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MODERN ELEMENTARY SCIENCE CURRICULA AND STUDENT ACHIEVEMENT

by

Ben A. Smith

A Dissertation Submitted to the Faculty of The Graduate College in partial fulfillment of the Degree of Doctor of Philosophy

Western Michigan University Kalamazoo, Michigan August 1972

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Ben A. Smith

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CHAPTER I

8.

THE PROBLEM

Introduction

The need for relevant research in elementary-science education has existed for many years. Smith (1968) states that little significant research had been undertaken in elementary science between Craig's work (1927) and the advent of the new science curricula of the 1960's. However, with the emergence in the early 1960's of new elementaryscience curricula there has been an increase in the numbers of research studies published in this area. Meppelink's (1961) summary of research in science education for the period 1938-60 lists 81 annotated research reports in the area of elementary science. But, Haney (1969) lists 120 research reports in the area of elementary science for the threeyear period 1965-67. Gallagher (1972) lists 124 research reports for the two-year period 1968-69.

This increase in elementary-science research is probably attributable to the curricular developments in elementary science that burgeoned in the 1960's. Prior to 1927, elementary science was generally non-integrated nature study. The 31st Yearbook, Part I, of The National Society for the Study of Education (NSSE), entitled <u>A</u> <u>Program for Science Teaching</u> (Powers chum., 1932), reflected a change in the thinking of science educators concerning what should be included in the elementary-science curricula. Emphasis was placed on developing skills in using scientific method, inculcating scientific

attitudes and understanding of important scientific concepts rather than on the acquisition of scientific facts. The 46th Yearbook of NSSE, <u>Science Blucation in American Schools</u> (Noll chmn., 1947), extended the philosophy of the jlst Yearbook by describing in greater detail the behavioral goals for science in the elementary and secondary schools. In addition, the yearbook emphasized the need for an integrated science program from grades K-12. However, at that time, few elementary-school students were exposed to unified sequential science programs.

In the past eight to ten years, curricula in elementary science have undergone significant changes as a result of efforts to implement the behavioral goals. From these changes contemporary programs have emerged, some completely new, others incorporating some of the new developments into older, more traditional programs.

Three of these new programs are being used in some of the elementary schools of Southwestern Michigan. These are the AAAS-Science -A Process Approach (SAPA), Elementary Science Study (ESS), and Science Curriculum Improvement Study (SCIS). All these were developed with support from the National Science Foundation. Two recent texts that have incorporated the newer developments of the modern curricula into the textbook format are the Harcourt, Brace, and Jovanovich series, <u>Concepts in Science</u>, edited by Paul Brandwein, and the Silver Burdett series, <u>Science</u>, by George G. and Jacqueline V. Mallinson and others. These textbooks are used in some of the schools in Southwestern Michigan.

Several studies have been undertaken to determine whether the

three modern curricula mentioned above have achieved their stated goals. However, in reviewing the literature the investigator has been unable to find any studies that have attempted to compare the various curricula mentioned for differences in the growth in achievement of students who used the different programs.

The investigator is of course cognizant that the term "achievement" is not educationally popular jargon. "Critical thinking," "inquiry approach," "problem-solving ability," "knowledge of science processes," and "manipulative skills" appear the socially and educationally acceptable goals of today's science programs.

While it is impossible to argue the importance of criticalthinking ability as a desired goal, there is some doubt that the new curricula are more effective than other curricula in developing this ability in students. For example, in the area of secondary-school science, Poel (1972) studied PSSC and non-PSSC physics and their effects on improving critical thinking. The former, according to those who developed the materials is, in a large degree, designed to improve critical thinking. But, he failed to find that the PSSC program was significantly more effective than the non-PSSC programs in improving critical-thinking ability.

It appears that many curriculum developers assume that if a student is involved in a new program with critical-thinking ability emphasized as one of its underlying goals, the student's ability in this area will <u>ipso facto</u> increase. However, Ausubel (1965) believes that critical-thinking cannot be taught as a generalized ability, but only in the context of a particular discipline. Several studies,

including those of Boeck (1953) and Meridith (1961) have shown that if one teaches with critical thinking as a direct objective and then tests for this ability, one will generally obtain significantly greater gains than in similar teaching situations where critical-thinking is not one of the direct behavioral objectives.

Although the viewpoints and findings just mentioned differ somewhat, the underlying premise seems to suggest that if one emphasizes a certain outcome in one teaching situation and not in another, the outcome will be attained to a much greater degree in the situation in which it is emphasized. It does not seem that such a premise is subject to challenge. Yet, researchers have used the same instruments designed to measure outcomes in situations in which certain objectives are emphasized as well as in situations in which they are not. One may therefore reasonably conclude that the instruments are weighted in favor of the first situation and may be used inappropriately in the latter. An example of this anomaly is evidenced in the early studies of BSCS biology. Classes that were taught BSCS biology were paired with classes that were taught non-BSCS biology. The two groups were then compared to determine what significant differences might exist between their performances on the BSCS tests. One could assume that if students using the BSCS program could not outperform the other classes on the BSCS tests designed specifically for that program, then there were some weaknesses in the instruments, or in the teaching of the BSCS program. Other similar examples of these research anomalies appear in elementary-science research reported by, among others, Pierce (1968), Howe and Butts (1969), and Ransom (1968).

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To date, this investigator has not located an instrument that is completely free of bias. Thus, the primary problem facing researchers is the identification of unbiased tools for comparing the merits of various science programs. With respect to this study, the investigator does not challenge the viewpoint that critical-thinking ability is an important goal of the total elementary-school program. But, he believes, for the reasons listed below, that there is value in measuring student science achievement in the areas of informational background, knowledge of terms, development of concepts, and interpretation of principles:

- 1. Gains in student achievement are measured more easily with paper and pencil tests in the typical elementary classroom during the relatively short time-span of a school year than are abilities of critical-thinking, Welch (1969) states that the Watson-Claser critical Thinking Appraisal, "measures qualities that are learned throughout a lifetime and that seem to be scarcely affected by the short-time instruction that is typically evaluated."
- 2. There appears to be a high positive relationship between tests of scientific knowledge and tests of problem-solving ability. A study that supports this statement is one by Meridith (1961) who worked with two physical-science programs at the secondary level. His experimental group involved students in a modern physical-science program, whereas his control group consisted of students in a more traditional physical-science program. He found that both groups achieved equally well on a test of science facts and principles. Coefficients of correlation between scores on this test and on a test of critical-thinking ability were relatively high (<u>r</u>'s .77-.92). Therefore, it appears that testing for science achievement may also serve in evaluating other aspects of growth in the science program.
- 3. The State of Michigan has adopted a program of State Assessment Tests. Consequently, school administrators are searching for programs that will help students perform well on achievement tests. If one or more of the programs involved in the study appears to produce greater gains in student achievement for certain types of pupils or in certain types of schools, the information would be of value to school administrators.

As a result of these factors it was decided to compare the growth in achievement of the students in various elementary-science programs in use in Southwestern Michigan.

As stated earlier the major problem faced in the comparison was the selection of an instrument to measure achievement. In reviewing the literature on tests of achievement in elementary science, the criteria for an appropriate test as indicated in the 46th Yearbook of the NSSE were accepted. These criteria were that it test the following:

- 1. Information background
- 2. Understanding of terms and concepts
- 3. Interpretation of principles

Specifically, the investigator sought an evaluation instrument that was up-to-date, designed for the upper-elementary level (4th, 5th, and 6th grades) and not in common use in the schools in which the study would be conducted. The test that seemed to meet these criteria best was the "Science" portion of the <u>Educational Development Series</u> of the Scholastic Testing Service (1963).

The Problem

For the purpose of comparing the growth in achievement of elementary-school students in the various programs in use in Southwestern Michigan, answers to the following questions were sought:

- 1. Which of the curricula dealt with in this study lead to greater gains in students' science achievement?
- To what extent do students' ranking in the four different quarters of class standings, as determined by the pre-test scores, differ in growth in science achievement?

- 3. What is the relationship between student achievement gains and the type of communities (urban, suburban, and rural), in which the schools are located?
- 4. What is the relationship between sex of students and growth in science achievement?
- 5. What is the relationship between the amount of teachers' preservice training in science and students' growth in science achievement?
- 6. What is the relationship between teachers' post-baccalaureate training in science and students' growth in science achievement?
- What is the relationship between a teacher's perception of the curriculum he is using and students' growth in science achievement?
- What is the relationship between the teachers' experience with a curriculum and students' growth in science achievement?
- 9. What is the relationship between the teachers' experience in teaching and students' growth in science achievement?
- What is the relationship between teachers' perception of class ability in science and students' growth in science achievement?

Thus, it is the purpose of this study to seek answers to these questions through the administration of a test of science achievement. Using the scores obtained, efforts will be made to answer these questions.

CHAPTER II

THE RESEARCH DESIGN

The purposes of this chapter are to (1) define the relevant terms used in this study, (2) report on the population and sample, (3) describe the research design and methods used to analyze the data, (4) and describe the instruments used to collect data.

Definitions

"<u>Modern Programs</u>" are those elementary-science programs indicated by their developers to be highly student-oriented with a minimum of "text" material and a maximum of student involvement. For the purposes of this study the AAAS - Science - A Process Approach (SAPA), Elementary Science Study (ESS), and Science Curriculum Improvement Study (SCIS) are considered to be modern programs.

"<u>Modern Textbooks</u>" are those elementary-science programs which the investigator considers to be highly student-oriented but are presented within a textbook format. For purposes of this study the investigator considers two textbook series that are currently in use in Southwestern Michigan, The Harcourt, Brace, and Jovanovich series, <u>Concepts in Science</u>, and the Silver Burdett series, <u>Science</u>, to be "Modern Textbooks."

"<u>Traditional Programs</u>," for the purposes of this study, will be all elementary-science programs other than those just mentioned and currently in use in Southwestern Michigan.

Student growth or gain in achievement is the algebraic difference between the post- and pre-test scores of students as measured by the criterion instrument used in this study.

