A STUDY OF THE RELATIONSHIP BETWEEN ACHIEVEMENT IN PSSC PHYSICS AND EXPERIENCE IN RECENTLY DEVELOPED COURSES IN SCIENCE AND MATHEMATICS

by

PAUL BERNDT ACKERSON

Bachelor of Science
University of Omaha
Omaha, Nebraska
1947

Master of Science
University of Omaha
Omaha, Nebraska
1952

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1959

Submitted to the Faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
May, 1965

A STUDY OF THE RELATIONSHIP BETWEEN ACHIEVEMENT
IN PSSC PHYSICS AND EXPERIENCE IN RECENTLY
DEVELOPED COURSES IN SCIENCE
AND MATHEMATICS

Thesis Approved:

Willard Marsden
Thesis Adviser

H. Harrington

H. Sorenson

Kenneth E. Wiggins

J. B. Boggs
Dean of the Graduate School

PREFACE

Some unprecedented revisions have been proposed for the secondary school science and mathematics curriculums during the past decade. Curriculum improvement committees of scores of individuals have developed new programs in mathematics, biology, chemistry, and physics. These new programs were designed to give more emphasis to the process dimension of science than was generally true of the earlier programs in science and mathematics.

The purpose of this study is to determine whether experience in one of the newly developed courses in science or mathematics is related to higher achievement in the physics course developed by the Physical Science Study Committee.

The writer is indebted to Dr. W. Ware Marsden, Dr. Kenneth Wiggins, Dr. Helmer Sorenson, and Dr. Harold Harrington for their encouragement and wise counsel during the completion of this study. A special thanks is given to Dr. J. Paschal Twyman for his advice in the statistical treatment of the data, and to the eight high school teachers and the hundreds of students who participated in the study.

And last, but not least, the writer wishes to thank his wife Edith and his children for their considerate understanding and assistance in the completion of this study.

TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

Since the turn of the twentieth century, science and mathematics have assumed a position of accelerating importance in the lives of all men, civilized and savage, who call this planet Earth, home. Man has steadily increased his ability to describe in the smallest detail almost every known factor of our rapidly expanding sphere of knowledge. He has learned to make generalizations which are ever more specific and ever more inclusive. Undoubtedly, the fulfillment of the plans and expectations of every living person, and those yet unborn, depends upon how well our youth are trained in the use, the understanding, and the management of the fundamental concepts of science and mathematics.

The increasing importance of science and mathematics to our nuclear-age civilization has created some very pressing problems for science education at all levels. In designing science and mathematics curriculums, educators are currently concerned with problems of course content, efficiency of teaching and learning, education for all levels of ability, open-ended investigative experiments for the laboratory, and evaluation of growth in both methods and content.

During the past decade the greatest emphasis has been given to the development of science and mathematics courses for the secondary schools.

Braced by federal grants and private endowments, committees of scores of individuals rather than single writers, who commonly composed curriculums in the rather recent past, have assumed the responsibility for the development and construction of these courses. The members of the committees have a great diversity of backgrounds in the subject matter disciplines as well as in professional education.

Some critics of the American educational system have charged that the launching of the space-age by Russia was almost completely responsible for these recent, almost frantic, curricular developments. However, the science education literature of the past half-century reveals that the seeds for change were planted in the minds of forward-looking teachers long before "Sputnik" roared into orbit. Almost a half-century ago John Dewey (23) wrote:

> That education is not an affair of 'telling' and being told, but an active and constructive process, is a principle almost as generally violated in practice as conceded in theory .... But its enactment in practice requires that the school environment be equipped with agencies for doing, with tools and physical materials, to an extent rarely attained.

The Thirty-First Yearbook, the Forty-Sixth Yearbook, and the Fifty-Ninth Yearbook of the National Society for the Study of Education were devoted entirely to science education. (58),(59),(60). These documents provide ample evidence that the changes which have occurred in science education have their roots extending beyond the last decade.

Brandwein (12) summed up the metamorphosis of the science curriculum during the first half of the twentieth century as follows:

> Early in this century the elementary school added science to its curriculum; it has always had nature study. But technological advance had hit the kitchen, the highway, the air; the children were beginning to ask questions about airplanes, radios, automobiles, refrigerators. Teachers were being

> trained in a science highly oriented in technology. Junior high schools added science to the areas of exploration. In the 1930's junior high school science drew on the content which until then was thought appropriate to the high school. The more alert professional high school cadres began to respond to this justifiable piracy. The responses were of two kinds: First, the courses in high schools began to have more rigor; and second, the most highly qualified youngsters began to get special opportunities, extra-curricular and co-curricular .... Schools began to organize special curriculums for the so-called gifted students....
> The environment was favorable in the decade from 1930 and 1940 for the mutant curriculum in the fields of science, mathematics, and in all areas. World War II came and there was a diversification to war courses in science with emphasis on technical training. The 'corrective' curriculum was postponed to the 1960's.

Certainly a fair observation to make is that while "Sputnik" may not have been the cause of the crisis in science education, this event acted as a catalyst to speed up the rate at which the changes already in progress were being made.

A great number of national-scale curriculum improvement projects have been attempted during the last decade. A report issued by the National Science Foundation in 1962 described 132 course content improvement projects at all levels of instruction which had received support from the Foundation up to October, 1962. (57).

Among the other projects described briefly in this Foundation report are the following which are of special concern to this study: Physical Science Study Committee, Biological Sciences Curriculum Study, Chemical Bond Approach Project, Chemical Education Material Study, and School Mathematics Study Group. Each of these groups has produced one or more courses in science or mathematics which are now being used in secondary schools.

The course revisions developed by these groups have all been experimentally tested in schools during the past several years. All have undergone revision as a result of evaluations and continuing study. The science courses, with some auxiliary materials, have been released to commercial publishers for publication in hardback form and are now available to school systems. (9),(10),(11),(13),(19),(63). The mathematics courses have not yet been issued in hardback form by commercial publishers. However, revised paperback editions in the area of mathematics are widely available.

The committees for the science courses agree that they are attempting to revise the science curriculums in order to bring the study of science out of the doldrums of unfettered diversification of topics brought about by the knowledge explosion in science. These same committees say they are trying to keep basic scientific principles free from dilution with elementary technological applications of science. An agreement seems to have been reached by these writers that science can no longer be pictured as a relatively static body of facts to be categorized and memorized, but rather it must be recognized that science is dynamic and developing. Scientists and teachers of science are well aware, from bitter experience, that today's facts may well be considered by the citizens of tomorrow as the misunderstandings and unfortunate guesses of the past.

Bently Glass (41) expressed his viewpoint of science education in Science and Liberal Education. His stand seems to be characteristic of the direction taken by the newly developed courses in science and mathematics:

> Much effort must be expended to develop courses that will avoid unnecessary jargon and that will aim not so much at the training of the technical expert as at the liberal education of the citizen.... To understand science one must see a problem unfold from its beginnings, see progress impeded by traditional ways of thought, learn that scientists make mistakes as well as achieve successes, and observe what experiments brought illumination, and why. One must ask continually, What is the evidence? One must observe how frequently the truth of today is a synthesis of opposing counterviews and counter theories held in their time to be irreconcilable. And one must learn from the study of cases how varied are the methods of science. As to its spirit .... it is born by contagion; its home is in the laboratory, the observatory, or the field, wherever the inexperienced person can observe experience, and the novitiate partake of the zest of discovery.

Frank B. Allen (56, p. 85), speaking for the National Council of Teachers of Mathematics, has given the purpose of courses which he feels should be developed for high school mathematics students:

> The new programs in school mathematics will serve to increase the nation's supply of technicians, engineers, scientists and mathematicians. They will also help, in some degree to bridge the terrifying gap that now exists between mathematics instruction and the outrushing frontiers of mathematics and science. Indeed, they are typical of the programs that must be established in all fields if the members of the next generation are to have the knowledge necessary to operate the complex civilization they inherit.

Although all of the recently developed courses do not include the same subject matter content, Brandwein (12) suggests that they do have much in common. Each is designed to center on a major conceptual scheme or pattern of concepts. Each provides for problem-solving as well as problem-doing. Each emphasizes scientific processes and ideas more than the history and the products of science. Basic research plays a greater part in the science laboratory experiences included in the science courses. The student is given the opportunity to observe, collect and analyze data, to design experiments, and to use mental and physical models in relating or explaining certain observations. Kenneth E. Brown (56, p. 22) suggests that a similar characteristic is found in the new mathematics courses. Unifying themes are carried throughout the various course revisions. The mathematics courses prepared by the School Mathematics Study Group aim not only at facts and skills, but also at basic concepts and mathematical structures which give meaning to these skills and provide a logical framework for the facts. (71).

Definition of Terms

The following terms and abbreviations will be used throughout this report:

New mathematics or new science courses refers to the courses which have been developed or revised by the large curriculum groups during the past decade. The author does not imply new to mean completely novel or different, but rather recently constructed or designed.

Conventional mathematics or conventional science courses are courses other than those which have been developed during the past decade by the curriculum revision groups. A valid assumption would be that these courses vary widely in method and content and would in most cases be based upon a commercially produced textbook.

PSSC refers to the Physical Science Study Committee and PSSC Physics refers to the high school physics course recently developed by that group.

BSCS refers to the Biological Sciences Curriculum Study which has recently produced three versions of a biology course for use in high school biology classes; BSCS Biology, Blue Version; BSCS Biology, Yellow Version; and BSCS Biology, Green Version.

CBA refers to the Chemical Bond Approach Project which recently wrote the CBA Chemistry course for high school chemistry students.

CHEMS or CHEM Study refers to the Chemical Education Material Study which has recently produced the CHEM Study course for high school chemistry.

SMSG refers to the School Mathematics Study Group which has produced a series of mathematics courses for both the high school and the elementary school.

Statement of the Problem

An examination of these new courses in science and mathematics reveals that they have both a content dimension and a process dimension. The substantive or content part of the courses includes what scientists have learned or discovered. The process dimension includes the on-going, inquiring, search for knowledge.

The content part of the PSSC physics course includes what scientists have learned or discovered about such physical aspects of our environment as time, space, motion, mass, light, waves, force, momentum, energy, electricity and magnetism. Ferris (34) says that the process dimension of PSSC physics includes the following:

Ability to demonstrate qualitative understanding of the fundamentals
Ability to apply knowledge to unfamiliar situations
Ability to analyze problem situations mathematically
Ability to use graphical presentations of the data
Ability to identify the problem in a new situation
Ability to formulate a simple scientific model
Ability to make logical predictions based on the model
Ability to suggest new lines of investigation based on observations

Ability to make approximations and to draw valid conclusions from observations and data

An observation of the CHEM Study materials shows that many of these same skills or abilities are included in the process part of this course. (20),(21).

Ability to use graphical presentations of data
Ability to formulate mental or physical models
Ability to accumulate information and data through observation
Ability to use the physical models to explain the physical results of an experiment
Ability to observe, to seek regularities, to generalize, and to test the generalization
Ability to make logical predictions by using the method of repetition of an experiment, by interpolation within the range of the data, and by extrapolation beyond the realm of experience
Ability to analyze problem situations mathematically
Ability to use a theory or a model to suggest further experiments
Ability to evaluate and interpret data in an intelligent fashion

Similarly, an examination of the CBA chemistry materials demonstrates that a list which is quite similar to the PSSC list can be compiled. (13).

Ability to analyze problem situations mathematically
Ability to use mental and structural models to explain experimental results
Ability to collect relevant information and data
Ability to analyze and interpret the results of a controlled experiment
Ability to use graphical analysis of data
Ability to apply knowledge to an unfamiliar situation
Ability to recognize a problem and to design an approach to the solution of the problem
Ability to formulate a model system
Ability to use models to suggest new lines of reasoning
Ability to use models to predict results in an unfamiliar situation
Ability to arrive at a conclusion through analysis of data

In the introduction to the teacher's guide for the laboratory manual used with the experimental edition of the Green Version of BSCS biology, a very definite statement is made by the writers about the two aims of studying any natural science. (8).

> One aim, the lesser in importance, is to become acquainted with the significant facts upon which rest the major concepts and theories of science.... The second objective is to know what science really is -- to recognize its spirit and appreciate its methods....If, however, every student at least glimpses the nature of experimental inquiry as man's most powerful tool for gaining knowledge, much will have been gained. This then is our main objective.

Klinckmann (46) says there are four major kinds of abilities which are tested by the BSCS Biology Tests. These abilities are assumed to be developed in the study of BSCS biology.

Ability to repeat or use information and meanings
Ability to apply key principles
Ability to apply intellectual skills crucial to an understanding of biological science -- interpret graphs, data, tables, and charts -- understand the relationship between the data presented and the generalizations drawn from them -- design experiments to test hypotheses -- identify problems and unanswered questions -- identify assumptions and principles of inquiry -- analyze research papers for these items
Ability to see and discuss significant relationships of various kinds

A special committee appointed by the Board of Directors of the National Council of Teachers of Mathematics examined eight new programs in mathematics. The results of this evaluation were published in 1963. (56).

From the report published by the National Council of Teachers of Mathematics and from a direct examination of the SMSG materials, a list of topics which are treated in SMSG mathematics was developed. (56, p. 32),(74),(75),(76),(77),(78).

Graphs, functions, slopes
Properties of number systems
Exponential notations
Vectors and vector algebra

Sets and fields
Inductive and deductive logic used in the discovery of fundamental theorems
Sentences
Topics from geometry
Topics from trigonometry

Many physical problems are used to illustrate principles which are developed in the SMSG texts; maxima and minima problems, laws of cooling, laws of motion, simple harmonic equations, vector problems, and mixtures.

The committee appointed by the National Council of Teachers of Mathematics noted that SMSG mathematics gives emphasis to student discovery and that SMSG mathematics is characterized by giving importance to the development of fundamental concepts as well as the development of skills. The students are encouraged to develop their own ways of solving problems.

A comparison of the lists of topics, abilities, and skills for each of the new courses shows that there is considerable duplication in the process dimension of science which the curriculum revision committees hoped to develop in students who take the courses. If two courses are taught within this same framework of abilities, skills, and concepts, experience in one of these courses should most likely be conducive to achievement in another of these courses. Furthermore, this achievement should presumably be greater for students with this double exposure to materials which emphasize the process dimension of science than for those with a lesser amount of such experience.

The purpose of this study is to determine whether growth in the specific abilities and skills developed in the process dimension of science through taking a course in SMSG mathematics, BSCS biology, CHEM Study chemistry, or CBA chemistry is related to higher achievement in PSSC physics.

That such a relationship might exist has been commonly suggested by teachers of PSSC physics classes who have students with experience in another of the new courses. An article which appeared in a BSCS Newsletter (7) included such a statement:

> For example, the concensus of the reviewers is that the BSCS materials provide an impressively valuable experience for high school students, providing they are teachable -- in view of the fact that the BSCS materials seem more sophisticated than other materials currently in use.... Also, a number of CHEM Study and PSSC teachers have indicated that BSCS students do better in these courses than do non-BSCS students.

A similar statement was included in a "feed-back" letter from Educational Services Incorporated to PSSC teachers. (24).

> Those students with a previous course in SMSG, CBA, BSCS, or CHEM Study do noticeably better in PSSC. The maturity of the student seems to depend upon the kind of math and science courses he has had previously. Students having SMSG, U. of Illinois Mathematics, etc. seem better prepared in slopes, functions, and ability to develop equations. These students ask 'why' more often. The same was said of those students who had a new course in science (BSCS, CHEM, CBA).

These statements indicate that some physics teachers who are using PSSC materials in the classroom are of the opinion that previous experience in one of the new science or mathematics programs is advantageous to students with such experience. However, most of the statements by the PSSC physics teachers have been made without the benefits of a scientific investigation of the relationships between experience in the new courses and achievement in the PSSC physics course.

Plan of the Study

Achievement in physics will be determined in this study by the student's ability to understand basic principles developed in PSSC physics and by his ability to use these principles in the solution of problems included in two tests prepared under the supervision of the Physical Science Study committee for use as semester achievement tests in PSSC physics. Ferris (34) has shown that these tests are designed to measure growth in both the content and the process dimension in PSSC physics. For the purposes of this study, the judgment of Ferris is accepted.

Student achievement data for this study will be obtained from the scores made on PSSC Test Number Five, which is a comprehensive test over Parts I and II of the PSSC course, and from scores made on PSSC Test Number Ten, which is a comprehensive test over Parts III and IV of the PSSC course.[1] Test Number Five will be given at the end of the first semester or at the completion of Parts I and II of the PSSC text, and PSSC Test Number Ten will be given at the end of the second semester or upon completion of Parts III and IV of the PSSC text.

The School and College Ability Test (SCAT, Form 2A) will be given to all members of the PSSC classes in the test group early in the school year.[2] This test will be used as a measure of student scholastic ability.

---

[1]PSSC Physics Tests are available from Educational Testing Service, Princeton, New Jersey.

[2]SCAT, Form 2A is available from Educational Testing Service, Princeton, New Jersey.

The scores obtained on SCAT and on the PSSC tests will become the basis for the comparison of achievement for students in PSSC classes who are included in this study.

The science and mathematics backgrounds of the students will be determined by means of a questionnaire which will be completed by the students during the first part of the school year. A copy of this questionnaire may be found in Appendix A.

The student data will be categorized according to the background which the student has, either in conventional science and mathematics courses or in a new course in science and mathematics. Using this division of data, the following comparisons of student achievement in PSSC physics will be made between students having different backgrounds in science and mathematics:

Conventional mathematics only	vs	One or more courses of SMSG mathematics
Conventional chemistry	vs	CHEMS chemistry
Conventional chemistry	vs	CBA chemistry
Conventional biology	vs	BSCS biology

In addition, the following comparisons of student achievement in PSSC physics will be made between students having different backgrounds in SMSG mathematics:

One or two semesters of SMSG Math.	vs	Three or four semesters of SMSG Math.	vs	Five or six semesters of SMSG Math.	vs	Seven or eight semesters of SMSG Math.

In the determination of the mathematics background of the students, current enrollment in a course in mathematics as well as completion of a course in mathematics will be counted as part of the background experience.

Further, since it is not anticipated that many of the students will have backgrounds in more than one new science course, no comparisons will be made which involve categories of multiple experiences in the new science courses. Some specific kinds of data may be included in more than one comparison for the purposes of relating the achievement of students with various backgrounds in science and mathematics.

It is assumed that the background of students in the same school will be similar enough so that data from all of the classes in PSSC physics may be combined. However, the backgrounds of the students from several schools may be different enough so that a combination of the data could be questioned. For this reason the data from individual schools will be treated separately before being pooled into a larger sample, and any conclusions reached from pooled samples will be accepted with some reservations.

