, answers were sought to three questions: (1) What characteristics of conceptual elements are specific to a sample group of specific cultural background? (2) What characteristics of conceptual elements correlate to student performance on a test? and (3) What characteristics of a physical science conceptual scheme are specific to a sample group of specified cultural background. Data were collected on (1) the personal characteristics of the sample students; (2) elements involved in their concepts of mass and weight as perceived by the students on word association tests; (3) the physics problem set used to focus the students perceptions of conceptual elements; and (4) the level of importance at which the student ranked a conceptual element. The data were resolved into two categories, matching measures and test variables. The matching measures of sex, score on the California Short-Form Test of Mental Maturity, reading score, and average score in science including biology and chemistry were used to select two groups of matched students, 19 each from Worthington, Onio, and from Taiwan. The two groups were then compared on the test variables that dealt with the conceptual elements inherent in the problem of the study.

An analysis of the characteristics of the conceptual elements failed to indicate significant differences within the same culture, and the understanding of concepts of mass and weight by students from Worthington and Taiwan seemed comparable. Also, the importance of problem-related conceptual elements was perceived similarly by both student groups. However, Taiwan students associated more physical science and problem-related conceptual elements with the stimulus words "mass" and "weight" than did the Worthington students.

It was interesting to note that more than one-third of 45 problem non-related conceptual elements perceived in the stimulus word "mass" by Worthington students were related to religion but only one of 30 problem non-related conceptual elements perceived in mass by Taiwan students related to "quality," an implied meaning of "mass" in Chinese. Taiwan students used more high level physical terms in solving problems than did Worthington students. Taiwan students were more influenced by the problem set and evidenced less divergent thinking to the stimulus work "mass." The Taiwanians also showed more memorization than did their Worthington counterparts.

It was concluded that there are cultural effects on perceptions of physics concepts resulting from attitudes toward tests, learning processes, human relationships, and societal economic achievement.

The studies reviewed so far in this major section entitled FOREIGN SCIENCE PROGRAMS - HOW OTHERS DO IT, indicate that there has been some influence from the modern science programs developed in the United States that emphasize inquiry. But, it is clear that there has been little attempt to "swallow them whole." One detects efforts of these other nations to develop instructional materials and teaching strategies that are relevant to their own cultures and the levels of educational development of their students.

The problems that exist in these other countries with improving science education programs differ little from those that exist in the United States. These include the need for better qualified teachers, the lack of clearcut strategies for teaching inquiry, the insensitivity of evaluation instruments in measuring development of inquiry and attitudes, and the provision for inservice education. These problems have existed for a long time as evidenced in earlier literature. It is likely they will continue to plague science education for a long time to come.

Nuffield

The purpose of this summary is not to review the background of curriculum movements except insofar as they are the topics of research. Consequently, no attempt will be made to describe the genesis of the Nuffield Projects except to say that they are the English analogue of certain programs of the National Science Foundation, particularly the Course Content Improvement Program.

Nicodemus (241) indicated in his research report that "it was with recognition of the importance of a broader study based on a national sample

that we continued investigating the important influences on diffusion and adoption of 25 new curriculum projects. In this paper only teacher reported familiarity with and use of Nuffield O-level Biology and A-level Biological Science are considered."

In the spring 1973, questionnaires were sent to all science teachers in 167 maintained secondary schools in 17 Local Education Authorities to assess their familiarity with the two courses in question. Fifty-one percent of 849 teachers responded with one or more responding from 85 percent of the schools polled. The responses were made to a four-point familiarity scale and a five-point use scale. As a basis for comparison, teachers were classified into three groups: (1) using all or most of the materials (high); (2) using less than two-thirds but more than one-third of the materials (medium); and (3) no response, using only ideas, or using less than on-third of the materials.

The responses indicated that 51 were high, and 71 were low, users of O-level Biology materials; and 24 were high, and 99 were low, users of A-level Biological Science materials. Teacher familiarity with the materials was about the same for biologists and physicists but high for chemists, 55 percent of whom reported reading all or most of these materials. It was indicated that the survey showed wide dissemination and high adoption. The high users (adopters) indicated that four factors facilitated their use: (1) time for preparation; (2) availability of grants to start projects; (3) money to keep projects going; and (4) requirement of external examinations. High adopters appeared to be frequent users of specialist subject journals, science fournals, university staff consultation, and professional meetings. They also approved attitudinal objectives, ability of students to take responsibility for planning activities, and the need to develop students' abilities to work in groups.