<u>Criterion instrument</u> is the "Science" section of the <u>Educational</u> <u>Development Series</u> published by the Scholastic Testing Service as modified by the investigator.

Population

It was decided to limit this study to schools within a circle, having a radius of 75 miles, with the center at Kalamazoo. The geographical area was selected for these reasons: (1) In the opinion of the investigator and the members of his Doctoral Advisory Committee this area contained a representative cross section of urban, suburban, and rural schools similar to those found in other regions of the Midwest, and (2) this area was small enough for the investigator to personally visit all schools and administer all pre- and post-tests within two four-week periods.

With the assistance of the investigator's Doctoral Advisory Committee, 30 school systems, in which there were lll elementary schools, were invited to participate in this study. An attempt was made to include schools from urban, suburban, and rural areas in a proportion approximating that in similar regions in Michigan. An initial letter was sent to the principals of 98 of the lll schools and to the superintendents of 3. This letter contained a cover letter by Dr. George G. Mallinson, Dean, The Graduate College, Western Michigan University, designed to introduce the investigator to the

school administrators and support the rationale for the study. A letter by the investigator, that explained the study and a business reply postcard upon which those who were interested could indicate a desire to discuss the possibility of participating were included. This letter was cent the first week of September, 1971. Copies of the letters and return card are in Appendix A.

Within two weeks 68 of the 98 to whom postcards were sent responded. Forty-nine of the school representatives (72% of those responding) agreed to discuss the possible participation of their school systems in the study.

The investigator telephoned these 49 representatives and set up appointments to discuss the study with them and representative teachers in the 4th, 5th, and 6th grades.

The selection of classes for inclusion in the study was made on the following bases:

- 1. The teachers and principals must be willing to participate in the study.
- 2. At least one 4th, 5th, and 6th grade teacher from each school must agree to participate.
- Teachers must agree to allow the investigator to visit each classroom on two occasions to administer the preand post-tests of achievement.
- 4. Teachers must be willing to fill out a personal information questionnaire.

In addition, an attempt was made to include at least one representative who used one of the six curricula defined earlier, from each of the three grade levels from the schools in each of the urban, suburban and rural areas.

On the basis of these criteria, 68 teachers representing 77 classes from 16 different schools agreed to participate in this investigation. This sample included 2029 4th, 5th, and 6th grade students. The characteristics of classes that participated appear in Table I.

Table I

School Code	Type of School	Numbe 4th	er of Cl 5th	asses 6th	Numbe 4th	r of St 5th	udents 6th
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16	Rural Rural Suburban Rural Urban Rural Suburban Suburban Suburban Suburban Suburban Suburban Suburban Rural	1 3 1 1 2 4 1 1 1 1 2 2 2	1 2 1 1 2 2 1 1 1 1 2 2 1 2 2 2 2 2	1 1 0 1 2 2 0 1 1 1 6 2	25 45 26 26 63 104 21 39 27 26 26 26 26 52	24 28 26 20 25 38 27 23 29 25 29 25 51	29 26 26 32 26 58 40 28 24 28 29 24 28 29 24 28 29 29 26 20 29 26 20 29 26 20 20 20 20 20 20 20 20 20 20 20 20 20
	Totals	25	28	24	644	705	680

Characteristics of Sample Schools.

^ASixth grade in middle school and not part of elementary program.

Procedures

Upon visiting the above schools, the investigator arranged dates for the administration of pre-tests. In order to maintain uniformity in the administration of the pre-test, the investigator personally administered all tests between September 20, 1971 and October 22, 1971.

The pre-test and the post-test consisted of the "Science" section of the <u>Educational Development Series</u> of the Scholastic Testing Service. This test, which was modified slightly for this study is described later in the chapter. Each student was provided with a test booklet in which he indicated his responses to the test items, instead of separate answer sheets. Since each student answered the questions directly in the test booklet all tests were hand scored by the investigator. These scores were recorded and punched on Hollerith cards for purposes of computer analysis.

At the time the investigator was administering the pre-test the teacher was asked to fill out a questionnaire that elicited information required for later analyses and comparisons. This questionnaire is described later in this chapter.

The investigator administered the post-test to the students between April 24, 1972 and May 24, 1972. An attempt was made to administer the post-test to the classes in the same sequence as the pre-test in order to approximate equivalent time-spans between tests.

Treatment of Data

A statistical analysis of the data was necessary to determine if

the findings were due to variance caused by chance or to the various treatments. Since this study was concerned with a number of questions it was necessary to employ different techniques of analysis in order to provide answers to the questions. These techniques include analysis of variance (henceforth referred to as ANOVA or "F"), strength of association (E^2) , and comparisons of multiple <u>t</u>'s (all possible <u>t</u>'s) (Kerlinger, 1967).

The questions posed in Chapter I fall into two groups. Questions 1 through 4 deal with differences that might exist between the growth in science achievement of students and the various elementary science curricula. Thus, the curricula serve as the major independent variable in these four questions. Each of the four questions has one other independent variable working on the dependent variable, namely, growth in science achievement. In question 1, the 2nd independent ... variable is grade level. In question 2, it is the quarter in which the student ranks in his class. In question 3, it is whether the student attends a urban, suburban, or rural school. In question 4, the associated independent variable is the sex of the student. All three of the statistical models mentioned above were used to analyze the data collected concerning these four questions.

In the second group of questions in Chapter I, questions 5 through 9, growth in student achievement is the dependent variable. However, the independent variables were information provided by the teachers involved in the study. These independent variables were:

Question 5: The teacher's pre-service training in science Question 6: The teacher's post-baccalaureate training in science

- Question 7: The teacher's perception of the science program he was teaching
- Question 8: The teacher's experience with the science program he taught
- Question 9: The number of years of teaching experience the teacher had acquired

The ANOVA, and all \underline{t} 's designs were used in analyzing the data concerning these variables. The mathematical results provided by these models were used to draw conclusions to the questions posed in this study.

Instrumentation

Science achievement test

It was decided by the investigator and his committee that the "Science" section of the <u>Educational Development Series</u>, Form A, of the Scholastic Testing Service best met the criteria established for determining science achievement of 4th, 5th, and 6th grade students. This 60 item test is divided into approximately equal numbers of items dealing with topics of life sciences and physical science. A few items dealing with topics of earth science and problems involving critical thinking¹ also are included. The investigator modified the test by separating the science section from the test booklets and producing individual test booklets for each student. In addition, the print on the individual booklets was enlarged. These activities

¹According to the Scholastic Testing Service, 10% of the items in the EDS test measure critical-thinking ability.

eliminated answer sheets and allowed each student to mark his responses directly in a smaller booklet. The investigator increased the 35 minute suggested time limit for administering the test to 50 minutes, to allow as many students as possible to complete the test.

Teacher questionnaire

Each participating teacher completed a questionnaire designed by the investigator to obtain information needed for some of the questions posed in Chapter I. A copy of the questionnaire appears in Appendix B.

These instruments provided the information for both the dependent and independent variables of this study, the only exception being the classification to which a school belonged. This was determined by the investigator from information furnished by the school administrators.

CHAPTER III

ANALYSES OF THE DATA

The Purpose

The purposes of this chapter are to (1) describe the methods used to analyze the data that were collected, (2) list the findings concerning the effectiveness of the various curricula, with which the study dealt, in producing gains in students' science achievement, (3) tabulate the results of the analyses of the main and interacting relationships of curriculum and teacher variables on the growth in student achievement, and (4) report on differences among various types of schools (urban, suburban, rural) with respect to growth in the students' science achievement.

Techniques Employed

The data for this study were obtained by analyzing the scores of students on a test of science achievement, and from information obtained on a teacher questionnaire for possible interacting variables. The sample population consisted of 68 teachers who taught science in 77 classrooms in 16 different elementary schools in Southwestern Michigan.

The scores used in the analyses were the differences between the raw scores the students obtained when the students were administered the science achievement test as a pre- and post-test. These dif-

ferences, or growth scores, take into account the initial differences between students and classes and are the means used to control for differences existing prior to the study.

Data used as independent variables that might affect growth in student achievement on the science tests were obtained from the teacher questionnaire. This information is summarized in Table II.

A key to Table II is given here to aid in its interpretation. Column one of the Table list the teachers by code numbers, column two lists the curriculum used by the teacher by code number (1 = ESS, 2 = SAPA, 3 = SCIS, 4 = Silver Burdett, 5 = Harcourt, Brace andJovanovich, 6 = "Traditional"), column three lists the teachers' experience with the curriculum by code numbers <math>(1 = first time, 2 =two to three years, 3 = four to five years, 4 = more than five years), column four lists the teachers experience in teaching by code numbers (1 = one to four years, 2 = five to nine years, 3 = ten to fourteenyears, 4 = fifteen or more years), column five of the table lists the teachers perception of the curriculum by code numbers (1 = Excellent, 2 = Above average, 3 = Average, 4 = Below average, 5 = Poor),and column six lists the teachers perception of the classes abilityby code numbers <math>(1 = Above average, 2 = Average, 5 = Below average).

The questions posed in Chapter I and which are answered here are grouped into those related to the (1) effectiveness of the curricula, dealt with in the study, in producing changes in student science achievement scores, (2) main and interacting effects of the curricula with the various student variables, (3) main and interacting relationships among the curricula and the teacher variables.

Table II

Teacher Generated Independent Variables

				· · · · · · · · · · · · · · · · · · ·	
Teacher Code	Curriculum	Experience in Teaching Curr.	Experience in Teaching	Perception of Curriculum	Perception of Class Ability
01 02 03 $a^{0}b^{0}a^{4}b^{0}$ 04 $b^{0}a^{0}b^{0}c^{5}b^{0}c^{5}b^{0}c^{5}b^{0}c^{5}c^{6}c^{5}c^{6}c^{5}c^{6}c^{5}c^{6}c^{5}c^{5}c^{5}c^{5}c^{5}c^{5}c^{5}c^{5$	4446673626666644416	2 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	1 1 1 2 2 2 2 1 3 5 1 3 3 2 2 4	53335555 <u>74</u> - e 3e e e e e s	1 2 2 2 2 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2

^aThe first class of a teacher teaching two classes.