Scope of the Study

The data for this study will be collected during the academic year 1963-64. This study will include an analysis of the achievement in PSSC physics of all of the students enrolled in PSSC classes distributed in 25 classes in seven schools found in four midwestern cities. Three of these schools are located in one city, two in another, and one in each of two other cities. The schools are listed in Appendix B.

Three of these cities are large metropolitan areas with a population of 200,000 or more, and the fourth has a population of somewhat less than 40,000.

Only one PSSC teacher is included on the staff of six of the schools, while there are two PSSC physics teachers in the seventh school.

Each of the teachers has had some special training in the methods, materials, and philosophy of PSSC physics. A list of the teachers may be found in Appendix B.

Hypotheses to be Tested

The hypotheses to be tested in this study stated in the null form are:

I. Achievement in PSSC physics is not significantly different for students with a background in SMSG mathematics from achievement of students with a background in conventional mathematics.

II. Achievement in PSSC physics is not significantly different for students with a background in BSCS biology from achievement of students with a background in conventional biology.

III. Achievement in PSSC physics is not significantly different for students with a background in CHEM Study chemistry from achievement of students with a background in conventional chemistry.

IV. Achievement in PSSC physics is not significantly different for students with a background in CBA chemistry from achievement of students with a background in conventional chemistry.

V. Achievement in PSSC physics is not significantly different for students with a background of one to two semesters of SMSG mathematics, three to four semesters of SMSG mathematics, five to six semesters of SMSG mathematics, or seven to eight semesters of SMSG mathematics.

Importance of the Study

Whenever changes are introduced into the curriculum of the high school, the administrators, teachers, counselors and others who are concerned with the total learning of the child desire to know the interrelationships which exist between courses so that prerequisites may be established.

The sequence of courses in the secondary school science curriculum is thought to be designed so that the understandings, skills, and attitudes which are developed in the earlier courses lead to greater achievement in subsequent courses. In this study, some of the students will have had exposure to various new courses in science and mathematics before enrolling in PSSC physics, while others will have had no contact with the new courses. If growth in the process dimension of science through contact with the new courses is possible, and if this growth is measurable, then it may be assumed that experience in more than one of the new courses is desirable.

Confirmation of the importance of a common philosophy in the science and mathematics curriculum would be of great value to administrators and curriculum directors who are responsible for the design of the sequence of courses in the secondary school program. It is also possible that the development of courses in areas other than science may be influenced by the recognition of the importance of a common underlying philosophy in the design of a sequence of courses. In addition, this study should lead to studies of a similar nature which will further interrelate the newly developed courses in the science and mathematics curriculum.

Summary

The science and mathematics curriculums of the secondary schools have been undergoing some unprecedented revisions during the last decade. Several new sequences of courses developed for use in the high school mathematics program, three new courses written in biology, two in chemistry, and one in physics are of immediate concern to this study.

These courses are said by the designers to differ from those previously used in the high schools in that there is a great deal more emphasis placed on the process dimension of science. An examination of the new courses reveals that there is a considerable overlapping of training in the process dimension between the new courses.

If this proposition is valid, and if growth in the process dimension of science is possible, then those students who have more experience in courses in which the process dimension is stressed should achieve at a higher level than those students with experience which did not stress the process dimension.

The purpose of this study is to determine whether such growth in the process dimension of science does take place discriminately.

CHAPTER II

REVIEW OF THE LITERATURE

Understanding the principles of science and appreciating the methods of science are playing a more important part in the lives and occupations of all citizens. This increasing importance of science to our Nation has created some difficult educational problems. Some good teachers and some good schools have always worked to create the best possible educational climate for young people, but the demanding preparation for the uncertainties of the future has created the need for new methods and strategy in science education. Anyone with a yen for science knows that many significant scientific and technological discoveries have been made in ever increasing numbers during the last five decades. Some way must be devised to organize this rapidly burgeoning information into meaningful learning experiences for students in our science classes.

The National Science Foundation has given support to a number of projects designed to improve instruction in science and mathematics. The Course Content Improvement Program, sponsored by NSF, was instituted to bring scholars from many fields together to develop courses and instructional materials which would reflect contemporary points of view in education and in contemporary scientific knowledge. (57). The changes which have been wrought in science education would have been much more difficult to achieve without the support of the National

Science Foundation.

To show the nature of the changes necessitates a look at the characteristics of the "old" courses. This is not to imply that all was bad about the courses which were used prior to the development of the new courses. Joseph J. Schwab (69) summarized the characteristics of the conventional or traditional courses as follows:

> The traditional courses have been, on the whole, a literal treatment of science and a rhetoric of conclusions. The traditional course has tended to treat only the outcomes, the conclusions, of inquiry, divorced from the data which support them and the conceptual frames which define -- and limit -- their validity.... The result.... has been to convey a false image of science.... as knowledge literally true, permanent -- even complete. This misleading image is further enforced by the neatness with which our courses are usually organized and expounded. We tend to provide a structure which admits of no loose ends. We minimize doubts and qualifications. We strive for exposition characterized by an almost artistic beginning, middle and end.

Brandwein (12) takes a slightly different approach:

> Until recently the vast majority of biology, chemistry and physics courses were patterned after courses in college. But with the appearance of the various high school science curriculum study groups, the winds of change began to blow. Their primary aim was to redirect the thinking of those who prepare the young for college or for work immediately after secondary school.... The work of fashioning the curriculums was accepted by the schools themselves. The work of developing the materials was in the hands of the teachers and the publishers. The collaboration resulted in one very important invention: the multi-faceted curriculums. A curriculum no longer consisted of textbooks alone -- but of scope and sequence, textbooks, tests, filmstrips, workbooks, teacher's handbooks, and sourcebooks. Materials were developed which served the demands of the schoolmen -- materials for 'college preparatory' and the 'terminal' student.

In the same article Brandwein (12) listed seven factors which have been lethal to the school science curriculum in the past. These factors have been adapted into the following list:

> First; built solidly into school curriculums was the incredibly naive notion that science has a successful method, and that this method could be itemized, in steps collectively called 'problem-solving'....
> Second; technology, a product of science, was confused with the purposes, and the processes of science....
> Third; the content of science was confused with a verified and certain body of facts.... The uncertainties and intelligent failures of science were not mentioned....
> Fourth; teaching in science had become equated with telling....
> Fifth; if science was to be taught as history rather than discovery, if facts were to be covered rather than uncovered, if the laboratory was a place for problem-doing rather than for problem-solving, if the product of science was the important aspect, not its process, then the path of teachers in training was clearly marked....
> Sixth; the objective of a literacy in science could not be attained. If science was to be taught as technology and history.... then it was clearly the fate of youngsters to enter school in one mileau of technology and leave school 12 years later unprepared for a new mileau....
> Seventh; the creative individual could not survive in a fixed curriculum with its fixed method and its succession of unchallenged facts.

A conference called by the Division of Physical Science of the National research Council in 1955 resulted in the appointment of a committee to review 14 currently used physics textbooks. (1). The Committee (52) found none of the books suitable and made the following criticisms:

> The textbooks fail to illustrate the essential unity of physics; the textbooks contain too many careless or incoherent statements and definitions; the textbooks rely on <u>ad hoc</u> statements rather than on experimental evidence; the textbooks avoid even the simplest mathematical reasoning; and the use of 'units' results in the fragmentation of the subject matter into a series of independent, small doses.

As a result of dissatisfaction with the courses then in existence, curriculum study groups were established in the 1950's in all areas of mathematics and science. In the pages that follow, a brief statement will be made about each of the projects of relevance to this study.

Historical Background

The Physical Science Study Committee

The Physical Science Study Committee (PSSC) was organized in 1956 under a grant from the National Science Foundation with additional funds coming from the Ford Foundation, the Fund for the Advancement of Education, and the Alfred P. Sloan Foundation. The Committee's work is administered by Educational Services, Inc., which is a non-profit corporation.

The PSSC held its first major planning conference in December, 1956, at the Massachusetts Institute of Technology. (62). Several syllabi were presented and the broad outline of a course was agreed upon. Forty-eight committee members from universities, government agencies, and commercial laboratories were present. Plans were laid for the development of a textbook, a program of laboratory work, examinations, a manual for teachers, resource book for teachers, and monographs for the students.

During the summer of 1957 more than 100 scientists, educators, secondary school teachers, and commercial writers representing film studios, television, and the press developed a syllabus for the PSSC physics course. (48).

A few schools tested this course during the academic year 1957-58. Eight teachers and about 300 students participated in the experimental program. As a result of this evaluation, certain parts of the course were rewritten. Originally, the committee had planned to have all of the laboratory equipment built by the students. Since this was found to be so demanding of teacher and student time, a decision was made to have a commercial supplier prepare easily assembled kits of pre-formed apparatus.

The PSSC physics course involves more than a textbook. A laboratory guide which accompanies the text has been developed. (64). The Science Study Series of monographs has been written by a number of eminent physicists. Approximately 60 teaching films have been produced and are available for rental or purchase. Laboratory apparatus kits are produced by a number of commercial suppliers. A series of 10 achievement tests has been developed. A Teacher's Resource Book and Guide is available in commercial edition. (65).

The growth in the number of students using the PSSC materials has been phenomenal. The Physical Science Study Committee reported that 125,000 students were using the course in the 1962-63 school year.

The Chemical Education Material Study

Seaborg (17), who is chairman of the CHEM Study Steering Committee, wrote a brief history of the CHEM Study Project in the first CHEM Study Newsletter. The project is an outgrowth of a committee set up by the American Chemical Society in 1959. A steering committee composed of 17 educators in the field of chemistry and representatives of industry, publishing firms, high school teachers, and others met for the first time in January, 1960. At this time a decision was made to produce a chemistry text which could be used in the public schools on a trial basis during the academic year 1960-61. A six-weeks writing conference was held during the summer of 1960, and a complete text and laboratory manual were produced by nine university professors and nine high school teachers. This course was field tested in 24 high schools during the following year.

As was the case with the PSSC physics course, many supplementary materials have been produced for use with the CHEM Study chemistry course. Twenty-six films have been produced and are available commercially; achievement tests have been written; a Teacher's Guide has been made available; a laboratory manual has been devised, and programmed sequences on "Exponential Notation" and on "Slide Rule" have been prepared. (20), (21).

The CHEM Study program has shown some rapid growth; sales of the hardback edition of the text had exceeded 90,000 in the fall of 1963, and in addition, it was estimated that 25,000 of the experimental editions of the text were still in use. (18).

The Chemical Bond Approach Project

The syllabus for the CBA chemistry course was developed at a summer institute of high school and mathematics teachers at Reed College in 1957. (81), (82). A proposal was made to build a high school chemistry course around a central theme, the chemical bond.

In 1959, nine high school teachers and nine college chemistry teachers prepared a preliminary draft of the CBA Chemistry course. This course was tried out in nine schools during the academic year 1959-60. (49). As a result of this field-testing, some revision was made of the textbook and the laboratory materials. Two hundred teachers and 10,000 students used CBA materials in 1961-62. (15).

Not as many supplementary materials have been produced for the CBA chemistry course as was the case with PSSC physics or CHEM Study chemistry. A student's laboratory manual, a teacher's guide and a teacher's laboratory guide are all available, or will be available in the near future. (13).

The Biological Sciences Curriculum Study

Hulda Grobman (43) summarized the salient points in the history of the BSCS in a mimeographed information sheet which was distributed by the BSCS. The Biological Sciences Curriculum Study was established in the fall of 1958 by the Education Committee of the American Institute of Biological Sciences.

During the summer of 1960, three writing teams, totaling 70 members, produced the three editions of BSCS biology. Each team was composed of an equal number of research biologists and high school biology teachers. All three versions encompass the same unifying threads, but the versions differ in the biological level at which emphasis is given. (5). In the Green Version, major emphasis is on the community and world biome; in the Blue Version, major emphasis is given to the molecular level of biology, and in the Yellow Version, major emphasis is given to the cellular level of biology.

The preliminary editions of the BSCS courses were tried out by 118 teachers with their 14,000 students. Armed with comments from teachers and students, the participants in a summer writing conference in 1961 reviewed and revised the three versions. All in all, a total of more than 2,000 persons have contributed in some manner to the development of the current editions. (43).

The revised editions of the BSCS courses were tested by 541 teachers and 52,000 students in 1961-62. Again some rewriting occurred as a result of the feed-back from the teachers who were using the materials in the biology classrooms. (5).

In addition to the three texts and associated laboratory manuals, BSCS has prepared the following supplementary materials for a comprehensive program in high school biology: Laboratory Blocks, Equipment and Techniques for the Biology Teaching Laboratory; Teacher's Handbook; Biological Investigations for Secondary School Students, films, tests, a Second Level Course, a course for low-performance students, and other materials suitable for use by the high school biology teacher to improve the teaching at the secondary level. (6).

The School Mathematics Study Group

A brief history of the SMSG appeared in SMSG Newsletter Number Six. (71). In the spring of 1958, the President of the American Mathematical Society appointed a committee of educators and university professors to organize the SMSG to study the improvement of the teaching of mathematics. Professor E. G. Begle was appointed Director of the Study.

The texts for grades 7 and 8 were prepared at a summer writing conference held at the University of Colorado in 1959. Detailed outlines for these courses had been made at a similar writing conference at Yale University in 1958. The texts prepared for use at the high school level were: First Course in Algebra, Geometry, Intermediate Mathematics, Elementary Functions, and Introduction to Matrix Algebra. A commentary for teachers was prepared for use with each text.

The preliminary versions of the high school texts were tested in the classroom by approximately 260 teachers and 18,000 students. Some revision of the materials took place during a writing conference at Stanford University in the summer of 1960.

Each of the texts passes through three editions: a Preliminary Edition, used to test new ideas and content level; a Revised Edition, which has been rewritten with changes based on the comments received from teachers using the Preliminary Edition; and a Sample Text Edition, which is the edition which appears when no further revision seems necessary. Each of the earlier editions may have been used in the field for one or more years before meeting the requirements for the status of a Sample Text. (73).

Supplementary materials have been prepared for use with the text materials. (73). One of these is SMSG New Mathematical Library. Included in this list of monographs for students are: Numbers, Rational and Irrational; What is Calculus About?; An Introduction to Inequalities; Geometric Inequalities; The Contest Problem Book; The Lore of Large Numbers; Uses of Infinity; and Geometric Transformations. Also prepared and available to teachers and teacher training institutions are the SMSG Studies in Mathematics.

The SMSG has taken the position that the texts are designed to serve as models for commercial textbooks which SMSG hopes will become available in the near future. The Committee stated that the approaches in the SMSG mathematics courses are not considered to be the only ways to teach high school mathematics. However, SMSG texts will continue to be available as long as they are needed until commercial texts have been prepared.

Objectives of the Course Revision Groups

Although there may be differences in the specific objectives of the new courses, many objectives common to all have been stated by each of the science curriculum study groups during the process of developing the new materials.

The Physical Science Study Committee (35) was organized in 1957 with the following aims:

> To plan a course of study in which the major developments of physics up to the present are presented in a logical and integrated whole; to present physics as an intellectual and cultural pursuit which is part of present-day human activity and achievement; and to assist physics teachers, by means of various teaching aids to carry out the proposed program.

The School Mathematics Study Group (71) stated its objectives in 1958 as follows:

> First, we need an improved curriculum which will offer students not only the basic mathematical skills, but also a deeper understanding of the basic concepts and structure of mathematics. Second, mathematics programs must attract and train more of those students who are capable of studying mathematics with profit. Finally, all help possible must be provided for teachers who are preparing themselves to teach these challenging and interesting courses.

The Chemical Bond Approach Committee began a series of conferences in 1957. (16). The Committee agreed that chemistry should be organized to explore three key points: Chemists work in the laboratory to obtain data; chemists use their imagination to develop ideas; and chemists combine experimental data and imaginative ideas to further their understanding of chemical systems. The Committee also decided to prepare teaching materials and to conduct an evaluation of these materials.

The Chemical Education Material Study (17) developed the following objectives in 1960:

> To develop new teaching materials for the high school chemistry course; to diminish the current separation between scientists and teachers on the understanding of science; to stimulate and prepare those high school students whose purpose it is to continue the study of chemistry; to encourage teachers to undertake further study of chemistry courses and thereby to improve their teaching methods; and to further an understanding of the importance of science in current and human activities in those students who will not continue the study of chemistry after high school.

The objectives of the Biological Science Curriculum Study were stated in the Science Teacher in 1960. (4).

> To develop an improved sequence of life science subjects in schools and colleges; to make recommendations for the content of courses; to suggest effective methods for presenting these materials; to recommend appropriate placement of biology topics with respect to other courses in the curriculum; to explore special courses for exceptional students; and to design materials for both in- and pre-service teachers of biological sciences.

Central Themes of the New Courses

One feature which is held in common by all of the new courses is that common or unifying threads, cardinal themes, or conceptual schemes provide the framework about which each of the new courses has been written.

Nine cardinal themes are listed as the threads of continuity for each of the three BSCS biology versions. (6).

> Change of living things through time -- evolution; Diversity of the type and unity of pattern of living things; Genetic continuity of life; Complementarity of organisms and environment; Biological roots of behavior; Complementarity of structure and function; Regulation and homeostasis; Science as inquiry; and Intellectual history of biological concepts.

Chemical bonds form the central theme of the CBA chemistry course. (14). Mental models form one kind of thread to explain structure and disorder; electrostatics is another thread; and energy is shown as an organizing concept of great utility to the chemist.

The experimental nature of chemistry provides the central theme for the CHEM Study chemistry course. (17). The foundation of the course is built upon the atomic theory, the nature of matter in its various phases, and the concept of moles. Many important chemical principles are discovered in the laboratory concerning energy, rate and equilibrium of chemical reactions, chemical periodicity, and chemical bonding.

PSSC physics is built around the idea that matter and energy are conserved and that matter, time and space cannot be separated. (12). Physical models are used as an aid to explain the relationships between data. Much emphasis is given to the areas of physics which contribute to a better understanding of an atomic picture of the universe. (35).

Brown (56) points out that the new programs in mathematics all give emphasis to such unifying themes or ideas as the structure of mathematics, operations and their inverses, measurement, extensive use of graphical representation, systems of numeration, properties of numbers, the real number system, statistical inference, sets, logical deductions, and valid generalizations in mathematics.

