

AN ABSTRACT OF THE THESIS OF

JOHN MICHAEL HOOVER for the DOCTOR OF EDUCATION  
(Name) (Degree)

in EDUCATION presented on August 12, 1976  
(Major department) (Date)

TITLE: THE EFFECTS OF THE SCIENCE CURRICULUM  
IMPROVEMENT STUDY (SCIS) ON SCIENCE ACHIEVEMENT  
OF SELECTED SIXTH GRADE STUDENTS  
**Redacted for Privacy**

Abstract approved: \_\_\_\_\_  
Dr. Carvel Wood

Purpose of the Study

The purpose of this investigation was to measure some of the effects of an elementary science program, the Science Curriculum Improvement Study (SCIS) on science achievement of certain sixth grade students. Important to the problem was how the SCIS students compared with students exposed to a second elementary science program, Experiences in Science (EIS).

Design of the Study

The subjects included in the study were sixth grade students enrolled in the Corvallis Intermediate schools or the Albany Elementary schools during the 1975-76 school year. There was a total

of 506 students in the Corvallis population and 324 students comprising the Albany group. The Corvallis students were considered the experimental group and were exposed to the SCIS program during the treatment period. The Albany sixth grade students were exposed to the EIS program and constituted the control group. Student assignment to the various schools and classes was determined by school attendance boundaries and computerized scheduling.

The elementary battery of the Analysis of Learning Potential (ALP) was administered prior to the treatment period as a group equivalent indicator. The science sub-test of the Comprehensive Tests of Basic Skills (CTBS), Level 2, Form S, was administered as a pre- and post-test during the first and fourth quarters of the school year.

#### Findings of the Study

The findings of the study are presented in terms of the two major hypotheses tested.

$H_{01}$ : There will be no significant difference between the mean scores of the SCIS group as taught in the Corvallis sixth grade as compared with the EIS group as taught in the Albany sixth grade.

Hypothesis 1 was retained. There was no significant difference between the CTBS mean scores of the experimental and control groups.

$H_{02}$ : There will be no significant difference between the mean scores of the SCIS group as taught in the Cheldelin, Highland View and Western View sixth grade as compared with the EIS group as taught in the Albany sixth grade.

Hypothesis 2 was retained. There was no significant difference between the CTBS mean scores of the Cheldelin, Highland View or Western View populations as compared with the Albany control group.

#### Conclusions of the Study

1. There was no significant difference in the science achievement of the students exposed to the SCIS program in the Corvallis sixth grade as compared with the students exposed to the EIS program in the Albany sixth grade.
2. There was no significant difference in the science achievement of the sixth grade students in the SCIS program at Cheldelin, Highland View or Western View Intermediate schools, as compared with the sixth grade students in the Albany EIS program.

#### Recommendations for Further Study

1. This investigation covered a time span of approximately 29 weeks. Longitudinal studies are recommended that would investigate students' retention of outcomes and

learnings as they may influence achievement in other science areas.

2. Although the SCIS program has been a part of the Corval-lis elementary school curriculum for some time, it was not recommended for use in all sixth grade classrooms until the 1975-76 school year. It is recommended that a future study be carried out to determine the effectiveness of the program after it has been more thoroughly implemented into the sixth grade.
3. The literature reveals several studies dealing with the effects of the SCIS program on achievement in other areas. It is recommended that a study of this nature be carried out at the local level.
4. This study placed a heavy emphasis on the significance of Piaget's philosophies in the development of the SCIS and EIS programs. It is recommended that further studies investigate the importance of an understanding of Piaget's theories to good teaching.

The Effects of the Science Curriculum Improvement Study  
(SCIS) on Science Achievement of Selected  
Sixth Grade Students

by

John Michael Hoover

A THESIS

submitted to

Oregon State University

in partial fulfillment of  
the requirements for the  
degree of

Doctor of Education

Completed August 1976

Commencement June 1977

APPROVED:

# Redacted for Privacy

~~Professor of Education~~  
in charge of major

# Redacted for Privacy

~~Dean of School of Education~~

# Redacted for Privacy

~~Dean of Graduate School~~

Date thesis is presented Aug 12, 1976

Typed by Velda D. Mullins for JOHN MICHAEL HOOVER

## ACKNOWLEDGEMENTS

The writer wishes to express his sincere thanks and appreciation to Dr. Carvel Wood, who as a major professor furnished that never failing "pat on the back" so many times throughout this study. His expressions of friendship, guidance and confidence served as a most necessary catalyst throughout this doctoral program.

Appreciation is also expressed to Dr. Gerald Becker, Dr. Fred Fox, Dr. Lafayette Harter and Dr. Robert Storm who gave so willingly of their time and efforts as members of my doctoral program committee.

A special thanks to Dr. Wayne Courtney who always seemed to have time for one more word of advice and direction through the statistical analysis of this study. His unselfish efforts and professional dedication will always be remembered.

Sincere appreciation is extended to the administrators, counselors, testing specialists and sixth grade teachers in the Corvallis and Albany school districts for their encouragement and cooperation.

Finally, a very special thanks to my wife Glenne and our sons, Mike, Jim and Mark, for the many sacrifices, concerns and disappointments which they have shared with me throughout the course of this doctoral study.

## TABLE OF CONTENTS

<u>Chapter</u>		<u>Page</u> °
I	INTRODUCTION	1
	The Psychological Basis of Elementary Programs	2
	Purpose of the Study	7
	Hypotheses Tested	8
	Assumptions of the Study	9
	Limitations of the Study	9
	Need for the Study	10
II	REVIEW OF SUPPORTING LITERATURE	18
	The Science Curriculum Improvement Study (SCIS)	18
	The SCIS Program Overview	26
	Psychological Background for the SCIS Program	30
	The Life and Philosophies of Jean Piaget	32
	The Piagetian Stages of Development	39
	Experiences in Science (EIS)	45
	The Comprehensive Tests of Basic Skills (CTBS)	49
	The Analysis of Learning Potential (ALP)	56
III	DESIGN OF THE STUDY	61
	The Populations	61
	Treatment Procedure	62
	Data Collecting Devices and Techniques	63
	Treatment of the Data	65
	Teacher Questionnaire	69
IV	RESULTS OF THE STUDY	70
	Introduction	70
	Part A - The Status of Teacher Preparation and Attitudes Toward the SCIS and EIS Programs	70
	Summary of Part A	76
	Part B - Findings of the Statistical Analysis Used in this Study	77
	Summary of Part B	87

<u>Chapter</u>	<u>Page</u>
V SUMMARY, DISCUSSION, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS	89
Nature of the Problem and Purpose of Study	89
Review of Related Literature	90
Design of the Study	99
Findings of the Study	102
Discussion	104
Conclusions	108
Implications	109
Recommendations for Further Study	110
BIBLIOGRAPHY	112
APPENDICES	
Appendix A - Comprehensive Test of Basic Skills	120
Appendix B - Concepts Covered in the SCIS Program	121
Appendix C - Units Covered in the EIS Program	123
Appendix D - The Analysis of Learning Potential	124
Appendix E - Science Questionnaire	125
Appendix F - Science Questionnaire	126
Appendix G - Experimental Group ALP and CTBS Pre- and Post-Test Scores	127
Appendix H - Control Group ALP and CTBS Pre- and Post-Test Scores	129
Appendix I - Pearson Product Moment Correlation Coefficient (r) Formula	131

## LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Frequency distribution of teachers who taught the EIS program during the 1975-76 school year.	71
2	Frequency distribution of teachers who taught the SCIS program during the 1975-76 school year.	71
3	Frequency distribution of EIS teachers who have had in-service or other formal training in the EIS program.	72
4	Frequency distribution of SCIS teachers who have had in-service or other formal training in the SCIS program.	72
5	Frequency distribution of formal training of the EIS teachers.	73
6	Frequency distribution of formal training of the SCIS teachers.	73
7	Frequency distribution of teacher estimated hours per week teaching EIS.	74
8	Frequency distribution of teacher estimated hours per week teaching SCIS.	74
9	Frequency distribution of teachers' opinions on qualifications for teaching the EIS program.	75
10	Frequency distribution of teachers' opinions on qualifications for teaching the SCIS program.	75
11	Frequency distribution of teachers' opinions on the EIS program meeting their needs and needs of their students.	75
12	Frequency distribution of teachers' opinions on the SCIS program meeting their needs and needs of their students.	76

<u>Table</u>		<u>Page</u>
13	Table of mean scores using CTBS as pre- and post-test.	79
14	Analysis of Covariance using CTBS pre- and post-test.	80
15	Mean raw scores on ALP and CTBS pre-test and Pearson "r" correlation coefficient.	81
16	Analysis of covariance using CTBS pre- and post- test (Cheldelin and Albany).	83
17	Analysis of covariance using CTBS pre- and post- test (Highland View and Albany).	84
18	Analysis of covariance using CTBS pre- and post- test (Western View and Albany).	85
19	ALP mean scores and adjusted CTBS mean scores for Cheldelin, Highland View, Western View and Albany.	86

# THE EFFECTS OF THE SCIENCE CURRICULUM IMPROVEMENT STUDY (SCIS) ON SELECTED SIXTH GRADE STUDENTS

## I. INTRODUCTION

Much momentum in science curriculum has been generated in the past two decades by the development of new programs such as the Physical Science Study Committee (PSSC), Chemical Education Material Study (CHEMS), Chemical Bond Approach (CBA), and the Biological Science Curriculum Study (BSCS). This momentum has moved into the junior high and intermediate schools in the form of programs such as the Earth Science Curriculum Project (ESCP), Intermediate Science Curriculum Study (ISCS), and the Introductory Physical Science (IPS). The focus of this attention has more recently shifted to the elementary schools with the development of many private and federally funded programs.

Fletcher G. Watson (1967) stated that statistically the secondary programs have been failures in the sense that present enrollment has not increased in physics and chemistry. Glatthorn (1968, p. 12) criticized the programs as being designed for the top students preparing for careers in science, and lacking the psychological basis on which to build the curricula, when he stated:

They (the new programs) were devised by scholars, were subject centered, were supported by federal funding, were packaged by large corporations, and designed to appeal to the mass

of schools. . . the major curriculum projects have done an excellent job of identifying the structures of a given discipline but they have also left undone. . . .

The "undone" that Glatthorn is referring to is that programs were designed to meet the needs of the more capable students who were planning on entering college. He also maintains that many of these programs were not conceptualized upon a sound psychological basis such as Piaget's stages of mental development.

Many of the new elementary programs, on the other hand, are designed with a broad base, in an attempt to include all normal children, and efforts have been made for individual differences. Further, programs such as the Elementary Science Study (ESS), Science a Process Approach (AAAS), Experiences in Science(EIS), and the Science Curriculum Improvement Study (SCIS), were developed on a child oriented psychological basis.

#### The Psychological Basis of Elementary Programs

The psychological foundation on which many of these elementary science curricula are based has its origin in the work of Jean Piaget, Swiss Director of the Jean Jacques Rosseau Institute in Geneva, Switzerland. Karplus (1967, p. 20-21) cited Piaget's work as the psychological basis for SCIS:

It is, therefore, the responsibility of the schools, to guide the children's development by providing them with particularly informative and suggestive experiences. . . . The awareness

just described is due in large part to the Swiss psychologist Jean Piaget . . . .

In the older programs such as AAAS, the influence of Piaget is seen in the discussion of the primary child whom Gagne' (1965, p. 21) described as an, "egocentric individual, incapable of handling many logical operations which are fundamental in adult manipulation of the world". These logical operations may be traced to Piaget's Concrete Operational Stage and certain conservation tasks which Piaget has empirically determined.

The importance of Piaget's work is exemplified in a description of the ESS program by Voelker and Rogers (1970, p. 38) when they referred to "using concrete things and the children's active involvement in learning". Thier (1973, SCIS Omnibus, p. 91) referred to implications of the Piagetian theory for teaching the SCIS program:

Piaget's theory of learning and development offers you many guidelines for improving instruction.

If we understand the stages of child development, we can plan and present a more relevant curriculum. We can give the young child the experiences he is ready for; we can give him experiences that will help lead him to the next stage of growth; and recognizing his misconceptions, we can give him experiences designed to correct them.

Thus, where the primary grade child is at the pre- or early concrete operational stages of development, Piaget's theory points up the value of extensive experience and activity in all subject areas. The learner needs to experience and act upon the various objects and events in his environment. And in his reaction there is a regulation of self which leads to development of learning . . . .

Piaget's ideas suggest that the reading program can be strengthened using childhood experiences as a basis for constructing stories, then using these stories as basic reading material for the group. Class discussions of classroom experiences can lead to the development of oral language skills which are so important a preliminary to formal reading.

The science program offers many opportunities for involving children with the real objects and systems which make up their environment. Such work is best done in small groups to foster social transmission. For example, small groups might dissolve rock salt in water, then discuss what happens to the salt and attempt by various means to get the salt back again. This would make evaporation real and promote understanding of conservation . . . .

A complete understanding of the ideas involved probably will not take place during the series of lessons or even in the primary grades. But in Piaget's view, there is no need for absolute standards; the emphasis is on the individual learner and his experience and development . . . .

What Piaget's findings call for, in essence, is what one might call a process of guided discovery, with the teacher acting as the expert individual who analyzes the children's interaction with their environment and, on the basis of this analysis, suggests further curricular experiences for the group or individuals in the group.

The accomplishment of this is difficult but will become more possible as curricular materials are developed based on the structure of the various disciplines and a careful consideration of Piaget's theory of intellectual development.

Karplus (1973, SCIS Omnibus, p. 31) referred to a unit in the SCIS program, "Variation and Measurement" which was developed around Piaget's conservation tasks:

The next topic on the first level is treated in the unit on Variation and Measurement. The tasks here are more difficult because understanding measurement presupposes an awareness of the constancy of the measuring instrument under the changes it undergoes (displacements, for example) as it is used to

compare different specimens. The children must also be aware that some changes (e.g., bending of a yardstick) may make the instrument no longer suitable for carrying out measurements. Piaget's work has shed much light on the formation of these conservation concepts, and his findings were considered in the construction of the unit . . . .

Studies by Newman (1969) and Allen (1967) found that children experiencing the new programs do no better than children experiencing traditional science programs when tested for conservation acquisition. Weber (1971) completed a study conducted through the University of Oklahoma's Science Education Center to determine the level to which SCIS develops the learner's ability to use selected science processes. The assessment was made by comparing the performance of a group of SCIS students with that of a group of non-SCIS students on a series of science process oriented tasks. Weber considered this a valid means of determining how effectively the SCIS curriculum is accomplishing its objectives. A special process instrument was designed to assess student performance on a series of 34 tasks. The reliability and validity of the instrument were ascertained to be acceptable to the researchers before it was used in the study. Two groups of subjects were selected. The experimental group consisted of 46 fifth grade students who had experienced only SCIS science units since entering the first year of school. The control group consisted of 69 fifth grade students who had been in a conventional, textbook based science curriculum since they entered their first year of school.

Statistical treatment of the results showed the SCIS group to be clearly superior in regard to the processes of observation, classification, measurement, experimentation, interpretation and prediction.

Stafford (1969), in a comparison between traditional elementary science programs and SCIS, found a significant difference on Piagetian conservation tasks. In another research project, directed by Stafford, the same six conservation tasks used in the first grade study were administered in pre- and post-tests to kindergarten children in experimental and control classes. The results indicated that kindergarten children can benefit from many activities of the SCIS first-year unit Material Objects, and that they enjoy doing them.

A study was carried out by Kellogg (1971) at the University of Oklahoma during the 1970-71 school year to determine whether the SCIS Material Objects unit positively influences reading readiness. Control and experimental groups were selected from first grade classes in the public schools in Ada, Oklahoma. The 32 students in the control group experienced a commercial reading-readiness program, while the 37 students in the experimental group used the Material Objects unit instead of a reading readiness program. The results indicated that the experimental group showed greater gains in five of the six subtest areas of the Metropolitan Reading Readiness Test.

In another study conducted by Coffia (1971), the effects of the

SCIS curriculum on achievement in other subject areas was considered. The Stanford Achievement Series, 1964 edition, was administered to control and experimental groups during the fifth month of entry into the fifth grade. The study involved 115 fifth grade pupils from two elementary schools, the same subjects used by Weber (1971) in his investigation. Forty-six pupils from the school who had utilized the SCIS program for five years comprised the experimental group. Sixty-nine subjects from the companion school, which used a textbook-based science curriculum, comprised the control group. Raw scores of the two sample groups in the Stanford Achievement Series were analyzed. The experimental group outscored the control group numerically on every subtest. A statistical comparison of the seven academic areas investigated revealed differences between the two groups in mathematics applications, social studies skills, and paragraph meaning. On the other hand, no significant differences were found in mathematics skills and concepts, social studies content, and word meaning.

#### Purpose of the Study

The purpose of this investigation was to compare some of the effects of the SCIS program as taught in the Corvallis sixth grade with the EIS program as taught in the Albany sixth grade during the 1975-76 school year. The testing instrument used was the

Comprehensive Test of Basic Skills (CTBS), Level 2, Form S (Appendix A). Adjunct to the fundamental purpose will be an analysis of the responses made by teachers involved in the study to a questionnaire relevant to the programs being evaluated. Although the administrators of the school districts involved in the study have made a concerted effort to launch and facilitate the use of the SCIS and EIS programs, individual teachers do have latitude within which they may function in presenting the materials. Thus, it may be more accurate to state that this study attempted to compare the SCIS and EIS programs as they were taught in the respective school districts during the 1975-76 school year.

Specifically then, the questions this study attempted to answer were:

- 1) Will students who were exposed to the SCIS program have a greater mean score on the CTBS than the students in the EIS program?
- 2) What formal training, commitments and opinions do teachers have relative to the SCIS and EIS programs?

#### Hypotheses Tested

The investigation was designed to test the following hypotheses during the 1975-76 school year:

$H_{01}$ : There will be no significant difference among the mean scores of the SCIS group as taught in the Corvallis sixth grade as compared with the EIS group as taught in the Albany sixth grade.

$H_{02}$ : There will be no significant difference between the mean

scores of the SCIS group as taught in the Cheldelin, Highland View and Western View sixth grade as compared with the EIS group as taught in the Albany sixth grade.

#### Assumptions of the Study

Because of the nature of this study certain factors were impossible to control, thus it was necessary to establish the following assumptions:

1. Class period time spent in science during the treatment was approximately equivalent for each student population.
2. The teachers involved in the study followed the "broad" directives of the respective programs, while exercising certain prerogatives to emphasize or modify various units as circumstances so dictated.
3. Similarity of the experimental and control groups was determined by the pre-test.