 ${}^{\mathrm{b}}\mathrm{The}$ second class of a teacher teaching two classes.

Table II (continued)

ption of Perception of Class Ability	~~~~
Percel Curri	
Experience in Teaching	キューコークーユーユーサーキ ミー ろうみ こ ろろこー
Experience in Teaching Curr.	キ 2 2 2 2 1 1 2 2 2 4 1 キ 1 キ 7 2 2 2 2 ろ ろ ろ ろ ろ
Curriculum	ユ ううろうろうろう くしくり うううみ みみみみ みん
Teacher Code	てあむのはののみののののれななみをがななるのよ

Table II (continued)

Perception of Class Ability	- ~
Perception of Curriculum	๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛
Experience in Teaching	よこころすぎみここここここれしししてぎること
Experience in Teaching Curr.	ろうゆ ろらろ こ こ こ こ こ こ こ こ こ こ こ こ こ こ こ こ こ こ
Curriculum	キキキキキキキキ ひひろうのうろうろうろうろう
Teacher Code	44444444444444444444444444444444444444

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Table	II ((continued)
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Teacher	Curriculum	Experience in	Experience in	Perception of	Perception of
Code		Teaching Curr.	Teaching	Curriculum	Class Ability
62 ^b 63 ^b 64 65 66 67 68	5555555	2 2 2 2 2 2 2 2 1	1 1 2 2 1 1	8 8 8 9 8 9 8	2 2 2 2 2 2 2 2

The questions will be discussed in the order listed on page 17.

Statistical Techniques Employed

In this study tests for significance were made with the standard <u>t</u> test for uncorrelated random samples. However, it should be noted that since the classes were selected using criteria designed to enhance the collection of data, they may not be random. However, only growth scores are used and so some compensation has been made for initial between-group differences.

A double-classification analysis of variance technique described by Spence <u>et al</u> (1968) was used to determine the main relationship and interacting relationships between the various elementary-science curricula and the student and teacher independent variables. These data were also subjected to the test of strength of association (E^2) , and tests of multiple <u>t</u>'s.

Relationships Between Various Elementary Science Curricula and Growth in Student Achievement

The results of the analyses described earlier for comparing the relationships among the elementary-science curricula involved in this study and growth in student achievement are summarized in Tables III and IV. The F value for the comparison of the 6 curricula over the total sample was 6.331, which is significant at the .01 level. The E² was 0.017. Therefore, there are significant differences among the various curricula with respect to their relationships to growth in science achievement in students in the 4th, 5th, and 6th grades.

22

Table III summarizes the results of the test of multiple \underline{t} 's for the various curricula for the total study sample.

The F values for the growth scores for each curriculum at each grade level give only one significant value at the .05 level and that is for the 4th grade. Table IV summarizes the \underline{t} 's for each curriculum by grade level.

An examination of Table III indicates the following:

- ESS produced significantly greater gains (.05 level) in student achievement when compared with SAPA, SCIS and "traditional" curricula. (Significant at the .01 level for SAPA and SCIS.)
- The Silver Burdett series produced significantly greater gains (.01 level) in student achievement when compared with SAFA, SCIS and "traditional" curricula.
- 3. The Harcourt, Brace and Jovanovich series produced significantly greater gains (.05 level) in student achievement when compared with SAPA, SCIS and "traditional" curricula. (Significant at .01 level for SCIS and "traditional".)
- 4. SAPA did not produce significantly greater gains (.05 level in growth of student achievement than any of the other curricula dealt with in the study.
- SCIS did not produce significantly greater gains (.05 level) in growth of student achievement than any of the other curricula dealt with in the study.
- The "traditional" curricula did not produce significantly greater gains (.05 level) in growth of student achievement than any of the other curricula dealt with in the study.

An examination of the information in Table IV indicates the

following for each of the grade levels.

- A. At the 4th grade level:
 - ESS produced significantly greater gains (.05 level) in student achievement when compared with SAPA and "traditional" curricula.

m ~ 1	L 1	TTT
Tai	DTG	T. T. T

Source of \underline{t}^1 DF \underline{t}^2 1-2 113 -3.18885 ^a 1-3 308 0.72886	
$1-2$ 113 -3.18885^{9} 1-3 308 0.72886	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	

Tests of Multiple t's Between Curricula Investigated in this Study

 $^{\rm L}{\rm Note}$: The numbers in the first column of the table are codes for the curricula being compared. The code numbers and corresponding curricula are listed below.

1 = AAAS-Science-A Process Approach

- 2 = Elementary Science Study
- 3 = Science Curriculum Improvement Study 4 = Silver Burdett Series, <u>Science</u>
- 5 = Harcourt, Brace, and Jovanovich Series, Concepts in Science
- 6 = "Traditional"

²Note: The negative sign in front of a \underline{t} indicates that the second number in the comparison shows the greater change in growth of science achievement.

^asignificant at the .01 level

^bsignificant at the .05 level

Table IV

Tests of Multiple 1's for Curriculum by Grade Level

	6th	ا ^{دل}	-1.34464 -0.07493 -0.97032	
evel		DF	46 95 223	
or Each Grade L	5th	I ^{ct}		
Values f		DF		
	4th	I4 ¹⁰	-2.95255 ^a -0.16830. -2.26690	
		DF	65 95 208	
	Source of <u>t</u> l		2-1-2 1-1-1 1-1-	

The numbers in the first column of the table are codes for the curricula being compared. code numbers and corresponding curricula are listed below. The Note:

Silver Burdett

Harcourt, Brace and Jovanovich "traditional"

1 - SAPA 2 = ESS 5 = SCIS 4 = Silves 5 = Harcol 6 = "tradi

²Note: The negative sign in front of a \underline{t} indicates that the second number of the comparison shows the greater change in growth of science achievement.

asignificant at the .01 level

^bsignificant at the .05 level

			Values f	or Each Grade Le	evel	
rrce of <u>t</u>		4th		5th		6th
	DF	I45	DF	et2	DF	e ^{to}
ччааааыы кактака кактака	166 1866 1873 1811 1812 1812 1812 1812 1812 1812 181	-2. 44.176 ^b -1. 08258 2. 14871 1. 14871 1. 14871 1. 08187 1. 08187 2. 58285 -2. 47744 -2. 47744 1. 6904 1. 6904 1. 76997	275 285 245 245 246 238 246	-2. 61546 ⁸ -2. 19448 ^b 1. 19838 0. 63153 0. 63153 0. 38536	289 45 75 74 74 74 74 74 74 74 74 74 74 74 74 74	-1. 17500 0.96989 0.96989 0.647955 0.42695 0.42695 2.47644 1.1.48820 0.42699 1.1.48882 0.48882 0.48882 0.48882 2.50941 2.50941 2.50941

Table IV (continued)

- Silver Burdett produced significantly greater gains (.05 level) in student achievement when compared with SAPA and SCIS curricula.
- Harcourt, Brace and Jovanovich produced significantly greater gains (.05 level) in student achievement when compared with SAPA and SCIS curricula.
- B. At the 5th grade level:
 - Silver Burdett produced significantly greater gains (.05 level) in student achievement when compared with SCIS.
 - Harcourt, Brace and Jovanovich produced significantly greater gains (.05 level) in student achievement when compared with SCIS.
- C. At the 6th grade level:
 - ESS produced significantly greater gains (.05 level) in student achievement when compared with "traditional" curriculum.
 - harcourt, Brace and Jovanovich and Silver Burdett both produced significantly greater gains (.05 level) in student achievement when compared with the "traditional" curriculum.

No other significant differences were found between the various curricula in terms of growth in students' science achievement at the three grade levels involved in this study.

> The Relationships of Curricula with Students Who Rank in the Different Quarters of Class

Answers to the questions concerning the differences in growth of science achievement of students in the different quarters of their class were sought by analyzing the growth scores of students in the lst, 2nd, 3rd, and 4th quarters of their class according to their scores on the pre-test. The ANOVA between growth in student achievement and the quarter ranking of students produced an F value of
14.370, significant at the .01 level. The $\frac{e^2}{2}$ value was 0.023. This indicates that there is a significant difference in student growth in science achievement depending where the students ranked on the pretest. Table V summarizes the result of the test of multiple <u>t</u>'s for the total sample involved in the study.

Table V

A Comparison of Growth in Student Achievement by Students from the Four Quarters of Class Rank

Source of <u>t</u> 1	DF	<u>t</u>
1-2 1-3 2-3 2-4 3-4	951 946 824 1001 879 874	2.37370 ^b 3.74875 ^a 6.68764 ^a 1.25378 4.21481 ^a 3.19968 ^a

- ¹Note: The numbers in the first column of the table are the quarter rankings of students. The code numbers and the corresponding quarter are listed below.
 - 1 = 0 to 25%
 - 2 = 25% to 50%
 - 3 = 50% to 75%
 - 4 = 75% to 100%

^asignificant at the .01 level

^bsignificant at the .05 level

The results of the \underline{t} tests reported in Table V indicate the following:

- Students in the lower 25% on the pre-test made significantly greater gains in achievement scores (.05 level) when compared with students in the 25% to 50%, 50% to 75%, and 75% to 100% quarters. (Significant at .01 level for the upper two quarters.)
- Students in the 25% to 50% quarter on the pre-test made significantly greater gains in achievement scores (.01 level) when compared with students in the upper quarter.
- Students in the 50% to 75% quarter on the pre-test made significantly greater gains in achievement scores (.01 level) when compared with students in the upper quarter.
- 4. Students in the 25% to 50% quarter did not make significantly greater gains (.05 level) in science achievement scores than did the students in the 50% to 75% quarter.