Further Comparisons of the New Courses

The SMSG materials do not contain topics which differ too much from conventional courses, but the organization and presentation of the topics is different. While mathematical facts and skills are stressed, the Committee says equal attention is given to basic concepts and mathematical structures which give meaning to the skills and provide a logical framework for the facts. (71). The SMSG material also provides opportunity for the discovery of basic structures of mathematics.

Rosenbloom (68) suggested the following common aims of the new mathematics courses:

> I. Giving the student a coherent structure which will make it easier to learn new things and remember the old.
> II. Emphasis on reasoning, beginning rather informally in elementary and junior high school, and leading to formal proof in algebra and geometry.
> III. Presenting mathematics as a creative art, rather than as the finished product, by giving students experience in discovery.
> IV. Unifying subjects such as arithmetic, algebra, and geometry, which are traditionally taught separately.
> V. Clarifying the language of school mathematics, which is sloppy and confused in the conventional curriculum.

Brandwein (12) suggests that the new science curriculums offer several correctives:

> First, science is to be considered one of the humanities ....
> Second, the new courses make provision for true investigation with emphasis on ingenuity and imaginative work ....
> Third, the history of science and the catalogue of the products of science have given way to processes and ideas which are durable for at least a generation ....
> Fourth, the new courses have restored the laboratory to its rightful place where skills are developed and exercises are not only qualitative but quantitative as well ....
> Fifth, the new courses demand better trained teachers in the content areas ....
> Sixth, the courses are based on conceptual schemes which are not overthrown by new discoveries, but which are only altered as new relationships are discovered ....

Comparative Studies

Only one study was found which was concerned with a problem similar to the problem being treated in this study. DeRose (22) in a study which was completed in 1962, analyzed the achievement of students in CBA chemistry and PSSC physics. The students' scholastic aptitudes were measured with SCAT Form 1A, and PSSC Tests and CBA Tests were used as the criteria of achievement in the respective courses. No statistically significant difference was found in the achievement of students in PSSC physics classes who had previously completed a course in CBA chemistry and the achievement of those who had previously completed a conventional course in chemistry. On the other hand, statistically significant differences were found in two of the six schools in which students in CBA chemistry with a background in PSSC physics achieved at a higher level than those who had a background in conventional physics.

While no other studies dealt specifically with this problem, several recent studies seemed to be probing in this same area.

Meredith (50), in a study reported in 1962, found that conceptually related subject matter content is more suitable for instruction directed toward a gain in problem solving ability than the more usual topical presentation of subject matter.

Berger (3) reported that students who were taught valence in chemistry by referring to atomic structure were significantly better at formula writing and problem solving than those taught by rote memory.

Montague (53) demonstrated that students who worked open-ended experiments in chemistry laboratory solved problems in an actual laboratory experience at a significantly higher level than those who used the conventional laboratory experiments.

Suchman (83) stated that the inquiry skills of fifth grade children can be improved over a fifteen week period as a result of specific training for this purpose. He also suggests that they can develop a quite consistent strategy which they can transfer to new problem situations.

Summary

A feeling of dissatisfaction by some teachers with the science and mathematics courses which were in use in the high schools has led to widespread efforts to produce courses for accomplishing the goal of providing literacy in science and mathematics for all high school students whether they go to college or not.

During the 1950's curriculum improvement projects of nationwide scope were organized on many university campuses. The members of the course development groups included educators, scientists, publishers, high school teachers, and others who could lend their talents to the writing of new courses.

For the most part, the high school teachers who participated in the evaluation of these new courses in the classrooms received special training in the use of the new materials. Their comments and the comments of the students provided the basis for the revision and rewriting of portions of each course.

While the subject matter of the new courses in science and mathematics is seen to differ, the objectives and the philosophies of the new courses have points in common. Central themes provide the framework for each of the new courses. Student discovery of generalizations is deemed to be of paramount importance. The mastery of fundamental concepts is given equal, if not more, emphasis over the development of manipulative skills and the memorization of facts. The students are given many opportunities to develop the techniques of inquiry which form the basis for the laboratory experiments and routine daily assignments. Some skills and abilities, such as collecting facts, tabulating data, using graphical solutions, formulating models, using these models to predict future events, recognition of problem situations, mathematical treatment of problems, and inductive and deductive logic, are characteristic of almost all of the new courses.

Although many teachers feel that there is a significant relationship between these new courses in science and mathematics, little formal study has been given to the identification of these relationships, or to the measurement of growth dimensions which may be common to all.

The similarities in structure, philosophy, and emphasis have led some PSSC physics teachers and teachers of the other new courses to speculate that experience in one of the new courses should lead to higher achievement in another. This study is designed specifically to determine whether or not students who have had a course in BSCS biology, CBA chemistry, CHEM Study chemistry, or SMSG mathematics perform any more effectively in the PSSC physics course.

CHAPTER III

PROCEDURES AND PERSONNEL

In many school systems the new courses in science and mathematics are being assimilated into the curriculum by using them on an experimental basis in a limited number of classes under the supervision of a limited number of teachers. This period of conversion from the conventional courses to the new courses has been extended by the reluctance of high school mathematics and science teachers to scrap the conventional courses currently being taught. In addition, many teachers feel unprepared to teach one of the new courses without the benefits of the experience which would be gained in a special teacher training program. This limited use of the new courses during the transitional period made this study possible since students who were enrolled in PSSC physics classes could have backgrounds either in the new courses or in their conventional counterparts. A decision was made by the author to conduct this study during the academic year 1963-64 so that the PSSC physics classes could include an experimental group with experience in a new course in science or mathematics and a control group with experience in a comparable conventional course.

Although this study could have been done with only one school and one PSSC physics teacher involved, a decision was made to include several schools and several teachers to increase the dependability of the results of the study. Garrett (39, p. 207) says that the dependability of a mean is contingent upon the size of the sample upon which the standard error in the estimation of the mean is based.

The standard error of the mean is a measure of the amount by which the sample means drawn from a population diverge from a population mean. Usually the population mean is an unknown quantity and the sample mean is used as a device for estimating the population mean.

Assumptions

The following assumptions were made in the process of conducting this study:

I. That the SCAT Form 2A could be used to measure the scholastic ability of the students involved in the study, and that SCAT Form 2A could be used as a control variable in the experimental design.

II. That the PSSC Test Number Five and the PSSC Test Number Ten could measure achievement in PSSC physics in both the process dimension of science and the content dimension of science.

III. That the sample of students included in the study is a representative sample of the students who are enrolled in PSSC physics classes.

IV. That the distribution of the scholastic abilities of the students included in the sample does not deviate seriously from a normal distribution so that valid results could not be obtained. Steel and Torrie (80, p. 129) suggest that deviation from a normal deviation will result in the true level of a test of significance being greater than the apparent level of a test of significance. This will have to be considered in the tests of the data.

V. That the PSSC materials were being used in the PSSC physics classes which were included in the sample.

VI. That the underlying philosophy of PSSC physics was accepted by the PSSC physics teachers and that this philosophy permeated the instruction in each of the PSSC physics classes.

VII. That the BSCS biology materials were used in the classes for those students who reported experience in one of the three versions of BSCS biology; that the CHEM Study materials were used in the classes for those students who reported experience in CHEM Study chemistry; that the CBA chemistry materials were used in the classes for those students who reported experience in CBA chemistry; and that SMSG materials were used in the classes for those students who reported experience in SMSG mathematics.

VIII. That the underlying philosophies of each of the new courses in science and mathematics, SMSG mathematics, CHEM Study chemistry, CBA chemistry, and BSCS biology were accepted by each of the respective teachers of those classes and that the philosophy of the new courses permeated each of these classes.

IX. That because of the nature of the teaching materials used in the PSSC physics classes, much greater emphasis was given to the process dimension of science than is usually given in many conventional courses in high school physics.

X. That greater emphasis was given to the process dimension of science in those classes for those students who reported experience in CHEM Study chemistry, CBA chemistry, BSCS biology, and SMSG mathematics than was given in the comparable conventional courses in high school science and mathematics.

Design of the Study

The following general procedures were followed in the completion of the study:

I. A sample of students enrolled in PSSC physics was selected from those who had a background either in one of the new courses in science or mathematics or had a background in a conventional counterpart of one of the new courses in science and mathematics.

II. A questionnaire was administered to each of the students included in the study to determine his previous experience in science and mathematics and to collect some personal information about each student.

III. SCAT Form 2A was administered to each of the students who was included in the study to provide a measure of his scholastic ability.

IV. PSSC Test Number Five was administered to each student included in the study at the completion of Parts I and II of the PSSC text or at the end of the first semester of the academic year 1963-64.

V. PSSC Test Number Ten was administered to each student included in the study at the completion of Parts III and IV of the PSSC text or at the end of the second semester of the academic year 1963-64.

VI. The data for each student were collected and analyzed to test the hypotheses stated earlier in the study.

The students involved in the study met the following general criteria:

I. Each was enrolled in PSSC physics during the academic year 1963-64.

II. Each completed the questionnaire which furnished the personal data and the science and mathematics background of each student.

III. Each completed SCAT Form 2A to provide a measure of the scholastic aptitude for each student.

IV. Each of those included in the first semester sample completed Parts I and II of the PSSC text and related materials and each completed PSSC Test Number Five.

V. Each of those included in the second semester sample completed Parts III and IV of the PSSC text and related materials and each completed PSSC Test Number Ten.

In addition, each of the students met at least one of the following specific criteria which formed the basis for the tests of the hypotheses:

I. Each had a background either in conventional mathematics or in SMSG mathematics.

II. Each had a background either in conventional biology or in one of the three BSCS versions.

III. Each had a background either in conventional chemistry or in CBA chemistry.

IV. Each had a background either in conventional chemistry or in CHEM Study chemistry.

Control of the Variables

Variability in achievement due to differences in scholastic ability was controlled by the covariance design of the analysis of the data.

It was anticipated that there would be some qualified students in each of the groups into which the students were separated according to stated criteria. It must be recognized that a degree of selectivity was employed in the placement of students in the experimental classes in each of the new courses in science and mathematics in each of the high schools included in this study, but it was further assumed that some selectivity was also employed in assigning students to the PSSC physics classes. It was further recognized that there is a tendency to place only those students of better than average ability in the experimental classes in the new science and mathematics courses. While this may be true, the testing program for the PSSC physics course demonstrated that most of the students who enroll for physics tend to be of better than average ability. (33). Since the author had no control over which students would be placed in the PSSC classes (this was done by the school officials in each of the schools) the assumption must be made that the process of selectivity plays only a partial role in the achievement of students in the PSSC physics course.

The influence of other variables (background of the teacher, degree to which the philosophy of the new courses permeated the instruction in the classes in the new courses and the PSSC physics classes, and others) was completely uncontrollable. It must be assumed that these variables also played a negligible role in the achievement of students in PSSC physics. The replication of the experiment in several other schools will help to reduce error which may be due to these causes.

Instrumentation

Three commercially produced instruments were used in this study to determine the scholastic aptitude of the students and their achievement in PSSC physics. The tests used were SCAT Form 2A, PSSC Test Number

Five, and PSSC Test Number Ten. A short description of each of these instruments follows.

School and College Ability Test (SCAT)

All forms of SCAT are made up of four parts or subtests.(30).

Part I consists of 30 sentence completion items designed to measure developed ability in the verbal areas of school learning.

Part II consists of 25 numerical computation items designed to measure developed ability in quantitative skills.

Part III consists of 30 vocabulary items chosen to measure developed ability in the verbal areas of school learning.

Part IV consists of 25 numerical problem-solving items selected to measure developed ability in quantitative skills.

SCAT produces a Verbal Score based on 60 items in Parts I and III, and a Quantitative Score based on 50 items in Parts II and IV. These scores are combined to give the Total Raw Score. The highest possible Total Raw Score would be 110 points.

It is reported in the Technical Report for SCAT that the reliability is 0.95 for the Total Raw Score. (26). The standard error of the means was reported as 4.34 for the Total Raw Score. The 1958 SCAT-STEP Supplement shows that there was a correlation of 0.44 between the SCAT Total Score and the science grade achieved by eleventh grade college preparatory students. (27).

The SCAT raw scores which correspond to the upper and lower quartile and the median for grades eleven and twelve are shown in Table I. This information was adapted from the SCAT-STEP Supplements for 1962 and 1963. (28), (29). Since this information is based upon data obtained from students at all ability levels in high school, it is to be expected that almost all of the students included in this study would score above the median scores indicated in the table. Ferris (33) reported that almost all of the students who were enrolled in the classes used in the evaluation studies for PSSC physics scored above the general mean for all levels of ability in high school students.

TABLE I

DISTRIBUTION OF SCAT FORM 2A SCORES FOR STUDENTS IN URBAN SCHOOLS IN GRADES ELEVEN AND TWELVE AS SHOWN IN THE 1962 AND 1963 SCAT-STEP SUPPLEMENTS

Quartile	Grade 11 Raw Score (Mid-year)	Grade 12 Raw Score (Estimated Mid-Year)
Upper Quartile	79	81
Median	64-65	66
Lower Quartile	50	51-52

The School and College Ability Tests (SCAT) have been widely used in evaluation studies of the new courses in science and mathematics. SCAT Form 2B, Parts I and II were used in evaluation studies of BSCS biology. SCAT Form 1A was used in evaluation studies of SMSG mathematics, CBA chemistry, and PSSC physics. (14),(72),(33). SCAT Form 1A was used in a study comparing CBA and CHEM Study chemistry. (44).

SCAT Form 2A is administered to all juniors in two of the high schools in this study as part of the regularly scheduled testing program in these schools. These testing programs limited the form of SCAT used in this study to Form 2A although Form 2B or 1A or 1B would also have been appropriate. The answer sheets completed by the students in these two schools are machine scored, and the results were obtained for this study from the master copies of the scores which were returned to the schools. This procedure involved Schools A and B.

In the other five schools which participated in the study, SCAT Form 2A was administered in one of two ways; (a) by the classroom teacher to each of the PSSC classes separately; (b) by counselors or other personnel to a single group consisting of all students enrolled in PSSC physics in that school. The answer sheets from these five schools were scored by hand and the results were returned to the schools. Instruction manuals were furnished with the tests and it must be assumed that the specific directions given in the manual were followed in the administration of the test.

In six of the schools, SCAT Form 2A was administered near the middle of the first semester. In the seventh school (School G) the test was not given until early in the second semester of the school year. Reference to Table I will show that little error will be introduced into the measurements of scholastic ability by this difference in the test dates. Since no comparisons were to be made between schools no difficulty was anticipated because of this deviation from the planned procedure.

Physical Science Study Committee Tests

A series of ten tests were constructed by the Physical Science Study Committee in cooperation with Educational Testing Service. These tests were specifically designed to be used as achievement tests over the material in the PSSC physics course. Test Number Five is a comprehensive test over Parts I and II of the PSSC physics course and Test Number Ten is a comprehensive test over Parts III and IV of the PSSC physics course. Tests One through Four and Six through Nine are designed to be used as achievement tests over smaller segments of the PSSC physics course.

PSSC Tests Five and Ten were used in this study to measure achievement in PSSC physics.

Each PSSC test consists of 35 multiple choice items based upon problems which require the application of principles rather than memory of facts and formulas from the PSSC text.

Ferris (34) explained the rationale behind the construction of the PSSC physics tests in an article prepared for publication in Physics Today. He states that each test question should require the application of substantive knowledge in one of the factors of the process dimension in PSSC physics. The list of factors which he considered to be important were included in Chapter I of this report. In the same article Ferris illustrated the theoretical construction of a PSSC test by showing a grid of these factors which formed the basis for the construction of the PSSC tests.

The percentile equivalents of the raw scores obtained for PSSC Tests Five and Ten are shown in Table II. The maximum possible raw score on each test is 35 points.

TABLE II

ESTIMATED PERCENTILE EQUIVALENTS OF RAW SCORES ON PSSC TESTS FIVE AND TEN

Estimated Percentile Equivalent	Raw Score PSSC Test Five	Raw Score PSSC Test Ten
90	24	24.5
75	21	21
50	17.5	18
25	14	15
Estimated Standard Deviation	5.0	5.0

In this study, the PSSC tests were administered by the classroom teachers in each of the classes involved in the study. Each teacher was supplied with a manual of instructions and it must be assumed that the directions for the administration of the tests were followed. PSSC Test Number Five was given at the end of the first semester of the academic year in six of the schools. However in School B, this test was not given until the middle of the second semester. This deviation from the planned procedure was brought about by a change in the sequence in which the PSSC text was used. The usual procedure is to follow a consecutive sequence of Parts I, II, III, and IV. This sequence was altered in School B to Part I followed by Part III, then Part II, and finally Part IV. In order to obtain data from these classes it became necessary to delay the administration of the test by a half-semester. Since no comparisons were contemplated between schools, the assumption was made that this data could be used to test the hypotheses stated for this study.

Presentation of the Data

The raw data collected for each student involved in the study are presented in Appendix C. This data were collected by means of the questionnaire, SCAT Form 2A, and PSSC Tests Five and Ten. Information has been assembled for all students for whom a complete set of data could be collected. For various reasons some students in the PSSC classes could not be included in the study; incomplete data, previous education in a foreign country, and others.

The sex, age, and grade distribution of the PSSC physics students included in the study is summarized in Tables III and IV.

TABLE III

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR FIRST SEMESTER OF STUDY

School	A	B	C	D	E	F	G	Total
Sex								
Male	146	26	49	42	79	64	38	444
Female	34	8	13	8	11	14	8	96
Age								
15	1	-	-	-	-	-	-	1
16	75	13	5	3	11	13	3	123
17	99	17	35	21	52	45	22	291
18	5	4	22	25	26	19	20	121
19	-	-	-	1	1	1	1	4
Grade								
10	-	-	1	-	-	-	-	1
11	180	27	14	2	28	35	7	293
12	-	7	47	48	62	43	39	246
Totals	180	34	62	50	90	78	46	540

The first semester information is summarized in Table III and the second semester information is summarized in Table IV. There are some differences in the numbers of students in some categories since some of the students who were in the PSSC physics classes during the first semester did not complete the second semester.

In Tables III and IV, the age for each student was computed to the nearest year as of January 1, 1964.

When comparisons are made between schools, some variability is noted in the ages of the students. The median age in every school but

TABLE IV

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR SECOND SEMESTER OF STUDY

School	A	B	C	D	E	F	G	Total
Sex								
Male	145	26	47	37	77	64	33	429
Female	32	8	11	8	10	13	7	89
Age								
15	1	-	-	-	-	-	-	1
16	74	13	4	3	11	12	3	120
17	97	17	33	19	50	45	19	280
18	5	4	21	22	26	19	17	114
19	-	-	-	1	-	1	1	3
Grade								
10	-	-	1	-	-	-	-	1
11	177	27	13	2	28	34	6	287
12	-	7	44	43	59	43	34	230
Totals	177	34	58	45	87	77	40	518

one is seen to be 17. Reference to the tables will show that the school programs vary somewhat in the grade level at which physics is offered.