#### Limitations of the Study

The following limitations were established in order to keep the study in proper perspective:

1. Since the sample population was small in terms of the number of students and classes involved, there was no evidence that the findings in this study were typical in all schools and

- classes involved with similar programs.
2. The experimental and control groups from which the random samples were drawn constituted naturally assembled, computer selected classroom populations, as similar as availability permitted but it was not established that the groups were, in fact, equivalent.
  3. Although many of the teachers involved in the study had some formal training in the programs involved, no effort was made to equate their experience, training, expertise or interest in the science area.
  4. The inherent complexities involving spontaneous verbal and non-verbal exchanges are impossible to control. Therefore, this study was limited to "mean scores" on the science sub-test of the CTBS.
  5. This study was not designed to make individual teacher, school or district comparisons.

#### Need for the Study

Every project for curriculum development includes the concept of assessment or evaluation. From a theoretical point of view, evaluation plays an important part in improving programs in several ways. Purposes can be selected, for example, on the basis of good data about the nature of society or the nature of the learner. Or, content,

experiences, organization, and methodology can be set forth in testable form. For instance, rather than assuming any particular selection of content or sequence of experiences or methodological approaches or organizational strategies is effective, one can hypothesize about these things, and then proceed to put these hypotheses to an empirical test. Over a period of time such evaluative and assessment techniques should enable steady progress in terms of improving programs. Any view of the educational scene suggests that programs are changing dramatically. At no time in the history of American schools have curricular changes been so widespread or so intensive as in the past two decades. Modifications of course content, organizational structures, methodologies, evaluation procedures, and even purposes themselves have been instituted. Changes in curriculum have been extensive and many have been positive, but Frymier (1970, p. 8) referred to the inadequacies of the American curriculum today when he stated:

Curriculum workers are dissatisfied, and they are continuously struggling to find new and more powerful ways to improve programs. This is partly because of a kind of gnawing professional perspective which says: "No program is perfect. We must improve." But they are dissatisfied most of all because of the very real fact that too many children hate the very thought of having to learn in school.

Too many children find school a boring, unexciting place to be. Too many are unsuccessful in acquiring ways of behaving which seem appropriate and desirable to people responsible for their learning. Why? Many factors probably account for such a state of affairs today, but two are suggested here. We can ask the wrong questions in curriculum, and we can use assessment ineffectively as part of the total educational scheme.

Frymier suggested the correct question that should be asked about curriculum development is the effectiveness question. Does the new program, do the new materials, will the new techniques enable students to learn more, better, faster, than some other approach? Does it make a significant difference in the lives and minds of those we teach? If it does, the program is effective. If it does not, the program is ineffective. Another, more elusive problem affecting program development, however, stems from the fact that education is a social system with a conceptual flaw. Every effective social system reflects three phases of operation which accomplish separate functions that enable the system to maintain itself in a dynamic way. The first phase includes the intellectual activities: planning, policy-making, and hypothesizing; the second phase: the doing, accomplishing, and effecting; phase three, the evaluating, assessing, reflecting, and judging. Taken together, they represent various aspects of social undertakings designed to allow the system to accomplish the objectives toward which it is aimed, and at the same time continue to improve its operations. These three phases are most clearly illustrated in our concept of government. The planning phase is represented by the legislative branch. The doing phase by the executive branch, and the evaluating or assessing phase by the judicial branch. In industry the model still applies; somebody plans, somebody produces, and somebody judges the effectiveness of activities in a

realistic way. Thus, any careful study of social systems other than education suggests that these three functions are relatively discreet, and that they are accomplished by different groups, each one of which has a realm of power. That is, the Congress, the President, and the Supreme Court are distinct entities. The same principle applies at the state and local level of government.

The significant point to be made here is the fact that fully-functioning social systems in any open society actually depend upon the third phase of the operation to assure improvement and intelligent change. If the courts decide that a particular law is constitutional or unconstitutional, or that a particular action by the executive branch of the government either is or is not appropriate, they feed back into the system new data which guarantee that the enterprise will be able to change itself and to improve. The same process is true in industry, where planning and producing a new product or service represent the first and second phases of that social system in operation. After the product goes on sale, however, evaluation must occur. If the general public buys the product or service, they really are feeding back into the system new data that indicate to those responsible for planning and production that the job has been well done. If the public refuses to buy, corrective feedback indicates that a product or service is not satisfactory and must be changed. In either event, evaluation plays the critical role of providing corrective feedback to the other parts of the system so that the entire operation can be improved.

If we view the public schools in terms of such social system models, they appear to have a conceptual flaw. School boards accomplish the policy-making role. Professional educators undertake the effecting, implementing, doing role. But no special group's responsibilities encompass the assessment function in any meaningful way. Often the general public may pass judgment on the effectiveness of schools, but seldom do they have a way of communicating their concerns with precision and dispatch to assure improvement in schools. Bond issues may be voted down, but no one is able to discern the many implications of this type of action in terms of curriculum evaluation or improvement. Curriculum and advisory councils often attempt to perform the evaluation role. However, because their recommendations are advisory, no one has an obligation to pay attention to the feedback. No aspect of the educational system regularly generates evaluative-type data, nothing in the concept requires that teachers and administrators outline and conduct a curriculum evaluation program on any regular basis. Frymier (1970, p. 11) refers to the need for local school evaluations:

This description of the reality, though, suggests exactly where we need to apply our energies if we really want curricula to be improved: program evaluation. Some might suggest an "outside" evaluation agency or group, such as "national assessment" or "statewide testing" to fill the void described. Our position is that local districts can and must undertake the evaluation activities themselves.

Educational professionals, working together in local

districts, must devise concepts and procedures for evaluating the programmatic activities in local schools. This book describes in specific terms many approaches to that problem area which one might follow, but the point is, either local schoolmen must generate and use evaluative-type data to improve the program in schools, or accept on faith the many curriculum materials and projects which appear.

However, the history of curriculum development activities in the last decade suggests that very few innovations are evaluated empirically either during development or after they appear fairly widespread on the educational scene. Further, evaluative data typically comes from those who have participated in the development of the new materials or new organizational or new methodological approaches, and utility of these data must be questioned in other situations with other teachers and other students than those originally involved. These evaluative data are essential if people in local schools hope to improve their educational programs, and customarily will have the greatest utility and impact if they concern teachers and students in their own schools.

According to a recent survey conducted by Thompson (1974, p. 82) involving 10,402 elementary teachers representing 902 elementary public schools in the State of Oregon, 58 percent of the teachers responded "no" to the question, "Is any provision made for evaluating the total science program in your school or district?" The same survey by Thompson showed that the SCIS program is being used in a slightly greater percentage of the schools than is the

EIS curriculum with 59 percent of the teachers indicating they were satisfied to highly satisfied with their present programs.

Since the initial pilot program with SCIS and EIS materials in the Corvallis and Albany school districts, parents, teachers, and administrators have been concerned about the additional cost and effort inherent in these programs. According to Johnson and Brown (1974, p. 1) the cost of the SCIS is higher than the traditional textbook approach:

SCIS requires more funds than a regular textbook science program. In addition to the requirement of special teacher training or inservice, there are special classroom kits to purchase and to refill after a unit is completed by a class. Assuming an elementary school with 300 pupils in grades 1 through 6 using SCIS in all grades, the cost of books, materials and teacher training of a SCIS program is \$6.80 per pupil per year or \$2,035.00 for the school per year. It is estimated that a regular textbook science program would cost about \$2.00 per pupil per year for books and materials or \$600.00 for the school year. Therefore, SCIS costs approximately  $3\frac{1}{2}$  times more in books and materials.

The same study however concluded that although the SCIS program did cost more in materials than a regular textbook science program, there was evidence based on student questionnaires that students had a more favorable attitude toward science and also higher achievement in science as measured by the Metropolitan Achievement Test. Science sub-test scores attained on the Metropolitan Achievement Test in April, 1973, showed sixth grade SCIS students significantly  $\alpha=.05$  higher than the non-SCIS students. However, the study also revealed no significant difference between SCIS and non-SCIS

students at the fifth grade level. Tanner (1971) conducted a study that included 262 elementary pupils in grades 1, 2, and 3 in the Corvallis schools. A group of 135 pupils who had received instruction in science in SCIS as a part of their school day and a control group of 127 who were in non-SCIS primary classrooms were involved. Pupils were asked by their teacher to name their three favorite subjects, and their single most favored subject. The results showed that the SCIS students listed science among their three favorite subjects three times as frequently as did the non-SCIS groups. Science was named as the single most favored subject by 14 percent of the SCIS students while only 2 percent of the non-SCIS students chose science as their favorite subject.

The assistant superintendent of instruction, for the Corvallis School District and the superintendent of the Albany Elementary School District have both expressed a need for a more extensive evaluation of the elementary science programs in their respective schools. These concerns for continued curriculum evaluation and improvement have set the stage for this investigator's interest and pursuit in attempting a more extensive study in this area.

## II. REVIEW OF SUPPORTING LITERATURE

### The Science Curriculum Improvement Study (SCIS)

In July, 1959, with financial support from the National Science Foundation, a group of scientists and educators at the University of California, Berkeley, began a study directed toward curriculum improvement in elementary school science. These scientists, under the direction of Dr. Robert Karplus, Professor of Physics, University of California, Berkeley, hoped to reorganize the science program around what they considered important and fundamental concepts. They felt that an understanding of these concepts ultimately would lead the student to an understanding of many diverse natural phenomena and to a feeling of familiarity with the natural environment. The scientists intended to stress the concepts and the methods of science, rather than the uses and the applications of science so often stressed in "traditional" science programs. It was the belief of this group that children should be made to feel that scientific concepts and methods are tools to be used to interpret or explain what they observed.

The net results of the year's activities were to confirm Dr. Karplus' belief in the importance of science instruction in the elementary school and to strengthen his convictions that scientists can make a

substantial contribution to a reformulation of the science curriculum. The cooperating scientists participated personally and actively by selecting topics, by originating teaching approaches, and by observing the pupils' gains. In this work the scientists were assisted by a technical writer who was an engineer and who had a background in university teaching. The cooperating scientists were assisted also by three teaching consultants who had been highly effective as teachers in elementary schools but did not have a special background in science.

The evaluation of the materials was directed by an educator and carried out by 18 teachers, one in each of the first six grades in each of three differing socioeconomic areas. About 500 pupils were involved, ranging in intelligence from quite low to exceptionally high, with an average intelligence quotient of about 115. It was necessary for the scientists and the staff members to conduct experimental classes, in order to formulate "lessons". The classes were conducted in public schools. A scientist or teaching consultant, who was responsible for preparing curriculum materials, led the instruction for one or two hours a week. The regular teacher remained as an observer and advisor. In these classes the pupils' reactions to a tentative teaching approach were observed.

The instructional program developed in this way was later put into a form that the laboratory teachers were to use. The project

provided all the equipment for demonstrations, for group experiments, and for individual pupil experiments. The laboratory teachers were introduced to these materials at a workshop before the instructional period. Project members visited the schools frequently to observe the teaching, answer questions and encourage teachers in their efforts.

The scientists selected the subjects to be included in the first year's program. In making their choice, they followed their interests and assumed that the topics they chose could be made meaningful to elementary school pupils. The only criterion was that the topic deal with a fundamental aspect of nature. The construction of a conceptual framework for the entire science curriculum was postponed until experience showed what could be accomplished in the classroom.

Three units were prepared by the project and tested by the laboratory teachers. The units were entitled "Coordinates", "Force", and "What Am I?" (human physiology and biochemistry). From the first unit, "Coordinates", teachers and pupils learned that coordinates are numbers that may be used to locate a point with respect to previously designated reference lines. One well-known example is the use of latitude and longitude to locate a point on the globe with respect to the equator and the Greenwich meridian. The subject was introduced to pupils by means of a picture graph. The children drew and numbered the coordinate axes as the teacher dictated the points to be connected,

basing the dictation on exercises listed in the teacher's manual or on exercises she made up. Sometimes the pupils made up lists of points and dictated them to one another.

A second section of the unit was devoted to the use of graphs to display a relationship between two quantities, such as the time elapsed on an automobile trip and the distance traveled. However, in the experimental use of this section, some of the teachers considered the discussion too abstract. It was their conclusion that the main problem in the teaching of graphical representation of relationships was to teach the notion that a certain distance on a piece of paper can represent different types of quantities, such as a time interval, a weight, a speed, or other quantities.

The unit on force was to serve as an introduction to Newton's laws of motion. The student's experience with pushes, pulls, and weight was used to introduce the word "force" and to establish the fact that in an interaction, two opposite forces are present. The unit was issued in three parallel versions. An abbreviated version, which considered only the qualitative features of the subject, was prepared for use in first grade. In the version for the second, third, and fourth grades, the author made an attempt at a careful, systematic development, in which forces (for example, electric, magnetic, gravitational) acting in various situations were introduced through experiments and illustrated in diagrams. The version for fifth and sixth

graders covered the same material more quickly but went on to a lesson on circular motion.

The third and last unit prepared in 1959-60 was entitled "What Am I? (Human Physiology and Biochemistry)." The purpose was to make the students aware of their own bodies as biologic units which consist of a number of interacting physiological systems (skeletal, muscular, nervous, digestive, circulatory, and respiratory) that perform various physical and biochemical functions.

The materials included a good deal of descriptive matter; nevertheless, observation and experimentation were stressed, with the students serving as their own experimental subjects. A section on embryonic development included instructions for the incubation of chicken eggs. Eggs were opened at regular intervals to reveal the growth of the embryo. For the fifth and sixth graders, additional material on body chemistry, and on energy conversion in living systems was included.

Children at all grade levels responded with alertness, interest, and enthusiasm to much of the experimental material. The reports of teachers and observers confirmed the authors' expectations that the pupils would be strongly motivated in the study of science and would find the combination of experiment and discovery a stimulating challenge.

SCIS Omnibus (Karplus, 1973, p. 5) referred to some of the problems

encountered with the experimental units developed in 1959-60 and stated:

The most difficult problem is to determine what the pupils are learning. The attempts at evaluation showed that the objective-tests that were used were not very informative. The classroom observation, while more informative, was incomplete and subjective, and tended to focus on the active pupils. The laboratory teachers themselves were sensitive to the pupils' satisfactions and frustrations but were not sufficiently experienced with the material to be able to judge effectively the pupils' progress . . . .

The second problem was the programming of the learning experience so that a secure connection is achieved between the pupils' intuitive or "common-sense" attitudes and the concepts that embody the modern scientific point of view. One difficulty here is that alert children generalize quickly and often in an invalid way on the basis of limited experience, even in the face of contradictory evidence . . . .

The third problem has to do with teaching materials and teacher preparation. The result of experimental work on the first two problems has to be communicated to teachers in such a way that they can use it. The information must go beyond the minimum required for the classroom presentation so that the teachers will have a reserve on which to draw in discussions, a reserve that is a basis for self-confidence in front of the class. Teachers must also acquire a many-sided view of the subject so that they can link it to the pupils' experience in diverse ways. All this in addition to their other teaching obligations.

Here the operations of the study can be improved in many ways. One is the use of pupil textbooks to enable the authors to communicate directly with their young audience. Another is a laboratory teaching program in which a teacher has the opportunity to teach a lesson two or three times . . . .

The general strategy of the SCIS experimental units was to confront the elementary school children with first-hand experience of natural phenomena and with intellectual challenges that would stimulate their further cognitive development. This strategy implies a

commitment to working with a group of children over a period of several years. It was decided, therefore, that the SCIS would begin its program with children in kindergarten and first grade; each year additional material would be made available to continue the program with the same group of children as they advanced from grade to grade.

In his recent book, *Intelligence and Experience*, J. McV. Hunt (1961) reviewed the curriculum status of experimental work and theories concerned with the intellectual development of children. He concluded that it is time to abandon the beliefs in a fixed intelligence and a predetermined mental development, beliefs that were dominant in the thinking of behavioral scientists until a few years ago. Together, these beliefs led to the view that intelligence was an innate characteristic of each individual and that it increased at a fixed rate to a predetermined level. These beliefs also led educators to de-emphasize intellectual stimulation and to prescribe a program that emphasized basic skills while the children's thinking abilities were thought to mature of their own accord.

In the new conception, intelligence is a hierarchy of strategies for processing information and schemata for assigning significance to information. This hierarchy is formed and structured in accordance with the experience of the individual. Intellectual stimulation during the formative years is therefore as important as native endowment in determining adult achievement. In this view, the contribution that

education can make to society is vastly greater and more vital than was previously thought possible.

The elementary school acquires a particularly deep responsibility, because the child's thinking is especially sensitive to experience as it undergoes a gradual transition from the concrete to the abstract in the age range from 6 to 14 years. At the beginning of this period the child is developing control of his muscles and gaining in ability to carry out physical manipulations; in his thinking he is dependent on direct experience. At the end of the transition, the child is able to focus his thoughts consciously and to manipulate abstract relationships without constant reference to specific examples.

SCIS Omnibus (Karplus, 1973, p. 36) referred to the rationale and program of the Science Curriculum Improvement Study and stated:

Even though the work of the SCIS is only at an early stage, some qualitative but significant findings have emerged. (1) Modern science depends on numerous man-made constructs which are not inherent in natural phenomena and which usually cannot be discovered by children through their observations. (2) The content of a science curriculum must be viewed as a hierarchy of superordinate and subordinate elements and not as an enumeration of many equivalent elements. (3) The pupils must have a great deal of autonomy-opportunities to carry out their own manipulations, to make their own observations, and to find their own applications for conceptual inventions. (4) The views of cognitive development held by leading students of the field, Piaget, Bruner, and Hunt, to name a few, support the introduction of a strong science program in the elementary school. (5) Much current teaching practice and to an extent teacher education are not yet in tune with these views and are actually based on ideas that are incompatible with the communication of scientific literacy. These findings, I believe, can be applied to facets of experience other than experience with natural phenomena. They may therefore, have value above and beyond the scope of the Science

Curriculum Improvement Study and may suggest a challenge to all concerned about the improvement of education.

### The SCIS Program Overview

(Kindergarten) The science for the kindergarten unit offers a wide variety of activities and experiences in both the life and physical sciences. The program has significant objectives: to develop the children's powers of observation, discrimination, and description. The children observe and describe a wide variety of objects and organisms in the classroom and outside. Through suggested games, puzzles, and other activities, the teacher helps develop the children's ability to describe objects by their color, shape, size, texture, smell and sound. The unit also includes many activities involving comparison of objects by properties. Ideas of number and volume are introduced in simple activities such as weighing objects, counting beads, and measuring quantities of water. Changes that occur over time are considered in the life science section when the children work with seeds, seedlings, and plants.