When students gain scores in science achievement were compared on the basis of the program in which they were enrolled and by the quarter of the class according to their pre-test scores, the following F values were found:

Table VI

Analysis of Variance for Programs and Student Growth in Achievement

	Curriculum	F
1.	SAPA	1.889
2.	ESS	2.156
3.	SGIS	1.553
4.	Silver Burdett	3.226 ^b
5.	Harcourt Brace and Jovanovich	7.143 ⁸
6.	"Traditional"	4.044 ^a

^asignificant at .01 level ^bsignificant at .05 level These F values indicate that Silver Burdett, Harcourt, Brace and Jovanovich, and "Traditional" curricula produce different amounts of growth in student science achievement in the different quarters of the sample.

The test of multiple $\underline{t}^{, t}$ s used to compare the quarters of the sample by curriculum are summarized in Table VII. The information in the table indicate the following:

- In the ESS curriculum, students in the second quarter of the sample make significantly greater gains (.01 level) than do students in the upper quarter of the sample.
- In the SCIS curriculum, students in the third quarter make significantly greater gains (.05 level) than students in the upper quarter of the sample.
- 3. In the Silver Burdett series students in the first and second quarters of the sample make significantly greater gains in student achievement (.05 level) than students in the upper quarter of the sample.
- 4. In the Harcourt, Brace and Jovanovich series, students in the first quarter make significantly greater gains in student achievement (.01 level) than do students in the third and fourth quarters, while students in the second quarter make significantly greater gains in achievement (.01 level) than students in the fourth quarter of the sample.
- In the "traditional" curriculum, students in the first (lowest) quarter make significantly greater gains in achievement (.01 level) than do students in the second and fourth quarters of the sample.
- There are no significant differences (.05 level) in growth in student achievement for students in any quarter who were taught using the SAPA series.

Other Student Independent Variables

Significant relationships were not found between the independent variables of the type of school attended (urban, suburban, rural) or

Table VII

A Comparison of Student's Growth in Achievement by Class Quarters and Curriculum Employed

						Curri	cula ²					
Source of \underline{t}^1		1		2		3		4		5		6
	DF	<u>t</u>	DF	<u>t</u>	DF	<u>t</u>	DF	<u>t</u>	DF	<u>t</u>	DF	t
1-2 1-3	33 25	1.790 0.509	21 23	0.428 0.582	95 110	0.605 0.874	266 280	0.054 1.865	376 364	1.330 3.155 ^a	150 134	2.857 ^a 1.715

¹Note: The numbers in the first column of the table are codes for the quarters of the class. The code numbers and the quarters for which they stand are listed below.

1. Students whose pre-test score placed them in the lower 25% of their group.

2. Students whose pre-test score placed them in the 25% to 50% of their group.

3. Students whose pre-test score placed them in the 50% to 75% of their group.

4. Students whose pre-test score placed them in the upper 25% of their group.

²Note: Curricula codes with corresponding curricula are listed below.

1.	SAPA					
2.	ESS	asignificant	at	the	.01	level
3.	SCIS					
4.	Silver Burdett	^b significant	at	the	.05	level
5.	Harcourt, Brace and Jovanovich					
6.	"Traditional"					

These F values indicate that Silver Burdett, Harcourt, Brace and Jovanovich, and "Traditional" curricula produce different amounts of growth in student science achievement in the different quarters of the sample.

The test of multiple \underline{t} 's used to compare the quarters of the sample by curriculum are summarized in Table VII. The information in the table indicate the following:

- In the ESS curriculum, students in the second quarter of the sample wave significantly greater gains (.01 level) than do students in the upper quarter of the sample.
- In the SGIS curriculum, students in the third quarter make significantly greater gains (.05 level) than students in the upper quarter of the sample.
- 3. In the Silver Burdett series students in the first and second quarters of the sample make significantly greater gains in student achievement (.05 level) than students in the upper quarter of the sample.
- 4. In the Marcourt, Brace and Jovanovich scries, students in the first quarter make significantly greater gains in student achievement (.01 level) than do students in the third and fourth quarters, while students in the second quarter make significantly greater gains in achievement (.01 level) that students in the fourth quarter of the sample.
- 5. In the "traditional" curriculum, students in the first (lowest) quarter make significantly greater gains in achievement (ol hevel) than do students in the second and fourth quarters of the sample.
- There are no significant differences (.05 level) in growth it student achievement for students in any quarter who were taught using the SAPA series.

Other Student Independent Variables

Significant relationships were not found between the independent variables of the type of school attended (urban, suburban, rural) or

Table VII

A Comparison of Student's Growth in Achievement by Class Quarters and Curriculum Employed

•

						Curri	cula ²				
Source of <u>t</u>		1		Q		10	4		5	-	10
	DF	۱۴	DF	lc+	DF	1-+		ΞĒ	ادب	DF	let.
1-2 1-3	25	1.790 0.509	53 53	0.428 0.582	95 110	0.00			1.330 3.155ª	150 134	2.857 ^a 1.715
lNote: The n code	numbers	in the s and th	first ne qua	column rters fo	of the r which	4	ÿ	V	s of th	e class	The .
	40.44 99999	udents r udents r udents r udents r	rhose rhose rhose rhose	pre-test pre-test pre-test	score score score score	plac plac	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		f their of their of their of their	group. group. group.	
² Note: Curri	cula (codes wi	th cor	respondi	ug curi	foula are		ì			
	-101-4-0-0 01-11-0-0-1-0-0-0-0-0-0-0-0-0-0-0-0	APA SS CIS CIS Ther Bu arcourt, Traditio	rdett Brace nal"	and Jov	anovich	c	a signi. Signi	ficant ficant	at the . at the .	01 leve 05 leve	d d

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Table VII (continued)

		9	اد.	3.140 ^a 1.154 0.558 1.613	
			DF	101 150 101	
	5	lct-	4. 292 ^a 1.721 2.923 ^a 1.395		
			DF	321 346 391 291	
icula ²	14	-PI	2.605 ^a 1.784 _b 2.468 ^b 0.834		
		DF	237 296 253 267		
	Curr	2	ЧЧ.	0.700 0.257 2.165b 2.165b	
		DF	112 135 137 152		
		5	۱۹	1.421 1.476 2.511 ^a 1.197	
			DF	18 29 31 31	
		-		۱۴	2.117 1.004 1.401
			DF	22 20 20 20 20 20 20 20 20 20 20 20 20 2	
		Source of <u>t</u>		4-1-2 2-2-2 4-2-2	

the sex of students. The growth in science achievement of students in any of the curricula involved in this study was not significantly related, at the .05 level, to either of these variables. The F value for type of school was 1.542 with an E^2 of 0.002. The F value for sex of students when compared with the curricula in which they were enrolled was 0.130, with an E^2 of 0.002.

Effect of Teacher's Pre-Service Training in Science on the Gain Scores in Student Science Achievement

Teachers were categorized into three groups by their pre-service training in science according to the numbers of semester hours in science they had completed. The categories were (1) teachers with less than ten semester hours of pre-service science training, (2) teachers with ten to twenty semester hours of pre-service science training, (3) teachers with more than twenty semester hours of preservice science training. The F value for all curricula when compared on the basis of the categories just mentioned, was 8.174, significant at the .01 level. The F^2 value was 0.009.

The results of the multiple test of \underline{t} 's for this variable are summarized in Table VIII. The information revealed in the table is as follows:

- Students with teachers having ten to twenty semester hours of pre-service science training had significantly greater gains (.01 level) in science achievement than did students whose teachers had less than ten hours of pre-service training in science.
- Students with teachers having more than twenty semester hours of pre-service training in science had significantly greater gains (.01 level) in science achievement than

Table VIII

The Relationship of Teachers' Pre-Service Training in Science on Students' Gain in Science Achievement

Source of \underline{t}^{1}	DF	t ²	
1-2	1611	-1.55169	
1-3	1038	-3.93255 ^a	
2-3	1.003	-2.97298 ^a	

"Note: The numbers in column one of the table are the code numbers for categories of teachers pre-service training in science. The code numbers and their corresponding categories are listed below.

- l = Teachers with less than ten semester hours of preservice science training.
- 2 = Teachers with ten to twenty semester hours of preservice science training.
- 3 = Teachers with more than twenty hours of pre-service science training.
- 2 Note: The negative sign with the <u>t</u> values indicates that the difference favored the second of the two groups compared.

^asignificant at the .01 level

did students whose teachers had less than twenty hours of pre-service science training.

The results of the \underline{t} tests used to compare the achievements of students in different curricula with the amount of pre-service training are summarized in Table IX.

These findings emerged from an examination of the results of the "t" tests.

The Relationships of Teachers' Pre-Service Science Training and Type of Curriculum on Students' Growth in Science Achievement

							Curricu	ıla ²				
Source of \underline{t}^1		1		2		3		4		5		6
	DF	t	DF	t	DF	<u>t</u> 3	DF	t	DF	t	DF	t
1-2	35	0.579	-	-	229	-0.607	512	-0.490	567	-1.799	204	-0.474
l Note: The a scien cate	umbers ce tra cries 1 = Te 2 = Te 3 = Te	s in colum sining of are liste eachers wi eachers wi eachers wi	n one the p d bel th le th te th mo	oî arti ow. ss t n to re t	the tab cipatin han ten twenty han two	ble are co ng teacher n semester y semester enty semes	de numbe s. The hours hours ter hou	ers for th code numb of pre-sen of pre-sen rs of pre-	ne categ pers and rvice sc rvice sc -service	ories of p their con ience tra: ience tra: science t	pre-serv rrespond ining. ining. training	ice ing
² Note: The	$1 = S^{\prime}$ $2 = E^{\prime}$ $3 = S^{\prime}$ $4 = S^{\prime}$	umbers tog APA SS CIS ilver Burd	ether lett	wit	h the d	correspond	ling cur: ^a si, ^b si	ricula are gnificant gnificant	e listed at the at the	below. .01 level .05 level		

Note: The negative sign with a t indicates the second number in the comparison has the greater effect.