Juniors and seniors are permitted to enroll in PSSC physics in all seven schools. This is not revealed by the tables in the case of School A. This may be explained by a situation which is peculiar to Schools A and B. In Schools A and B, SCAT Form 2A is administered to all junior students each year as part of a regularly scheduled testing program. Thus any seniors who were enrolled in the PSSC physics classes in Schools A or B could have taken the test in the fall of 1962 rather than in the fall of 1963. Since the senior students in the PSSC classes in

School A represented only a small fraction of the total students in the PSSC physics classes in that school, a decision was made to eliminate these students from the study. This decision was made because the SCAT scores were not current scores obtained in the fall of 1963.

However, in School B, since fewer classes and fewer students were involved, elimination of the senior students' data would have resulted in the complete elimination of this school from the study. Therefore, a decision was made to retain the senior student data for seven students who had backgrounds in the new courses in science and mathematics. This means that any decisions which are based on the data from School B will be slightly biased. Reference to Table II will show that this may be rather insignificant since the median score for seniors on SCAT Form 2A is only slightly higher that the median score for juniors. It was concluded that the error introduced by including these seven students in the study was probably very small.

Two teachers were assigned to teach the PSSC physics classes in School A while there was only one teacher assigned to teach the PSSC physics classes in each of the other schools included in the study. The backgrounds of the two PSSC physics teachers in School A are very similar; both have taught conventional physics for a number of years, both have had special preparation in the use of the PSSC materials, and both have had some experience in using the PSSC materials in the classroom. Because of the similarity in the background of the two PSSC physics teachers in School A, data from all classes in School A were combined and treated as a single unit of data.

The science and mathematics backgrounds of the students included in the study are summarized in Tables V and VI. This information was

TABLE V

SUMMARY OF SCIENCE BACKGROUNDS FOR ALL STUDENTS
FOR BOTH SEMESTERS OF THE STUDY

Science Background in Years Conv.	New	Semester	School A	B	C	D	E	F	G	Total
Biol.	None	1st	115	5	4	1	7	6	8	146
		2nd	112	5	3	1	6	6	8	141
None	BSCS	1st	4	1	1	1	-	-	-	7
		2nd	4	1	-	1	-	-	-	6
Chem.	None	1st	-	2	8	9	26	1	1	47
		2nd	-	2	8	8	26	1	-	45
None	CHEMS	1st	-	-	1	-	-	-	6	7
		2nd	-	-	1	-	-	-	5	6
None	CBA	1st	-	-	-	-	5	-	-	5
		2nd	-	-	-	-	5	-	-	5
Biol. & Chem.	None	1st	52	20	30	28	42	53	6	231
		2nd	52	20	29	24	40	52	6	223
Biol.	CHEM	1st	-	-	12	-	1	-	20	33
		2nd	-	-	11	-	1	-	16	28
Biol.	CBA	1st	-	3	-	-	6	18	-	27
		2nd	-	3	-	-	6	18	-	27
Chem.	BSCS	1st	8	2	2	11	1	-	-	24
		2nd	8	2	2	11	1	-	-	24
None	BSCS & CHEM	1st	-	-	2	-	-	-	-	2
		2nd	-	-	2	-	-	-	-	2
None	None	1st	1	1	2	-	2	-	5	11
		2nd	1	1	2	-	2	-	5	11
Totals		1st	180	34	62	50	90	78	46	540
		2nd	177	34	58	45	87	77	40	518

TABLE VI

SUMMARY OF MATHEMATICS BACKGROUNDS FOR ALL STUDENTS
FOR BOTH SEMESTERS OF THE STUDY

Mathematics Background in Semesters Conv.	SMSG	Semester	School A	B	C	D	E	F	G	Total
3-4	None	1st	-	1	2	-	1	1	-	5
		2nd	-	1	2	-	1	1	-	5
5-6	None	1st	93	21	27	5	2	5	-	153
		2nd	91	21	25	5	1	5	-	148
7-8	None	1st	-	-	33	21	3	3	1	61
		2nd	-	-	31	18	3	3	1	56
1-2	1-2	1st	-	-	-	-	-	1	1	2
		2nd	-	-	-	-	-	1	-	1
3-4	1-2	1st	86	11	-	5	7	11	5	125
		2nd	85	11	-	5	7	10	5	123
5-6	1-2	1st	-	1	-	14	7	8	7	37
		2nd	-	1	-	12	7	8	4	32
7-8	1-2	1st	-	-	-	1	-	-	-	1
		2nd	-	-	-	1	-	-	-	1
None	3-4	1st	-	-	-	-	-	1	-	1
		2nd	-	-	-	-	-	1	-	1
1-2	3-4	1st	1	-	-	-	10	24	2	37
		2nd	1	-	-	-	10	24	2	37
3-4	3-4	1st	-	-	-	4	11	22	13	50
		2nd	-	-	-	4	11	22	13	50
5-6	3-4	1st	-	-	-	-	-	1	-	1
		2nd	-	-	-	-	-	1	-	1
None	5-6	1st	-	-	-	-	13	-	3	16
		2nd	-	-	-	-	13	-	3	16
1-2	5-6	1st	-	-	-	-	31	1	14	46
		2nd	-	-	-	-	29	1	12	42
None	7-8	1st	-	-	-	-	5	-	-	5
		2nd	-	-	-	-	5	-	-	5

gathered by means of the questionnaire which each student completed. The numbers appearing in the body of each table show the number of students in each school during each semester with the specific background in science or in mathematics indicated in the margins of the tables.

The science backgrounds of the students are summarized in Table V. Approximately two of every five students in the study had a background in either biology or chemistry and approximately three of every five students had a background in biology and chemistry. Some of the students had a background in conventional science courses; others in new science courses; and others in a combination of new and conventional science courses. Only two students reported a background in more than one of the new science courses. Eleven students reported that they had neither biology nor chemistry before enrolling in PSSC physics. Many students had backgrounds in other courses in science. These courses included physical science, radio, electricity and others. Since these courses do not play a part in testing the hypotheses stated for this study, student experience in these courses was not included in the summary in Table V. The variety of experience in science courses provided the basis for testing the hypotheses stated for this study.

The mathematics backgrounds of the students are summarized in Table VI. These backgrounds are indicated by semesters rather than by years since many students were enrolled in mathematics courses as well as PSSC physics. Current enrollment in mathematics courses, as well as completion of mathematics courses, was counted as experience in mathematics in the determination of the mathematics backgrounds of the students.

Most of the students in the PSSC classes in this study had completed or were enrolled in their third or fourth year of mathematics. Some of these students had no SMSG mathematics; some had no conventional mathematics; and many had a combination of conventional courses and SMSG courses. This variety of experiences provides the basis for testing the hypotheses stated for this study.

The student data were separated into various categories in order to compare the achievement of students in PSSC physics who had backgrounds either in a conventional course in science or in a comparable new course in science. The achievement of students who reported a background in BSCS biology was compared with the achievement of students who reported a background in conventional biology. Similarly, the achievement of students who reported a background in CHEM Study chemistry was compared with the achievement of students who reported a background in conventional chemistry. In the same manner, the achievement of students who reported a background in CBA chemistry was compared with the achievement of students who reported a background in conventional chemistry. Note that some student data appeared in several categories, i.e., those who reported a background in conventional biology as well as conventional chemistry. These data were used to compare the achievement of students who reported experience in biology as well as those who reported experience in chemistry.

In the same fashion, the student data for those who reported experience in SMSG mathematics were separated from those who reported no experience in SMSG mathematics. The achievement in PSSC physics of these two groups was compared.

In another comparison, the student data were separated according to the amount of SMSG mathematics reported, i.e., one to two semesters, three to four semesters, five to six semesters, and seven to eight semesters. These groups were compared in achievement in PSSC physics.

Further explanation of the details of the separation of the student data into various categories will be found in Chapter IV of this report.

Analysis of the Data

The selection of the design for the analysis of the data to evaluate the results of the mathematics and science experience upon achievement in PSSC physics was based upon the existing structure of the PSSC classes in the seven schools involved in the study. The author had no control over the assignment of the students to the various classes. This assigning was done by the school officials in the various schools. It must be assumed that the students in each school who desired to enroll in PSSC physics during the academic year 1963-64 were assigned more or less at random to the several classes in each school. If the assignments were made at random, then the backgrounds of the students in these classes should reflect considerable variation in previous experience in science and mathematics as well as variation in scholastic aptitude.

An examination of the data revealed that such a situation did exist within the PSSC classes in each school. Not only were there considerable differences in the number of students in each class who reported various categories of experience, but there were differences in the academic and scholastic abilities of the students in each group as shown by the SCAT scores. To remove some of the inequality of numbers included in each of the various categories of experience, the student data for all PSSC physics classes in each school were combined into a single school sample.

Further examination of the data revealed that there were considerable differences in the number of students included in each school who had backgrounds in one of the new courses as opposed to those who had backgrounds in conventional courses in the same subject. Since this classification was to be used to provide the basis for the testing of the hypotheses in this study, this imposed the restriction of sub-groups to be compared which were not of equal number. Further, when the scholastic abilities of the students in these sub-groups were compared, it could be shown that there were significant differences in the abilities as measured by SCAT Form 2A.

As a result of these limitations, sub-groups with unequal numbers and sub-groups with scholastic abilities which differed significantly, a decision was made to use the method of analysis of covariance with a single classification to compare the achievements in PSSC physics. Garrett (39, p. 295) says that analysis of covariance is the appropriate method to use in the analysis of data when it is impossible to equate control and experimental groups at the start of an experiment.

The design chosen for the analysis of the data is a completely randomized design. This design was chosen because no comparisons were planned between schools; the basic comparisons were to be made within schools, and within schools pooled into single groups.

In this study the SCAT score is the independent variable. This score is used as a control variable in the comparisons. The PSSC test score is the dependent variable or the criterion in this study.

In order to provide more than one comparison of achievement in PSSC physics in each category of classification, the scores made on PSSC Test Number Five are used as one criterion, the scores made on PSSC Test Number Ten as another criterion, and the sum of the scores on PSSC Tests Number Five and Ten as a third criterion. This will provide a comparison of achievement in PSSC physics for the first semester, the second semester, and the entire year.

The use of the method of analysis of covariance necessitates certain assumptions. Steele and Torrie (80, p. 309) say that three assumptions are necessary for a valid use of analysis of covariance: (a) the independent variable is fixed and associated with the means of the sampled dependent variable populations, (b) the regression of the dependent variable on the independent variable is linear and, (c) the residuals are normally and independently distributed with zero mean and a common variance.

The analysis of the data and the results of the tests of the hypotheses follow in Chapter IV.

Summary

The data for this study were collected during the transition period when schools were in the process of introducing the new courses in science and in mathematics into the high school curriculum. Since PSSC physics was among the first of the new courses to be produced and tested in the schools, there were PSSC physics classes in many high schools in which students had backgrounds either in conventional courses in science and mathematics or in newly developed courses in science and mathematics. This situation in which students had variable backgrounds provided the opportunity to conduct a study to determine the relationships which exist between previous experience in science and mathematics and achievement in PSSC physics.

Personal data for each student was collected by means of the questionnaire which was completed by each student.

SCAT Form 2A was used as a measure of scholastic aptitude of each student and as a control factor in the covariance design.

PSSC Tests Five and Ten were used to measure student achievement in PSSC physics. These tests are comprehensive examinations over the PSSC text.

Comparisons in achievement in PSSC physics were made between those students with and without experience in one of the new courses in science and mathematics. The results of these comparisons are given in Chapter IV.

Since the groups to be compared in achievement in PSSC physics differed in scholastic ability, analysis of covariance was considered to be the appropriate method to employ to make the comparisons. Three separate tests of the hypotheses were employed: a comparison of achievement at the end of the first semester, a comparison of achievement at the end of the second semester, and a comparison of achievement for the entire year.

CHAPTER IV

ANALYSIS OF THE DATA AND RESULTS OF THE STUDY

In this chapter an analysis of the data collected in the study will be presented and the results of the tests of the hypotheses will be stated.

The statistical data will be summarized in a series of tables and a short explanation will be given for each table. The raw data collected for each student included in the study appear in Appendix C.

In order to test each of the hypotheses stated for this study, the student data were separated into five different categories. This division of the data was based upon experience in conventional science and mathematics courses or in new science and mathematics courses as reported by the students.

Accordingly, the student data were separated into five opposing categories. Those who reported experience in conventional biology or in BSCS biology were separated from those who reported no experience in biology. Those who reported experience in conventional chemistry or in CHEM Study chemistry were separated from those who reported no experience in chemistry. Those who reported experience in conventional chemistry or in CBA chemistry were separated from those who reported no experience in chemistry. Those who reported experience in SMSG mathematics were separated from those who reported no experience in SMSG mathematics. In addition, those who reported experience in SMSG mathematics were separated according to the number of semesters of SMSG mathematics experience reported.

By using these five classifications of the student data, five different comparisons of achievement in PSSC physics were made based upon the background experience of the students.

The achievement in PSSC physics of students with a background in conventional biology was compared with the achievement of students with a background in BSCS biology.

The achievement in PSSC physics of students with a background in conventional chemistry was compared with the achievement of students with a background in CHEM Study chemistry.

The achievement in PSSC physics of students with a background in conventional chemistry was compared with the achievement of students with a background in CBA chemistry.

The achievement in PSSC physics of students with a background in conventional mathematics was compared with the achievement of students with a background in SMSG mathematics.

Likewise, achievement in PSSC physics of students with varying backgrounds in SMSG mathematics was compared to see if differences existed.

In the pages which follow, the comparisons in achievement in PSSC physics between the various groups and the results of the comparisons will be presented.

The SMSG Sample

In six of the high schools included in the study, there were students in the PSSC physics classes who had backgrounds in conventional and SMSG mathematics. The data collected from these six schools have been designated the SMSG Sample and the individual school data have been designated A-SMSG, B-SMSG, etc. The first letter of the designation refers to the school from which the data were collected.

In these comparisons, the achievement of students with no experience in SMSG mathematics was compared with the achievement of students with varying levels of experience in SMSG. The data were divided into two groups in each school, students with experience in conventional mathematics only versus students with a specified amount of experience in SMSG mathematics.

The sex, age, and grade classifications for each of these groups in each of the schools included in this sample are summarized in Table VII. Although the same classes were included in both the first and second semesters of the study, the second semester groups were slightly smaller because some students did not complete both semesters of the PSSC course.

The mean and the standard deviation for the SCAT scores, the PSSC Test Number Five scores, the PSSC Test Number Ten scores, and the Total PSSC score are given in Table VIII. This information is given for each school, for each of the groups included in this sample, and for the first and second semesters of the study. In addition, the six school samples were pooled into a large sample. The mean and the standard deviation are shown for each test involving this SMSG sample.

The mean SCAT scores for those students with a background in SMSG mathematics exceeded the mean SCAT scores for those students with a background in conventional mathematics in four of the six schools.

TABLE VII

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR SMSG SAMPLE

School Sample	Back-ground	Sex M	Sex F	Age 15	Age 16	Age 17	Age 18	Age 19	Grade 10	Grade 11	Grade 12	Total
A-SMSG												
1st Sem.	Conv.	75	18	1	44	45	3	-	-	93	-	93
	SMSG	71	16	-	31	54	2	-	-	87	-	87
2nd Sem.	Conv.	75	16	1	44	43	3	-	-	91	-	91
	SMSG	70	16	-	30	54	2	-	-	86	-	86
B-SMSG												
1st Sem.	Conv.	18	4	-	12	10	-	-	-	22	-	22
	SMSG	8	4	-	1	7	4	-	-	5	7	12
2nd Sem.	Conv.	18	4	-	12	10	-	-	-	22	-	22
	SMSG	8	4	-	1	7	4	-	-	5	7	12
D-SMSG												
1st Sem.	Conv.	23	3	-	1	12	12	1	-	1	25	26
	SMSG	19	5	-	2	9	13	-	-	1	23	24
2nd Sem.	Conv.	20	3	-	1	12	9	1	-	1	22	23
	SMSG	17	5	-	2	7	13	-	-	1	21	22
E-SMSG												
1st Sem.	Conv.	6	-	-	-	4	1	1	-	-	6	6
	SMSG	73	11	-	11	48	25	-	-	28	56	84
2nd Sem.	Conv.	5	-	-	-	4	1	-	-	-	5	5
	SMSG	72	10	-	11	46	25	-	-	28	54	82
F-SMSG												
1st Sem.	Conv.	7	2	-	1	8	-	-	-	3	6	9
	SMSG	57	12	-	12	37	19	1	-	32	37	69
2nd Sem.	Conv.	7	2	-	1	8	-	-	-	3	6	9
	SMSG	57	11	-	11	37	19	1	-	31	37	68
G-SMSG												
1st Sem.	Conv.	-	1	-	-	1	-	-	-	-	1	1
	SMSG	38	7	-	3	21	20	1	-	7	38	45
2nd Sem.	Conv.	-	1	-	-	1	-	-	-	-	1	1
	SMSG	33	6	-	3	18	17	1	-	6	33	39
TOTAL												
1st Sem.	Conv.	129	28	1	58	80	16	2	-	119	38	157
	SMSG	266	55	-	60	176	83	2	-	160	161	321
2nd Sem.	Conv.	125	26	1	58	78	13	1	-	117	34	151
	SMSG	257	52	-	58	169	80	2	-	157	152	309

TABLE VIII

MEAN AND STANDARD DEVIATION OF TEST SCORES FOR SMSG SAMPLE

School Sample	Back-ground	No. Stud.	Mean SCAT	S.D. SCAT	Mean PSSC 5	S.D. PSSC 5	Mean PSSC 10	S.D. PSSC 10	Mean PSSC Tot.	S.D. PSSC Tot.
A-SMSG										
1st Sem.	Conv.	93	77.72	12.02	12.41	3.85				
	SMSG	87	87.28	12.27	14.89	4.20				
2nd Sem.	Conv.	91	77.87	12.00			11.02	3.22	23.48	5.95
	SMSG	86	87.16	12.29			12.71	3.37	27.61	6.27
B-SMSG										
1st Sem.	Conv.	22	93.09	8.14	19.82	5.90				
	SMSG	12	91.42	12.77	19.58	3.84				
2nd Sem.	Conv.	22	93.09	8.14			18.91	5.47	38.73	10.29
	SMSG	12	91.42	12.77			17.58	4.15	37.17	6.56
D-SMSG										
1st Sem.	Conv.	26	92.00	9.02	17.54	3.78				
	SMSG	24	100.17	6.43	21.75	4.87				
2nd Sem.	Conv.	23	93.26	8.18			15.13	3.78	33.70	6.39
	SMSG	22	100.91	6.13			15.95	3.45	36.43	7.87
E-SMSG										
1st Sem.	Conv.	6	78.50	16.21	14.50	6.66				
	SMSG	84	93.23	9.93	19.07	4.48				
2nd Sem.	Conv.	5	79.80	17.77			13.40	4.83	29.00	10.94
	SMSG	82	93.07	10.00			16.40	4.30	35.38	7.73
F-SMSG										
1st Sem.	Conv.	9	76.89	16.38	15.56	4.42				
	SMSG	69	92.83	10.33	18.23	3.73				
2nd Sem.	Conv.	9	76.89	16.38			12.56	3.78	28.11	7.20
	SMSG	68	92.69	10.35			12.46	3.72	30.82	6.55
G-SMSG										
1st Sem.	Conv.	1	104.00	-	12.00	-				
	SMSG	45	95.47	10.84	16.76	5.55				
2nd Sem.	Conv.	1	104.00	-			15.00	-	27.00	-
	SMSG	39	94.59	11.27			16.51	4.25	33.46	9.15
TOTAL										
1st Sem.	Conv.	157	82.39	13.38	14.56	5.24				
	SMSG	321	92.29	11.38	17.65	4.84				
2nd Sem.	Conv.	151	82.61	13.45			12.99	4.69	27.67	8.91
	SMSG	309	92.03	11.41			14.53	4.35	32.23	8.07

The mean score on PSSC Test Number Five was greater for those students with a background in SMSG than for those students with a background in conventional mathematics in five of the six schools.