(The First Year) The first year units are Material Objects and Organisms. These units have certain common objectives: to sharpen children's powers of observation, discrimination, and accurate description. The objectives are accomplished as children care for aquatic plants and animals, raise seedlings, and investigate the properties of a broad range of non-living solid specimens (metal, wood,

plastic, sand, ice), liquids (water, oil), and gases (air, Freon). The units complement each other and can be taught effectively in either order.

(The Second Year) The second year units are Interaction and Systems, and Life Cycles. In both, the theme is change, observed either as evidence of interaction or by the development of an animal or plant. Both units require children to add the mental process of interpreting evidence to the observational skills they developed in the first year. In their laboratory work, children use magnets, batteries, wires, various chemicals, photographic paper, pulleys, electric motors, seeds, mealworms, frog eggs, and fruit flies. The two units can be taught effectively, regardless of order. Some teachers, however, recommend that they be used simultaneously. Then the Interaction and Systems activities can be completed, while Life Cycles organisms grow without immediately observable change.

(The Third Year) During the third year students observe and experiment with increasingly complex phenomena as they build on the first two years of the program and move toward an understanding of the Energy, Matter, and Ecosystem concepts. In the physical science unit, Subsystems and Variables, they experiment with solid, liquid, and gaseous forms of matter, making measurements and analyzing results. In the life science unit, Populations, the pupils observe the interactions of various organisms within a community of plants and

animals, and they consider the interdependence of individuals and populations within the community.

(The Fourth Year) In the life science unit, Environments, children consider for the first time some of the physical conditions that shape an organism's environment. These investigations make use of the measurement skills and scientific background developed in the physical and life science units during the first three years. The physical science unit, Relative Position and Motion, introduces techniques for dealing with spatial relationships of stationary and moving objects. The interaction studies are relatively simple. However, it is important that the students be able to describe the changes they observe with increased precision so they may deal more effectively with such topics as their own spatial environment, energy of moving objects, and behavior of organisms.

(The Fifth Year) The conceptual development of the SCIS program is continued with the introduction of energy transfer in the physical science unit, Energy Sources, and of food transfer in the life science unit, Communities. In these units, the interactions of objects and of organisms are investigated from a more comprehensive point of view, in which their dynamic interdependence is taken into account. The pupils apply the systems concept, the identification of variables, and the interpretation of data, with which they have become familiar during the earlier years of the program.

(The Sixth Year) Both a climax and a new beginning occur in the last year of the SCIS program. The physical and life science concepts previously studied are integrated in the Ecosystems unit, where the students investigate the exchange of matter and energy between organisms and their environment. The concept of a scientific model is introduced in the physical science unit, Models: Electric and Magnetic Interactions. In this unit students interpret data and make hypotheses on a more sophisticated level. As they carry out the activities, they begin to relate matter and energy to electrical phenomena, acquiring a concrete basis for their later understanding of the electrical nature of matter. The two units may be used in either order, or concurrently. Extended investigations and formulation of scientific models in this unit conclude the SCIS physical science sequence. The identification of systems of interacting objects and important variables is a central aspect in the student's investigations. As a final and most important concept in the Ecosystems unit the pupils investigate various aspects of water pollution. They define pollution as a sequence of changes in which the normal functioning of the ecological cycles is disrupted. The presence of a pollutant, the material triggering the disturbance, thereby affects the entire ecosystem. The student's awareness of pollution problems in their local environment will enable them to relate the study of ecosystems to current events.

A complete listing of the Life and Physical Science concepts covered in the SCIS program (Appendix B) are selected to develop the four major concepts: Matter, Energy, Organism and Ecosystem. These concepts are combined in the main thrust of the program, that of developing Scientific Literacy, a blend of knowledge, skills and attitude.

#### Psychological Background for the SCIS Program

In the nineteenth century, European psychologists and educators, notably the Swiss educator Pestalozzi, placed great emphasis on direct, immediate experiences on the part of the student. John Dewey in the United States later took a similar view. They encouraged children to use their senses to see, touch, listen, and smell. First-hand experiences were stressed.

Pestalozzi and Dewey emphasized proceeding from concrete experiences to the abstract, an idea that contrasted sharply with the memorizing and reciting so widely used at that time. The Pestalozzian ideas were brought to the Western Hemisphere and influenced elementary science at that time. Dewey's approach also was widely implemented. Yet, neither led to inquiry-oriented science because both lacked vital contributions from research scientists who could interpret the nature and content of science in terms appropriate to young children. Nevertheless, many key features of Pestalozzian

education and of Dewey's influence can be seen in the SCIS program.

The SCIS program, however, has been influenced more by recent developments in psychology and education. Especially important was the work of such psychologists as Piaget, Bruner, and Almy, who stress not only direct experience but also autonomy for the child in conducting his own explorations and investigations. They believe that young children pass through a stage of "concrete operations" during the years when they are in the early grades of elementary school. During this stage, children should have a wide variety of experiences with different kinds of objects, as is provided in the SCIS program.

There are a number of psychological theories of learning that have been used in the development of educational materials. One of these is the theory of "learning-by-association", which views the student's behavior as a response to well-planned stimuli. With repetition, practice, correction of errors, and suitable rewards or punishment, the learner is expected to master the desired behavior. This is the theory behind rote learning of past education and has led to programmed instruction in more recent times.

A sharp contrast is provided by the theory of "learning-by-discovery", which claims that everything of which an individual is capable is latent within him. Given a sufficiently rich environment, the learner is expected to discover the properties of objects,

the conditions under which interaction takes place, and the concepts necessary for understanding life. In its extreme forms this theory allows no direct input that might limit or focus the student's natural interests.

Still another theory, based on the work of Jean Piaget, may be called "learning-by-reasoning". According to this theory, the student is brought to understand relationships through logical reasons provided by himself, the teacher, or classmates.

The learning cycle of the SCIS program, reflects the three theories in a complementary way, using each of them for its strongest points but giving greatest weight to "learning-by-reasoning", as outlined by Jean Piaget.

#### The Life and Philosophies of Jean Piaget

Jean Piaget was born at Neuchatel, Switzerland, in 1896. He became interested in zoology at an early age, and at the age of ten his written observations of the behavior of an albino sparrow were printed in the local journal of natural history. The curator of the Neuchatel Museum, a leading authority on mollusks, encouraged his natural interest, and directed it to the task of classifying and labelling the specimens of fresh-water shells to be found in the nearby lake, and also to investigating the different types of snail and mussel to be found

there. The results of this piece of study were printed in a series of articles in the Revue Suisse de Zoologie while he was still attending college. Piaget obtained a doctorate in the Natural Sciences in 1918 with a thesis entitled "Alpine Mollusks".

As a result of family upbringing and his education, Jean Piaget found himself in the center of a conflict of ideas. His was a strictly religious family, and he realized increasingly that the biologist's view of human nature that he held, as a result of his education, seemed to be opposed to the doctrines held by his religion. He attempted to escape from the emotional crises that resulted by writing a philosophical novel which dealt with the problem of the two irreconcilable viewpoints. The novel dealt with an investigation of how human knowledge has evolved, by applying the methods of the biologist rather than those of the philosopher.

It was shortly after this that Piaget enrolled in the psychological laboratory at Zurich. There he attended Jung's lectures and read the works of Herbert Spencer which exercised considerable influence on his later writings. In 1919 he went to Paris where Dr. Simon (Binet's collaborator on the scale of intelligence tests that bear his name) gave him the task of standardizing Burt's reasoning tests for Parisian children. He commenced this task without much enthusiasm and soon decided that it was far more important to discover how each child reached his conclusions, especially when those conclusions were wrong,

than it was to establish norms.

Two years later, when he returned to Switzerland, he was invited to become Director of Studies at the Rousseau Institute of Geneva, which is now part of the University of Geneva, and is known as the Institute of Educational Science. He accepted the appointment at the age of 26 and has remained there. He and his research students continue to study the mental development of the child. (His present appointment is that of Professor of Psychology at Geneva, and until recently he was also Professor at the Sorbonne.) In his work, Piaget's problem has always been the same. It arises out of Spencer's own doctrine of adaptation: how does the growing child adjust himself to the world in which he lives and how are we to account for the constant recurrence of what, to the rational adult, seems extreme instances of maladjustment?

Jean Piaget's search for answers to these questions was begun in the familiar form of keeping careful records of what young children said and did. He soon found that these methods were insufficient and unsatisfactory, however, and he started to develop the ingenious techniques for which he is now world famous. The results of his work have appeared in a flow of books and other publications which has gone on since 1924. Piaget has utilized an extraordinary imagination to support his scientific research. His unique perception and his intuition have led to many unusual child centered experiments.

He is constantly trying to get inside the mind of the child in order that he may see the world from the child's own standpoint. An often quoted example of this was the set of experiments which involved his joining in each child's favorite game on an equal footing with the child, which included such activities as learning how to make a good shot at marbles, how to make a bad shot, and even how to cheat!

Most of Piaget's published works are very difficult to read, especially in the theoretical sections. There are a number of reasons for this, and the first, of course, is that he is investigating and writing about an extremely intricate and involved process. Another minor cause is that all of his publications are written in French and it is often extremely difficult to find exact English equivalents for the original French terms used. The greatest share of the difficulty arises from the fact that, as has already been discussed, Piaget's own intellectual development and education has been so very comprehensive and complex. Piaget's terminology, to those who have not studied his sciences, makes the reading of his books exceptionally difficult, for he very seldom defines the terms he uses, and they often appear most obscure to the non-scientist reader.

Piaget's approach is a genetic and biological one. He attempts to distinguish stages of development in the evolution of thought, and to show how each stage reveals a progressive sequence from simpler to more complex levels of organization. To do this, he has developed

a series of experiments which require a child to solve a problem that reveal the stages of development toward the full pattern of thought processes involved in the final solution of the problem. Therefore, when each child's answers are recorded, they enable the experimenter to place them at their stage of development in the evolution of that particular pattern of thought. Chronologically, Piaget was at first a biologist, and so it is easy to understand his selected starting point for all of his theories on the development of intelligence, that higher psychological functions grow out of biological mechanisms. It would follow that it is logical for him to describe the actions producing this development in biological terms, and thus develop his doctrine of maturation.

Helmore (1969, p. 5) quoted Piaget as defining intelligence as, "the state of equilibrium towards which all successive adaptations of a sensori-motor and cognitive nature, as well as all assimilatory and accommodatory interactions between the organism and the environment." He looks upon the growth of intelligence as the growth of the ability to achieve equilibrium at an increasingly high level of complexity. The meaning of the term, "equilibrium", becomes clearer from a consideration of a further statement, "intelligence is adaptation . . . adaptation must be described as an equilibrium between the action of the organism upon the environment." Piaget means assimilation, insofar as this action depends upon previous behavior

involving the same or similar objects (or circumstances).

Helmore (1969, p. 6) further quoted Piaget when he stated:

The organism absorbs substances and changes them into something compatible with its own substance. Now, psychologically, the same is true except that the modifications with which it is then concerned are no longer of a physico-chemical order but entirely functional, and are determined by movement, perception or the interplay of real or potential actions (conceptual operations, etc.). Mental assimilation is thus the incorporation of objects into patterns of behavior, these patterns being none other than the whole gamut of actions capable of active repetition.

By "assimilation", then, Piaget seems to mean the way in which the mind takes its continuing experience of objects, circumstances, situations, etc., and orders them into schemata of thought for future use. The response of the organism to the environment is referred to by Piaget as accommodation. In the physiological sense the individual never suffers the impact of surrounding stimuli as such, but simply modifies the assimilatory cycle. The equivalent is true in the psychological sense, where the pressure of circumstances always leads, not to a passive submission to them, but to a simple modification of the action affecting them. By "accommodation", then, it seems that Piaget means the way in which the mind modifies its schemata in the light of new experience.

In his studies of the progress made by children towards higher levels of equilibrium, there are two key factors emphasized in Piaget's work. The first of these is the extent to which an organism can control shifts of orientation; the second is the ability of an organism to

develop operations. An operation is an action that has been internalized into a thought process. The act of thinking involves the use of groups of systems of such operations:

- (1) Composition. Any two units can be combined to produce a new unit.
- (2) Reversibility. Two units combined may be separated again.
- (3) Associativity. The same results may be obtained by combining units in different ways.
- (4) Identity. Combining an element with its inverse annuls it.
- (5) Tautology. A classification or relation which is repeated is not changed.
- (6) Iteration. A number combined with itself gives a new number.

Operations and their groupings (i. e., thought processes and their groupings) are the main thesis of Piaget's developmental approach to concept formation. From his many experiments with children of all ages, he contends that there are five main stages in the development of a concept through which the vast majority of children pass. The highly intelligent child will pass through these stages at an earlier age than the child with less ability. In some cases a child with very low ability may fail to reach the final stage(s) of maturity. The final conclusion suggested by Piaget's work, then, is that what we term "thinking", for example, the ability to solve theoretical and practical problems (to make reasoned judgements), the recognition of relationships, and the associations of ideas, etc., is, in fact, only

the result of a system of thinking that has been slowly built up within the brain. Our ideas of number, space, time, weight, measurement, etc., are not innate, but are built up piecemeal as we live our early lives, initially through the sensory and motor activities of our early infancy and then at an accelerated rate through our association with the people around us and our developing ability to understand and use language. These background schemata so built, then, are the foundations for all our subsequent thinking, will always affect it, and without them, suggests Piaget, "thinking" would be virtually impossible.

#### The Piagetian Stages of Development

The Sensori-Motor Stage (0-2 yrs.). In this stage the infant can perform only motor actions, manipulating objects in trial and error fashion. At birth the baby has innate reflexes only. For some weeks his world consists of visual patterns, etc., which follow in a timed sequence that is so temporal that the child does not have a chance to arrive at any real understanding of the situation. He coordinates perception and movement but without any real awareness of the situation. Objects are without permanence at first, but gradually, because of his actions, the baby builds up a picture of the world as a succession of objects with permanence in its surroundings. During the early months of life the distinction between self and non-self is not realized, but he finally regards himself as one object among many.

The child begins to learn through interaction between himself and his environment. His actions of assimilation and accommodation commence; he learns, for example, that certain movements in certain directions carried out at certain times lead to certain results.

By approximately the first birthday the ability to imitate makes its appearance and the child tends to assimilate the movement repertoire of others. During the second year this developing ability to imitate is extended to deferred imitation, or the imitation of an absent person. Imagery is deferred imitation, and so, the first indications of imagery are seen in the second year of life, and with imagery comes symbolic or make-believe play. Language develops too, and the child learns to use words as symbols. By the time the child is two years old, he can invent new patterns of behavior by means of words, actions, and symbolic play, and shows he can understand the results of his actions before he performs them. True thought is thus commencing for he is internalizing some of his actions into thought, but it goes without saying that this organization, circumscribed as it is by the limitations of action, still does not constitute a form of thought.

The Preconceptual Stage (2-4 yrs.). After the appearance of language, or, more precisely, the symbolic function that makes its acquisition possible, there begins a period which lasts until nearly the fourth year, and includes the development of symbolic and

preconceptual thought. The deferred imitation and imagery development commenced in the previous stage develops still further and with it the rapid development of the understanding of symbols follows. Preconcepts are the notions which the child attaches to the first verbal signs he learns to use. These preconcepts lie somewhere between a concept of an individual object and a concept of the general class of the object. To the child at this stage "dog" and "dogs" are indistinguishable, he cannot yet cope with general classes, being unable to distinguish between "all" and "some".

Furthermore, the child is unable to argue in a deductive manner from the general to the particular or vice versa, inductively. Piaget states that he argues "transductively", from the particular to the particular consisting merely of a sequence of actions symbolized in thought, a true mental experiment. If two objects or situations are alike in some respects, then arguing transductively the child will claim that they are alike in all respects. Symbols and the objects which they represent are frequently confused and the child has an egocentric attitude toward his world.

The Intuitive Stage (4-7 yrs.). From four to about seven or eight years, intuitive thought develops as a very close linked continuation of the previous stage, and its progressive articulations lead to the threshold of the operation. It is in this stage that Piaget states it is possible to involve the child in short experiments,

in which he has to manipulate experimental objects which enable us to obtain regular answers and to converse with him. This fact alone indicates a new structure.

Intuitive thought, in the Piagetian meaning, is thought determined by a way of looking by perception. During this period, there is a very considerable increase in the internalization of thought, but the child can only consider one action or one variable at a time. Reversibility is not achieved, although there is an advance towards its achievement. This means the child is still unable in thought to return to his starting point. For example, if the shape of a lump of plasticine is altered, he believes that the amount of the plasticine in the lump alters too. The permanent nature of the quantity irrespective of shape is beyond him, his thought is affected only by his perception of the alteration of one dimension, e.g., it has been flattened, therefore there is less, thus what Piaget calls "conservation" is not realized. The child is only able to consider one "view" of the situation, but as he progresses through this stage he shows a developing ability to attain different "views" and when he learns to coordinate these he will achieve "conservation" and this stage is behind him. This stage can be observed in many of Piaget's experiments, in which the child will commence his answering from the level of internalized thought, but as the experiment progresses and the gap between the reasoned answer and the perceptive observation widens, the former will eventually be

abandoned and all subsequent answers will be given as a perceptive level only.

The Concrete Operations Stage (7-11 yrs.). From the seventh to the eleventh or twelfth year, the "concrete operations" are organized, i.e., operational groupings of thought concerning objects that can be manipulated or known through the senses. In this stage, reversibility is developed and thus logical thought begins to develop. Logical thought arises when the child has built up a stock of concrete concepts which he begins to manipulate into a system. This stage is of operational thought development and in it the child develops three kinds of concepts. The first of these is the concept of classification, the inclusion of one class within another; for example, the child can group together all bricks of a similar color from a collection of bricks of mixed colors. The second concept is that of seriation, of ordering in size in a systematic way. From such an activity and understanding, the child arrives at a conception of relationships between objects. The third concept is that of number, and it arises out of the first two. The number system is the product of the joint concepts of class and relationship, e.g., the number seven involves the ability to see seven similar objects and then to see their relationship to the numbers six and eight.

In spite of the conceptual development that is taking place, however, the child is still limited in the number of variables he can

consider and still achieve conservation, a third variable will still confuse him. The ability to deal with more than two variables is achieved at the end of this stage and the five properties of systems of operations (composition, reversibility, associativity, identity, tautology, and iteration) have taken their place in the child's thought process.