Table IX (continued)

		9	اد 	0 -0.847 0 -0.619 F = 0.411
	{		A	181
		5	الد	-4.549 ⁸ -4.717 ⁸ F = 14.842 ⁸
	Curricula ²		DF	210 559
		4	le.	-2.610 ^b -2.128 ^a F = 3.296 ^b
			ΞŒ	385 171
		3	الر	-0.778 -0.201 F = 0.457
			DF	225 142
		S	DF t	1 1 1 1
		н	14	2.767 ^a 2.488 ^b F = 4.316 ^b
			DF	34 43
		Source of <u>t</u>		1-3 2-3

- 1. Students in the SAPA curriculum whose teachers had less than ten semester hours of pre-service science training made significantly greater gains (.01 level) in science achievement than did students whose teachers had more than twenty semester hours of pre-service science training. Students in this curriculum whose teachers had ten to twenty semester hours of pre-service training made significantly greater gains (.05 level) than students whose teachers had more than twenty semester hours of pre-service science training. The F value for the ANOVA between hours of pre-service science training and the SAPA curricula was 4.516, significant at the .05 level.
- Teachers of the EES curriculum were not distributed sufficiently well in the three categories of pre-service training to provide usable data.
- Significant differences (.05 level) in gains in student achievement were not found among any of the categories of teachers pre-service science training for the SCIS curriculum.
- 4. Students in the Silver Burdett series whose teachers had more than twenty semester hours of pre-service science training made significantly greater gains in science achievement than students whose teachers had less than ten semester hours of pre-service science training (.01 level) and students whose teachers had ten to twenty semester hours of pre-service science training (.05 level). The F value for the ANOVA between hours of pre-service science training and the Silver Burdett series was 3.296, significant at the .05 level.
- 5. Students who used the Harcourt, Brace and Jovanovich series and whose teachers had more than twenty semester hours of preservice training made significantly greater gains (.01 level) in science achievement than students whose teachers had less than twenty semester hours of pre-service science training. The F value for ANOVA between hours of pre-service science training and achieveness of students who used the Harcourt, Brace and Jovanovich series was 14.842, significant at the .01 level.
- Significant differences were not found (.05 level) among student's gains in science achievement in the "traditional" curricula for any of the categories of pre-service training.

Relationships of Teachers' Post-Baccalaureate Training in Science on the Gain Scores on Student Science Achievement

An analysis was made of the relationships between teachers' postbaccalaureate training in science and gains in student achievement in the different curricula. Teachers were assigned to one of three categories according to the number of semester hours of science they had taken since completing the bachelors degree. The three categories were (1) teachers with zero to two semester hours, (2) teachers with three to five semester hours, and (3) teachers with six or more semester hours of science. Although these categories did not differ greatly numerically, teachers of some curricula did not fall in any of the categories. Hence, usable data were not always available.

The F value for the ANOVA between number of semester hours of post-baccalaureate science training and gains in science achievement for the total sample was 9.903, which is significant at the .01 level. The results of the test of multiple \underline{t} 's using these data are summarized in Table X. Inspection of this table shows that:

- Students whose teachers had three to five semester hours of post-baccalaureate science training made significantly greater gains (.01 level) in science achievement than students whose teachers had zero to two semester hours.
- Students whose teachers had six or more semester hours of post-baccalaureate science training made significantly greater gains (0.5 level) in science achievement than with students whose teachers had zero to two semester hours of training.
- 3. Significant differences (.05 level) were found between gains in science achievement of students whose teachers had three to five semester hours of post-baccalaureate science training and students of teachers who had six or more hours of training.

Table X

The Relationship of Teachers' Post-Baccalaureate Science Training in Science on Students Cain in Science Achievement

			2					
	Source of t	DF	<u>_t</u> "					
	1-2 1-3 2-3	1673 1111 868	-4.1675 ^a -2.53654 ^b -0.14128					
lNote:	The numbers in colum categories of teache The code numbers and	n one of the tab rs' post-baccals their categorie	ble are codes for the aureate training in science. are listed below.					
	l = Teachers wi baccalaurea	th zero to two s te training in s	semester hours of post- science.					
2 = Teachers with three to five hours of post-bac- calaureate training in science.								
) = Teachers wi baccalaurea	th six or more s te science train	emester hours of post- ing.					
² Note:	Note: The negative sign with a \underline{t} value indicates that the second number in the comparison had the greater effect.							
as	ignificant at the .01	level						
bs	ignificant at the .05	level						
	The Relationshi of Cu Students' Grow	p of Teachers' F rriculum and the th in Science Ac	Perception hievement					
Во	th a one way ANOVA and	d a test of mult	iple \underline{t} 's were run on the					

data collected on the teachers' perception of the curriculum they were teaching and the students' growth in science achievement.

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Teachers were asked to classify the curriculum as being (1) Excellent, (2) Above Average, (3) Average, (4) Below Average, or (5) Poor.

The F value for the ANOVA was 6.645 which is significant at the .01 level. The results of the test of multiple <u>t</u>'s are summarized in Table XI. These results are for the total sample since there were not enough ratings in each classification to provide usable data.

Table XI

	1	
Source of t^{\perp}	DF	<u>t</u>
1-2 1-3 1-4 1-5 2-3 2-4 2-5 3-4 3-5 4-5	1060 668 318 407 1236 886 975 494 583 233	0.36382 0.00625 0.77152 3.81055 ^a 0.46130 0.59740 4.70791 ^a 0.95537 4.80239 ^a 3.56569 ^a

Teachers' Perception of Curriculum and Students' Growth in Science Achievement

¹Note: The numbers in column one of the table are codes for the teacher's perception of the curriculum. The code numbers and their appropriate meanings are listed below. The teacher considers the curriculum he is using as:

- 1 = Excellent
- 2 = Above Average
- 3 = Average
- 4 = Below Average
- 5 = Poor

^asignificant at the .01 level

Table XI reveals that students whose teachers perceived their curricula in any of the classification higher than "Poor" made significantly greater gains (.01 level) than students whose teachers perceived their curriculum as "Poor." Students of teachers who had a poor perception of their science curricula made significantly lower gains in science achievement than students of teacher having a higherlevel of perception of their science curriculum.

The Relationship of Teachers' Experience With Curriculum on Students' Growth in Science Achievement

An analysis was made to compare the teachers' experience with the curriculum being used with the growth in science achievement of the students. The teachers were classified into four groups by the number of years they had taught using the curriculum. The four classifications were: (1) first year, (2) two to three years, (3) four to five years, and (4) more than five years.

The F value for the ANOVA for the total sample for experience in the use of curriculum was 5.543 which is significant at the .01 level. The results of the test of multiple <u>t</u>'s for this variable are summarized in Table XII. The data in this table reveal the following concerning the teacher's experience with a curriculum and student growth in science achievement.

Table XII

The Relationship of Teachers' Experience Teaching a Certain Curriculum Program with Students' Growth in Science Achievement

Source of \underline{t}^{1}	DF	<u>t</u> ²	
1-2 1-3 2-3 2-4 3-4	1388 798 640 1164 1006 416	1.39846 -1.07502 3.47787 -2.20406 2.54112 ^b 4.01147 ^a	

Note: The numbers in column one of the table are codes for the teacher's years of experience with a curriculum. The code numbers and the associated classifications are listed below.

- 1 = Teachers using curriculum for the first time.
- 2 = Teachers having used the curriculum for two to three years.
- 3 = Teachers having used the curriculum for four to five years.
- 4 = Teachers having used the curriculum for more than five years.
- ²Note: The negative sign with a <u>t</u> value indicates that the second number in the comparison had the greater effect.

^asignificant at the .01 level

^bsignificant at the .05 level

- Students who had teachers with more than five years experience teaching a certain curriculum program made significantly smaller gains in science achievement (.05 level) than students who had teachers with four to five years experience, students who had teachers with two to three years experience, and students who had teachers who were teaching the curriculum for the first time.
- 2. Students who had teachers with two to three years experience

teaching a certain curriculum program made significantly greater gains in science achievement (.05 level) than students who had teachers with four to five years experience teaching a certain curriculum program.

It was found that there were not enough teachers in the upper two classifications to analyze the data by individual curriculum. Therefore, the upper two classifications were combined into one classification, namely teachers having more than four years experience with a curriculum. Nevertheless, certain curricula did not have teachers in sufficient numbers in certain categories to warrant analysis. The results of the test of multiple \underline{t} 's for the variable of teachers' experience with the different curricula involved in this study are summarized in Table XIII. The blanks indicate that no teachers fell in those categories.

The data in Table XIII indicate the following:

- With the SCIS curriculum, students who had teachers who were using the curriculum for the first time made significantly greater gains in science achievement (.01 level) than students who had teachers who had used the curriculum four or more years. Also, students who had teachers who had used the curriculum for two to three years made significantly greater gains in science achievement (.05 level) than students who had teachers who had used the curriculum for more than four years.
- In the "traditional" curriculum, students who had teachers who were using the curriculum for the first time made significantly greater gains than students who had teachers that had used the curriculum for two to three years (.01 level.
- In all other curricula significant differences (.05 level) were not found between students growth in science achievement and the amount of experience teachers had teaching a certain curriculum.

The Relationship between Teachers' Experience with Teaching a Certain Curriculum and Students Growth in Science Achievement

Source of t						Curri	cula ²				**	
	1		2	2		3	1	+		5		6
	DF	<u>t</u> 3	DF	t	DF	t	DF	<u>t</u>	DF	<u>t</u>	DF	t
1-2	-		-	-	230	1.670	247	0.837	669	-1.029	144	3.027 ^a

¹Note: The numbers in the first column of the table are code numbers for the numbers of years of experience teachers had teaching a certain curriculum program. The code numbers and the experience classifications are listed below.

- 1 = Teachers using a curriculum for the first time.
- 2 = Teachers with two to three years experience with a curriculum.
- 3 = Teachers having used a curriculum four or more years.

 2 Note: Curricula are given by code numbers in the table heading. The code numbers with the corresponding curriculum are listed below.

l = SAPA	_
2 = ESS	asignificant at the .01 level
3 = SCIS	- -
4 = Silver Burdett	significant at the .05 level
5 = Harcourt, Brace and Jovanovich 6 = "Traditional"	

³Note: The negative sign with a t value indicates difference favored the curriculum designated by the second number.