The mean score on PSSC Test Number Ten was greater for those students with a background in SMSG than for those students with a background in conventional mathematics in four of the six schools.

The mean score for the total of PSSC Tests Number Five and Ten was greater for those students with a background in SMSG than for those students with a background in conventional mathematics in five of the six schools.

In the SMSG sample considered as a whole the students with a background in SMSG scored higher than did those with a background in conventional mathematics as measured by SCAT scores, PSSC Test Number Five scores, PSSC Test Number Ten scores, and the total PSSC score.

The method of analysis of covariance was used to treat the data from each of Schools A, B, and D, separately. The data from Schools E, F, and G were not treated separately because the number of students with no experience in SMSG was considered to be too small to give reasonably valid results.

In the comparisons of achievement in PSSC physics for the first semester, SCAT Form 2A functioned as the control variable, and PSSC Test Number Five was used as the criterion of achievement.

In the comparisons of achievement in PSSC physics for the second semester, SCAT Form 2A functioned as the control variable, and PSSC Test Number Ten was used as the criterion of achievement.

In the comparisons of achievement in PSSC physics for the whole year, SCAT Form 2A functioned as the control variable, and the sum of PSSC Tests Five and Ten was used as the criterion of achievement.

The analysis of covariance of the test data in School Sample A-SMSG for the first semester, the second semester, and the whole year is shown in Table IX. One analysis revealed a significant difference in achievement in PSSC physics between students with a background in SMSG mathematics and students with a background in conventional mathematics.

The F-value for the first semester analysis approached significance at the 0.05 level. The computed F was 3.855 for 1 and 177 degrees of freedom. The tabulated F at the 0.05 level of confidence is 3.90 for 1 and 177 degrees of freedom.

The F-value for the total year data exceeded the tabulated F for the 0.05 level of significance. The computed F was 5.031 for 1 and 174 degrees of freedom. The tabulated F is 3.90 for 1 and 174 degrees of freedom. This indicated a significant difference in achievement.

The analysis of covariance of the test data in School Samples B-SMSG and D-SMSG for the first semester, the second semester, and the whole year is shown in Tables X and XI. Each analysis showed no significant difference in achievement between the two groups.

Although there is some evidence to the contrary presented by the analysis of the data in School A, the hypothesis that there is no difference in achievement in PSSC physics between students with a background in SMSG mathematics and students with a background in conventional mathematics was not rejected by these analyses.

Further tests of the hypothesis were provided by pooling the data from all six schools in the SMSG Sample. The method of analysis of covariance was applied to the pooled data. These data were treated as a single large sample. The analysis of covariance of the student data

TABLE IX

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE A-SMSG

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	4104.13	1059.06	273.28	-	-	-
Within Groups	178	26518.11	3613.66	2911.50	2419.06	177	13.67
Total	179	30622.24	4672.72	3184.78	2471.76	178	-
Difference for testing adjusted means					52.70	1	52.70

F = 3.855   F at 0.05 level = 3.90   DF 1/177

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	3819.73	693.43	125.88	-	-	-
Within Groups	175	26168.15	2191.33	1919.69	1736.19	174	9.98
Total	176	29987.88	2884.76	2045.57	1768.06	175	-
Difference for testing adjusted means					31.87	1	31.87

F = 3.193   F at 0.05 level = 3.90   DF 1/174

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	3819.73	1693.61	750.92	-	-	-
Within Groups	175	26168.15	6042.36	6599.29	5204.08	174	29.91
Total	176	29987.88	7735.97	7350.21	5354.56	175	-
Difference for testing adjusted means					150.48	1	150.48

F = 5.031*   F at 0.05 level = 3.90   DF 1/174
F at 0.01 level = 6.79

Note: Differences significant at $.01 < P < .05$ are indicated with an asterisk.

TABLE X

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE B-SMSG

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	21.76	3.06	0.43	-	-	-
Within Groups	32	3182.74	814.44	896.19	687.79	31	22.19
Total	33	3204.50	817.50	896.62	688.07	32	-
Difference for testing adjusted means					0.28	1	0.28

F = 0.013 F at 0.05 level = 4.16 DF 1/31

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	21.76	17.24	13.64	-	-	-
Within Groups	32	3182.74	918.26	816.74	551.81	31	17.80
Total	33	3204.50	935.50	830.38	557.28	32	-
Difference for testing adjusted means					5.47	1	5.47

F = 0.307 F at 0.05 level = 4.16 DF 1/31

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	21.76	20.28	18.91	-	-	-
Within Groups	32	3182.74	2032.72	2694.03	1395.79	31	45.03
Total	33	3204.50	2053.00	2712.94	1397.66	32	-
Difference for testing adjusted means					1.87	1	1.87

F = 0.042 F at 0.05 level = 4.16 DF 1/31

TABLE XI

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE D-SMSG

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	832.35	429.24	221.36	-	-	-
Within Groups	48	2987.33	853.00	1084.96	841.40	47	17.90
Total	49	3819.68	1282.24	1306.32	875.55	48	-
Difference for testing adjusted means					34.15	1	34.15

F = 1.908 F at 0.05 level = 4.05 DF 1/47

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	657.75	70.87	7.64	-	-	-
Within Groups	43	2276.25	251.13	565.56	537.85	42	12.81
Total	44	2934.00	322.00	573.20	537.86	43	-
Difference for testing adjusted means					0.01	1	0.01

F = 0.001 F at 0.05 level = 4.07 DF 1/42

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	657.75	377.98	217.22	-	-	-
Within Groups	43	2271.25	764.02	2198.69	1942.23	42	46.24
Total	44	2934.00	1142.00	2415.91	1971.41	43	-
Difference for testing adjusted means					29.18	1	29.18

F = 0.631 F at 0.05 level = 4.07 DF 1/42

TABLE XII

ANALYSIS OF COVARIANCE OF DATA IN SMSG SAMPLE

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	10342.47	3227.31	1007.06	-	-	-
Within Groups	476	69645.78	15116.61	11927.60	8646.54	475	18.20
Total	477	79988.25	18343.92	12934.66	8727.80	476	-
Difference for testing adjusted means					81.26	1	81.26

F = 4.465* — F at 0.05 level = 3.86 — DF 1/475
F at 0.01 level = 6.70

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	9000.49	1472.02	240.74	-	-	-
Within Groups	458	67496.69	16709.80	9173.89	5037.13	457	11.02
Total	459	76497.18	18181.82	9414.63	5093.18	458	-
Difference for testing adjusted means					56.05	1	56.05

F = 5.086* — F at 0.05 level = 3.86 — DF 1/457
F at 0.01 level = 6.70

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	9000.49	4291.34	2046.07	-	-	-
Within Groups	458	67496.69	26402.67	32464.15	22136.22	457	48.44
Total	459	76497.18	30694.01	34510.22	22194.44	458	-
Difference for testing adjusted means					58.22	1	58.22

F = 1.202 — F at 0.05 level = 3.86 — DF 1/457

Note: Differences significant at $.01 < P < .05$ are indicated with an asterisk.

from the six schools in the SMSG Sample for the first semester, the second semester, and the entire year is shown in Table X.

The computed F-value for the first semester data was 4.465 for 1 and 475 degrees of freedom. This exceeded the tabulated value for F at the 0.05 level of confidence. A significant difference is indicated.

The computed F-value for the second semester data was 5.086 for 1 and 457 degrees of freedom. This exceeded the tabulated F-value at the 0.05 level of confidence. A significant difference is indicated.

The computed F-value for the data covering both semesters was less than the tabulated F at the 0.05 level of confidence.

The hypothesis that there is no difference in achievement in PSSC physics between the two groups in the six schools in the SMSG Sample is rejected by the analysis of the first semester data and the second semester data. The hypothesis could not be rejected by the analysis of the data for the entire year.

Although the analysis of the pooled data in the SMSG Sample did not confirm that students with a background in SMSG mathematics showed a higher level of achievement in PSSC physics than students with a background in conventional mathematics, adjusted mean scores were calculated for each of these groups. The adjusted mean scores for the SMSG Sample for PSSC Test Number Five, PSSC Test Number Ten, and the total PSSC score are shown in Table XIII. These scores were calculated by using the general formula presented by Garrett. (39, p. 302).

$$M_{Y.X} = M_Y - b(M_X - GM_X)$$

$M_{Y.X}$ is the adjusted mean PSSC score for group

M_Y is the mean of the PSSC scores for group b is the within groups regression

M_X is the mean of the SCAT scores for the group

GM_x is the general mean of the SCAT scores for both groups

TABLE XIII

ADJUSTED MEAN CRITERION TEST SCORES FROM
POOLED DATA FOR SMSG SAMPLE

Criterion Test	Math. Back-ground	Number of Students	Mean of SCAT Scores	Mean of PSSC Scores	Regression	Adjusted Mean Scores
PSSC Test Five	Conv.	157	82.39	14.56	0.286	16.46
	SMSG	321	92.29	17.65	0.286	16.72
PSSC Test Ten	Conv.	151	82.61	12.99	0.110	13.69
	SMSG	309	92.03	14.53	0.110	14.19
PSSC Total Score	Conv.	151	82.61	27.67	0.391	30.15
	SMSG	309	92.03	32.27	0.391	31.06

The adjusted mean score for the group with a background in SMSG mathematics is greater than the adjusted mean score for the group with a background in conventional mathematics in all three cases. Significant differences in achievement were found between the mean scores for PSSC Test Number Five and PSSC Test Number Ten but no significant difference was found between the mean scores for the total PSSC score.

The CHEMS Sample, the CBA Sample, and the BSCS Sample

In three of the high schools there were students in the PSSC physics classes who had backgrounds either in conventional chemistry or in CHEM Study chemistry. The data from these schools have been designated the CHEMS Sample. Individual school data from this sample have been designated C-CHEMS, E-CHEMS, and G-CHEMS.

TABLE XIV

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR CHEMS SAMPLE

School Sample	Back-ground	Sex M	Sex F	Age 15	Age 16	Age 17	Age 18	Age 19	Grade 10	Grade 11	Grade 12	Total
C-CHEMS												
1st Sem.	Chem.	32	8	-	3	18	19	-	1	6	33	40
	CHEMS	12	3	-	1	11	3	-	-	7	8	15
2nd Sem.	Chem.	32	7	-	3	18	18	-	1	6	32	39
	CHEMS	11	3	-	-	11	3	-	-	6	8	14
E-CHEMS												
1st Sem.	Chem.	58	11	-	10	39	20	-	-	23	46	69
	CHEMS	1	-	-	-	-	1	-	-	-	1	1
2nd Sem.	Chem.	57	10	-	10	37	20	-	-	23	44	67
	CHEMS	1	-	-	-	-	1	-	-	-	1	1
G-CHEMS												
1st Sem.	Chem.	6	1	-	2	1	4	-	-	1	6	7
	CHEMS	22	4	-	-	17	8	1	-	3	23	26
2nd Sem.	Chem.	5	1	-	2	1	3	-	-	1	5	6
	CHEMS	18	3	-	-	14	6	1	-	2	19	21
TOTAL												
1st Sem.	Chem.	96	20	-	15	58	43	-	1	30	85	116
	CHEMS	35	7	-	1	28	12	1	-	10	32	42
2nd Sem.	Chem.	94	18	-	15	56	41	-	1	30	81	112
	CHEMS	30	6	-	-	25	10	1	-	8	28	36

The sex, age, and grade classifications for the groups with a background in conventional chemistry or in CHEM Study chemistry are shown in Table XIV.

The mean and the standard deviation of the SCAT scores and the PSSC test scores are shown in Table XV. This information is given for each of the schools in the CHEMS Sample. The same statistics were computed for the pooled data from all three schools.

TABLE XV

MEAN AND STANDARD DEVIATION OF TEST SCORES FOR CHEMS SAMPLE

School Sample	Back-ground	No. Stud.	Mean SCAT	S.D. SCAT	Mean PSSC 5	S.D. PSSC 5	Mean PSSC 10	S.D. PSSC 10	Mean PSSC Tot.	S.D. PSSC Tot.
C-CHEMS										
1st Sem.	Chem.	40	93.13	8.55	18.50	3.99				
	CHEMS	15	95.50	9.31	19.26	4.78				
2nd Sem.	Chem.	39	93.13	8.65			15.54	3.47	34.18	5.77
	CHEMS	14	95.07	9.48			13.50	2.93	32.79	6.44
E-CHEMS										
1st Sem.	Chem.	69	93.59	10.09	19.30	4.60				
	CHEMS	1	87.00	-	16.00	-				
2nd Sem.	Chem.	67	93.42	10.19			16.31	4.57	35.51	8.18
	CHEMS	1	87.00	-			16.00	-	32.00	-
G-CHEMS										
1st Sem.	Chem.	7	99.71	7.06	17.29	3.31				
	CHEMS	26	96.69	10.33	17.88	5.92				
2nd Sem.	Chem.	6	98.33	6.63			15.83	3.19	33.83	4.16
	CHEMS	21	95.95	11.54			17.33	5.54	35.67	10.83
TOTAL										
1st Sem.	Chem.	116	93.80	9.52	18.90	4.35				
	CHEMS	42	96.05	9.86	18.33	5.40				
2nd Sem.	Chem.	112	93.58	9.58			16.02	4.16	34.95	7.40
	CHEMS	36	95.36	10.42			15.81	4.86	34.44	8.96

In three of the high schools there were students in the PSSC physics classes who had backgrounds either in conventional chemistry or in CBA chemistry. The data from these schools have been designated the CBA Sample. Individual school data have been designated B-CBA, E-CBA, and F-CBA.

The sex, age, and grade classifications for the groups with a background in conventional chemistry or in CBA chemistry are shown in Table XVI.

TABLE XVI

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR CBA SAMPLE

School Sample		Back-ground	Sex M	Sex F	Age 15	Age 16	Age 17	Age 18	Age 19	Grade 10	Grade 11	Grade 12	Total
B-CBA													
1st Sem.		Chem.	16	8	-	8	12	4	-	-	17	7	24
		CBA	3	-	-	2	1	-	-	-	3	-	3
2nd Sem.		Chem.	16	8	-	8	12	4	-	-	17	7	24
		CBA	3	-	-	2	1	-	-	-	3	-	3
E-CBA													
1st Sem.		Chem.	58	11	-	10	39	20	-	-	23	46	69
		CBA	11	-	-	-	7	4	-	-	2	9	11
2nd Sem.		Chem.	57	10	-	10	37	20	-	-	23	44	67
		CBA	11	-	-	-	7	4	-	-	2	9	11
F-CBA													
1st Sem.		Chem.	43	11	-	7	33	14	-	-	22	32	54
		CBA	16	2	-	4	10	4	-	-	10	8	18
2nd Sem.		Chem.	43	10	-	6	33	14	-	-	21	32	53
		CBA	16	2	-	4	10	4	-	-	10	8	18
TOTAL													
1st Sem.		Chem.	117	30	-	25	84	38	-	-	62	85	147
		CBA	30	2	-	6	18	8	-	-	15	17	32
2nd Sem		Chem.	116	28	-	24	82	38	-	-	61	83	144
		CBA	30	2	-	6	18	8	-	-	15	17	32

The mean and the standard deviation of the SCAT scores and the PSSC test scores for the CBA Sample are shown in Table XVII. This information is given for each of the schools in the CBA Sample. The same statistics were computed for the pooled data from all three schools in the sample.

In five of the high schools included in the study there were students in the PSSC physics classes who had backgrounds either in conventional biology or in BSCS biology. The data from these schools have been designated the BSCS Sample. Individual school data have been designated A-BSCS, B-BSCS, C-BSCS, D-BSCS, and E-BSCS.

TABLE XVII

MEAN AND STANDARD DEVIATION OF TEST SCORES FOR CBA SAMPLE

School Sample	Back-ground	No. Stud.	Mean SCAT	S.D. SCAT	Mean PSSC 5	S.D. PSSC 5	Mean PSSC 10	S.D. PSSC 10	Mean PSSC Tot.	S.D. PSSC Tot.
B-CBA										
1st Sem.	Chem.	24	91.63	10.41	19.29	5.67				
	CBA	3	101.67	4.19	24.00	3.46				
2nd Sem.	Chem.	24	91.63	10.41			18.25	4.90	37.54	9.39
	CBA	3	101.67	4.19			26.33	0.58	50.33	3.83
E-CBA										
1st Sem.	Chem.	69	93.59	10.09	19.30	4.60				
	CBA	11	88.45	13.10	18.18	4.71				
2nd Sem.	Chem.	67	93.42	10.19			16.31	4.57	35.51	8.18
	CBA	11	88.45	13.10			16.00	3.56	34.18	6.90
F-CBA										
1st Sem.	Chem.	54	91.81	9.81	17.63	3.93				
	CBA	18	91.89	16.72	19.17	3.22				
2nd Sem.	Chem.	53	91.62	9.80			12.56	3.66	30.34	6.65
	CBA	18	91.89	16.72			12.39	3.44	31.56	5.62
TOTAL										
1st Sem.	Chem.	147	92.62	10.05	18.69	4.61				
	CBA	32	91.63	14.65	19.28	3.96				
2nd Sem.	Chem.	144	92.46	10.09			15.25	4.81	33.88	8.24
	CBA	32	91.63	14.65			14.94	5.14	34.22	7.80

The sex, age, and grade classifications for the groups with a background in conventional biology or in BSCS biology in each of the schools in the BSCS Sample are shown in Table XVIII.