The Formal Operations Stage (11 yrs. and beyond). Finally, from 11 to 12 years and during adolescence, formal thought is perfected and its groupings characterize the completion of reflective intelligence. The child is no longer deterred by his perception, nor limited to the concrete situation; he can consider a number of variables at the same time. He can increasingly set up anticipatory schema in his mind, he can manipulate in his mind the propositions that link the classes and relationships, and he can set up an hypothesis. Four abilities developed at this stage are:

- (1) The ability to reason on relations between propositions.
- (2) The ability to consider and use all possible disjunctions and combinations.
- (3) The ability to use both inversion and the reciprocal in a single system.
- (4) The ability to increase understanding of action and reaction.

Experiments used by Piaget and Inhelder demonstrate that these four abilities are clearly developing in the adolescent, and ability (2) will enable him to think and reason inductively, generalizing from a

number of instances, the child has reached the structure of the final equilibrium to which concrete operations tend, when they are reflected in more general systems linking together the propositions that express them.

#### Experiences in Science (EIS)

Experiences in Science is a privately supported elementary science program produced by the McGraw-Hill Book Company, entitled "Experiences in Science" (Tannebaum et al., 1969). It was developed as an experience-centered program for grades 1 through 6. It builds upon a child's natural curiosity, encouraging him to discover fascinating scientific facts about his world himself. The authors are Dr. Harold E. Tannenbaum, professor of Science Education, Hunter College; Beulah Tannenbaum, a former elementary school teacher and author of a number of young people's science books; Dr. Nathan Stillman, professor of Education, Yeshiva University; and Myra Stillman, teacher, librarian and social worker.

The Experiences in Science program provides a set of systematically planned experiences that enable students to build understandings of some of the fundamental principles of science. This pattern is essential to the new elementary school science curriculum based on the work of such scholars as Piaget, Bruner, and Gagné since it provides a structure around which students may build

conceptual understandings. It includes content from several fields of science. About one-third with the physical sciences, one-third with the biological sciences, and one-third with the earth sciences. A graded sequence of units permits control of the level of difficulty. When offered in sequence, conceptual understandings are expanded, modified, and reinforced as the students increase in maturity. However, each unit stands alone with a beginning and an end, thus permitting greater flexibility in the use of the units and allowing for their adaptation to the particular needs of a school.

The program fosters conceptual learning by stressing the processes of science, not as opposed to content, but as essential to learning and understanding. The students learn, as scientists do, by becoming actively involved in obtaining knowledge, rather than being told a series of facts or principles by the teacher or being asked to read about them in a textbook. The students are led to discover for themselves some of the fundamental principles necessary for explaining natural phenomena. The role of the teacher is recast to become a catalyst of learning, a guide in the process of investigating. The students are thus led to use their information to formulate concepts which will be understandable to them. The six major generalizations used as a basis for selecting content material for Experiences in Science are:

1. There are many kinds of living things and they are inter-dependent.
2. Living things, including men, are dependent upon the earth, its atmosphere, and the sun for their existence.
3. The sun furnishes the earth with most of the energy which, in its varied and interchangeable forms, yield the chemical and physical forces at work in the world.
4. The earth is a small part of a vast universe containing other planets, stars, and astral bodies.
5. The earth's history and current condition can be read from its rocks, soils, and waters.
6. Through a growing knowledge of science, men have learned to promote their health and welfare by devising methods and machines to manipulate natural forces and materials.

These generalizations are not taught as such, but rather the involvement of students as they investigate a given unit, or series of units, slowly instills an awareness of, and rationale for, these generalizations. For example, one of the areas under generalization (1) is "classification". In treating classification, experiences are presented which help the students recognize on their own level the usefulness of classification before they are asked to devise classification systems or are given information about commonly used systems. The "whys" and "hows" are held to be as important as the "whats", a statement often preached in science teaching, but seldom practiced in traditional programs.

Both inductive and deductive reasoning are used, with the emphasis where possible on inductive reasoning. Because the EIS is a

"doing" program all of the units include a number of the processes of science. Eight of these processes which are considered basic to the program are:

1. Observing
2. Comparing
3. Classifying
4. Quantifying
5. Measuring
6. Experimenting
7. Inferring
8. Predicting

Most units include observing, comparing, measuring, and experimenting. However, in certain units, various processes have been given relatively greater emphasis. For example, classifying is taught specifically in the unit "Groups", but also is involved in several other units. Processes are stressed as the "ways" of inquiry and investigation. These processes are not structured in any formal way yet confront children continuously. The anticipation being that these processes in time will be recognized as the necessary means in obtaining information about the world, and that as these processes are developed our knowledge will become more extensive, precise and understandable.

A complete listing of the units covered in grades 1 through 6 in the Experiences in Science program (Appendix C) shows that the physical, biological and geological science concepts are integrated throughout all levels, thus developing a "whole" picture of our surroundings and the universe in which we live.

The Comprehensive Tests of Basic Skills (CTBS)

The Comprehensive Tests of Basic Skills, Expanded Edition, is a series of batteries for Kindergarten through Grade 12. The batteries comprise seven overlapping levels, for which the designations and grade ranges are as follows:

Level A	Grades K.0	-	1.3
Level B	Grades K.6	-	1.9
Level C	Grades 1.6	-	2.9
Level 1	Grades 2.5	-	4.9
Level 2	Grades 4.5	-	6.9
Level 3	Grades 6.5	-	8.9
Level 4	Grades 8.5	-	12.9

Level A is designed to be a prereading test and assumes minimum experience with school activities. Level B assumes approximately one year of instruction, while Level C would normally be given after two years of instruction. The overlapping of Levels 1 through 4 at grades 4, 6, and 8 allows the user to choose the one most appropriate for his students. A major aim in the development of the CTBS, was to provide improved measurement of the basic skills through improved content validity. To accomplish this, special attention was given to a comprehensive and systematic approach to measuring the basic skills by:

1. Clearly delimiting the scope of the tests in the rationale for the tests.
2. Spelling out the objectives, separating the basic skills from "knowledge of specifics".

3. Selecting a wide variety of content to be used as a basis for writing items to measure these skills.
4. Developing specifications for item writing on two-dimensional, process/content charts to ensure comprehensive coverage of each process and each content category.

The tests were designed to measure the extent to which individual students have developed the capabilities and learned the skills that are prerequisite to studying and learning in subject matter courses, and necessary for functioning in a society based on daily use of language and number. These basic skills are developed through exposure to a variety of curriculums and instructional procedures. Unlike tests of academic achievement in a particular subject area, these tests of basic skills are not greatly affected by the particular content material used to teach the students. Performance on these tests is affected, however, by the grade level at which topics are introduced into the curriculum and by the development of the capabilities necessary to perform the task. The tests were developed on the assumption that a student's competence in dealing with content of high complexity increases as he progresses through school.

The CTBS Test Coordinator's Handbook (1974, p. 13) refers to the rationale for the CTBS:

The measurement of these skills and abilities cannot be divorced entirely from the measurement of knowledge acquired through schooling, but it is not the intent of these tests to measure this knowledge directly. The emphasis in this series is on the measurement of the grasp of broad concepts and abstractions as developed by all curriculums, and on facility in the

skills that are required in the effective use of language and number such as classifying, manipulating, translating, and interpreting.

The complete classification scheme for the rationale (Appendix A) was developed with the view that it would be understood by teachers and could be used to determine major strengths and weaknesses in terms of instructional objectives and content. The scheme is so arranged that there is an inherent hierarchy of skills, or levels of thinking, consistent with what is currently known about child development, cognitive structures, and learning processes. In the development of the tests, attention was given to long-term trends in curriculum such as contemporary mathematics programs and the linguistic approach to the teaching of language arts. Items reflecting these trends were used only when there was reasonable expectation that students in traditional curriculums would understand them. Items were excluded that could not be assumed to be based on common experience.

For several years, CTB/McGraw-Hill has been conducting research in an attempt to identify and eliminate racial and ethnic bias in its products. CTBS, Expanded Edition, reflects the first application of the research conducted throughout the entire process of development, from item tryout to final product. The procedures involved three steps. First, through the gathering of separate item data on minority groups, items that appeared to be biased against a particular

ethnic or cultural group were identified and eliminated. Second, members of minority groups knowledgeable about how students learn and perform in test situations reviewed the tests for content bias. Finally, studies were made of the standardization of CTBS/S to see how students from different groups actually performed on the tests.

The process classification of items for CTBS follows essentially the approach presented in "Taxonomy of Educational Objectives" (Bloom, 1967). This approach has been adapted to the CTBS design. Two major components provided the basis for devising the classification scheme for CTBS: the "process" dimension and the "content" dimension. Because of the nature and purpose of CTBS, measurement is concentrated on the basic processes. The emphasis in the process dimension is on the measurement of comprehension and application of concepts and principles rather than on the measurement of knowledge per se. In other words, the tests measure knowledge of ways and means of dealing with these concepts and principles as reflected in applying rules, conventions, methodology, and processes. The science tests, Levels C through 4, contain test items which closely reflect the process approach currently employed in contemporary science curriculums. Some of the processes tested for are: Recognition, Classification, Quantification, Interpretation of Data, Prediction from Data, Hypothesis Evaluation, and Design Analysis. The testing of the so-called higher mental processes that require

solving problems through evaluation and synthesis in novel situations is sampled only minimally in this classification.

The classification scheme is hierarchical in nature; as the level increases, the more complex processes are used with greater frequency than the simpler processes. In a number of tests in the primary levels, only Recognition or Translation is tested, since students have not had the training or experience to do the kind of thinking required at the higher process levels. There is also an increase in complexity and/or abstractness of the test items over the levels; i. e., although categories have the same number of items for a process at each of the levels, the items become more difficult. For example, in the content category Punctuation, at Level 1, only simple punctuation errors involving the elementary use of periods, commas, and question marks are tested. However, at Level 4, the more advanced use of these types of punctuation, as well as the use of colons, semicolons, single and double quotation marks, parentheses, and dashes, is tested. As an example, from the primary levels in Language, at Level A, the student is asked only to determine whether a sentence is correct or incorrect, while at the upper levels he is asked to locate and analyze the type of language error.

The standardization of CTBS/S, primary and upper levels, was designed to provide both national norms and large-city norms, based upon a probability sample of the entire national school population.

The sample, drawn from public and Catholic schools within the 50 states, comprised approximately 130,000 students in Grades K through 12. Grades K and 1 were administered CTBS/S in October, 1972; these grades were retested in April, 1973, at which time grades 2 through 12 were tested. CTBS/S and the Short Form Test of Academic Aptitude (SFTAA) were administered jointly to one-sixth of the sample at Levels 1 through 4 during the April study to establish equations for anticipated achievement at grades 2 through 12. The size of the sample for the normative data collection was determined to allow raw scores to be identified with the extreme percentile ranks with a high degree of accuracy. The method of multistage, stratified random sampling with proportional allocation was applied. The sampling unit chosen for the first-stage sampling was the school district. For the second-stage sampling, the sampling unit chosen was the school. Each school was identified as one of three types: greater city public schools, other public schools, and Catholic schools. The two public school samples were stratified according to geographic region, average enrollment per grade, and community type. The greater city public school sample was drawn from schools located in urban centers with a minimum average enrollment of 5,000 students per grade. The Catholic school population, including parochial and private schools, was stratified by geographic region and enrollment. In this case the sampling unit was the diocese or archdiocese, classified into one of

two enrollment categories: greater than 60, 000 students or less than 60, 000 students.

The 50 states and the District of Columbia were grouped into seven categories. These correspond to the nine United States Office of Education (USOE) regions, except that region 7, West, was obtained by consolidation of USOE regions 7, 8, and 9 (Rocky Mountain, Far West, and Noncontiguous). Once the sample of school districts within the cells of the stratification sampling design had been drawn and agreement secured for their participation, a list of schools and the number of classrooms by grade within each school was requested. A random sample of classrooms was drawn from alphabetical lists of classroom teachers' names, by grade and school. To obtain background information for use in the evaluation and presentation of the standardization data, a questionnaire was sent to each of the 285 participating schools in the spring of 1973. All 285 schools responded to the questionnaire. For the analyses, the schools were grouped in three ways:

1. By geographic region and school size.
2. By neighborhood self-description.
3. By large-city public schools and all other schools.

The questionnaires provided information in two general areas: student demographic characteristics and staff, and materials characteristics. These responses were broken down by elementary and

and secondary schools.

The United States Office for Civil Rights (1972) reported the following breakdown of the public school population in 1970: 14.9 percent black, 5.1 percent Spanish-American, and 79.1 percent "nonminority". With respect to ethnic composition, the averages for black, Spanish-speaking, and other, for the 1973 CTBS/S sample, were 16.7 percent, 7.9 percent, and 74.6 percent. Thus, the questionnaires suggest a slight overrepresentation of minority students in the sample. In general, the schools that participated in the CTBS/S 1973 standardization appear to be representative of the schools in the nation. It also appears that the basic student demographic patterns and school characteristics remained fairly stable between 1970 and 1973.

#### The Analysis of Learning Potential (ALP)

The Analysis of Learning Potential (ALP) test series (Appendix D) was developed specifically to provide for the assessment of school learning ability of pupils typically found in grades 1 through 12 in the United States schools. The subtests in each of the various batteries were selected for inclusion in the final test on the basis of their relationship to selected school achievement criteria. Thus, the various subtests within each battery have demonstrated their ability to predict specific criteria of scholastic success, while, at the same time, they remain relatively free from assessing those behaviors specifically

taught in school.

Before undertaking development of the experimental tests, the authors of the series outlined a constellation of basic abilities which, in their judgement, contributed substantially toward mastery of the basic curricular emphasis at each grade level. A total of 73 experimental tests were then developed to assess each of these behaviors judged to be basic to success in the language arts, mathematics, and science-social studies curricular areas. From these experimental tests, the 39 tests included in the final edition of the ALP were selected by using a variety of achievement test criterion data collected in three extensive research programs. The current editions of both Stanford Achievement Test and Metropolitan Achievement Tests were used to determine the relative contribution of the ALP experimental tests to the prediction of academic success as defined by these two achievement batteries.

The specific tests included in the Elementary Battery, together with the original underlying rationale, are set forth below:

Test 1: Word Meaning. The 30 items in this test assess the ability to recognize whether pairs of words are the same or opposite in meaning. Knowledge of word meanings was presumed to underlie success in those curricular areas requiring the use and understanding of language.

Test 2: Number Relations. The 16 items in this test assess the ability to educe the number relation of two ordered pairs, and to apply this relation in constructing a third ordered pair. It was hypothesized that this is an ability essential for success in mathematics.

Test 3: Word Categories. The 20 items in this test assess the ability to educe relations among groups of five words to determine the word which does not belong with the other four. Such categories as material, use, condition, function or purpose, scientific classification, adjectival descriptions, and other classification strategies are sampled. The test was devised to sample a variety of reasoning abilities believed to underlie success in a number of school subjects.

Test 4: Number Fluency. The 25 items in this test measure facility in performing the basic number operations with two- and three-digit numerals.

Test 5: Number Operations Reasoning. The 17 items in this test measure insight into the algorithm of a number operation. Solving the items requires discovering the appropriate operation, and then supplying the missing numeral. Emphasis is placed upon measuring basic algorithms essential for success in mathematics.

Test 6: Word Clues. The 20 items in this test assess the ability to supply contextual synonyms--an important element in reading. An aided recall test format is employed to approximate more closely the reading process.

Test 7: Reasoning by Logic. The 18 items in this test assess the ability to reason in a variety of logical situations. It was hypothesized that this ability is needed in mathematics, scientific thinking, and in meeting the demands of higher level reading.

Selection of items for the various Analysis of Learning Potential batteries was based upon data obtained from two separate item-analysis research programs conducted during 1965 and 1966. A total of 22,759 pupils from 13 carefully selected school systems participated in these studies. Durost et al. (1970, p. 37) refers to the selection of these schools when he stated:

An effort was made to obtain school systems with diverse socioeconomic characteristics. A total of 2,297 items from 73 different tests were analyzed. Thirty-nine subtests were selected for inclusion in the final edition of ALP . . . . A comparison was made between the socioeconomic level of the ALP weighted standardization sample and the socioeconomic level of the United States as a whole. For the systems comprising the ALP sample, median family income and median years of school completed by adults 25 years of age and older were \$5,457 and 10.4 years, respectively, as compared with \$5,620 and 10.6 years for the United States as reported by the United States Bureau of the Census.

Results obtained from ALP reflect performance on tests designed, for the most part, to be relatively free from specific school-learned skills. The tests employed do assess learned abilities gained from a number of somewhat diffuse sources whose exact nature cannot be clearly specified. The series was not developed within a specific theoretical framework concerning the nature of mental ability or intelligence. Thus, the tests were designed to measure neither a single, general ability factor nor to provide factorially "pure" measures of somewhat discrete mental functions. Tests appearing in each battery were selected solely from the standpoint of their contribution to the prediction of academic success. Thus, the ALP series of test batteries (Appendix D) serve as a useful measure of a student's general potential for school learning when his test performance is compared with that of other pupils of the same chronological age, irrespective of grade level. Teachers and other school personnel have found this index helpful in attempting to formulate more realistic academic expectations in view of the pupil's estimated learning potential. The

ALP is particularly useful at those junctures in the pupil's school career where decisions of considerable import must be made considering a specific course of study or type of curriculum best suited to his needs and general academic capabilities.

School systems in the United States are organized by grade levels primarily as an administrative convenience. Specific grade designations are somewhat arbitrary; moreover, the composition of various grade groups varies not only from community to community, but also from school to school within a single community. Since the ALP can refer the pupil's performance to his national chronological age group, it thus becomes possible to evaluate his general capacity for school learning free from local administrative practices resulting in his placement at a specific grade level.

This investigator has considered the CTBS and ALP test batteries, well documented and validated evaluation instruments to use in a research project involving pupil achievement in the public schools.

### III. DESIGN OF THE STUDY

The purpose of the study was to investigate the science achievement of sixth grade students who were exposed to the SCIS science program during the 1975-76 school year. An important aspect of the study was that it investigated two laboratory oriented science programs as they were being taught in two public school systems during the treatment period.