Table XIII (continued)

		10	ابد	1.632 -1.514
		Ű	DF	184 134
			۱۹	
		5	DF	1 1
		+	14	0.115 -1.156
	Curricula ²	ħ	DF	504 504
		1 2 3	14	2.944 ⁸ 2.063 ^b
			DF	75 191
			lc+	11
			DF	1.1
			اط	-1.195
			DF	- 57
	Source of $\frac{1}{2}$			1-3 2-3

The Relationship of Numbers of Years of Teaching Experience to Student Growth in Science Achievement

The relationship between the number of years of teaching experience and student growth in science achievement was analyzed by both the ANOVA and a test of multiple \pm 's for the total sample. The teachers were categorized into one of four classifications of teaching experience, namely, (1) one to four years, (2) five to nine years, (3) ten to fourteen years, and (4) fifteen or more years of teaching experience for the analysis.

The F value for the ANOVA was 3.936, significant at the .01 level. The results of the \underline{t} test comparisons are summarized in Table XIV. The findings from the data in Table XIV follow.

- Students who had teachers with ten to fourteen years of teaching experience made significantly greater gains (.05 level) in science achievement than students who had teachers with one to four years experience or of teachers with five to nine years experience.
- Students who had teachers with ten to fourteen years experience made significantly greater gains (.01 level) in science achievement than students who had teachers with fifteen or more years of experience.
- Significant differences (.05 level) were not found for other comparisons that were made.

An attempt to analyze the relationship of teaching experience on students' growth in science achievement by individual curriculum was not possible since there were some classifications in which there were no teachers.

Tak	le	XIV

The Relationship Between Numbers of Years of Teaching Experience and Student Growth in Science Achievement

Source of t	DF	<u>_t</u> 2
1-2 1-3 2-3 2-4 3-4	1282 1197 1056 769 628 543	0.27473 -2.53480 1.51609 -2.55556 1.23653 3.22834

¹Note: The numbers in column one of the table are codes for the classifications of teacher experience. The code numbers and their classifications are listed below.

- 1 = Teachers with one to four years of teaching experience.
- 2 = Teachers with five to nine years of teaching experience.
- 3 = Teachers with ten to fourteen years of teaching experience.
 - 4 = Teachers with fifteen or more years of teaching experience.
- $^2 Note:$ The negative sign with a <u>t</u> value indicates that the differences were in favor of the phenomenon associated with the second number.

^asignificant at the .01 level

^bsignificant at the .05 level

The Relationship Between Teachers' Perception of the Ability of the Class in Science and Students' Growth in Science Achievement

The investigator sought to determine what relationship existed between the teacher's perception of the ability of the class in science and student growth in science achievement. Teachers were asked to judge the ability of their classes in science in one of three categories. These categories were: (1) above average ability, (2) average ability, and (3) below average ability. The analyses were made with the total sample.

The F value for the ANOVA for this variable was 14.608 which was significant at the .01 level. The results of the test of multiple \underline{t} 's are summarized in Table XV. The findings from the data in this table are listed below.

- Students who had teachers who rated their classes ability in science as either above average or average made significantly greater gains (.01 level) in science achievement than students of teachers rated their classes ability as below average in science.
- Significant differences were not found (.05 level) between students whose teachers classified their abilities as above average and students whose teachers classified their abilities as average.

In summary, there seem to be many factors that are significantly and positively related to student growth in science achievement as measured by a paper and pencil test of science achievement. The findings reported above identify many of the variables that are related to student growth in science achievement. The curriculum

Table XV

Relationship Between Teachers' Perception of Class Ability and Student Growth in Science Achievement

Source of \underline{t}^1	DF	<u>t</u>	
1-2	1738	1.88331	
1-3	989	4.97738	
2-3	839	5.01157	

¹Note: The numbers in the first column of the table are code numbers for different categories of teachers' perception of class ability. The numbers and their categories are listed below.

> Teacher perceives the class as of above average ability.
> Teacher perceives the class as of average ability.
> Teacher perceives the class as of below average

ability. ^asignificant at the .01 level

being used seems to have a significant relationship. There is a significant relationship between a student's standing in class (quarter of the class) in which the students pre-test score on the criterion instrument falls. Significant relationships also exist between science achievement and the teachers' perception of the curriculum in use, the teachers' post-baccalaureate training in science, the teachers' experience with the curriculum, the numbers of years of teaching experience and the teachers' perception of the ability of their classes.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

The Problem

The purposes of this investigation were to (1) compare the growths in science achievement of students in various elementary-science curricula in use in Southwestern Michigan, (2) determine the relationships of variables such as students' rank in class, type of school (urban, suburban, rural), and sex, with student growth in science achievement, (3) assess the relationships of the teacher variables including pre-service training in science, post-baccalaureate training in science, perception of curriculum, experience with curriculum, experience in teaching, and perception of the ability of the class in science, with students' growth in science achievement.

In order to obtain the data needed, approximately 2,000 students from 16 elementary schools in Southwestern Michigan who were taught by 68 teachers in 77 classrooms were tested during the 1971-72 school year with pre- and post-tests of science achievement. The test used was the "Science" portion of the <u>Elucational Development Series</u> of the Scholastic Testing Service. In addition, data concerning characteristics of the teachers were collected by means of a teacher questionnaire. The data collected were analyzed for answers to the following questions:

1. Which of the curricula dealt with in this study lead to greater gains in students' science achievement?

- To what extent do students' ranking in the four different quarters of class standings, as determined by the pre-test scores, differ in growth in science achievement?
- 3. What is the relationship between student achievement gains and the type of communities (urban, suburban, and rural), in which the schools are located?
- 4. What is the relationship between sex of students and growth in science achievement?
- 5. What is the relationship between the amount of teachers' preservice training in science and students' growth in science achievement?
- 6. What is the relationship between teachers' post-baccalaureate training in science and students' growth in science achievement?
- What is the relationship between a teacher's perception of the curriculum he is using and students' growth in science achievement?
- What is the relationship between the teachers' experience with a curriculum and students' growth in science achievement?
- 9. What is the relationship between the teachers' experience in teaching and students' growth in science achievement?
- 10. What is the relationship between teachers' perception of class ability in science and students' growth in science achievement?

The results of the analyses of the data are found in Tables III through XIV of the preceding chapters. Conclusive answers were not obtained to all the questions listed above, and hence, one important aspect of this study concerns the implications for further research. However, answers that were elicited to some questions may have immediate application in the elementary-science classroom. For convenience, the discussion that follows is presented under two major headings. These headings are (1) Summary and Conclusions, and (2) Recommendations for Further Research.

Summary and Conclusions

The following summary of the findings and conclusions that follow are based on the data collected in the elementary-science classrooms during the 1971-72 school year. The questions listed previously will be dealt with in the order they were presented.

1. Students who used the "modern textbooks" had significantly greater gains in science achievement than students who used the "modern curricula". The only comparison in which students using modern curricula made significantly greater gains was the one in which ESS and the "traditional" curricula were compared. Students using the "modern textbooks" namely the Silver Burdett and Harcourt, Brace and Jovanovich series had significantly greater gains in achievement than those who used SAPA, SCIS or the "traditional" curricula. This conclusion applies to students in the 4th, 5th and 6th grades and to all three grades combined.

Thus, one may conclude that in terms of growth in science achievement, the "modern textbook" series generally produce greater gains in science achievement in terms of the tests used than do the modern curricula.

2. Students in the lst and 2nd quarters (lower quarters) who used the "traditional" curriculum, the Silver Burdett series, and the Harcourt, Brace, and Jovanovich series, made significantly greater gains in science achievement than did students in the upper quarters of the class. Therefore, one may conclude that the curricula represented by these materials are especially effective with students

in the lower quarters of the 4th, 5th and 6th grades.

3. The analyses for the relationships between growth in science achievement and the types of communities in which the schools were located, failed to evidence significant differences between growth in science achievement for any of the curricula involved in this study.

4. It was concluded that significant differences were not evident between student growth in science achievement in the curricula involved in this study and students sex.

5. The following conclusions emerged from the analyses of the relationships between the teachers' pre-service training in science and students growth in science achievement:

- a. Students who had teachers with 10 or more semester hours of pre-service science training made significantly greater gains in science achievement than did students of teachers with less than 10 semester hours of pre-service science training. This was true of all curricula except SAPA.
- b. The students who had teachers using SAPA who had less than 10 semester hours of pre-service science training made significantly greater gains in science achievement than students who had teachers who completed more than 10 semester hours of pre-service training in science.
- c. Growth in student science achievement was influenced more by the amount of pre-service science training of teachers who used the Silver Burdett scries, and the Harcourt, Brace, and Jovanovich series than did any of the other curricula.

These findings contradict the widely-accepted belief that teachers of the "modern" curricula need more training in science to be effective than do teachers of the "textbook" type of curriculum.

 Analyses of the data concerning the relationship between teachers' post-baccalaureate training in science and students growth in science achievement indicate that students who had teachers who completed 3 or more semester hours of training in science since graduation made significantly greater gains in science achievement than did students who had teachers who completed less than 3 semester hours of science training. The implication is that teachers of elementaryschool science should be encouraged to take post-baccalaureate training in science.

7. Students whose teachers expressed the opinion that their curricula were poor made significantly smaller gains in science achievement than did students whose teachers indicated that their curricula were average or above average. This seems to imply that if teachers do not support the curriculum they are teaching, the students will not make the gains in science achievement they might have made if the teacher had a better opinion of the curriculum. This finding is in accord with that of the <u>Rockefeller Foundation's Report on the Pursuit</u> <u>of Excellence in Teaching</u> which stated that "no curriculum is any better than the teacher teaching it, and the key is the teacher's enthusiasm for the curriculum he is using."

8. It was found that there was an inverse relationship between students growth in achievement and the number of years that the teacher had taught the curriculum. Students whose teachers had taught a curriculum for more than 5 years made significantly smaller gains in science achievement than did students of teachers who had taught the curriculum for fewer or greater numbers of years.