The mean and the standard deviation of the SCAT scores and the PSSC test scores for the BSCS Sample are shown in Table XIX. This information is given for each of the schools in the BSCS Sample. The same statistics were computed for the pooled data from the five schools in the BSCS Sample.

TABLE XVIII

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR BSCS SAMPLE

School Sample	Back-ground	Sex M	Sex F	Age 15	Age 16	Age 17	Age 18	Age 19	Grade 10	Grade 11	Grade 12	Total
A-BSCS												
1st Sem.	Biol.	136	31	1	70	91	5	-	-	167	-	167
	BSCS	9	3	-	4	8	-	-	-	12	-	12
2nd Sem.	Biol.	135	29	1	69	89	5	-	-	164	-	164
	BSCS	9	3	-	4	8	-	-	-	12	-	12
B-BSCS												
1st Sem.	Biol.	20	8	-	11	14	3	-	-	23	5	28
	BSCS	3	-	-	-	3	-	-	-	2	1	3
2nd Sem.	Biol.	20	8	-	11	14	3	-	-	23	5	28
	BSCS	3	-	-	-	3	-	-	-	2	1	3
C-BSCS												
1st Sem.	Biol.	35	11	-	4	27	15	-	1	14	31	46
	BSCS	5	-	-	-	3	2	-	-	-	5	5
2nd Sem	Biol.	34	9	-	3	26	14	-	1	13	29	43
	BSCS	4	-	-	-	2	2	-	-	-	4	4
D-BSCS												
1st Sem.	Biol.	26	3	-	-	12	16	1	-	-	29	29
	BSCS	9	3	-	-	7	5	-	-	-	12	12
2nd Sem.	Biol.	22	3	-	-	11	13	1	-	-	25	25
	BSCS	9	3	-	-	7	5	-	-	-	12	12
E-BSCS												
1st Sem.	Biol.	49	7	-	6	28	21	1	-	11	45	56
	BSCS	1	-	-	-	1	-	-	-	-	1	1
2nd Sem.	Biol.	47	6	-	6	26	21	-	-	11	42	53
	BSCS	1	-	-	-	1	-	-	-	-	1	1
TOTAL												
1st Sem.	Biol.	266	60	1	91	172	60	2	1	215	110	326
	BSCS	27	6	-	4	22	7	-	-	14	19	33
2nd Sem.	Biol.	285	55	1	89	166	56	1	1	211	101	313
	BSCS	26	6	-	4	21	7	-	-	14	18	32

TABLE XIX

MEAN AND STANDARD DEVIATION OF TEST SCORES FOR BSCS SAMPLE

School Sample	Back-ground	No. Stud.	Mean SCAT	S.D. SCAT	Mean PSSC 5	S.D. PSSC 5	Mean PSSC 10	S.D. PSSC 10	Mean PSSC Tot.	S.D. PSSC Tot.
A-BSCS										
1st Sem.	Biol.	167	81.56	12.85	13.49	4.26				
	BSCS	12	95.08	6.74	15.83	2.52				
2nd Sem.	Biol.	164	81.59	12.82			11.63	3.33	25.15	6.42
	BSCS	12	95.08	6.74			14.50	3.39	30.33	5.11
B-BSCS										
1st Sem.	Biol.	28	93.89	8.81	20.04	5.70				
	BSCS	3	94.67	3.52	22.00	1.73				
2nd Sem.	Biol.	28	93.89	8.81			19.00	5.07	38.82	9.23
	BSCS	3	94.67	3.52			19.00	3.61	41.00	5.00
C-BSCS										
1st Sem.	Biol.	47	94.06	8.64	19.17	3.85				
	BSCS	5	96.00	6.93	20.20	6.54				
2nd Sem.	Biol.	43	93.98	8.87			15.14	3.76	34.26	6.04
	BSCS	4	98.25	5.50			13.50	3.11	32.75	9.43
D-BSCS										
1st Sem.	Biol.	29	93.79	9.85	18.86	5.41				
	BSCS	12	97.33	6.44	17.92	3.29				
2nd Sem.	Biol.	25	95.16	9.00			15.92	3.08	36.00	6.58
	BSCS	12	97.33	6.44			13.17	4.00	31.08	6.55
E-BSCS										
1st Sem.	Biol.	56	93.13	10.91	18.73	5.17				
	BSCS	1	92.00	-	22.00	-				
2nd Sem.	Biol.	53	93.28	10.76			16.58	4.67	35.49	8.74
	BSCS	1	92.00	-			21.00	-	43.00	
TOTAL										
1st Sem.	Biol.	326	87.48	11.68	16.21	5.38				
	BSCS	33	95.91	6.10	18.00	3.94				
2nd Sem.	Biol.	313	87.46	12.93			13.96	4.60	30.24	8.87
	BSCS	32	96.19	6.11			14.50	3.90	32.31	6.80

The method of analysis of covariance was used to treat the data in the CHEMS Sample, the CBA Sample, and the BSCS Sample. In each analysis SCAT Form 2A was used as the control variable for the comparisons; PSSC Test Number Five was used as the criterion test of achievement in PSSC physics for the first semester; PSSC Test Number Ten was used as the criterion test of achievement in PSSC physics for the second semester; and the sum of PSSC Tests Five and Ten was used as the criterion of achievement for the entire year.

The analyses of covariance of the test data in the CHEMS Sample, the CBA Sample, and the BSCS Sample are shown in Tables XX through XXVIII. An analysis was performed on individual school data when sufficient test data were available. An analysis was made of the pooled data in each sample. Since there may be differences in the backgrounds of the students in the various schools, any conclusions which are reached by an analysis of pooled samples would need to be accepted with some caution.

Each analysis of the test data in the CHEMS Sample revealed that there was no significant difference in achievement in PSSC physics between students with a background in CHEM Study chemistry and students with a background in conventional chemistry. Therefore, the hypothesis that there is no significant difference in achievement in PSSC physics between students with a background in CHEM Study chemistry and students with a background in conventional chemistry is not rejected by the analysis of the data in the CHEMS Sample.

Each analysis of the test data in the CBA Sample revealed that there was no significant difference in achievement in PSSC physics between students with a background in CBA chemistry and students with a

TABLE XX

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE C-CHEMS

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	63.28	20.14	6.42	-	-	-
Within Groups	53	4134.11	706.37	928.93	808.26	52	15.54
Total	54	4197.39	726.51	935.35	809.60	53	-
Difference for testing adjusted means					1.34	1	1.34

$F = 0.086$ F at 0.05 level = 4.03 DF 1/52

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	38.90	-40.81	42.81	-	-	-
Within Groups	51	4089.29	41.52	581.19	580.77	50	11.62
Total	52	4128.19	0.71	624.00	624.00	51	-
Difference for testing adjusted means					43.23	1	43.23

$F = 3.72$ F at 0.05 level = 4.03 1/50

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	38.90	-29.70	20.02	-	-	-
Within Groups	51	4089.29	821.12	1968.10	1803.22	50	26.06
Total	52	4128.19	791.42	1988.12	1836.40	51	-
Difference for testing adjusted means					33.18	1	33.18

$F = 1.273$ F at 0.05 level = 4.03 DF 1/50

TABLE XXI

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE G-CHEMS

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	49.79	-9.98	1.98	-	-	-
Within Groups	31	3073.54	801.65	978.08	769.32	30	24.17
Total	32	3123.33	791.67	980.06	779.62	31	-
Difference for testing adjusted means					10.30	1	10.30

F = 0.426 F at 0.05 level = 4.17 DF 1/30

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	26.46	-16.66	10.50	-	-	-
Within Groups	25	2880.28	654.34	665.50	516.86	24	21.53
Total	26	2906.74	637.68	676.00	536.11	25	-
Difference for testing adjusted means					19.25	1	19.25

F = 0.894 F at 0.05 level = 4.26 DF 1/24

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	26.46	-20.37	15.69	-	-	-
Within Groups	25	2880.28	1509.00	2433.50	1642.92	24	68.45
Total	26	2906.74	1488.63	2449.19	1686.82	25	-
Difference for testing adjusted means					43.90	1	43.90

F = 0.641 F at 0.05 level = 4.26 DF 1/24

TABLE XXII

ANALYSIS OF COVARIANCE OF DATA IN CHEMS SAMPLE

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Σx^2	Σxy	Σy^2	$\Sigma y^2_{y.x}$	DF	Mean Square
		Sums of Squares & Products			Deviations about Regression		
Among Means	1	155.54	-39.60	10.08	-	-	-
Within Groups	156	14602.04	3171.05	3423.29	2734.65	155	17.64
Total	157	14757.58	3131.45	3433.37	2768.90	156	-
Difference for testing adjusted means					34.25	1	34.25

F = 1.942 F at 0.05 level = 3.91 DF 1/155

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Σx^2	Σxy	Σy^2	$\Sigma y^2_{y.x}$	DF	Mean Square
		Sums of Squares & Products			Deviations about Regression		
Among Means	1	86.39	-10.30	1.23	-	-	-
Within Groups	146	14153.59	2642.37	2781.60	2288.28	145	15.78
Total	147	14239.98	2632.07	2782.83	2296.33	146	-
Difference for testing adjusted means					8.05	1	8.05

F = 0.510 F at 0.05 level = 3.91 DF 1/145

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Σx^2	Σxy	Σy^2	$\Sigma y^2_{y.x}$	DF	Mean Square
		Sums of Squares & Products			Deviations about Regression		
Among Means	1	86.39	-24.80	7.11	-	-	-
Within Groups	146	14153.59	4737.14	9015.67	7430.17	145	51.24
Total	147	14239.98	4712.34	9022.78	7463.36	146	-
Difference for testing adjusted means					33.19	1	33.19

F = 0.648 F at 0.05 level = 3.91 DF 1/145

TABLE XXIII

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE E-CBA

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	250.62	54.74	11.95	-	-	-
Within Groups	78	8697.37	2240.61	1678.25	1101.03	77	14.29
Total	79	8947.99	2295.35	1690.30	1101.40	78	-
Difference for testing adjusted means					0.37	1	0.37

F = 0.026 F at 0.05 level = 3.90 DF 1/77

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	232.76	14.70	0.93	-	-	-
Within Groups	76	8625.03	2180.22	1522.42	971.31	75	12.95
Total	77	8857.79	2194.92	1523.35	979.46	76	-
Difference for testing adjusted means					8.15	1	8.15

F = 0.627 F at 0.05 level = 3.90 DF 1/75

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	232.76	62.08	16.58	-	-	-
Within Groups	76	8625.03	4371.97	4962.41	2746.29	75	35.21
Total	77	8857.79	4434.05	4978.99	2759.39	76	-
Difference for testing adjusted means					13.10	1	13.10

F = 0.372 F at 0.05 level = 3.90 DF 1/75

TABLE XXIV

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE F-CBA

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	0.07	1.54	31.30	-	-	-
Within Groups	70	9953.93	1542.63	1013.69	774.62	69	11.50
Total	71	9954.00	1544.17	1044.99	805.44	70	-
Difference for testing adjusted means					30.82	1	30.82

F = 2.68 F at 0.05 level = 3.98 DF 1/69

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	0.95	-0.57	44.05	-	-	-
Within Groups	69	9848.24	592.72	909.41	873.74	68	12.85
Total	70	9849.19	592.15	953.46	917.86	69	-
Difference for testing adjusted means					44.12	1	44.12

F = 3.433 F at 0.05 level = 3.98 DF 1/68

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	0.95	4.46	19.87	-	-	-
Within Groups	69	9848.24	1874.90	2878.33	2521.39	68	37.08
Total	70	9849.19	1879.36	2898.20	2539.59	69	-
Difference for testing adjusted means					18.20	1	18.20

F = 0.491 F at 0.05 level = 3.98 DF 1/68

TABLE XXV

ANALYSIS OF COVARIANCE OF DATA IN CBA SAMPLE

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	25.97	-15.52	9.27	-	-	-
Within Groups	177	21720.17	4605.85	3630.08	2653.39	176	15.07
Total	178	21746.14	4590.33	3639.35	2670.39	177	-
Difference for testing adjusted means					17.00	1	17.00

F = 1.128   F at 0.05 level = 3.90   DF 1/176

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	18.19	6.82	2.56	-	-	-
Within Groups	174	21533.25	3810.75	1184.87	3510.48	173	20.29
Total	175	21551.44	3817.57	1187.43	3511.19	174	-
Difference for testing adjusted means					0.71	1	0.71

F = 0.035   F at 0.05 level = 3.90   DF 1/173

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	18.19	-5.98	1.96	-	-	-
Within Groups	174	21533.25	8174.29	11967.03	8863.97	173	51.24
Total	175	21551.44	8168.31	11968.99	8873.08	174	-
Difference for testing adjusted means					9.11	1	9.11

F = 0.178   F at 0.05 level = 3.90   DF 1/173

TABLE XXVI

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE A-BSCS

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	2048.39	355.62	61.74	-	-	-
Within Groups	177	28072.13	4491.06	3091.38	2372.89	176	11.22
Total	178	20120.52	4846.68	3152.12	2373.24	177	-
Difference for testing adjusted means					0.35	1	0.35

F = 0.031 F at 0.05 level = 3.90 DF 1/176

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	2035.43	432.35	91.84	-	-	-
Within Groups	174	27448.55	2500.99	1949.05	1721.17	173	9.95
Total	175	29483.98	2933.34	2040.89	1749.05	174	-
Difference for testing adjusted means					27.88	1	27.88

F = 2.80 F at 0.05 level = 3.90 DF 1/273

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σx^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	2035.43	781.61	300.14	-	-	-
Within Groups	174	27448.55	6875.88	7037.86	5315.45	173	30.72
Total	175	29483.98	7657.49	7338.00	5349.22	174	-
Difference for testing adjusted means					33.77	1	33.77

F = 1.10 F at 0.05 level = 3.90 DF 1/173

TABLE XXVII

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE D-BSCS

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	106.47	-28.35	7.58	-	-	-
Within Groups	39	3081.43	919.45	912.37	638.02	38	16.79
Total	40	3187.90	891.10	919.95	670.86	39	-
Difference for testing adjusted means					32.84	1	32.84

F = 1.96 F at 0.05 level = 4.10 DF 1/38

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	38.29	-49.86	60.97	-	-	-
Within Groups	35	2400.03	202.00	460.00	389.00	34	11.44
Total	36	2438.32	152.14	466.97	457.48	35	-
Difference for testing adjusted means					68.48	1	68.48

F = 5.99* F at 0.05 level = 4.13 DF 1/34
F at 0.01 level = 7.44

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	38.29	-86.64	196.00	-	-	-
Within Groups	35	2400.03	758.67	1510.92	1271.10	34	37.39
Total	36	2438.32	672.03	1706.92	1521.70	35	-
Difference for testing adjusted means					250.60	1	250.60

F = 6.70* F at 0.05 level = 4.13 DF 1/34
F at 0.01 level = 7.44

TABLE XXVIII

ANALYSIS OF COVARIANCE OF DATA IN BSCS SAMPLE

First Semester
Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	2129.86	451.02	95.51	-	-	-
Within Groups	357	45686.08	11349.51	9960.97	7141.48	356	19.22
Total	358	47815.94	11800.53	10056.48	7144.22	357	-
Difference for testing adjusted means					2.74	1	2.74

F = 0.143 F at 0.05 level = 3.86 DF 1/356

Second Semester
Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	2212.93	138.07	8.62	-	-	-
Within Groups	343	53564.54	9557.40	7113.37	5408.07	342	15.81
Total	344	55777.47	9695.47	7121.99	5436.68	343	-
Difference for testing adjusted means					28.61	1	28.61

F = 1.810 F at 0.05 level = 3.86 DF 1/342

Total Year
Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	2212.93	824.55	124.35	-	-	-
Within Groups	343	53564.54	23028.45	26575.43	25585.39	342	74.81
Total	344	55777.47	23853.00	26699.78	25679.72	343	-
Difference for testing adjusted means					94.33	1	94.33

F = 1.271 F at 0.05 level = 3.86 DF 1/342

background in conventional chemistry. The hypothesis that there is no significant difference in achievement in PSSC physics between students with a background in CBA chemistry and students with a background in conventional chemistry is not rejected in this analysis.

Significant differences in achievement were found in the School Sample D-BSCS for the second semester test data and for the entire year test data. All of the other tests of the data revealed no significant differences in achievement in PSSC physics between students with a background in BSCS biology and students with a background in conventional biology. Although significant differences in achievement were found in two of nine tests of the data in the BSCS Sample, this was not considered to be sufficient evidence to refute the hypothesis which applies to this sample. In this case the two tests which revealed significant differences in achievement in PSSC physics were performed on data obtained from a small group of students in just one school. Therefore, the hypothesis that there is no significant difference in achievement in PSSC physics between students with a background in BSCS biology and students with a background in conventional biology is not rejected in this analysis of the data in the BSCS Sample.

Although the analysis of the pooled data in the BSCS Sample, the CBA Sample, and the CHEMS Sample did not reveal significant differences in achievement in PSSC physics for the groups under comparison, adjusted mean scores were calculated for the criterion scores in each sample. The adjusted mean scores were calculated by using the same formula as that used for the SMSG Sample. The adjusted mean scores for the CHEMS Sample, the CBA Sample, and the BSCS Sample are shown in Tables XXIX, XXX, and XXXI.