#### The Populations

The students included in this study were sixth grade students enrolled in Albany Elementary Schools or Corvallis Intermediate Schools during the 1975-76 school year. There was a total of 324 students in the Albany Elementary School population and 506 students comprising the Corvallis Intermediate School population. The students in the Albany District attended one of the following Elementary schools: Central, Lafayette, Liberty, Madison, Oak, South Shore, Sunrise, Takena or Waverly. The Corvallis students attended one of three Intermediate Schools: Cheldelin, Highland View, or Western View. All of the sixth grade students in both districts who had taken the ALP tests and the pre- and post-tests using the CTBS were included in the study, as mentioned previously, this involved a total of 830 students. Assignment of students to the various schools was determined by attendance boundaries established by the school districts. The

students were assigned to classes by computer and any differences or similarities which existed between them was not by design but rather by similarities in student schedules. Also, since the assignments of teachers, teaching assistants, and/or teaching aides were made independently from scheduling, the groups constitute naturally assembled collectives of students and can be considered as nearly similar as availability permits. However, no effort was made in this study to analyze the socioeconomic strata or clientele of the Albany or Corvallis School Districts.

The Albany population of students was defined as the control group and was exposed to the Experiences in Science Program (EIS). The Corvallis population was defined as the experimental group and was exposed to the Science Curriculum Improvement Study (SCIS) during the treatment period.

#### Treatment Procedure

Fifteen sixth grade teachers and classes in the Albany district and 21 sixth grade teachers and classes in the Corvallis district were involved in the study. They had an average of one (quarter hour) college credit designed to improve their skills in teaching the SCIS or EIS programs. In addition, approximately 25 percent of those responding to questionnaires (Appendices E and F) indicated that they participated in in-service courses offered by their respective school

districts.

The science curriculums of the schools, which included the SCIS and EIS programs were not changed in any way to facilitate the study as the programs had been a part of the respective schools' curriculums for approximately five years. In order to study an in-school classroom situation concerning the two programs, teachers were not notified that their classes were involved in a study, until after the treatment period when questionnaires were distributed. These questionnaires were used to obtain further information as to teacher preparation, estimated time spent in science, teacher attitudes about their personal qualifications to teach the programs and teacher opinions on adequacy of the programs in meeting their needs and the needs of their students.

#### Data Collecting Devices and Techniques

The information for the major emphasis of this study was obtained from student scores on the ALP and CTBS test batteries as discussed in Chapter II. Additional information was obtained from teacher questionnaires (Appendices E and F) which were distributed at the end of the treatment period. The experimental group of Corvallis students was given the ALP on February 17, 1975. The CTBS was administered as a pre- and post-test on October 6, 1975 and April 6, 1976, respectively. The control group of Albany students

was given the ALP on October 30, 1975. The CTBS was administered as a pre- and post-test on September 18, 1975 and April 12, 1976, respectively. This allowed a treatment period of 26 weeks for the Corvallis group and 29 weeks for the Albany group. The tests were administered by the regular classroom teachers under the direction of the administrators, counselors and the investigator. The test results were machine scored by the Intermediate Education District, Albany, OR., and by CTB/McGraw-Hill, Monterey, CA.

The entire populations of both the experimental and control groups were tested, thus the students were not aware that they were involved in a research project. Campbell (1963, p. 50) referred to the advantages of treating and testing entire populations, as opposed to selected samples of students:

Where one has the alternative of using two intact classrooms with design 10, or taking random samples of the students out of the classrooms for different experimental treatments under a design 4, 5 or 6, the latter arrangement is almost certain to be the more reactive, creating more awareness of experiment, I'm-a-guinea-pig attitude, and the like.

Due to school district testing schedules, the investigator was limited in the degree of control over the pre- and post-tests on the CTBS. However, the results of the teacher questionnaire furnished valuable information which was used to determine actual class time spent in science instruction for both groups. This information showed that class time spent in the involved programs was equitable.

The variance in administration time on the ALP was not considered to be a factor by the investigator. The Elementary Battery used in the study was designed to be administered to grades four through six. Thus, it was designed to cover a rather broad range of maturity and to predict academic success which does not change appreciably in less than a year. The authors of the ALP, Durost et al., (1970, p. 5, 6) discussed the purpose of the tests when they stated:

The various subtests within each battery have demonstrated their ability to predict specific criteria of scholastic success while, at the same time, they remain relatively free from assessing those behaviors specifically taught in school. . . . Thus, the tests were designed to measure neither a single, general ability factor nor to provide factorially "pure" measures of somewhat discrete mental functions. Tests in this battery were selected solely from the standpoint of their contribution to the prediction of academic success.

Thus the variance in testing dates on the ALP and CTBS used in this study were not considered to be significant factors involved in drawing conclusions based on the data gathered.

#### Treatment of Data

As stated in Chapter I, this investigation was designed to test two hypotheses. For the purpose of this chapter, the hypotheses were stated followed by the chosen statistical analysis used. Hypothesis 1 was as follows:

$H_{01}$ : There will be no significant difference between the mean scores of the SCIS group as taught in the Corvallis sixth grade as compared with the EIS group as taught in the Albany sixth grade.

Statistical Analysis:

The "Nonequivalent Control Group Design", was used. In this design, control and experimental groups which did not have pre-experimental sampling equivalence were given a pre- and post-test. This may be described as Campbell's quasi-experimental design number 10 (Campbell 1963, p. 47), which can be modeled as follows:

---

0	X	0	(Pre-test; SCIS Treatment; Post-test)
<hr/>			
0		0	(Groups not equated by random assignment)
			(Pre-test; No treatment; Post-test)
<hr/>			

---

For the study the pre-test scores on the CTBS and the ALP were considered as the covariants. The analysis of covariance tool uses the covariant as a method of statistically matching the samples and is particularly appropriate for ad hoc (or intact) populations where matching may be difficult to achieve. The Analysis of Covariance utilizes the F test. As Courtney and Sedgwick (1969) described it, the analysis of covariance made use of both analysis of variance and regression. The problem was involved with covariance

analysis as it was used to adjust treatment means of the dependent variable for differences in the independent variable. The ANOCOVA FIXED ARRANGEMENT (1-way) may be diagrammed as follows:

Source of variation	df	SS	MS	F -Ratio
Program	1	A	A/1	MS (Prog. )/MS(Error)
Error (within)	118	B	B/117	
Total	119	C		

Hypothesis Tested:

$$H_{01}: \mu_{\text{Corvallis (SCIS)}} = \mu_{\text{Albany (EIS)}}$$

If the computed F was equal to or greater than the tabular F with  $df = 1, 117$  and  $\alpha = .05$ , then the null hypothesis was rejected; if the computed F was less than the tabular F value, the null hypothesis was retained.

Hypothesis 2 was as follows:

$H_{02}$ : There will be no significant difference between the mean scores of the SCIS group as taught in the Cheldelin, Highland View and Western View sixth grade as compared with the EIS group as taught in the Albany sixth grade.

Statistical Analysis:

The ANOCOVA FIXED ARRANGEMENT (1-way) used to test the total populations was used to test each of the sub-populations listed in the second hypothesis. The F table was utilized in each of the tests as a basis to retain or reject the null hypotheses. The adjusted mean scores generated by the analysis of covariance were also used to compare each of the sub-group populations with the Albany population. A Pearson Product Moment Correlation Coefficient "r" test was used to consider the linear correlation which existed between the ALP scores and the CTBS pre-test scores. This information was then used to determine the feasibility of using the ALP scores as a covariant with the CTBS post-test scores in an analysis of covariance.

## Hypotheses Tested:

$$\begin{aligned} H_{02}: \quad & 1) \mu \text{ Cheledin (SCIS)} = \mu \text{ Albany (EIS)} \\ & 2) \mu \text{ Highland View (SCIS)} = \mu \text{ Albany (EIS)} \\ & 3) \mu \text{ Western View (SCIS)} = \mu \text{ Albany (EIS)} \end{aligned}$$

If the computed F for each of the sub-populations, was equal to or greater than the tabular F with  $df = 1, 117$  and  $\alpha = .05$ , then the null hypothesis was rejected; if the computed F was less than the tabular F value, the null hypothesis was retained.

Teacher Questionnaire

The results of the teacher questionnaires (pages 62-66) were summarized in frequency of responses and also on a percentage basis. Information from the questionnaires was used to calculate the total number of hours spent in instruction during the treatment period, teacher training in the respective programs, percentage of teachers who were teaching the SCIS and EIS programs, and teacher opinions on adequacy of the programs in meeting their needs and the needs of their students.

#### IV. RESULTS OF THE STUDY

##### Introduction

This chapter is divided into two parts. Part A provided a picture of the status of teacher preparation and attitudes toward the SCIS and EIS programs. Part B provided a statistical analysis of the data obtained from tests administered during the study. These analyses were used to retain or reject the hypotheses tested.

##### Part A - The Status of Teacher Preparation and Attitudes Toward the SCIS and EIS Programs

This section includes a summary of the data obtained from the questionnaires sent to the teachers involved in the study. The questionnaires were mailed April 19, 1976, which was approximately one week after the treatment period ended for the experimental and control groups. Sixteen of the 21 teachers in the SCIS group from Corvallis returned questionnaires for a 76 percent return. Ten of the 15 teachers in the EIS group from Albany returned questionnaires for a 67 percent return. All questionnaires mailed included a self-addressed stamped envelope for return. Frequency distributions and percentages were used as the statistical measure for describing the raw data.

Question #1. (EIS GROUP) Have you been teaching the EIS science program this year (1975-76)?

Table 1. Frequency distribution of teachers who taught the EIS program during the 1975-76 school year.

Response	Frequency	Percentage
Yes	8	80
No	2	20

Question #1. (SCIS GROUP) Have you been teaching the SCIS science program this year 1975-76)?

Table 2. Frequency distribution of teachers who taught the SCIS program during the 1975-76 school year.

Response	Frequency	Percentage
Yes	15	94
No	1	6

A greater percentage of the teachers in the SCIS group followed the SCIS program as compared with the teachers in the EIS group. However, both groups claim a high percentage of participation in the programs, indicating that teachers did attempt to follow the recommended programs in their classrooms.

Question #2. (EIS GROUP) Have you had any in-service or other formal training specifically designed to improve your skills in teaching the EIS program?

Table 3. Frequency distribution of EIS teachers who have had in-service or other formal training in the EIS program.

Response	Frequency	Percentage
Yes	6	60
No	4	40

Question #2. (SCIS GROUP) Have you had any in-service or other formal training specifically designed to improve your skills in teaching the SCIS program?

Table 4. Frequency distribution of SCIS teachers who have had in-service or other formal training in the SCIS program.

Response	Frequency	Percentage
Yes	13	81
No	3	19

The data indicates that more SCIS teachers have had training in their program than the EIS teachers. The SCIS is a more structured, sequential type of program and thus administrators and teachers may have felt more need for specialized training in introducing the materials, however, both groups of teachers have had a considerable amount of formal training in their respective programs.

Question #3. (EIS GROUP) If your answer to #2 is yes, approximately how many quarter hours (district or college) credit did you receive?

Table 5. Frequency distribution of formal training of the EIS teachers.

Type and amount of training	Frequency	Percentage of group responding
In-service with no credit	1	17
1 hour credit	2	33
2 hours credit	3	50

Question #3. (SCIS GROUP) If your answer to #2 is yes, approximately how many quarter hours (district or college) credit did you receive?

Table 6. Frequency distribution of formal training of the SCIS teachers.

Type and amount of training	Frequency	Percentage of group responding
In-service with no credit	3	23
1 hour credit	1	8
2 hours credit	6	46
3 hours credit	3	23

One of the EIS teachers and three of the SCIS teachers indicated having in-service courses with no credit. EIS teachers who had received formal credit, had an average of 1.6 quarter hours of training. The SCIS teachers showed an average of 2.2 quarter hours in the same category.

Question #4. (EIS GROUP) Could you estimate approximately how many hours per week you have spent teaching the EIS program this year (1975-76)?

Table 7. Frequency distribution of teacher estimated hours per week teaching EIS.

Time estimate (hrs/week)	Frequency	Percentage
0	2	20
1/2	0	0
1	1	10
1-1/2	4	40
2	3	30

Question #4. (SCIS GROUP) Could you estimate approximately how many hours per week you have spent teaching the SCIS program this year (1975-76)?

Table 8. Frequency distribution of teacher estimated hours per week teaching SCIS.

Time estimate (hrs/week)	Frequency	Percentage
0	1	6
1/2	1	6
1	4	25
1-1/2	6	38
2	0	0
2-1/2	3	19
3	1	6

The EIS teachers averaged 1-1/3 hours per week in instruction while the SCIS group indicated an average of 1-1/2 hours per week. To estimate the total hours of instruction during the treatment periods for each group the following calculations were made:

Average time per week (hrs)	X	Weeks of treatment	=	Total hrs spent in instruction
EIS	1-1/3	X	29	= 38
SCIS	1-1/2	X	26	= 39

Thus the data indicated that the total time spent in instruction during the treatment periods for both groups was approximately the same.

Question #5. (EIS GROUP) Do you feel qualified to teach the EIS program?

Table 9. Frequency distribution of teachers' opinions on qualifications for teaching the EIS program.

Response	Frequency	Percentage
Yes	7	70
No	3	30

Question #5. (SCIS GROUP) Do you feel qualified to teach the SCIS program?

Table 10. Frequency distribution of teachers' opinions on qualifications for teaching the SCIS program.

Response	Frequency	Percentage
Yes	14	87
No	2	13

A greater percentage of the SCIS teachers indicated that they felt qualified to teach the program as compared with the EIS group. This would tend to agree with question three which showed that the EIS teachers did have less formal training in the EIS program.

Question #6. (EIS GROUP) Do you feel that the EIS program has met your teaching needs as well as the needs of your students?

Table 11. Frequency distribution of teachers' opinions on the EIS program meeting their needs and needs of their students.

Response	Frequency	Percentage
Yes	7	70
No	3	30

Question #6. (SCIS GROUP) Do you feel that the SCIS program has met your teaching needs as well as the needs of your students?

Table 12. Frequency distribution of teachers' opinions on the SCIS program meeting their needs and needs of their students.

Response	Frequency	Percentage
Yes	12	75
No	4	25

Although more of the SCIS teachers indicated they felt the program had met their needs and the needs of their students, about 73 percent of both groups indicated that they had faith in their respective programs. The questionnaire also furnished valuable information in terms of the estimated time spent in instruction during the treatment period. This data plus that furnished by the ALP scores helped establish the group equivalency necessary for the study.

Summary of Part A - The Status of Teacher Preparation and Attitudes toward the SCIS and EIS Programs.

In summary, the results of the teacher questionnaire showed that the following conditions existed during this study which took place during the 1975-76 school year:

1. Ninety four percent of the SCIS and 80 percent of the EIS teachers taught the respective programs during the treatment period.
2. Eighty one percent of the SCIS and 60 percent of the EIS

teachers have had in-service or other formal training in the programs.

3. The SCIS teachers had an average of 2.2 quarter hours of formal program training as compared with an average of 1.6 quarter hours for the EIS teachers.
4. The SCIS teachers taught science an average of 1-1/2 hours per week as compared with 1-1/3 hours per week for the EIS teachers. However, the total hours of instruction time during the study showed 39 hours for the SCIS and 38 hours for EIS, thus the instructional time was comparable considering hours per week and weeks of instruction.
5. Eighty-seven percent of the SCIS, and 70 percent of the EIS teachers felt qualified to teach their programs.
6. Seventy-five percent of the SCIS, and 70 percent of the EIS teachers felt that their programs were meeting their needs and the needs of their students.

#### Part B. Findings of the Statistical Analysis Used in the Study

The purpose of this study was to determine if there was a significant difference among the mean scores of sixth grade students who were exposed to the SCIS science program as compared with sixth grade students who were exposed to the EIS program.

#### Hypotheses Tested:

$H_{01}$  There will be no significant difference between the mean scores of the SCIS group as taught in the Corvallis sixth grade as compared with the EIS group as taught in the Albany sixth grade.

$H_{02}$  There will be no significant difference between the mean scores of the SCIS group as taught in the Cheldelin,

Highland View and Western View sixth grade as compared with the EIS group as taught in the Albany sixth grade.

Hypothesis 01: The analysis of covariance was used and utilized the F test. The analysis of covariance made use of both analysis of variance and of regression. The present problem was involved with covariance analysis as it was used to adjust treatment means of the dependent variable for differences in the independent variable. For this portion of the study, the pre-test score on the CTBS was considered as the covariant (independent) factor and the post-test score on the CTBS was considered as the dependent variable (Appendices G and H). If the computed F value generated by the analysis of covariance was found to be equal to or greater than the tabular F value, the null hypothesis was rejected. If the computed F value was found to be less than the tabular F value, the null hypothesis was retained.

The analysis of covariance results are shown in Table 14. The computed F value generated by the analysis of covariance was .224 and the tabular F value at the  $\alpha = .05$  level of significance with  $df = 1, 120$  was 3.92. Since the computed F value was less than the tabular F value,  $H_{01}$  was retained.  $Df = 1, 120$  on the F table was used because  $df = 1, 117$  was not available on the table and  $df = 1, 120$  is more stringent than 1, 117.

Because the hypothesis was retained, it can be assumed that there was no significant difference between the mean scores of the experimental and control groups (see Table 13) as determined by using the pre and post-test on the CTBS. The experimental group's adjusted mean score was 25.04 and was not found to be significantly higher than the control group's adjusted mean score of 24.72. The experimental SCIS group experienced an unadjusted mean gain of 2.22 raw score points as compared with 2.52 raw score points for the control EIS group.

Table 13. Table of mean scores using CTBS as pre- and post-test.

Group	Observations	Mean X*	Mean Y**	Adjusted Mean Y
Experimental	60	23.70	25.92	25.04277
Control	60	21.33	23.85	24.72390

\*X Factor is pre-test CTBS.

\*\*Y Factor is post-test CTBS.

To obtain additional data beyond that provided by the analysis of covariance using the pre- and post-tests of the CTBS, the ALP score was considered as the covariant. To document the use of the ALP as the covariant, the Pearson Product Moment Correlation Coefficient "r" (See Appendix I) was used to determine the degree of linear relationship existing between the CTBS pre-test scores and

Table 14. Analysis of covariance using CTBS pre- and post-test.

Source of variation	df	XX*	XY	YY	df	Adjusted.		F
						SS**	MS***	
<b>Group</b>								
Exp. / Cont.	1	168.03	146.73	128.13	1	2.93	2.93	.224
Error (within)	118	3997.93	2952.50	3708.23	117	1527.79	13.06	
Total	119	4165.97	3099.23	3836.37	118	1530.72		

\* Factor X is pre-test; Factor Y is post-test  
 Pre-test was used as the covariant

Tabular F

$$\alpha = .05 \\ df = 1, 120 = 3.92$$

\*\* SS = Sum of Squares

$H_{01} = \mu_{\text{Exp.}} = \mu_{\text{Cont. retained}}$

\*\*\* MS = Mean Square

the ALP scores. The results of the Pearson "r" correlations for the SCIS and EIS groups are shown in Table 15.