 The data concerning the relationship between numbers of years of teaching experience and growth in student science achievement

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indicated that students who had teachers with 10 to 14 years of teaching experience made significantly greater gains in science achievement than did students who had teachers with less than 10, or more than 15, years of teaching experience.

10. The relationship between the teacher's perception of the ability of the class in science and the students' growth in science achievement is of interest. The analyses indicated that the relationship between students who had teachers who rated the class ability as below average made significantly smaller gains in science achievement than students who had teachers who rated the classes ability as average or above average.

Recommendations for Further Research

Because this study was exploratory, much of its significance concerns implications for further research in science education. One problem of this study was its breadth. Since many variables were involved the recommendations that follow are only a few of those that might be suggested.

The recommendations include the following:

- Longitudinal studies designed to determine the extent of the relationship between growth in achievement and growth in critical-thinking ability.
- Controlled studies involving fewer variables than involved in this study.
- An examination of the factors influencing the relationship between a teachers' experience and the growth in students' science achievement.
- 4. An investigation of factors related to the relationships between teachers perceptions of the ability of the class and students' growth in science achievement.

APPENDIX A

September 3, 1971

One of the areas in elementary-school education which has been the subject of increasing attention, is elementary science. The Federal government has given extensive support for the development of a number of programs and meanwhile, many of the commercial publishing companies have produced materials that emphasize the newer orientation to Inquiry Skills. All of this is to the good.

Unfortunately, as with many educational efforts, little has been done to evaluate these programs other than internally, or to compare the relative values of the programs under school conditions. Mr. Ben A. Smith at Western Michigan University is now working on such an evaluation which is sorely needed. Obviously, the data for the evaluation must be obtained from the schools in which the various programs are used. Consequently, your aid and that of your teaching colleagues and students is a source for this information.

Mr. Smith is dealing directly with you to discuss the possibility of your participating in this evaluation. I hope sincerely that conditions in your school system will permit you to do so. Without the help of persons such as yourself, it is perfectly obvious that studies such as these cannot be carried out.

Your cooperation will be appreciated.

Sincerely,

George G. Mallinson, Dean

GGM/lkf

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Dear

The Division of Science Education at Western Michigan University is currently concerned with determining the various individual characteristics and strengths of the current science curricula in the elementary schools of Michigan. An effort is being made to survey the major curricula used in the elementary schools of Southwestern Michigan with the hope of comparing the successes of the curricula in achieving certain common goals of elementary-science education. This, of course, will require the assistance of elementary teachers and students from a representative sampling of schools. We are writing this letter to inquire about the possibility of certain of your teachers and pupils participating in this study during the 1971-72 school year.

There has been little study comparing the major "new" elementary-science curricula (AAAS: Science - A Process Approach, ESS: Elementary Science Study, SCIS: Science Curriculum Improvement Study) with each other and with the traditional science taught in the fourth, fifth and sixth grades of the elementary school. It is believed that such a study would be profitable to teachers and administrators who will, in the future, be faced with the problem of selecting the direction that the elementary-science curriculum will take in their schools. The need for, and importance of, a strong elementary-science curriculum has been established in the past few years. This attitude is becoming increasingly stronger even though government funding of programs to develop and study elementary science has been reduced.

We are hoping for your participation for the reasons that are implied in the previous statement. A maximum of three periods during the school year of student time and approximately one hour of teacher time will be needed in order to gather the data. No teacher or school will be rated or judged in any way by the researcher, and all the data will be kept completely confidential and complete anonymity is assured.

Page 2

Before we proceed, we would like to ask your permission to write certain members of your elementary staff a letter similar to this one describing the study. In addition, we would like to arrange a conference with you on a date that is mutually satisfactory to describe the study further, review the letter, and discuss your possible cooperation. We hope to arrange the conference as soon as convenient. Where possible, it is also hoped that the elementary teacher or teachers may be available so that any questions they may have concerning the study can be answered.

If such an arrangement is satisfactory with you, please fill out the enclosed postcard and return it. Upon receipt of the card, we will be contacting your office to set up a conference.

Your cooperation will be appreciated.

Sincerely,

Ben A. Smith Science Education Chemistry Department Western Michigan University Kalamazoo, Michigan 49001

BAS:js

Enclosure

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Participation in A Study of Elementary Science Curricula

1.	We would be	interest	ed in	discussing	the opportunity
	to particips	ite in a	study	of elements	ry-science
	curricula.				

Yes	No	
		the second se

2.	Comments:	

Signed:

APPENDIX B
Dear Colleague:

The following questionnaire will be used to determine some background information about the teachers using the various curricula with which this study is concerned. The information will be used to develop cells for the analysis of variance between groups during the data analysis. No one but the researcher will see the forms and your anonymity is guaranteed. Thank you for taking time to fill out the questionnaire.

Sincerely,

Ben A. Smith Science Education Department Chemistry Department Western Michigan University Kalamazoo, Michigan 49001 Teacher Questionnaire

Nar	ne	
		last first
Scl	100l	Grade
1.	The	science curriculum I am teaching is:
	1. 2. 3. 4. 5.	ESS (Elementary Science Study).
2.	I ha	we taught science using this curriculum:
	1. 2. 3. 4.	This is the first time
3.	I ha	we taught elementary school:
	1. 2. 3. 4.	One to four years.
4.	I am	teaching this science curriculum because:
	1. 2. 3. 4.	I was given my own free choice
5.	I th	ink that the science program I am using is:
	1. 2. 3. 4. 5.	Excellent

6. If I had my choice, I would teach science using:

1.	Above average.	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	
2.	Average			•	٠	•	٠	•	٠	٠	•	•		٠	•		٠		•	•	
3.	Below average.																				

8. I would like to know if you have been involved in any post-bachelors work in science. This post-bachelors work should be graduate or undergraduate science courses taken since you received your bachelors degree, workshops, or in-service training which consisted of three or more sessions of an hour or longer duration. If you have participated in any such program, please describe it below.

9. I received my bachelors degree from:

Year

SCIENCE ACHIEVEMENT TEST

This is a test of your understandings in science and your ability to work with problems in science. The test questions look like this:

S1. We use a thermometer to measure

- a) rain.
- b) snow.
- c) air pressure.
- d) time.
- e) temperature.

Circle your answer to question S_1 in your test booklet. A thermometer is used to measure <u>temperature</u>, and you should have circled the fifth answer for problem S_1 . In this test you will find 60 problems like this one. Your score will be the number of answers you get right. Be sure to circle one answer - the answer you think is right for each problem.

> This test is a portion of the EDUCATIONAL DEVELOPMENT SERIES of SCHOLASTIC TESTING SERVICE It is reprinted through their cooperation for research purposes only.

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- Important Facts and Principles -

- 1. Which of the following causes the greatest absence from school?
 - a) colds
 - b) scarlet fever
 - c) mumps
 - d) measles
 - e) chicken pox
- 2. You will probably live longer than your grandparents because
 - a) homes are better heated than in the past.
 - b) people retire sooner than they used to.c) modern homes are air conditioned.

 - d) people are stronger than they used to be.
 - e) more is known about the causes of disease.
- 3. If water contains harmful germs, it can be made safe to drink by
 - a) straining it through a clean cloth.
 - b) boiling it for at least 10 minutes.
 - c) mixing it with air.
 - d) allowing it to stand in sunlight.
 - e) adding a teaspoon of baking soda.
- 4. The most common cause of home injuries is
 - a) fires.
 - ъ)́ poisons.
 - c) falls.
 - d) electric wiring.
 - careless use of guns.
- 5. Which of these is not a good conductor of heat?
 - a) aluminum
 - b) rock wool
 - c) copper
 - d) brass
 - e) steel

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- 6. Clothes dry fastest outside when the air is
 - a) cold and moist.
 - b) cold and dry.
 - c) warm and moist.
 - d) warm and dry.
 - e) none of these.

7. Thunder is heard after a flash of lightning because

- a) the air is full of moisture.
- b) light travels faster than sound.
- c) sound travels only through air.
- d) sound travels in straight lines.
- e) sound travels faster than light.
- 8. The main difference between clouds and fog is that
 - a) one is denser.
 - b) one is heavier.
 - c) one is closer to the ground.
 - d) one contains more dust.
 - e) one contains more water vapor.

9. Day and night are caused by the

- a) phases of the moon.
- b) rotation of the moon.c) revolution of the sun.
- d) tilt of the earth's axis.
- e) rotation of the earth.

10. The seasons change because the

- a) earth's axis is tilted.
- b) sun turns on its axis.
- c) moon travels around the earth.
- d) earth turns on its axis.
- e) earth's orbit is oval.

11. Moonlight is caused by

- a) gases on the moon.
- b) radioactivity on the moon.
- c) light reflected from the earth.d) light reflected from the sun.
- e) the moon's hot surface.

- 12. The star nearest to the earth is
 - a) Vega.
 - ъ) Alpha Centauri.
 - c) the North Star.
 - d) Orion.
 - e) the sun.
- 13. Volcanoes are found mainly in
 - a) desert regions.
 - b) mountain regions.
 - c) offshore regions.
 - d) arctic regions.
 - e) deltas.
- 14. Which chemical is added to drinking water to help reduce tooth decay?
 - a) bromine
 - b) chlorine
 - c) salt
 - a iodine
 - e) fluorine
- 15. A carbon dioxide fire extinguisher puts out a fire by
 - a) forming water over the fire.
 - b) smothering it.
 - c) cooling it.
 - d) combining with the fuel.
 - e) combining with the oxygen.
- 16. Oxygen combines with another material in all of the following except in the
 - a) melting of ice.
 - b) rotting of wood.
 - c) burning of coal.

 - d) rusting of iron.e) burning of fuel in a rocket.

17. All of these types of water contain dissolved minerals except

- a) ocean water.
- b) lake water.
- c) rainwater.
- d) well water.
- e) river water.