TABLE XXIX

ADJUSTED MEAN CRITERION TEST SCORES FROM POOLED DATA FOR CHEMS SAMPLE

Criterion Test	Chem. Back-ground	Number of Students	Mean of SCAT Scores	Mean of PSSC Scores	Regression	Adjusted Mean Scores
PSSC Test	Chem.	116	93.80	18.90	0.217	19.03
Five	CHEMS	42	96.05	18.33	0.217	17.97
PSSC Test	Chem.	112	93.58	16.02	0.187	16.10
Ten	CHEMS	36	95.36	15.81	0.187	15.56
PSSC Total	Chem	112	93.58	34.95	0.335	35.09
Score	CHEMS	36	95.36	34.44	0.335	33.99

TABLE XXX

ADJUSTED MEAN CRITERION TEST SCORES FROM POOLED DATA FOR CBA SAMPLE

Criterion Test	Chem. Back-ground	Number of Students	Mean of SCAT Scores	Mean of PSSC Scores	Regression	Adjusted Mean Scores
PSSC Test	Chem.	147	92.62	18.69	0.187	18.66
Five	CBA	32	91.63	19.28	0.187	19.43
PSSC Test	Chem.	144	92.46	15.25	0.177	15.21
Ten	CBA	32	91.63	14.94	0.177	15.00
PSSC Total	Chem.	144	92.46	33.88	0.380	33.82
Score	CBA	32	91.63	34.22	0.380	34.48

The adjusted mean criterion scores were higher for the students with backgrounds in conventional science courses in seven of nine cases in which comparisons were made in the CHEMS Sample, the CBA Sample, and the BSCS Sample. However, none of the differences were shown to be significant.

TABLE XXXI

ADJUSTED MEAN CRITERION TEST SCORES FROM POOLED DATA FOR BSCS SAMPLE

Criterion Test	Biology Back-ground	Number of Students	Mean of SCAT Scores	Mean of PSSC Scores	Regression	Adjusted Mean Scores
PSSC Test	Biol.	326	87.48	16.21	0.248	16.40
Five	BSCS	33	95.91	18.00	0.248	16.10
PSSC Test	Biol.	313	87.46	13.96	0.178	14.10
Ten	BSCS	32	96.19	14.50	0.178	13.09
PSSC Total	Biol.	313	87.46	30.24	0.430	30.59
Score	BSCS	32	96.19	32.31	0.430	28.92

In summary, the analysis of the data gives little evidence that there is a significant difference in achievement in PSSC physics between students with a background in BSCS biology and students with a background in conventional biology.

No evidence has been found to indicate that there is a significant difference in achievement in PSSC physics between students with a background in CHEM Study chemistry and students with a background in conventional chemistry.

Similarly, no evidence has been found to indicate that there is a significant difference in achievement in PSSC physics between students with a background in CBA chemistry and students with a background in conventional chemistry.

As a result of the analyses of the data in the CHEMS Sample, the CBA Sample, and the BSCS Sample the following are not rejected:

Achievement in PSSC physics is not significantly different for students with a background in BSCS biology from achievement of students with a background in conventional biology.

Achievement in PSSC physics is not significantly different for students with a background in CHEMS chemistry from achievement of students with a background in conventional chemistry.

Achievement in PSSC physics is not significantly different for students with a background in CBA chemistry from achievement of students with a background in conventional chemistry.

The I-SMSG Sample

In three of the high schools included in the study there were students who reported more than one to two semesters of experience in SMSG mathematics. The data from these schools have been designated the I-SMSG Sample and the individual school samples have been designated EI-SMSG, FI-SMSG, and GI-SMSG.

The achievement in PSSC physics between students with different levels of experience in SMSG mathematics is compared by using the data from this sample.

The sex, age, and grade classifications for the groups with different levels of experience in SMSG mathematics is shown in Table XXXII. The same classes were included for both the first and the second semesters of the study, but the second semester numbers are somewhat lower than the first semester numbers since not all of the students completed the second semester of the PSSC physics course.

The mean and the standard deviation of the SCAT scores and the PSSC test scores for the I-SMSG Sample are shown in Table XXXIII. These statistics were computed for each school in the I-SMSG Sample. Finally, the three school samples were pooled and a mean and standard deviation

TABLE XXXII

FREQUENCY DISTRIBUTION OF STUDENT SEX, AGE, AND GRADE FOR I-SMSG SAMPLE

School Sample	Semes. SMSG	Sex M	Sex F	Age 15	Age 16	Age 17	Age 18	Age 19	Grade 10	Grade 11	Grade 12	Total
EI-SMSG												
1st Sem.	1-2	14	-	-	1	10	3	-	-	3	11	14
	3-4	21	-	-	3	12	6	-	-	10	11	21
	5-6	34	10	-	7	25	12	-	-	15	29	44
	7-8	4	1	-	-	1	4	-	-	-	5	5
2nd Sem.	1-2	14	-	-	1	10	3	-	-	3	14	14
	3-4	21	-	-	3	12	6	-	-	10	11	21
	5-6	33	9	-	7	23	12	-	-	15	27	42
	7-8	4	1	-	-	1	4	-	-	-	5	5
FI-SMSG												
1st Sem.	1-2	17	3	-	4	11	5	-	-	8	12	20
	3-4	39	9	-	8	25	14	1	-	23	25	48
	5-6	1	-	-	-	1	-	-	-	-	1	1
2nd Sem.	1-2	17	2	-	3	11	5	-	-	7	12	19
	3-4	39	9	-	8	25	14	1	-	23	25	48
	5-6	1	-	-	-	1	-	-	-	-	1	1
GI-SMSG												
1st Sem.	1-2	10	3	-	1	6	5	1	-	2	11	13
	3-4	13	2	-	-	8	7	-	-	1	14	15
	5-6	15	2	-	2	7	8	-	-	4	13	17
2nd Sem.	1-2	6	3	-	1	4	3	1	-	2	7	9
	3-4	13	2	-	-	8	7	-	-	1	14	15
	5-6	13	2	-	2	6	7	-	-	3	12	15
TOTAL												
1st Sem.	1-2	41	6	-	6	27	13	1	-	13	34	47
	3-4	73	11	-	11	45	27	1	-	34	50	84
	5-6	50	12	-	9	33	20	-	-	19	43	62
	7-8	4	1	-	-	1	4	-	-	-	5	5
2nd Sem.	1-2	37	5	-	5	25	11	1	-	12	30	42
	3-4	73	11	-	11	45	27	1	-	34	50	84
	5-6	47	11	-	9	30	19	-	-	18	40	58
	7-8	4	1	-	-	1	4	-	-	-	5	5

TABLE XXXIII

MEAN AND STANDARD DEVIATION OF TEST SCORES FOR I-SMSG SAMPLE

School Sample	Semes. SMSG	No. Stud.	Mean SCAT	S.D. SCAT	Mean PSSC 5	S.D. PSSC 5	Mean PSSC 10	S.D. PSSC 10	Mean PSSC Tot.	S.D. PSSC Tot.
EI-SMSG										
1st Sem.	1-2	14	83.93	10.17	14.64	3.61				
	3-4	21	91.24	8.60	15.87	3.60				
	5-6	44	96.91	8.30	20.48	4.34				
	7-8	5	95.20	11.49	21.20	3.28				
2nd Sem.	1-2	14	83.93	10.17			14.93	3.03	29.57	5.17
	3-4	21	91.24	8.60			16.33	3.34	34.90	6.08
	5-6	42	96-79	8.48			17.10	5.05	37.45	8.50
	7-8	5	95.20	11.49			15.00	3.09	36.20	5.46
FI-SMSG										
1st Sem.	1-2	20	93.50	9.07	17.80	3.08				
	3-4	48	92.42	10.94	18.42	4.03				
	5-6	1	99.00	-	18.00	-				
2nd Sem.	1-2	19	93.05	9.09			12.26	4.34	30.00	6.93
	3-4	48	92.42	10.94			12.48	3.52	31.10	6.50
	5-6	1	99.00	-			15.00	-	33.00	-
GI-SMSG										
1st Sem.	1-2	13	88.46	15.79	15.00	4.55				
	3-4	15	95.00	6.47	16.33	6.32				
	5-6	17	101.24	5.60	18.47	5.85				
2nd Sem.	1-2	9	83.56	16.73			15.56	4.34	30.33	8.35
	3-4	15	95.00	6.47			16.40	5.42	32.73	10.50
	5-6	15	100.80	5.69			17.20	5.69	36.07	8.20
TOTAL										
1st Sem.	1-2	47	89.26	11.91	16.09	3.86				
	3-4	84	92.58	9.72	18.08	4.44				
	5-6	61	98.11	7.86	19.92	4.72				
	7-8	5	95.20	11.49	21.20	3.28				
2nd Sem.	1-2	42	87.98	11.92			13.86	4.08	29.93	6.50
	3-4	84	92.58	9.72			14.14	4.28	32.35	7.34
	5-6	58	97.86	8.00			17.09	4.73	37.02	8.32
	7-8	5	95.20	11.49			15.00	3.09	36.20	5.46

were computed for each test.

A tendency is seen for the students with a higher level of experience in SMSG mathematics to score higher on the SCAT and PSSC tests than students with less experience in SMSG mathematics.

In each of the comparisons of achievement SCAT Form 2A functioned as the control variable. PSSC Test Number Five was used as the criterion of achievement in PSSC physics for the first semester. PSSC Test Number Ten was used as the criterion of achievement in PSSC physics for the second semester. The sum of PSSC Tests Five and Ten was used as the criterion of achievement in PSSC physics for the entire year.

The analysis of covariance of the test data in the School Sample EI-SMSG for the first semester, the second semester and the entire year is shown in Table XXXIV. No significant differences in achievement were indicated between students with one to two, three to four, five to six, and seven to eight semesters of experience in SMSG mathematics.

The analysis of covariance of the test data in the School Sample FI-SMSG for the first semester, the second semester, and the entire year is shown in Table XXXV. No significant difference in achievement in PSSC physics was indicated for one to two and three to four semesters of experience in SMSG mathematics.

The analysis of covariance of the test data in the School Sample GI-SMSG for the first semester, the second semester, and the entire year is shown in Table XXXVI. No significant differences in achievement in PSSC physics was indicated one to two, three to four, and five to six semesters of experience in SMSG mathematics.

TABLE XXXIV

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE EI-SMSG

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	3	1909.52	846.33	389.44	-	-	-
Within Groups	80	6379.18	1333.31	1296.13	1017.46	79	12.88
Total	83	8288.70	2179.64	1685.57	1112.40	82	-
Difference for testing adjusted means					94.94	3	31.65

$F = 2.456$ F at 0.05 level = 2.72 DF 3/79

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	3	1842.95	284.47	60.50	-	-	-
Within Groups	78	6364.61	1661.12	1453.22	1019.69	77	13.24
Total	81	8207.56	1945.59	1513.72	1052.52	80	-
Difference for testing adjusted means					32.83	3	10.94

$F = 0.826$ F at 0.05 level = 2.72 DF 3/77

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	3	1842.95	1093.80	660.84	-	-	-
Within Groups	78	6364.61	2971.93	4238.44	2850.71	77	37.02
Total	81	8207.56	4065.73	4899.28	2885.27	80	-
Difference for testing adjusted means					34.56	3	11.52

$F = 0.311$ F at 0.05 level = 2.72 DF 3/77

TABLE XXXV

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE FI-SMSG

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	16.57	-9.43	5.37	-	-	-
Within Groups	66	7312.67	1177.67	958.87	769.21	65	11.83
Total	67	7329.24	1168.24	964.24	778.03	66	-
Difference for testing adjusted means					8.82	1	8.82

F = 0.746 F at 0.05 level = 3.99 DF 1/65

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	5.50	-1.88	0.64	-	-	-
Within Groups	65	7236.62	522.16	933.66	895.99	64	14.00
Total	66	7242.12	520.28	934.30	896.92	65	-
Difference for testing adjusted means					0.93	1	0.93

F = 0.066 F at 0.05 level = 3.99 DF 1/64

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	1	5.50	-9.56	16.59	-	-	-
Within Groups	65	7236.62	434.92	2894.48	2868.34	64	44.82
Total	66	7242.12	425.36	2911.07	2886.09	65	-
Difference for testing adjusted means					17.75	1	17.75

F = 0.396 F at 0.05 level = 3.99 DF 1/64

TABLE XXXVI

ANALYSIS OF COVARIANCE OF DATA IN SCHOOL SAMPLE GI-SMSG

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	2	1206.91	331.01	92.74	-	-	-
Within Groups	42	4080.29	811.12	1291.57	1130.33	41	27.57
Total	44	5287.20	1142.13	1384.31	1137.12	43	-
Difference for testing adjusted means					6.79	2	3.40

F = 0.123 F at 0.05 level = 3.23 DF 2/41

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	2	1676.82	158.39	15.52	-	-	-
Within Groups	36	3276.62	750.82	784.22	612.17	35	17.49
Total	38	4953.44	909.21	799.74	632.85	37	-
Difference for testing adjusted means					20.68	2	10.34

F = 0.592 F at 0.05 level = 3.27 DF 2/35

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	2	1676.82	548.86	197.83	-	-	-
Within Groups	36	3276.62	1514.53	3041.86	2341.81	35	66.91
Total	38	4953.44	2063.39	3239.69	2380.17	37	-
Difference for testing adjusted means					38.36	2	19.18

F = 0.287 F at 0.05 level = 3.27 DF 2/35

TABLE XXXVII

ANALYSIS OF COVARIANCE OF DATA IN I-SMSG SAMPLE

First Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 5

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	3	2229.97	939.90	435.86	-	-	-
Within Groups	193	18894.36	3399.67	3737.47	3125.77	192	15.87
Total	196	21124.33	4339.57	4191.33	3299.85	195	-
Difference for testing adjusted means					174.08	3	58.03

F = 3.657* F at 0.05 level = 2.65 DF 3/192
F at 0.01 level = 3.88

Second Semester

Control (X): SCAT Form 2A — Criterion (Y): PSSC Test 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	3	2458.22	858.20	368.89	-	-	-
Within Groups	185	18079.10	2688.55	3576.10	3176.28	184	17.26
Total	188	20537.32	3546.75	3944.99	3332.47	187	-
Difference for testing adjusted means					156.19	3	52.06

F = 3.016* F at 0.05 level = 2.66 DF 3/184
F at 0.01 level = 3.89

Total Year

Control (X): SCAT Form 2A — Criterion (Y): Sum of PSSC Tests 5 & 10

Source of Variation	DF	Sums of Squares & Products Σx^2	Σxy	Σy^2	Deviations about Regression $\Sigma y^2_{y.x}$	DF	Mean Square
Among Means	3	2458.22	1822.89	1387.09	-	-	-
Within Groups	185	18079.10	4817.95	10429.56	9145.61	184	49.70
Total	188	20537.32	6640.84	11826.65	9679.30	187	-
Difference for testing adjusted means					533.69	3	177.90

F = 3.579* F at 0.05 level = 2.66 DF 3/184
F at 0.01 level = 3.89

Three more tests of the hypothesis were provided by pooling the data from the three schools in the I-SMSG Sample. This pooling has some validity since all of these schools are in the same city and in the same area of the city.

The analysis of covariance of the test data from the three schools in the I-SMSG Sample is shown in Table XXXVII. Significant differences in achievement in PSSC physics were found for the first semester, the second semester, and the entire year. The F-value in each case exceeded the tabulated F-value at the 0.05 level of confidence.

The adjusted mean scores for the criterion tests in the I-SMSG Sample are shown in Table XXXVIII. These adjusted mean scores were calculated by using the same formula as that used for the SMSG Sample.

TABLE XXXVIII

ADJUSTED MEAN CRITERION TEST SCORES FROM POOLED DATA FOR I-SMSG SAMPLE

Criterion Test	Semes. SMSG	Number of Students	Mean of SCAT Scores	Mean of PSSC Scores	Regression	Adjusted Mean Scores
PSSC Test Five	1-2	47	89.26	16.09	0.180	16.87
	3-4	84	92.58	18.08	0.180	18.26
	5-6	61	98.11	19.92	0.180	18.10
	7-8	5	95.20	21.20	0.180	20.91
PSSC Test Ten	1-2	42	87.98	13.86	0.149	14.65
	3-4	84	92.58	14.14	0.149	14.24
	5-6	58	97.86	17.09	0.149	16.40
	7-8	5	95.20	15.00	0.149	14.71
PSSC Total Score	1-2	42	87.98	29.93	0.266	31.12
	3-4	84	92.58	32.35	0.266	33.50
	5-6	58	97.86	37.02	0.266	35.98
	7-8	5	95.20	36.20	0.266	35.76

The adjusted mean scores tend to be higher for students with higher levels of experience in SMSG mathematics than for students with less experience in mathematics.

In summary, the comparisons of achievement in PSSC physics in the I-SMSG Sample give conflicting evidence that there is a significant difference in achievement between groups of students with different levels of experience in SMSG. Significant differences in achievement were noted in three of twelve tests of the test data in this sample.

Conclusion

The results of the analyses of the data do not confirm the existence of a positive relationship between experience in one of the new science or mathematics courses and higher achievement in PSSC physics. On the other hand, these tests do not deny that such a relationship might exist since many of the samples were of less than adequate size to show differences in achievement unless these differences were quite large.

There are many problems associated with a study of this type. The cause and effect relationships between experiences in courses with a common philosophic background may be obscured by a variety of other variables such as school differences, teacher differences, class differences, classroom differences, and others. It would be very difficult to control all of these variables. Any conclusions which are reached must be made with caution and must be regarded only as indications that relationships might exist.

The teacher in the classroom plays a key role in a study of this type. To say that teachers differ in personality, training, and methods of instruction is to make an understatement of the true situation. Certainly, the teacher's attitudes, methods, and philosophy will be important in the classroom whether the materials are new or conventional. It must be true that a conventional course could be taught from a conventional book with a new course philosophy or that a new course could be taught with new materials with a conventional philosophy. This will tend to hide the results which might accrue from experience in a new course as opposed to experience in a conventional course.

This study has indicated that growth in the process dimension of science is not necessarily transferred from one course to another unless the subject matter of the courses is closely related. Both PSSC physics and SMSG mathematics give emphasis to problem solving. This may account for the indication of a positive outcome in the comparisons of achievement between students with a background in SMSG and students with a background in conventional mathematics.

Summary

The results of the analyis of the data have in general given little evidence to reject the null hypothesis that there is no difference in achievement in PSSC physics between students with a background in one of the new courses in science or mathematics and students with a background in a conventional course in science or mathematics.

In the comparisons of achievement in PSSC physics between students with experience in SMSG mathematics and students with experience in conventional mathematics, nine of twelve tests of the data gave no evidence that the null hypothesis should be rejected. However, the evidence was conflicting in these tests.

In the comparisons of achievement in PSSC physics between students with experience in CHEM Study chemistry and students with experience in conventional chemistry, nine of nine tests gave no evidence that the null hypothesis should be rejected.

In the comparisons of achievement in PSSC physics between students with experience in CBA chemistry and students with experience in conventional chemistry, nine of nine tests gave no evidence that the null hypothesis should be rejected.