Table 15. Mean raw scores on ALP and CTBS pre-test and Pearson "r" Correlation Coefficient.

Group	ALP	CTBS Pre-Test	Pearson "r"
SCIS	82.19	23.70	-0.17846
EIS	82.42	21.33	-0.08982

Glass and Stanley (1970) were hesitant to refer to "high" or "low" correlations but did refer to .00 as no linear relationship, with +1.00 as a perfect direct relationship and -1.00 as a perfect inverse relationship. The inverse relationship between the ALP and the CTBS pre-tests indicated that the ALP would serve as a poor covariate with the CTBS post-test. Therefore, an analysis of covariance using the ALP was not used in this portion of the study.

Hypothesis 02: To determine if there was a significant difference between the Cheldelin, Highland View and Western View SCIS groups as compared with the Albany EIS group, an analysis of covariance was conducted between the Albany EIS group and each of the three SCIS groups. The pre-test on the CTBS was used as the covariant and the post-test as the dependent variable.

The SCIS group from Cheldelin (see Table 16) had a computed F score of .01 which was less than the tabular F of 3.65 with 1, 75

degrees of freedom and  $\alpha = .05$ ; therefore, the null hypothesis was retained and it can be assumed that there was no significant difference between the SCIS and EIS groups as taught in the Cheldelin and Albany sixth grades. Cheldelin had a mean raw score on the pre-test of 25.26 as compared with 21.33 for the Albany group. Cheldelin's mean score on the post-test was 27.10 with the Albany group scoring 23.85. However, the adjusted mean scores showed 24.71 for the SCIS group and 24.61 for the Albany group.

The SCIS group from Highland View (see Table 17) showed a computed F score of 1.664 which was less than the tabular F of 3.65 with 1, 74 degrees of freedom and  $\alpha = .05$ ; therefore, the null hypothesis was retained and it can be assumed that there was no significant difference between the mean scores of the SCIS and EIS groups as taught in the Highland View and Albany sixth grades. Highland View had a mean raw score on the pre-test of 22.05 as compared with 21.33 for the Albany group. Highland View's mean score on the post-test was 25.66 with the Albany group scoring 23.85. The adjusted mean scores were 25.27 for Highland View and 23.97 for the Albany group.

The Western View SCIS group had a computed F score of .494 (see Table 18) which was also less than the Tabular F of 3.65 with 1, 79 degrees of freedom and  $\alpha = .05$ ; thus, the null hypothesis was retained and it can be assumed that there was no significant difference

Table 16. Analysis of covariance using CTBS pre- and post-test (Cheldelin and Albany).

Source of variation	df	XX*	XY	YY	Adjusted			F
					df	SS**	MS***	
Group Exp./Cont.	1	222.86	184.60	152.91	1	.12085	.12085	.010
Error (within)	77	2529.02	2033.47	2529.44	76	894.41	11.77	
Total	78	2451.87	2218.08	2682.35	77	894.53		

\* Factor X is pre-test; Factor Y is post-test  
 Pre-test was used as the covariant

\*\* SS = Sum of Squares  
 \*\*\* MS = Mean Square

Tabular F

$\alpha = .05$   
 $df = 1, 120 = 3.92$   
 $H_{02} = (\text{Cheldelin}) \mu \text{ Exp.} = \mu \text{ Cont. retained.}$

Table 17. Analysis of covariance using CTBS pre- and post-test (Highland View and Albany).

Source of variation	df	XX*	XY	YY	df	Adjusted		F
						SS**	MS***	
Group Exp. / Cont.	1	7.22		18.16	45.70	1	23.50	23.50 1.664
Error (within)	76	2894.28		2053.33	2515.65	75	1058.92	14.12
Total	77	2901.50		2071.50	2561.35	76	1082.42	

\* Factor X is pre-test; Factor Y is post-test  
Pre-test was used as the covariant.

\*\* SS = Sum of Squares

\*\*\* MS = Mean Square

Tabular F

$\alpha = .05$

df = 1, 120 = 3.92

$H_{02} = (\text{Highland View}) \mu \text{ Exp.} = \mu \text{ Cont. retained}$

Table 18. Analysis of covariance using CTBS pre-and post-Test (Western View and Albany).

Source of variation	df	XY*	XY	YY	df	Adjusted SS**	MS***	F
Group Exp. /Cont.	1	92.79	50.29	27.26	1	5.91	5.91	.494
Error (within)	81	2494.20	1992.91	2548.26	80	955.89	11.95	
Total	82	2586.99	2043.20	2575.52	81	861.79		

\* Factor X is pre-test; Factor Y is post-test  
 Pre-test was used as the covariant

\*\* SS = Sum of Squares

\*\*\* MS = Mean Square

Tabular F

$\alpha = .05$

df = 1, 120 = 3.92

$H_{02} = (\text{Western View } \mu \text{ Exp. } \mu \text{ Cont. retained}$

Table 19. ALP mean scores and adjusted CTBS mean scores for Cheldelin, Highland View, Western View and Albany.

Group	ALP	CTBS Adjusted Mean Score
Cheldelin (SCIS)	88.74	24.71
Albany (EIS)	82.42	24.61
Highland View (SCIS)	75.33	25.27
Albany (EIS)	82.42	23.97
Western View (SCIS)	82.52	23.77
Albany (EIS)	82.42	24.37

between the mean scores of the SCIS and EIS groups as taught in the Western View and Albany Sixth grades. Western View had a mean raw score on the pre-test of 23.69 as compared with 21.33 for the Albany group. Western View's mean score on the post-test was 25.13 with the Albany group scoring 23.85. The adjusted mean scores were 23.77 for Western View and 24.37 for the Albany group.

Based on this study, it can be assumed that there was no significant difference  $\alpha = .05$ , between the CTBS mean scores of the SCIS and EIS groups as taught in the Cheldelin, Highland View, Western View or Albany sixth grades during the 1975-76 school year.

In comparing the ALP scores with the CTBS adjusted mean scores for each of the experimental and control groups (see Table 19) the Highland View group, which scored lower than the other three groups on the ALP, had the highest adjusted mean score on the CTBS. This negative correlation would tend to agree with Table 15, which showed a slight negative Pearson "r" correlation between the ALP and the CTBS pre-test scores.

Summary of Part B - Findings of the Statistical Analysis Used in the Study.

The following conclusions were drawn from the statistical analysis concerned with this portion of the study:

Hypothesis 01:

- 1) The experimental and control groups' mean scores on the ALP were 82.33 and 82.42, respectively. This would indicate that the predicted academic success as measured by the ALP, was equitable for the two groups.
- 2) Based on the analysis of covariance, no significant difference existed between the CTBS mean scores of the experimental and control groups at the  $\alpha = .05$  level of confidence.
- 3) The ALP scores showed a slight negative correlation with the CTBS pre-test scores as measured by the Pearson Correlation Coefficient "r". As a result of this inverse relationship, the ALP was not used as a covariant in an analysis of covariance.

Hypothesis 02:

- 1) Cheldelin's experimental group had an adjusted mean score of 24.71 as compared with 24.61 for the Albany control group. The analysis of covariance showed no significant difference between these mean scores at the  $\alpha = .05$  level of significance.
- 2) Highland View's experimental group had an adjusted mean score of 25.27 as compared with 23.97 for the Albany control group. No significant difference was determined at the  $\alpha = .05$  level of confidence.
- 3) Western View's experimental group had an adjusted mean score of 23.77 compared with the Albany group's 24.37. No significant difference was determined at the  $\alpha = .05$  level of confidence.
- 4) The Highland View SCIS group which had the lowest score on the ALP maintained the highest CTBS mean score supporting the negative Pearson Correlation Coefficient "r" results.

## V. SUMMARY, DISCUSSION, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

This chapter deals with (1) a summary of the nature of the problem and purpose of the study, review of related literature, design and findings of the study, (2) discussion of the findings of the study, (3) implications, and (4) recommendations for further study.

### Nature of the Problem and Purpose of Study

The problem focused on the effects of an elementary science program, the Science Curriculum Improvement Study (SCIS) on science achievement of sixth grade students. Important to the problem was how the SCIS program compared with a second elementary science program, Experiences in Science (EIS). The study was designed to investigate the programs as they were being taught in two public school systems during the 1975-76 school year.

Much interest and momentum has been generated in the past two decades by the development of new science programs at the secondary and elementary levels. Evaluation of many of these programs has been limited to studies directed by authors and coordinators of the programs who conduct the research under rigid atypical conditions in laboratory schools. However, the literature shows very little research to indicate how effectively these programs function after they

have become a part of the public school curriculum.

Many psychologists, educators and behavioral scientists, such as Piaget, Bruner and Dewey, have agreed that an experience oriented laboratory program in science is superior to the traditional textbook centered curriculums so prevalent throughout the history of the American public school. The cost of materials, supplies and teacher training necessary to implement many of these programs has raised questions as to their instructional value. This concern has emphasized the need for curriculum evaluation at the local level to furnish additional information necessary for direction in program development.

The primary purpose of the study was to investigate the effectiveness of the SCIS program in an unaltered public school situation where neither the teachers nor the students were aware of their involvement in the study. It was felt that this type of research could serve as a valuable addition to the very controlled, theoretical, type of research involving selected populations in laboratory-type schools.

#### Review of Related Literature

The review of literature and research related to three areas:

- (1) the background and philosophies of the SCIS and EIS programs,
- (2) the life and teachings of Jean Piaget, and (3) the development and use of the CTBS and ALP test batteries. This summary follows that

order of presentation.

A research project for the improvement in elementary school science began in 1959 under the direction of Dr. Robert Karplus, professor of physics, University of California, Berkeley. This nationally funded project involved a group of scientists and educators who hoped to develop a science program around what they considered important and fundamental concepts. Feeling that an understanding of these concepts ultimately would lead the student to an understanding of many diverse natural phenomena and a sense of familiarity with the natural environment, the scientists intended to stress the concepts and the methods of science, rather than the uses and applications of science so often stressed in "traditional" science programs. It was the belief of this group that children should be made to feel that scientific concepts and methods are tools to be used to interpret or explain what they observed. The net results of these activities was to confirm Dr. Karplus' belief in the importance of science instruction in the elementary school and to strengthen his convictions that scientists can make a substantial contribution to a reformulation of the science curriculum. The program developed during this project was to become known as the Science Curriculum Improvement Study which was based on the philosophies of the Swiss psychologist Jean Piaget. The general strategy of the SCIS program was to confront the elementary school children with first-hand experience of natural

phenomena and with intellectual challenges which would stimulate their further cognitive development. Piaget conceives intelligence as a hierarchy of strategies for processing information and schemata for assigning significance to information. This hierarchy is formed and structured in accordance with the experience of the individual. Piaget believes intellectual stimulation during the formative years is therefore as important as native endowment in determining adult achievement.

The elementary school acquires a particularly deep responsibility because the child's thinking is especially sensitive to experience as it undergoes a gradual transition from the concrete to the abstract in the age range from 6 to 14 years. At the beginning of this period the child is developing control of his muscles and gaining in ability to carry out physical manipulations; in his thinking he is dependent on direct experience. At the end of the transition, the child is able to focus his thoughts consciously and to manipulate abstract relationships without constant reference to specific examples.

Four influences have been important in the evolution of elementary school science: developments in psychology and education, concern for the nature and structure of science, demands of society, and changes in the nature of the child's environment. The SCIS authors considered each of these influences in developing the units for the program. The program consists of two series of related and

sequential units. One unit in life science, and one in physical science are paired for each of the six grade levels beginning in the kindergarten or first grade and continuing through sixth grade. Taking advantage of the natural curiosity of children, SCIS presents a wide variety of phenomena for classroom exploration and investigation. At each of the six levels numerous inquiry-oriented activities help children accumulate experiences and ideas which advance their thinking from the concrete to the abstract, and enable them to relate scientific concepts to the everyday world.

The Experiences in Science (EIS) is a privately supported experience-centered science program that was developed by (Tannenbaum and Stillman, 1965). The EIS program provides a set of systematically planned experiences that enable students to build understandings of some of the fundamental principles of science. This pattern is essential to the new elementary school science curriculum based on the work of such scholars as Piaget, Bruner, and Gagné since it provides a structure around which students may build conceptual understandings. The program fosters conceptual learning by stressing the processes of science, not as opposed to content but as essential to learning and understanding. Many of the psychological principles and underlying philosophies of the SCIS and EIS programs are very similar although the EIS claims more flexibility in individual

unit presentation. It presents a graded sequence of units which permits control of the level of difficulty. When offered in sequence, conceptual understandings are expanded, modified, and reinforced as the students increase in maturity. However, each unit stands alone with a beginning and an end, thus permitting greater flexibility in the use of the units and allowing for their adaptation to the particular needs of a school.

In the nineteenth century, European psychologists and educators, notably the Swiss educator Pestalozzi, placed great emphasis on direct, immediate experiences on the part of the student. John Dewey in the United States later took a similar view. They encouraged children to use their senses in first-hand experiences with their surroundings. Pestalozzi and Dewey emphasized proceeding from the concrete experiences to the abstract, an idea that contrasted sharply with the memorizing and reciting so widely used at the time. The Pestalozzian ideas were brought to the Western Hemisphere and influenced elementary science of their day. Dewey's approach also was widely implemented. Yet, neither led to inquiry-oriented science because both lacked vital contributions from research scientists who could interpret the nature and content of science in terms appropriate to young children. Nevertheless, many key features of Pestalozzian education and of Dewey's influence can be seen in the SCIS program.

The SCIS program and to an extent the EIS program have been

influenced more by recent developments in psychology and education. Especially important was the work of such psychologists as Piaget, Bruner, and Almy, who stress not only direct experience but also autonomy for the child in conducting his own explorations and investigations. They believe that young children pass through a stage of "concrete operations" during the years when they are in the early grades of elementary school. During this stage, children should have a wide variety of experiences with different kinds of objects, as is provided in the SCIS program.

There are a number of psychological theories of learning that have been used in the development of educational materials. One of these is the theory of "learning-by-association", which views the student's behavior as a response to well planned stimuli. With repetition, practice, correction of errors, and suitable rewards or punishment, the learner is expected to master the desired behavior. This is the theory behind rote learning of past education and has led to programmed instruction in more recent times.

A sharp contrast is provided by the theory of "learning-by-discovery", which claims that everything of which an individual is capable is latent within him. Given a sufficiently rich environment, the learner is expected to discover the properties of objects, the conditions under which interaction takes place, and all the concepts necessary for understanding life. In its extreme forms this theory

allows no direct input that might limit or focus the student's natural interests.

Still another theory, based on the work of Jean Piaget, may be called "learning-by-reasoning". According to this theory, the student is brought to understand relationships through logical reasons provided by himself, the teacher, or classmates. The learning cycle of the SCIS program, reflects the three theories in a complementary way, using each of them for its strongest points but giving greatest weight to "learning-by-reasoning", as outlined by Jean Piaget.

Jean Piaget was born in Neuchatel, Switzerland, in 1896. At a very early age he became interested in Zoology and pursued this interest to receive his doctorate in the natural sciences at 22 years of age. Shortly after receiving his doctorate he enrolled in the psychological laboratory at Zurich where he attended Jung's lectures and read the works of Herbert Spencer which exercised considerable influence on his later writings. Piaget accepted the directorship of studies at the Rousseau Institute of Geneva, now known as the Institute of Educational Science, at the age of 26. He has spent more than 50 years working with research students at the institute studying the mental development of the child. In his work, the problem of Piaget has always been the same, and it arises out of Spencer's own doctrine of adaptation involving the adjustment of the growing child to the world in which he lives.

Piaget's search for the answers to questions in human behavior was begun in the form of keeping careful records of what young children said and did. He soon found that these methods were insufficient and unsatisfactory, however, and he started to develop the ingenious techniques for which he is now world famous. From his many experiments with children of all ages, Piaget contends that there are five main stages in the development of a concept, through which the vast majority of children pass: The Sensory-Motor Stage (0-2 yrs); the Preconceptual Stage (2-4 yrs); the Intuitive stage (4-7 yrs); the Concrete Operations Stage (7-11 yrs); and the Formal Operations Stage (11 yrs and beyond). Piaget believes that educators must determine at which of these levels a student is capable of functioning and design educational experiences to enable him to move to the next stage if maximum learning is to be achieved. A study by Stafford (1969) showed that there was a significant difference between the achievement of SCIS and non-SCIS students in the achievement of Piagetian conservation tasks. In another research project by Stafford the same Piagetian conservation tasks were administered to kindergarten children. The results indicated that kindergarten children can benefit from many activities based on the Piagetian tasks.

The testing instruments used in the study were the Comprehensive Tests of Basic Skills (CTBS) and the Analysis of Learning Potential (ALP). The CTBS is a series of test batteries designed

for kindergarten through twelfth grade. The tests were designed to measure the extent to which individual students have developed the capabilities and learned the skills that are prerequisite to studying and learning in subject matter courses, and necessary for functioning in a society based on daily use of language and number. These basic skills are developed through exposure to a variety of curriculums and instructional procedures. Unlike tests of academic achievement in a particular subject area, the tests are not greatly affected by the particular content material used to teach the students. Performance on these tests is affected, however, by the grade level at which topics are introduced into the curriculum and by the development of the capabilities necessary to perform the task. The tests were developed on the assumption that a student's competence in dealing with content of high complexity increases as he progresses through school.

The emphasis of the tests is on the measurement of the grasp of broad concepts and abstractions as developed by all curriculums, and on facility in the skills that are required in the effective use of language and number such as classifying, manipulating, translating, and interpreting.

The second test used was the Analysis of Learning Potential (ALP) which was developed specifically to provide for the assessment of school learning ability of pupils typically found in grades 1 through 12 in the United States schools. The various sub-tests within each

battery have demonstrated their ability to predict specific criteria of scholastic success while, at the same time, they remain relatively free from assessing those behaviors specifically taught in school.

The current editions of both the Stanford Achievement Test and Metropolitan Achievement Tests were used to determine the relative contribution of ALP experimental tests to the prediction of academic success as defined by these two achievement batteries. The CTBS and ALP were considered well documented testing instruments to be used in the study.

#### Design of the Study

The populations involved in this investigation included 506 sixth grade students enrolled in the Corvallis intermediate schools and 324 sixth grade students enrolled in the Albany elementary school system during the 1975-76 school year. The samples included 60 experimental and 60 control group participants selected at random from each of the respective populations.