18. Which of these is important in controlling insects?

- a) early plowingb) field mice
- c) bees
- d) birds
- e) fertilizers

19. Bees are important to farmers chiefly because they

- a) serve as food for birds.
- b) scare away harmful birds.
- c) scare away harmful animals.
- d) help spread pollen.
- e) remove nectar from flowers.
- 20. Dogs, cats, humans, and cows are called "mammals" because they have
 - a) four limbs.

 - b) two eyes.c) digestive systems.
 - d) milk glands.
 - e) teeth.

21. A man would die most quickly if he could not get any

- a) food.
- b) clothing.
- c) shelter.
- d) water.
- e) air.

- 22. A mother may take calcium pills before her baby is born. These pills help to form the baby's
 - a) blood.
 - b) brain.

 - c) skin. d) bones.
 - e) muscles.
- 23. An ice cube tray was filled with water. It was placed in a freezer and allowed to freeze. When the tray was removed, it was noticed that the ice cubes had "bulged up." The reason is that
 - a) cold water freezes faster than warm water.
 - b) water expands when it freezes.
 - c) most things expand when they are cooled.
 d) water is a liquid, but ice is a solid.
 e) the freezer was too cold.

- A Study of the Parts of a Flower -

The diagram below shows the main parts of a flower. Use the letters in the diagram to answer the following questions.



24. The "sepals" of a flower protect the bud before the flower opens. Which letter shows the sepals?

a) A b) B c) C d) D e) E

- 25. If this is an apple blossom, which part will develop into the apple?
 - a) A b) B c) C d) D e) E
- 26. Where are the seeds formed?

a) A b) B c) C d) D e) E

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27. Where are the pollen grains formed? a) A b) B c) C d) D e) E 28. Which letter shows the flower petals? a) A b) B c) C d) D e) E 29. By holding a plant upright, the stem helps the plant to get a) chlorophyll. b) air and sunshine. c) water. d) nitrogen. e) minerals. 30. The main job of a leaf on a green plant is to a) make food. b) protect the plant. c) protect the flower. d) absorb rainwater. e) shade the stem. 31. The main job of flower seeds is to a) start new flowers.

- c) store food.
- d) attract bees.
- e) carry on photosynthesis.

- b) make food.

- A Study of Simple Machines -

Simple machines are used to do work. Here is a list of five simple machines:

A - Lever B - Wedge C - Wheel-and-Axle D - Pulley E - Inclined Plane

Decide which simple machine would be most useful to do each of the jobs listed below.

32.	A man wants	to ra	aise a	box	to the	top	of a t	all	building.
	a) A	b)]	В	c)	С	d)	D	e)	Е
33.	A man is can	rryiną	g his s	uitc	ase up	an a	airport	ram	p.
	a) A	ъ) I	В	c)	C	d)	D	e)	Е
34.	A boy scout	is cl	nopping	woo	d for a	car	mpfire.		
	a) A	ъ) I	3 (c)	С	d)	D	e)	Е
35.	A man is jac	king	up his	aut	omobile				
	a) A	b) I	3 (e)	С	d)	D	e)	Е
36.	A girl is tw	vistir	ng a doo	orkn	ob.				
	a) A	b) I	3 (2)	С	a)	D	e)	E
37.	A man is ope	ening	a crate	e wi	th a cr	owba	r.		
	a) A	b) Е	3 0	2)	C	a)	D	e)	Е

38. A boy is pushing the pedals of his bicycle to make it go faster.

a) A b) B c) C d) D e) E

39. A boy is raising the sail on his sailboat.

a) A b) B c) C d) D e) E

- Birds That Stand While They Sleep -

Some birds sleep while perched on a tree-limb or a wire. Other birds, like storks or herons, sleep while standing on one leg.

Birds that stand on a limb or wire have a tendon in their feet and legs that draws tight when the birds' toes are curled around an object. As the toes curl around a tree-limb or wire, the tendon is locked in place with a "special locking device."

With birds that stand on one leg, the leg "locks" in position, much like the blade of a jacknife snaps into the open position.

Using just the information in this story, mark problems 40-46 with these marks: T - The statement is all true. t - The statement is probably true. ? - We cannot tell from this story. f - The statement is probably false. F - The statement is completely false.

40. All birds sleep while standing on one leg. (T - t - ? - f - F)

41. Some animals sleep while standing on all four legs. (T - t - ? - f - F)

42. Most birds sleep about eight hours a night. (T - t - ? - f - F)

43. All birds sleep while standing on two legs. (T - t - ? - f - F)

44. Woodpeckers sleep with their feet hooked into the bark of a tree. (T - t - ? - f - F)

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- 45. Perching birds can sleep on wires because they have special locking devices in their feet and legs. (T - t - ? - f - F)
- 46. Many birds prefer to live in birdhouses, rather than sleeping outside. (T - t - ? - f - F)

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- An Experiment with Green Ink -

Tom wrote these notes in his science notebook:

"We filled a small medicine dropper with green ink. Then Mary put the dropper in a glass of water without squeezing out any ink. The teacher left the glass on her desk without letting anyone touch it. When we came to school the next day, all the water in the glass was green."

- 47. Which statement best explains what happened?
 - a) A liquid takes the shape of its container.
 - b) Heating a liquid makes the molecules move faster.
 - c) The molecules of gas move faster than those of a liquid.
 - d) The molecules in a liquid are always moving.
 - e) Air pressure was pushing on the water in the glass.
- 48. Suppose the water in the glass was hot, rather than at room temperature. How would this affect the experiment?
 - a) The green color would spread faster.

 - b) The green color would spread more slowly.c) The green color would stay in the dropper.
 - d) The water would evaporate quickly.
 - e) There would be no difference.
- 49. Four of the following observations are similar to the observation with the green ink. Which is not similar?
 - a) If a large balloon is placed in a refrigerator, it soon becomes smaller.
 - b) If a lady is cooking onions, you can soon smell them all over the house.
 - c) If a tablet of food coloring is placed in a cup of water, soon all of the water is colored.
 - d) If an open bottle of perfume is placed in a room, it can soon be smelled all over the room.
 - e) If sugar is placed in a glass of lemonade without stirring it. the whole glass of lemonade soon tastes sweet.

- An Experiment with Mildew -

"Mildew" is a small, non-green plant. To study mildew, some fifth-graders sprinkled two old pillowcases with water, and wrapped each in a piece of plastic. They put one pillowcase in a refrigerator, and they put the other pillowcase in a dark warm closet. At the end of one week, the students opened both packages. The pillowcase in the refrigerator looked the same as it did at the start. But, the pillowcase that had been in a dark warm closet was covered with mildew.

- 50. Mildew must have all these things to grow except
 - a) a place to grow.
 - b) food (cloth).
 - c) moisture.
 - d) warmth.
 - e) sunlight.
- 51. Which reason best explains why the children wrapped the pillowcases in plastic?
 - a) To keep the mildew from escaping
 - b) To keep the cloth warm
 - c) To keep out the light
 - d) To keep the moisture from evaporating
 - e) To keep out the air
- 52. Mildew did not grow on one pillowcase because it did not have enough
 - a) room to grow.
 - b) moisture.
 - c) food.
 - d) light.
 - e) warmth.
- 53. Which of the following is the best example of mildew?
 - a) Potatoes that sprout when kept in the dark.
 - b) Wet clothes that get spotted before they are ironed.
 - c) Oranges that get covered by green mold. d) Window curtains that rot.

 - e) Holes that appear in winter clothes that are stored in closets.

- A Study of Sounds -

All sounds are caused by the vibration, or back-and-forth movement, of the molecules of some material. Differences in sounds are caused by differences in the way objects vibrate.

For example, if objects vibrate slowly, the sounds produced are usually low. If objects vibrate rapidly, the sounds are higher. Some objects vibrate so fast that the sound cannot be heard by human ears.

- 54. A man's voice is deeper than your voice because
 - a) his vocal cords vibrate more slowly than yours.
 - b) his vocal cords vibrate more rapidly than yours.
 - c) he talks louder than you do.
 - d) he has larger lungs than you have.
 - e) his vocal cords have a back-and-forth movement.
- In a piano, long heavy strings produce low notes, and short thin 55. strings produce high notes. The reason for the differences is that
 - a) thin strings vibrate too rapidly to be heard by humans.
 - b) long heavy strings are used the most and will last longer.
 - c) long heavy strings vibrate faster than short thin strings.
 - d) long heavy strings vibrate more slowly than short thin strings.
 - e) long heavy strings stay in tune better.
- 56. There are special dog whistles that can be used to call dogs. The dogs can hear the whistle, but most people cannot. The reason is that
 - a) dogs have longer ears than humans.
 - b) dogs are trained to hear the whistle.c) dogs have smaller eardrums than humans.

 - d) the whistle vibrates very rapidly.
 - e) the whistle vibrates very slowly.

57. Scientists know that no sounds can be heard in outer space. The reason is that

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- a) light travels faster than sound.
- b) there are no molecules in outer space.
- cosmic rays in outer space destroy sound.
 d) it is too dark in outer space.
 e) it is too cold in outer space.

- A Study of Colors -

Some fourth-grade boys and girls decided to make a "stained glass window" for use in a class play. First they planned the design, and then they painted the design on a large sheet of tissue paper.

Later, they put the tissue-paper "window" on one of the real windows in their room. When the sun shone on the window, John saw that the design appeared on one of the desks in the room. John also noticed that this desk was cooler than other desks on which the direct sunlight was shining.

- People who passed the school could see the design that the child-58. ren painted. From the outside, the red section of the design looked red because it
 - a) reflected red light.
 - b) reflected a mixture of yellow and orange light.
 - c) reflected all the sunlight.
 - d) absorbed all the sunlight.
 - e) absorbed all the green light from the sun.
- 59. The students used black, white, red, green, and blue paint to make the design. Which color absorbed all the light from the sun?
 - a) blue
 - b) green
 - c) red
 - d) white
 - e) black
- 60. The desk under the window was cooler than the other desks because the "stained glass window"
 - a) absorbed none of the sunlight.

 - b) reflected all the sunlight.c) absorbed some of the sunlight.
 - d) transmitted all the sunlight.
 - e) bent the sun's rays.

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