The factors that facilitated were much the same as those that would be reported in the United States. It's obvious that those who use innovative materials are among the more professionally oriented teachers. The work "use" means exactly that, not the mere presence of materials in the classroom which happens all too frequently.

Three studies dealt with the Nuffield Advanced Chemistry Course. In one, The Department of Educational Research, Lancaster University (378) reviewed a number of developments with this course beginning with curriculum reforms in the 1950s with changes in the examinations for the General Certificate of Education. In general, these included the use of new techniques (objective type, multiple choice and structural questions); the introduction of examination specifications (quantitative statements of what the examination was designed to test); and an extension of teacher involvement (greater use of teachers in constructing the examination).

The Nuffield Advanced Chemistry Course and Examination were developed together in 1965-1968 with two years of practical and theoretical work. There were five distinct parts to the examination, Paper one - a 50-item multiple-choice objective test; Paper two - eight or nine structured questions, each with 45-50 subquestions; Paper three A - test attainment in a special study [this was not investigated in this Project]; Paper three

B - nine questions requiring imaginative responses, three to be answered; and assessment of practical work. The data from student papers were used in this study, with 86 percent of those of 694, 1970 candidates being considered, 97 percent of 1,084, 1971 candidates, and 33.7 percent of those of 2,174, 1972 candidates.

The analysis indicated that Paper two items discriminated better between high and low performance students than did Paper one; classification sets displayed the highest facility, with multiple completion the lowest. Also, it was found that topics dealing with the halogens and oxidation numbers, atomic structure, energy changes and bonding, and reaction rates seemed to be the least difficult and those with carbon chemistry and d-block elements the most difficult. Little difference in difficulty was found among items of knowledge, comprehension, and analysis.

In general, increased involvement of teachers with preparing the examinations did not concern the teachers even though their work was increased, and there did not seem to be anxiety in either teachers or students with the new emphasis on assessment.

Mathews and Leece (210) described the results of using examinations with the Nuffield Advanced Chemistry course that allowed freedom of choice and response, and listed some of the outcomes of assessing practical work internally by teachers. Nine questions for each of the years 1970, 1971 and 1972 were scored by two markers. The r's for total scores were .85 for 1970; .84 for 1971; and .82 for 1972 which were considered to be adequate. It was indicated that higher r's might indicate markers who were too lenient or too tough.

Of 3,208 answers in 1971, two markers differed by two grades on a 0-5 scale for 74 questions and three grades on three. It was found that the facility index was easy to compute on compulsory and structure questions, but not so easy on free response. The stronger students chose first type questions-problem solving, exact, mathematical - whereas the weaker tended to reduce their total scores by their choice of questions. Most students agreed that internal assessment by the teacher was more satisfactory than external assessment. On practical skills (laboratory) work the teachers seemed prone to give higher scores.

Leece and Mathews (196) attempted "to determine whether a more continuous process of change was possible using the outcomes of examinations as one source of information (as opposed to a batch process when a period of development and trials followed by publication of curricula and examinations that were not likely to change for a time). In order to do this, it was necessary to investigate a course to which an examination system had been specially matched, hence the use of the Nuffield Advanced Chemistry Course as the source of data." The scores obtained by students on the examinations for 1970, 1971 and 1972 were used in the one way analysis of variance to test mean discrimination indices and r's were computed between performance on each question and on the total examination.

The analysis indicated that structured questions discriminated significantly better among candidates than did the objective type for the

years taken separately, and combined. Questions that had the highest facility were classification, and the lowest, multiple completion. Classification questions were also found to have high discrimination power. An analysis of facility indices for topical breakdown did not indicate causes of apparent ease or difficulty of questions. It was suggested that topics may be intrinsically easy or difficult, the teacher may not be adequate, the topics may be above the intellectual level of the students, or school facilities and equipment may be inadequate - all these possibly affecting the facility indices.

It was not clear how this report was directed toward the stated purpose. Also, the three reports dealing with the Nuffield Advanced Chemistry Course dealt largely with development and "statistical massaging" of scores rather than with implications for teaching and outcomes of learning.