The ALP tests were administered to the populations prior to the treatment period to establish a measure of group equality. The CTBS science sub-test was administered as a pre-test during the first quarter of the school year. This science achievement sub-test consisted of 36 objective items testing the science processes of: Recognition, Classification, Quantification, Interpretation of Data,

Prediction from Data, Hypothesis Evaluation and Design Analysis.

These include many of the objectives which the SCIS and EIS programs were attempting to teach.

During the fourth quarter the experimental and control groups were administered the post-test, consisting of the same items as the pre-test. At the close of the treatment period, teacher questionnaires were sent to the teachers involved in the study. The questionnaires were designed to investigate teacher training and commitment to the programs, time spent in instruction and opinions of teachers in regard to the programs meeting their needs and the needs of their students. Information from the questionnaires was used to determine what variables existed within the classrooms for the experimental and control groups.

The treatment of the data was designed to explore two general hypotheses: Hypothesis 1 stated that:

There will be no significant difference between the mean scores of the SCIS group as taught in the Corvallis sixth grade as compared with the EIS group as taught in the Albany sixth grade.

The statistical analysis chosen to provide data on the hypothesis was the Analysis of Covariance. For this study, the pre-test score on the CTBS was considered the covariant factor and the post-test score was the dependent variable. If the computed F value generated by the analysis of covariance was equal to or greater than the tabular

F value at the  $\alpha = .05$  level of significance the null hypothesis was rejected. The ALP score was considered as a covariant with the CTBS post-test score to be used as the dependent variable. To document the use of the ALP score as the covariant, a Pearson Product Moment Correlation Coefficient "r" was used to determine if a positive linear relationship existed between the ALP score and the CTBS pre-test score. This analysis showed a slight negative correlation between the scores, thus the ALP score was not used in an analysis of covariance test.

Hypothesis 2 was as follows:

There will be no significant difference between the mean scores of the SCIS group as taught in the Cheldelin, Highland View and Western View sixth grade as compared with the EIS group as taught in the Albany sixth grade.

The statistical analysis of hypothesis 2 was broken down into three separate analyses which compared the Albany group with each of the three intermediate schools in the Corvallis district. The Analysis of Covariance was chosen to provide the data for each of the tests conducted. For each of these tests, the pre-test score on the CTBS was considered the covariant factor and the post-test score was the dependent variable. If the computed F value generated by the analysis of covariance was equal to or greater than the tabular F value at the  $\alpha = .05$  level of significance, the hypothesis was rejected.

The summary of the teacher questionnaires utilized frequency distributions and percentages for describing the data. Summary

tables were used to improve data interpretation.

#### Findings of the Study

Hypothesis 1 was retained. Based on this study, it can be assumed that there was no significant difference between the mean score of the SCIS and EIS groups as taught in the Corvallis and Albany sixth grade.

The computed F generated by the analysis of covariance was .224 and the tabular F at the  $\alpha = .05$  and df = 1, 120 was 3.92. The computed F value was less than the tabular F value and therefore  $H_{01}$  was retained. The experimental group's adjusted mean score of 25.04 was not found to be significantly higher than the control group's adjusted mean score of 24.72. The experimental SCIS group experienced an unadjusted mean gain of 2.22 raw score points as compared with 2.52 raw score points for the control EIS group.

Hypothesis 2 was retained. Based on this study, it can be assumed that there was no significant difference between the CTBS mean score of the SCIS and EIS groups as taught in the Cheldelin, Highland View, Western View or Albany sixth grades.

In comparing the Cheldelin SCIS group with the Albany EIS group the computed F score of .01 was less than the tabular F of 3.65 at the  $\alpha = .05$  level of significance. Therefore, the null hypothesis was retained and it was assumed that there was no significant

difference between the CTBS mean score of the Cheldelin SCIS group as compared with the Albany EIS group.

The Highland View SCIS group had a computed F score of 1.664 which was less than the tabular F of 3.65 at the  $\alpha = .05$  level of significance. Therefore, the null hypothesis was retained and it was assumed that there was no significant difference between the CTBS mean score of the Highland View SCIS group as compared with the Albany EIS group.

The Western View SCIS population had a computed F score of .494, which was less than the tabular of 3.65 at the  $\alpha = .05$  level of significance. The null hypothesis was retained and it was assumed that there was no significant difference between the CTBS mean score of the Western View SCIS group as compared with the Albany EIS group.

The results of the teacher questionnaire showed that the programs involved in the study were comparable in terms of teacher preparation, percentage of teachers who were teaching the SCIS and EIS, hours spent in instruction and teacher attitudes toward the programs meeting their needs and the needs of their students.

The ALP scores were used to compare the Corvallis and Albany groups in terms of predicted academic success. It was found that the Corvallis population had a mean score on the ALP of 82.19 as compared with the mean score of 82.42 for the Albany group. Thus it can

be assumed, based on the ALP scores, that the Corvallis and Albany students were similar in terms of academic potential.

### Discussion

Beyond the retention of hypotheses 1 and 2, the data gathered in this investigation provided some interesting observations and speculations. The experimental group did show a higher mean score than the control group although the difference was not significant at the  $\alpha = .05$  level. Most of the literature was concerned with comparing the SCIS program with traditional textbook type of programs. These studies were quite frequently carried out in very rigidly controlled conditions with highly trained teachers and in many instances in laboratory schools with academically selected students. The majority of these studies did show a significant difference between the science achievement of the SCIS students as compared with the non-SCIS students. The literature, however, does not show many studies involving a comparison between two of the laboratory experience oriented programs such as the SCIS and EIS. There were likewise few studies involving these programs as they were being taught in a public school situation where the groups involved were unaware they were participating in a research project.

The lack of strong positive correlation between the ALP scores and the CTBS pre-test scores, as indicated by the Pearson

Correlation "r" was supported in the comparisons involving the intermediate schools and the EIS population. Highland View students who showed the lowest mean score on the ALP had the highest mean score on the CTBS. This negative correlation is difficult to explain as many of the broad concepts, abstractions, and skills such as classifying, manipulating, translating and interpreting are common objectives of both tests. However, in observing the correlation between the scores of the Cheldelin, Western View and Albany populations, a positive correlation was determined between the ALP and CTBS pre-test scores. Any attempt at resolving this difference in correlation would be an exercise in pure conjecture.

Many public schools have adopted one or more of the elementary laboratory oriented science programs. Most of these programs have been modified and adapted to meet local, district, school and teacher needs. Administrators and curriculum directors have provided in-service and other formal training procedures to encourage teacher enthusiasm in the implementation and use of these programs. Much of the impetus toward the adoption of these programs has been stimulated by a desire on the part of educators to develop a basic science curriculum extending from kindergarten through grade 12. This basic curriculum including goals and objectives commensurate with state and district basic competencies would facilitate the development of a scope and sequence type of structure in the science area.

Some teachers, however, resist any program resembling a common set of district goals, suggesting that such a procedure dampens individual initiative and infringes on freedoms inherent in good education in a democratic society. Many elementary teachers also feel unprepared and inadequate in the field of laboratory science and thus are hesitant and insecure in venturing beyond the traditional textbook approach. Laboratory science programs also require extra time and effort in planning, utilization of equipment, supplies, physical plant facilities and care of living organisms during week-ends and holidays. Many elementary teachers are unwilling to devote the extra time required to carry out this type of program in a crowded daily schedule covering many subject areas.

Recent state guidelines concerning basic competencies in the various curricular areas covered in the public schools have encouraged local districts to re-evaluate their educational goals in terms of these suggested competencies. The general results of this focus has been a more extensive delineation of curriculum guidelines and a moral commitment on the part of most teachers to function within the directives of their planned course statements. Thus, it would appear that the educational pendulum in the public schools is swinging from a rather loose undefined curriculum structure typified by the multitude of mini courses so common during the past decade, to a more defined scope and sequence type design. Much of this focus on

survival skills and basic competencies has stemmed from recent legal implications involving the responsibility of the public school toward the basic education of students receiving the high school diploma. Many of these factors should serve as an additional catalyst to stimulate district interest in adopting an elementary science program having a set of goals and objectives commensurate with those outlined in state and local curriculum guidelines.

Research lends itself very well to controlled laboratory surroundings. It is this type of research which has helped build the science and technology in our world today and will continue to move it forward in the future. However, many of these research tools, while very adequate in the laboratory, prove to be somewhat inadequate in the "real" world. The frustrations experienced by the researcher as he attempts to control, evaluate and categorize his natural surroundings in a field type situation can be sensed in much of the literature. Yet, both the theoretical and the practical must be investigated if a complete understanding of any problem is to be gained. It was in the realm of the "practical" that this research was conducted and the conclusions reached although not "laboratory" pure, were based on instruction as it was taking place in two public schools during the 1975-76 school year.

Conclusions

The following conclusions are presented on the basis of information drawn from this study and from conclusions generated by other writers and researchers.

1. There was no significant difference in the science achievement of the students exposed to the SCIS program in the Corvallis sixth grade as compared with the students exposed to the EIS program in the Albany sixth grade.
2. There was no significant difference in the science achievement of the sixth grade students in the SCIS program at Cheldelin as compared with the sixth grade students in the Albany EIS program.
3. There was no significant difference in the science achievement of the sixth grade students in the Highland View SCIS program as compared with the sixth grade students in the Albany EIS program.
4. No significant difference was determined in the science achievement of the sixth grade students in the Western View SCIS program as compared with the sixth grade students in the Albany EIS program.

Implications

The following implications are presented on the basis of information gained from this study. In some instances the study reaffirms implications generated by previous studies, and in other cases the implication is inherent to the information gathered in this investigation.

1. The SCIS and EIS programs have many objectives in common and produce similar academic results. Therefore, school districts may wish to consider the cost of the programs as a further criterion for determining which materials to select in curriculum development.
2. Given the equality of the SCIS and EIS programs, curriculum directors may choose to adopt both the SCIS and EIS, and allow teachers the option of selecting the program they feel will best meet their needs and the needs of their students.
3. Classroom facilities such as counter space, storage area, window access and the type of student desks available could be considered as further evidence in determining which program to adopt in a given school or district.
4. Living specimens utilized by the SCIS and EIS are not the same. Many school districts culture and supply these

organisms through a central media center. The directors of these centers should be consulted in reference to program selection based on facilities and personnel expertise.

#### Recommendations for Further Study

The elementary laboratory centered science programs available to schools today offer an opportunity to strengthen the student's abilities in observation, classification, quantification and many other processes of science so necessary in a technological society. Scientific literacy is claimed as one of the general goals of many of these science programs. The main focus of this study centered on the SCIS program as compared with the EIS program as they functioned in two public school systems.

The following recommendations were generated from information obtained during the process of the investigation.

1. This investigation covered a time span of approximately 29 weeks. Longitudinal studies are recommended that would investigate student's retention of outcomes and learnings as they may influence achievement in other science areas.
2. Although the SCIS program has been a part of the Corvallis elementary school curriculum since 1970, it was not

recommended for use in all sixth grade classrooms until the 1975-76 school year. It is recommended that a future study be carried out to determine the effectiveness of the program after it has been more thoroughly implemented into the sixth grade.

3. The literature reveals several studies dealing with the effects of the SCIS program on achievement in other areas. It is recommended that a study of this nature be carried out at the local level.
4. Many of the laboratory oriented science programs were developed around the philosophies of modern psychologists. It is recommended that further studies investigate the importance of an understanding of contemporary psychologists to good teaching.
5. It is recommended that this study be replicated to further test the significance of the reported findings. It is suggested that, in any replication, additional efforts be made to equate teacher training and commitment to the programs involved.
6. It is suggested that a further study be conducted at the local level which would compare SCIS with a traditional textbook type program.

## BIBLIOGRAPHY

- Allen, L. R. 1973. Evaluation of children's performance on certain cognitive, affective, and motivational aspects of the systems and subsystems unit of the science curriculum improvement study's elementary science program. *Journal of Research in Science Teaching.* Vol. 10, p. 125-134.
- Allen, L. R. 1973. Examination of the ability of third grade children from the science curriculum improvement study to identify experimental variables and to recognize change. *Science Education.* Vol. 57. p. 135-151.
- Allen, Leslie Robert. 1967. An examination of the classificatory ability of children who have been exposed to one of the "new" elementary science programs. Unpublished doctoral dissertation, University of California, Berkeley. 139 p.
- Beard, Ruth Mary. 1969. An outline of Piaget's developmental psychology for students and teachers. New York, Basic Books. 139 p.
- Bloom, Benjamin S. 1967. Taxonomy of educational objectives. New York, David McKay Co.
- Bruce, Larry Rhea. 1969. A determination of the relationships among SCIS teachers' personality traits, attitude toward teacher-pupil relationship, understanding of science process skills and question types. University Microfilms, Ann Arbor, MI.
- Bruner, Jerome S. 1968. Toward a theory of instruction. New York, W. W. Norton and Co. 176 p.
- Campbell, Donald T. 1963. Experimental and quasi-experimental designs for research. Chicago, Rand McNally and Co. 84 p.
- Charles, Edward. 1970. An investigation of the use of tests to compare gain scores of students in science who have used individualized science materials and those who have used traditional textbook materials. Doctoral dissertation, LeHigh University, Bethlehem, PA. 89 p.

- Coffia, William J. 1971. The effects of an inquiry-centered curriculum in science on a child's achievement in selected academic areas. Unpublished doctoral dissertation. University of Oklahoma, Norman, 136 p.
- Comprehensive tests of basic skills, 1974. Expanded edition, test coordinator's handbook. Monterey, CA, CTB/McGraw-Hill. 94 p.
- Coon, George Laus. 1972. An assessment of the change in the learning environment as perceived by junior high students whose teachers are participating in a field-centered teacher-education program. Doctoral dissertation, Oregon State University, Corvallis. 97 p.
- Courtney, E. Wayne. 1965. Applied research in education. Totowa, NJ, Littlefield, Adams. 341 p.
- Courtney, Wayne and Larry Sedgwick. 1969. Statistical concepts. Menomonie, WI, Stout State University. n.p.
- Dale, Edgar. 1972. Building a learning environment. Bloomington, IN, Phi delta kappa educational foundation. 132 p.
- Denzil, Ray Porterfield. 1969. Influence of preparation in science curriculum improvement study on questioning behavior of selected second and fourth grade reading teachers. Unpublished doctoral dissertation, University of Oklahoma, Norman.
- Durost, Walter N., Eric F. Gardner, and Richard Madden. 1970. Analysis of learning potential, manual for administration. San Francisco, Harcourt Brace Hovanovich, 38 p.
- Elkind, David. 1961. The development of quantitative thinking: a systematic replication of Piaget's studies. Journal of Genetic Psychology. Vol. 98, p. 37-46.
- Evans, Richard Isadore. 1973. Jean Piaget: The man and his ideas, by Richard I. Evans, Translated by Eleanor Duckworth. New York, E. P. Dutton. 189 p.
- Flavell, John H. 1963. The developmental psychology of Jean Piaget. New York, Van Nostrand Reinhold Co. 472 p.

Frymier, Jack Rimmel and Horace C. Hawn. 1970. Curriculum improvement for better school. Worthington, OH, C. A. Jones Publishing Co. 270 p.

Furth, Hays G. and Harry Wachs. 1974. Thinking goes to school, Piaget's theory in practice. New York, Oxford University Press. 297 p.

Gage, Nathaniel Lee. 1963. Handbook of research on teaching; a project of the American Educational Research Association, Chicago, Rand McNally. 1218 p.

Gage, Nathaniel Lee. 1973. Second handbook of research on teaching; A project of the American Educational Research Association. Edited by Robert M. W. Troyers. Chicago, Rand McNally. 1400 p.

Gagné, Robert M. and William D. Rohwer, Jr. 1969. Instructional psychology. In Paul H. Mussen Ed. Annual Review of Psychology. Vol. 20. p. 381-418.

Gagné, Robert M. 1965. The psychological bases of Science-A-process approach. Washington, D.C. American Association for the Advancement of Science. 35 p.

Glass, Gene V. 1970. Statistical methods in education and psychology. Englewood Cliffs, NJ, Prentice Hall. 596 p.

Glatthorn, Allan A. 1968. Curriculum reform has failed in three important ways. Ohio Schools. Vol. 46, p. 12-14.

Haan, Norma. 1968. An exploratory investigation of the effect of an initial experience with SCIS's material objects unit on first grade children and their teachers. Berkeley, CA. Far West Laboratory for Educational Research and Development.

Halpern, Esther. 1965. The effects of incompatibility between perception and logic in Piaget's stage of concrete operations. Child Development. Vol. 36. p. 491-497.

Harms, Kenneth Kiely. 1972. A comparison of theoretical model construction between primary students using science curriculum improvement study materials (SCIS) and non-SCIS primary students. Master's thesis, Oregon State University, Corvallis. 54 p.

- Helmore, G. A. 1969. Piaget - a practical consideration. London, Pergamon Press. 73 p.
- Hunsaker, Floyd Rex. 1975. A comparison of attitudes between two field-based teacher education programs. Doctoral dissertation, Oregon State University, Corvallis. 100 p.
- Hunt, J. McV. Intelligence and experience. New York. The Ronald Press Co. 416 p.
- Hurd, Paul Dehart and James Joseph Gallagher. 1968. New directions in elementary science teaching. Belmont, CA. Wadsworth Publishing Co. 166 p.
- Inhelder, Barbel. 1958. The growth of logical thinking from childhood to adolescence; an essay on the construction of formal operational structures of Barbel Inhelder and Jean Piaget. New York, Basic Books. 356 p.
- Jacobson, Willard J. and Harold E. Tannenbaum. 1961. Modern elementary school science: a recommended sequence. New York, Bureau of Publications, Teachers College, Columbia University. 194 p.
- Johnson, Harry B. and Raymond N. Brown. 1974. Evaluation of SCIS (Science Curriculum Improvement Study). Unpublished paper, Corvallis School District 509J, Corvallis, OR. 4 p.
- Karplus, Robert. 1968. What is curriculum evaluation? Science Curriculum Study, University of California, Berkeley.
- Karplus, Robert and Cynthia Ann Powell. 1963. A concept of matter for the first grade. Journal of Research in Science Teaching. December 1963.
- Karplus, Robert and Herbert D. Thier. 1967. A new look at elementary school science. Chicago, Rand McNally. 204 p.
- Karplus, Robert and Herbert D. Thier. 1966. Science teaching is becoming literate. Education Age, January/February 1966
- Kellogg, Donald H. 1971. An investigation of the effect of the science curriculum improvement study's first year unit Material Objects, on gains in reading readiness. Unpublished doctoral dissertation, University of Oklahoma, Norman. 71 p.