Two studies were found concerning the Nuffield Physical Science Course. In one study, Swain (329) designed a teacher questionnaire to evaluate details about (1) the type and size of Physical Science schools; (2) Physical Science and the curriculum; and (3) teacher perceptions of the course, its structure, time allocations, and "its interest and its difficulty." A similar student questionnaire was prepared for students to provide a basis for comparison. The questionnaires were circulated to all known Nuffield Physical Science schools (75) with responses from 69 (92 percent) schools, 178 from teachers and 596 from students.

Analyses of the responses indicated that slightly more than half of both students and teachers indicated that minor changes were needed in Nuffield Physical Science, and about one-fourth of each stated that major changes were needed. Less than 3 percent of each group rated the course as "excellent." The teachers claimed that the course, involving 14 basic topics with seven general and three "materials" options, was too extensive for the time allotted. More than three-fourths of teachers and students agreed that the boundaries between physics and chemistry had been removed effectively, and about 60 percent of the teachers and 50 percent of the students supported the allocation of topics. However, if pruning were necessary, chemistry should be cut. [Reviewer's note: Weren't the boundaries between physics and chemistry removed effectively?] Teachers thought that chemical equilibrium and intermolecular forces in the basic course, and thermodynamics and molecular spectrum in the general options, were difficult. Students, however, thought electromagnetic induction and oscillations were difficult. Students found electromagnetic radiation, covalent bonds, carbon compounds, electricity and atomic structure interesting. They indicated low interest in group relationships in the periodic table but didn't find them difficult.

A high r was found between teacher and student perceptions of difficulty, but a small r between pupil interest and perceptions of difficulty.

In a study complementing the one preceding, Swain (329) indicated that it had been the policy of the Nuffield Physical Science Project to investigate the influence of Nuffield Physical Science on schools' curriculum and also to record the destinations and future courses taken by candidates from the examination in 1973 and 1974. So the Nuffield Physical Science Schools were asked to complete record sheets for those years indicating student's

course schedules, grades, destinations in university or future education, and student's selection of university courses. An 86 percent return was received in 1974 for the 1973 graduates, and a 79 percent return in 1975 for the 1974 graduates.

A tabulation of the responses indicated that of the 69 of 75 schools returning record sheets, 43 were original trial schools. Twenty-nine of the schools enrolled only males, 12 enrolled only females, the remainder being co-ed. In 52 of the Nuffield Physical Science Schools, chemistry and physics were still taught. The classes in Physical Science were in general small, with enrollments ranging from 5-20. In most schools chemistry or physics was a requirement for enrollment in Nuffield Physical Science whereas in others there was no entry requirement. Students elected many different subject combinations with NPS but the most popular were mathematics, biology, geography and geology.

The "proposed educational destinations" of the students were not in agreement with the actual. Greater numbers "proposed" the university in 1974 than went in 1971, 1972 or 1973. Those who were enrolled in Nuffield Physical Science entered engineering, mathematics, medicine and other sciences in higher education in large numbers.

The studies of the Nuffield Project indicate that research is still in the "counting stage." As of 1975, there were no long-range longitudinal studies about the successes and failures of students who participated in the various curriculum projects. If and when these are undertaken, some valid judgments can be made about Nuffield. The same, however, can be said about the projects funded by the National Science Foundation.

An Epilogue

This Summary of Research in Science Education - 1975 has been extensive with many intermediate summations and generalizations at the end of sections and subsections. The introduction also contains some comments that could be considered generalizations. Consequently, another summary here would be redundant. However, a few points may be worthy of consideration.

If one were to rate the quality of writing in research reports including articles, monographs and dissertations on a scale of A to E, the reviewer believes that a mean rating of C may be charitable. This is distressing when one realizes that practically all of those who prepare the reports are well along in their educational careers. The current concern with mediocrity in communication at the elementary and secondary school level certainly is applicable at the level of the graduate school and particularly with the products of doctoral programs.

The terminology used in many reports would in many circumstances put a federal bureaucrat, assigned the task of writing regulations, to shame. The incomprehensibility of much that is written is astonishing. Also, the use of acronyms such as SART, CACKLE, NOST, FTCFL and the like, particularly with investigator-made tests, the reliability and validity of which are highly questionable, has reached ridiculously epidemic proportions. One may

also emphasize the need for training researchers to prepare comprehensible and valid abstracts, for many of those in Dissertation Abstracts International are neither.

There is little wonder that research findings are not widely disseminated. Far too many reports are too difficult to read, and if deciphered, are found to deal with trivialities.

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