- Kondo, Allan K. 1969. The questioning behavior of teachers in the science curriculum improvement study teaching. Paper presented at the NARST meeting, Pasadena, CA, February 1969.
- Kuslan, Louis I. and Stone A. Harris. 1969. Readings on teaching children science. Belmont, CA, Wadsworth Publishing Co.
- Kuslan, Louis I. and Stone A. Harris. 1968. Teaching children science. Belmont, CA, Wadsworth Publishing Co. 464 p.
- Lepper, Robert E. 1967-68. A cross-cultural investigation of the development of selected Piagetian science concepts, social status, and reading readiness. *Journal of Research in Science Teaching*. Vol. 5. p. 324-337.
- Lerner, Marjorie and Edward Victor. 1967. Readings in science education for the elementary school. New York, Macmillan Co. 527 p.
- Lockard, J. David (ed). 1968. Sixth report of the international clearinghouse on science and mathematics curricular developments. College Park, MD, University of Maryland and AAAS.
- McClure, Sherman Le Jeal. 1971. The application of cognitive dissonance theory to the acquisition of a Piagetian conservation task by selected elementary school children. Doctoral dissertation, Oregon State University, Corvallis. 116 p.
- Molitor, Loretta Louise. 1971. An investigation to develop an instrument to evaluate the science skills of inference, prediction, and verification of children in grades four, five and six. Unpublished doctoral dissertation, University of Pennsylvania, Philadelphia. 242 p.
- Moon, Thomas Charles. 1969. A study of verbal behavior patterns in primary grade classrooms during science activities. Unpublished doctoral dissertation, Michigan State University, East Lansing. 184 p.
- Newman, Donald B. 1969. The influence of selected science experiences on the attainment of concrete operations by first grade children. Paper read before the 42nd meeting of the National Association for Research in Science Teaching, Pasadena, CA.

- Pagano, Arnold Robert. 1970. A comparison of the effects of four teaching strategies on the acquisition, retention, and transfer of selected science concepts in the sixth grade. Doctoral dissertation, University of California, Berkeley. 203 p.
- Piaget, Jean, 1964. Development and learning. Journal of Research in Science Teaching. September 1964.
- Piaget, Jean, 1970. Science of education and the psychology of the child. (Translated from the French by Derek Coltman.) New York, Orion Press. 188 p.
- Piaget, Jean. 1929. The child's conception of the world. (Translated from the French by Paul K. Landon, Trench, Truber and Co., Ltd.) New York, Harcourt Brace and Co. 397 p.
- Pulaski, Mary Ann Spencer. 1971. Understanding Piaget; an introduction to children's cognitive development. New York, Harper and Row. 241 p.
- Raven, Ronald J. 1967. The development of the concept of momentum in primary school children. Journal of Research in Science Teaching. Vol. 5.
- Renner, J. W. 1973. Evaluation of the science curriculum improvement study. School Science and Math, April 1973. p. 291-318.
- Sanders, Norris M. 1966. Classroom questions. New York, Harper and Row. 176 p.
- Schatz, Albert. 1971. Teaching science with garbage. Emmaus, PA, Rodale Press. 60 p.
- Science Curriculum Improvement Study. 1974. SCIS Teacher's Handbook. Lawrence Hall of Science, University of California, Berkeley. 179 p.
- SCIS Omnibus. 1973. Science Curriculum Improvement Study. Lawrence Hall of Science, University of California, Berkeley. 159 p.
- Science Curriculum Improvement Study. 1964. Newsletter, Nos. 1-18, Science curriculum improvement study, Lawrence Hall of Science, University of California, Berkeley.

- Showalter, Victor. 1964. Unified science, an alternative to tradition. *The Science Teacher*. February 1964.
- Simpson, R. D. 1974. Comparison of biologic content in three elementary school science curriculum projects: ESS, SAPA, SCIS. *American Biology Teacher*. Vol. 36. p. 340-343.
- Stafford, Donald G. 1969. The influence of the first grade program of the science curriculum improvement study on the rate of attainment of conservatives. Unpublished doctoral dissertation, University of Oklahoma, Norman. 102 p.
- Stafford, Donald G. and John W. Renner. 1971. SCIS helps the first grader to use logic in problem solving. *School Science and Mathematics*, February 1971. p. 159-164.
- Struve, N. L. 1974. Science curriculum improvement study (SCIS) materials-centered science and manipulative skill. *Exceptional Child*. Vol. 40. p. 515-517.
- Swinney, Richard James. 1976. A study to develop a career education component for teacher education students. Doctoral dissertation, Oregon State University, Corvallis. 129 p.
- Taba, Hilda. 1962. Curriculum development; theory and practice. Under the general editorship of Willard B. Spalding. New York, Harcourt Brace and World. 529 p.
- Tannenbaum, Harold E., Beulah Tannenbaum, Nathan Stillman, and Myra Stillman. 1969. Experiences in science. Manchester, MO, Webster Division, McGraw-Hill Book Co. Brochure, 10 p.
- Tannenbaum, Harold E., Beulah Tannenbaum, Nathan Stillman, and Myra Stillman. 1965. Science education for elementary school teachers. Boston, Allyn and Bacon. 339 p.
- Tanner, Thomas, 1971. Favorite subjects study. A cooperative study with the Corvallis Public School District 509J, Corvallis, OR. Brochure.
- Thier, Herbert D. 1970. Teaching elementary school science; a laboratory approach. Lexington, MA, Heath and Co. 273 p.
- Thier, Herbert D. 1965. A look at a first grader's understanding of matter. *Journal of Research in Science Teaching*. March 1965.

- Thompson, Thomas Edward. 1974. A survey of the status and the needs opinion of science education in Oregon during the 1973-74 school year, grades K-12. Unpublished doctoral dissertation. Oregon State University, Corvallis. 353 p.
- Trowbridge, L. W. 1974. Trends and innovations in junior high school science teaching in the United States. *Science Teacher*. April 1974. p. 12-15.
- U.S. Department of Commerce. Bureau of the Census. 1972. *Statistical abstract of the United States*.
- Van Til, William. 1974. Comprehensive curriculum: Quest for relevance. 2nd ed. Boston, Houghton Mifflin. p. 432.
- Vivian, V. Eugene. 1969. An evaluation scheme for elementary science. Glassboro State College. Paper read before the National Science Teachers Association. Dallas, Texas.
- Voelker, Alan, and Robert Rogers. 1970. Programs for improving science instruction. *Science and Children*. January/February 1970.
- Watson, Fletcher G. 1967. Why do we need more physics courses? *The Science Teacher*. Vol. 5, p. 212-214.
- Weber, M. C. 1971. The influence of the science curriculum improvement study on the learner's operational utilization of science processes. Unpublished doctoral dissertation, University of Oklahoma, Norman. 112 p.
- Weber, M. C. and J. W. Renner. 1972. How effective is the SCIS science program? *School Science and Mathematics*. Vol. 72. p. 729-734.
- Williams, David Lee and Wayne L. Herman, Jr. 1971. *Current research in elementary school science*. New York, Macmillan Co. 436 p.
- Wilson, John H. 1968. Differences between inquiry-discovery and the traditional approaches to teaching science in the elementary schools. Unpublished doctoral dissertation, University of Oklahoma, Norman. 110 p.

## APPENDICES

## APPENDIX A

Comprehensive Test of Basic Skills

The authors of the CTBS have denied a request by the investigator to reproduce any portion of their materials in this document.

## APPENDIX B

Concepts Covered in the SCIS ProgramKindergarten:

Life Science Concepts:

Color, Shape, Texture, Odor, Sound.

Physical Science Concepts:

Size, Quantity, Position, Organisms.

Grade 1:

Life Science Concepts:

Organism, Birth, Death, Habitat, Food Web,  
Detritus.

Physical Science Concepts:

Object, Property, Material, Serial Ordering,  
Change, Evidence.

Grade 2:

Life Science Concepts:

Growth, Development, Life Cycle, Genetic Identity,  
Generation, Biotic Potential, Plant and Animal,  
Metamorphosis.

Physical Science Concepts:

Interaction, Evidence of Interaction, System,  
Interaction-at-a-distance.

Grade 3:

Life Science Concepts:

Population, Predator, Prey, Community, Plant  
Eater, Animal Eater, Food Chain, Food Web.

Physical Science Concepts:

Subsystem, Histogram, Evaporation, Solution,  
Variable.

Grade 4:

Life Science Concepts:

Environment, Environmental Factor, Range, Optimum Range.

Physical Science Concepts:

Reference Object, Relative Position, Relative Motion, Rectangular Coordinates, Polar Coordinates

Grade 5:

Life Science Concepts:

Producer, Consumer, Decomposer, Photosynthesis, Community, Food Transfer, Raw Materials.

Physical Science Concepts:

Energy Transfer, Energy Chain, Energy Source, Energy Receiver.

Grade 6:

Life Science Concepts:

Ecosystem, Water Cycle, Oxygen-Carbon Dioxide Cycle, Pollutant, Food-Mineral Cycle.

Physical Science Concepts:

Scientific Model, Electricity, Magnetic Field.

## APPENDIX C

Units Covered in the EIS ProgramGrade 1:

Hot and Cold, Young Animals, Light and Shadow, Earth and Sun, Weather, Plants in Spring.

Grade 2:

Magnets, Batteries, Groups, Balances, Air, Living Things

Grade 3:

Motion, Earth, Sun and Seasons, Heat, Sound, Life Histories, Plant and Animal Responses.

Grade 4:

Solids, Liquids, and Gases, Adaptations, Atmosphere and Weather, Chemical Change, Geologic Processes, Ecology

Grade 5:

Microscopic Life, Molds, Unbalanced Forces, Balanced Forces, Mapping, Time.

Grade 6:

Electricity, Life Processes of Plants, Light, Color, the Universe, Continuity of Life.

## APPENDIX D

### The Analysis of Learning Potential

The authors of the ALP have denied a request by the investigator  
to reproduce any portion of their materials in this document.

## APPENDIX E

SCIENCE QUESTIONNAIRE

TO: Corvallis Sixth Grade Teachers

FROM: John Hoover

With the approval of Dr. Fred Quale, Assistant Superintendent of Instruction, I am doing a study involving the Experiences in Science (EIS) and the Science Curriculum Improvement Study (SCIS) programs in the Albany and Corvallis schools. Would you be kind enough to take a few minutes to answer the following questions?

1. Have you been teaching the SCIS program this year?

Yes \_\_\_\_\_ No \_\_\_\_\_

2. Have you had any inservice or other formal training specifically designed to improve your skills in teaching the SCIS program?

Yes \_\_\_\_\_ No \_\_\_\_\_

3. If your answer to number 2 is yes, approximately how many quarter-hours credit (district or college) did you receive?

a) Inservice course with no district or college credit \_\_\_\_.  
 b) 1 hour \_\_\_\_\_ f) 5 hours \_\_\_\_\_  
 c) 2 hours \_\_\_\_\_ g) Other \_\_\_\_\_  
 d) 3 hours \_\_\_\_\_  
 e) 4 hours \_\_\_\_\_

4. Could you estimate approximately how many hours per week you have spent teaching the SCIS program this year (1975-76)?

a) 0 hours per week \_\_\_\_\_ e) 2 hours per week \_\_\_\_\_  
 b)  $\frac{1}{2}$  hour per week \_\_\_\_\_ f)  $2\frac{1}{2}$  hours per week \_\_\_\_\_  
 c) 1 hour per week \_\_\_\_\_ g) Other \_\_\_\_\_  
 d)  $1\frac{1}{2}$  hours per week \_\_\_\_\_

5. Do you feel qualified to teach the SCIS program?

Yes \_\_\_\_\_ No \_\_\_\_\_

6. Do you feel that the SCIS program has met your teaching needs as well as the needs of your students?

Yes \_\_\_\_\_ No \_\_\_\_\_

THANK YOU VERY MUCH FOR YOUR COOPERATION!

## APPENDIX F

SCIENCE QUESTIONNAIRE

TO: Albany Sixth Grade Teachers  
 FROM: John Hoover

With the approval of Dr. Fred Quale, Assistant Superintendent of Instruction of Corvallis School District, I am doing a study involving the Experiences in Science (EIS) and the Science Curriculum Improvement Study (SCIS) programs in the Albany and Corvallis schools. Would you be kind enough to take a few minutes to answer the following questions?

1. Have you been teaching the EIS science program this year?

Yes \_\_\_\_\_ No \_\_\_\_\_

2. Have you had any inservice or other formal training specifically designed to improve your skills in teaching the EIS program?

Yes \_\_\_\_\_ No \_\_\_\_\_

3. If your answer to number 2 is yes, approximately how many quarter-hours credit (district or college) did you receive?

a) Inservice course with no district or college credit \_\_\_\_.  
 b) 1 hour \_\_\_\_  
 c) 2 hours \_\_\_\_ f) 5 hours \_\_\_\_  
 d) 3 hours \_\_\_\_ g) Other \_\_\_\_\_  
 e) 4 hours \_\_\_\_

4. Could you estimate approximately how many hours per week you have spent teaching the EIS program this year (1975-76)?

a) 0 hours per week \_\_\_\_ f)  $2\frac{1}{2}$  hours per week  
 b)  $\frac{1}{2}$  hour per week \_\_\_\_ g) Other \_\_\_\_\_  
 c) 1 hour per week \_\_\_\_  
 d)  $1\frac{1}{2}$  hours per week \_\_\_\_  
 e) 2 hours per week \_\_\_\_

5. Do you feel qualified to teach the EIS program?

Yes \_\_\_\_\_ No \_\_\_\_\_

6. Do you feel that the EIS program has met your teaching needs as well as the needs of your students?

Yes \_\_\_\_\_ No \_\_\_\_\_

THANK YOU VERY MUCH FOR YOUR COOPERATION!!

## APPENDIX G

## Experimental Group ALP and CTBS Pre- and Post-Test Scores

Student I. D. #	ALP	Pre-test	Post-test	Difference	CTBS
061	057	13	19	+ 6	
062	094	16	27	+ 11	
063	047	21	21	0	
064	055	26	29	+ 3	
065	056	19	12	- 7	
066	085	31	30	- 1	
067	093	28	27	- 1	
068	069	19	22	+ 3	
069	084	17	22	+ 5	
070	120	26	31	+ 5	
071	105	28	29	+ 1	
072	096	24	31	+ 7	
073	122	24	29	+ 5	
074	063	18	17	- 1	
075	078	27	30	+ 3	
076	098	26	33	+ 7	
077	109	31	30	- 1	
078	085	19	23	+ 4	
079	046	17	20	+ 3	
080	068	22	20	- 2	
081	080	22	29	+ 7	
082	095	21	20	- 1	
083	079	27	27	0	
084	086	21	21	0	
085	117	32	35	+ 3	
086	082	26	26	0	
087	092	29	31	+ 2	
088	098	28	30	+ 2	
089	103	18	27	+ 9	
090	059	13	12	- 1	
091	072	18	23	+ 5	
092	113	32	31	- 1	
093	100	26	30	+ 4	
094	073	27	29	+ 2	
095	061	23	28	+ 5	
096	036	13	18	+ 5	

Continued

**Experimental Group ALP and CTBS Pre- and Post-Test Scores -  
(continued)**

Student I. D. #	ALP	Pre-test	Post-test	Difference CTBS
097	119	34	34	0
098	077	09	25	+ 16
099	126	31	34	+ 3
100	102	31	29	- 2
101	037	22	17	- 5
102	074	16	30	+ 14
103	105	32	31	- 1
104	084	24	23	- 1
105	078	30	27	- 3
106	052	18	19	+ 1
107	072	25	23	- 2
108	066	24	22	- 2
109	078	22	28	+ 6
110	096	22	24	+ 2
111	095	28	28	0
112	114	29	31	+ 2
113	048	30	30	0
114	085	25	31	+ 6
115	062	21	22	+ 1
116	044	24	26	+ 2
117	046	13	15	+ 2
118	097	26	29	+ 3
119	098	27	28	+ 1
120	109	31	30	- 1

## APPENDIX H

## Control Group ALP and CTBS Pre- and Post-Test Scores

Student I. D. #	ALP	Pre-Test	Post-Test	Difference	CTBS
001	089	23	25	+ 2	
002	102	29	29	0	
003	101	27	29	+ 2	
004	110	27	30	+ 3	
005	075	14	14	0	
006	063	21	27	+ 6	
007	053	13	19	+ 6	
008	055	25	30	+ 5	
009	099	19	20	+ 1	
010	084	23	28	+ 5	
011	101	34	33	- 1	
012	084	21	25	+ 4	
013	054	14	16	+ 2	
014	116	28	32	+ 4	
015	113	27	32	+ 5	
016	064	13	18	+ 5	
017	055	08	08	0	
018	106	27	32	+ 5	
019	077	23	26	+ 3	
020	083	19	20	+ 1	
021	059	13	19	+ 6	
022	096	26	25	- 1	
023	100	30	29	- 1	
024	057	17	14	- 3	
025	081	13	20	+ 7	
026	050	10	20	+ 10	
027	096	28	29	+ 1	
028	079	22	20	- 2	
029	084	16	14	- 2	
030	080	14	14	0	
031	063	20	21	+ 1	
032	094	23	25	+ 2	
033	079	17	20	+ 3	
034	077	20	21	+ 1	
035	093	26	29	+ 3	
036	090	15	23	+ 8	

Continued

## Control Group ALP and CTBS Pre- and Post-Test Scores - (continued)

Student I. D. #	ALP	Pre-Test	Post-Test	Difference	CTBS
037	092	21	24	+ 3	
038	097	22	27	+ 5	
039	104	26	30	+ 4	
040	065	16	20	+ 4	
041	075	24	18	- 6	
042	088	18	24	+ 6	
043	098	23	26	+ 3	
044	062	19	21	+ 2	
045	044	15	23	+ 8	
046	046	14	18	+ 4	
047	117	32	34	+ 2	
048	053	14	24	+ 10	
049	068	27	23	- 4	
050	095	24	32	+ 8	
051	096	25	32	+ 7	
052	077	27	21	- 6	
053	066	23	21	- 2	
054	099	27	22	- 5	
055	093	26	24	- 2	
056	108	26	30	+ 4	
057	072	19	25	+ 6	
058	056	17	19	+ 2	
059	098	23	24	+ 1	
060	114	27	33	+ 6	

## APPENDIX I

Pearson Product Moment Correlation Coefficient (r) Formula

$$r = \frac{\sum (X_1)(X_2) - \frac{(\sum X_1)(\sum X_2)}{n}}{\sqrt{\sum X_1^2 - \frac{(\sum X_1)^2}{n_1}} \sqrt{\sum X_2^2 - \frac{(\sum X_2)^2}{n_2}}}$$