In the comparisons of achievement in PSSC physics between students with experience in BSCS biology and students with experience in conventional biology, seven of nine tests gave no evidence that the null hypothesis should be rejected.

In the comparisons of achievement in PSSC physics between students with different levels of experience in SMSG mathematics, there was some tendency demonstrated for students with more experience in SMSG mathematics to achieve at a higher level than those with less experience in SMSG mathematics.

CHAPTER V

SUMMARY AND CONCLUSIONS

In this chapter the problem will be restated, a summary of the tests of the hypotheses will be given, an interpretation will be given for some of the results, and conclusions and recommendations will be presented.

The purpose of this study was to determine whether growth in the specific abilities and skills developed in the process dimension of science through taking a course in SMSG mathematics, BSCS biology, CHEM Study chemistry, or CBA chemistry is related to higher achievement in PSSC physics.

Results of the Tests of the Hypotheses

At the beginning of this study five hypotheses which were concerned with the relationship between achievement in PSSC physics and the background experience of the student were stated.

In order to test the hypotheses, data were collected from PSSC classes in different high schools in which the students had backgrounds either in conventional courses in science and mathematics or in the new courses in science and mathematics. Certain portions of this data were used to test each of the hypotheses.

The same general pattern of testing was used in each of the schools to provide achievement data for the tests of the hypotheses. SCAT

Form 2A was used as a control variable; PSSC Tests Five and Ten were used as the criterion tests in each of the comparisons of achievement.

The statement of each hypothesis follows with the results of the tests.

Hypothesis I. Achievement in PSSC physics is not significantly different for students with a background in SMSG mathematics from achievement of students with a background in conventional courses in high school mathematics.

Twelve tests of this hypothesis were made. Nine of the tests were performed on data from three individual schools and three tests were made on pooled data from six schools. Tests were made on first semester data, second semester data, and data for the entire year.

One significant difference in achievement in PSSC physics was shown by the tests involving data from individual schools. No doubt the size of the groups being compared in achievement played a part in preventing the discovery of other differences if such differences did exist.

When the data were pooled, a significant difference in achievement was shown for the first semester and for the second semester. No significant difference in achievement was shown for the entire year. Since the achievement of the students was judged on the basis of only two tests, no set pattern could be established for achievement in PSSC physics for each student. No doubt this played a part in causing the whole year data to show a great deal of variability and led to the situation described for this sample.

The student data in this sample revealed that the scholastic aptitude of SMSG mathematics students is somewhat greater than the scholastic aptitude for students with a background in conventional mathematics.

Selectivity by the teachers, or personal choice of the students may have been responsible for this.

If differences in achievement between these groups exist, as some PSSC physics teachers suggest, perhaps part of the difference may be due to the superiority of the SMSG students in native ability. This study has shown that the adjusted mean scores for the groups give an advantage to the students with a background in SMSG mathematics even though some of the differences have not been shown to be significant.

As a result of these tests, one might be led to believe that there is some relationship between experience in SMSG mathematics and higher achievement in PSSC physics which does not exist between experience in conventional mathematics and success in PSSC physics. More studies need to be done in this area before this relationship can be shown to exist in fact.

Hypothesis II. Achievement in PSSC physics is not significantly different for students with a background in BSCS biology from achievement of students with a background in conventional biology.

Six tests of this hypothesis were made on data from two schools individually, and three tests were made on pooled data from five schools. Two of the six tests on the individual school data showed that there were significant differences in achievement between students with a background in BSCS biology and students with a background in conventional biology. The students in the conventional biology group were favored in these comparisons. No differences in achievement were shown to be significant by the analysis of the pooled data from five schools.

The tests of the data in the BSCS Sample do not show that experience in BSCS is advantageous to those students in PSSC classes who have this experience. Much more evidence needs to be obtained to demonstrate that this hypothesis is true since the number of BSCS biology students included in this sample was very small and perhaps could not be expected to represent the whole population of BSCS students in achievement in PSSC physics.

Hypothesis III. Achievement in PSSC physics is not significantly different for students with a background in CHEM Study chemistry from achievement of students with a background in conventional chemistry.

Six tests of this hypothesis were made on data from two schools individually and three tests were made on the pooled data from three schools. In each case the achievement of students with a background in CHEM Study chemistry was shown to be not significantly different from the achievement of students with a background in conventional chemistry.

The tests of the data in the CHEM Sample show no advantage in achievement in PSSC physics for students with a background in CHEM Study chemistry. However, the number of students reporting experience in CHEM Study chemistry was small and may not represent the total population of CHEM Study students in PSSC physics classes. More evidence needs to be presented to demonstrate that there is no real difference in achievement in PSSC physics between students with a background in CHEM Study and students with a background in conventional chemistry.

Hypothesis IV. Achievement in PSSC physics is not significantly different for students with a background in CBA chemistry from achievement of students with a background in conventional chemistry.

Six tests of this hypothesis were made on data from two schools individually and three tests were made on the pooled data from all three schools. In each test the achievement of students with a background in

CBA chemistry was shown to be not significantly different from the achievement of students with a background in conventional chemistry.

The tests of the data in the CBA Sample do not reveal any advantage in achievement in PSSC physics for students who have a background in CBA chemistry over those students who have a background in conventional chemistry. However, the number of students who reported a background in CBA chemistry was limited and may not represent the whole population of CBA students in the PSSC classes.

Hypothesis V. Achievement in PSSC physics is not significantly different for students with a background of one to two semesters of SMSG mathematics, three to four semesters of SMSG mathematics, five to six semesters of SMSG mathematics, or seven to eight semesters of SMSG mathematics.

Nine tests of the hypothesis were performed on data from three schools individually and three tests were made on the pooled data from all three schools in the sample.

The nine tests performed on the data from the individual schools did not show any significant differences in achievement between students with different levels of experience in SMSG mathematics. However, when the data from the three schools were pooled and three more tests were performed, significant differences in achievement were found for the first semester data, the second semester data, and the data for the entire year. The adjusted mean scores tended to be higher for those students with a higher level of experience in SMSG.

There is some difficulty associated with the conclusions which could be drawn from the data in the I-SMSG Sample. There seems to be a tendency for students with higher ability to continue to the higher level courses in SMSG mathematics; this was revealed by an examination of the data. This could mean that these students tend to show a higher over-all achievement in school and thus would have an advantage. It could also mean that a conscious or unconscious effort had been made to keep these students in the new program. However, there is some evidence to support a positive relationship between higher achievement in PSSC physics and more experience in SMSG mathematics. More evidence needs to be collected than was presented in this study before such a relationship is confirmed.

Recommendations for Further Study

The author hopes that this study will provide some background for other studies in the same area of interest. One of the school systems which cooperated in the study has indicated a desire to continue with a study of the relationships which exist between the new courses in science and mathematics.

There are a number of problems which have been suggested by this study which are of importance to science education. Some of these problems are:

Does growth <u>really</u> take place in the process dimension of science and is this growth <u>transferrable</u> from one subject matter area to another?

How can growth in the process dimension of science be measured if such growth does exist?

What sort of experience in the classroom is most valuable in promoting growth in the process dimension?

Do the commercial tests which are used with the new courses in science measure growth in the process dimension, or do these tests in reality measure acquired knowledge or innate abilities?

What relationship exists between the measurement of success in PSSC physics as shown by the results of the PSSC tests and the measurement of success as shown by other methods of evaluation devised by the classroom teacher?

Does the previous experience of the teacher make a difference in the achievement of growth in both the content and the process dimension of science?

Many other problems surely exist. There is a need for the development of more precise measuring instruments to be used in science as well as other subject matter areas. With more precise instruments inferences could be made which were based on more reliable evidence than the evidence which could be presented in this study.

A SELECTED BIBLIOGRAPHY

(1) _______. "AIP-NRC Conference on the Production of Physicists." Physics Today, VIII (June, 1957), 6-12.

(2) Beberman, Max. "The University of Illinois School Mathematics Program." The School Review, LXV (Winter, 1957), 457-465.

(3) Berger, J. Joel. "A Determination of the Relative Effectiveness of Two Specific Teaching Methods on the Ability of High School Students to Write Chemical Formulas and to Apply This Knowledge to a New Problem Solving Situation." Unpublished PH.D. Thesis, 1963, Dissertation Abstracts, XXIV, No. 7, (January, 1964), pp. 2806-7, New York University.

(4) _______. "The Biological Sciences Curriculum Study." The Science Teacher, XXVII (Spril, 1960). 42.

(5) Biological Sciences Curriculum Study. BSCS Newsletter No. 12, (February, 1962), AIBS Biological Sciences Curriculum Study, University of Colorado, Boulder.

(6) Biological Sciences Curriculum Study. BSCS Newsletter No. 17, (March, 1963), AIBS Biological Sciences Curriculum Study, University of Colorado, Boulder.

(7) Biological Sciences Curriculum Study. BSCS Newsletter No. 19, (September, 1963), AIBS Biological Sciences Curriculum Study, University of Colorado, Boulder.

(8) Biological Sciences Curriculum Study. High School Biology, Green Version, Teachers Guide, Revised Edition. Boulder: University of Colorado Press, 1961, pp. xiii-xvi.

(9) Biological Sciences Curriculum Study. Biological Science: An Inquiry into Life. New York: Harcourt, Brace and World, 1963.

(10) Biological Sciences Curriculum Study. High School Biology, BSCS Green Version. Chicago: Rand McNally, 1963.

(11) Biological Sciences Curriculum Study. Biological Science: Molecules to Man. Boston: Houghton-Mifflin, 1963.

(12) Brandwein, Paul F. "The Revolution in Science Education: An Examination of the New Science Curriculums." Teacher's Notebook in Science, (Spring, 1962), Harcourt, Brace and World School Department.

(13) Chemical Bond Approach Project. Chemical Systems. New York: McGraw-Hill, 1964.

(14) Chemical Bond Approach Project. CBA Newsletter No. 9, (February, 1961), CBA Project, Earlham College, Richmond, Indiana.

(15) Chemical Bond Approach Project. CBA Newsletter No. 13. (May, 1962), CBA Project, Earlham College, Richmond, Indiana.

(16) Chemical Bond Approach Project. CBA Newsletter No. 2, II (April, 1963), CBA Project, Earlham College, Richmond, Indiana.

(17) Chemical Education Material Study. CHEM Study Newsletter No. 1, I (November, 1960), CHEMS, Harvey Mudd College, Claremont, California.

(18) Chemical Education Material Study. CHEM Study Newsletter No. 1, IV (February, 1964), CHEMS, Harvey Mudd College, Claremont, California.

(19) Chemical Education Material Study. Chemistry: An Experimental Science. San Francisco: W. H. Freeman and Co., 1963.

(20) Chemical Education Material Study. Teachers Guide for Chemistry: An Experimental Science. San Francisco: W. H. Freeman and Co., 1963.

(21) Chemical Education Material Study. Chemistry: An Experimental Science, Laboratory Manual. San Francisco: W. H. Freeman and Co., 1963.

(22) DeRose, James V. "Relationships Between Achievement in PSSC Physics and CBA Chemistry." Unpublished Doctoral Thesis, 1962, University of Pennsylvania.

(23) Dewey, John. Democracy and Education. New York: Macmillan, 1917, p. 46.

(24) Educational Services Incorporated. Mimeographed letter to PSSC physics teachers. Watertown, Massachusetts, February, 1963.

(25) Educational Testing Service. Cooperative School and College Ability Tests, Manual for Interpreting Scores, Princeton: Educational Testing Service, 1957, p.5.

(26) Educational Testing Service. Cooperative School and College Ability Tests, Technical Report. Princeton: Educational Testing Service, 1957, p. 10.

(27) Educational Testing Service. SCAT-STEP Supplement, 1958. Princeton: Educational Testing Service, 1958.

(28) Educational Testing Service. SCAT-STEP Supplement, 1962. Princeton: Educational Testing Service, 1962, p. 39.

(29) Educational Testing Service. SCAT-STEP Supplement, 1963. Princeton: Educational Testing Service, 1963.

(30) Educational Testing Service. Tests, Materials, and Services. Princeton: Educational Testing Service, 1963.

(31) Edwards, Allen L. Experimental Design in Psychological Research. New York: Rinehart and Company, Inc., 1950.

(32) Fast, Kenneth V. "The Role of Laboratory Experiences in the CHEM Study Program." School Science and Mathematics, LXIII (February, 1963), 147.

(33) Ferris, Frederick L. "An Achievement Test Report." The Science Teacher, XXVI (December, 1959), 576-9.

(34) Ferris, Frederick L. "Testing for Physics Achievement." American Journal of Physics, XXVIII (March, 1960), 269-78.

(35) Finlay, Gilbert C. "Physical Science Study Committee, A Status Report." The Science Teacher, XXVI (December, 1959), 574-6.

(36) Finlay, Gilbert C. "The Physical Science Study Committee." The School Review, LXX (Spring, 1962), 63-81.

(37) Finlay, Gilbert C. "Secondary School Physics: The Physical Science Study Committee." American Journal of Physics, XXVIII (March, 1960), 286.

(38) Garrett, Alfred B. "The New Chemistry." The Science Teacher, XXVIII (April, 1961), 15-21.

(39) Garrett, Henry E. Statistics in Psychology and Education. Fifth Edition. New York: David McKay, 1962.

(40) Glass, Bently. "A New High School Biology Program." American Scientist, XLIX (December, 1961), 524-31.

(41) Glass, Bently. Science and Liberal Education. Baton Rouge: Louisiana State University Press, 1959, pp. 62-3.

(42) Grobman, Arnold B. "Life Sciences in American Schools." Educational Leadership, XVII (December, 1961), 153-6.

(43) Grobman, Hulda. "Questions Often Asked About the BSCS." Mimeographed Information Sheet, AIBS Biological Sciences Curriculum Study, University of Colorado, Boulder, September, 1962.

(44) Heath, Robert W., and David W. Stickell. "CHEM and CBA Effects on Achievement in Chemistry." The Science Teacher, XXX (September, 1963), 45-6.

(45) Hurd, Paul DeHart. "The New Curriculum Movement in Science." The Science Teacher, XXIX (February, 1962), 6-9.

(46) Klinkmann, Evelyn. "Preparation of Tests for BSCS Biology." BSCS Newsletter 9 & 10, Reprint, (1961), AIBS Biological Sciences Curriculum Study, University of Colorado, Boulder.

(47) Little, Elbert P. "PSSC: A Physics Program." Educational Leadership, XVII (December, 1961), 167-9.

(48) Little, Elbert P. "From These Beginnings." The Science Teacher, XXiv (November, 1957), 318.

(49) Livermore, Arthur H., and Lawrence E. Strong. "A Writing Conference for CBA High School Chemistry Project." Journal of Chemical Education, XXXVII (April 1960), 209.

(50) Meredith, Charles Earling. "Development of Problem Solving Skills in High School Physical Science." Unpublished Ph.D. Thesis, 1962, Dissertation Abstracts, XXII, Pt. 5 (April, 1962), p. 3550, Stanford University.

(51) Merrill, Richard J. "Chemistry: An Experimental Science." The Science Teacher, XXX (April, 1963), 26.

(52) Michels, Walter C. "High School Physics, A Report of the Joint Committee on High School Teaching Materials." Physics Today, X (January, 1957), 20-1.

(53) Montague, Earl John. "Using the College Chemistry Laboratory to Develop an Understanding of Problem Solving in Science." Unpublished Ph.D. Thesis, 1963, Dissertation Abstracts, XXIV, No. 7 (January, 1964), p. 2815, Ohio State University.

(54) McKibben, Margaret J. "The Study of New Developments in Secondary School Science --- Grades 7-12." Science Education, XLV (December, 1961), 403-9.

(55) National Council of Teachers of Mathematics. An Analysis of the New Mathematics Programs. Washington: National Council of Teachers of Mathematics, 1963.

(56) National Council of Teachers of Mathematics, The Revolution in School Mathematics. Washington: National Council of Teachers of Mathematics, 1961.

(57) National Science Foundation. Science Course Improvement Projects. NSF 62-38, October, 1962.

(58) National Society for the Study of Education. A Program for Teaching Science. Thirty-First Yearbook, Part I. Chicago: University of Chicago Press, 1932.

(59) National Society for the Study of Education. Science Education for American Schools. Forty-Sixth Yearbook, Part I. Chicago: University of Chicago Press, 1947.

(60) National Society for the Study of Education. Rethinking Science Education. Fifty-Ninth Yearbook, Part I. Chicago: University of Chicago Press, 1960.

(61) Neal, Louise N. "Method of Scientific Inquiry." The Science Teacher. XXIX (September, 1962), 53-5.

(62) _______. "Physical Science Study Committee, A Planning Conference Report." Physics Today, X (March, 1957), 28.

(63) Physical Science Study Committee. PSSC Physics. Boston: D. C. Heath, 1960.

(64) Physical Science Study Committee. PSSC Physics, Laboratory Guide. Boston: D. C. Heath, 1960.

(65) Physical Science Study Committee. PSSC Physics, Teacher's Resource Book and Guide. Boston: D. C. Heath, 1960.

(66) Physical Science Study Committee. Tests of the Physical Science Study Committee, Handbook. Princeton: Educational Testing Service, 1959, p. 39.

(67) _______. "Reed College Conference on the Teaching of Chemistry." Journal of Chemical Education, XXXV (February, 1958), 54.

(68) Rosenbloom, Paul C. "Mathematics, K-14." Educational Leadership, XIX (March, 1962), 359-63.

(69) Schwab, Joseph J. "Inquiry, the Science Teacher, and the Educator." The School Review, LXVIII (Summer, 1960), 185.

(70) Schwab, Joseph J., and Paul B. Brandwein. The Teaching of Science as Enquiry. Cambridge: Harvard University Press, 1962.

(71) School Mathematics Study Group. SMSG Newsletter No. 6, (March, 1961), SMSG, Stanford University, Stanford, California.

(72) School Mathematics Study Group. SMSG Newsletter No. 10, (November, 1961), SMSG, Stanford University, Stanford, California.

(73) School Mathematics Study Group. SMSG Newsletter No. 13, (July, 1962), SMSG, Stanford University, Stanford, California.

(74) School Mathematics Study Group. Mathematics for High School, First Course in Algebra, Revised Edition. New Haven: Yale University Press, 1961.

(75) School Mathematics Study Group. Mathematics for High School, Geometry, Revised Edition. New Haven: Yale University Press, 1961.

(76) School Mathematics Study Group. Mathematics for High School, Intermediate Mathematics, Revised Edition. New Haven: Yale University Press, 1961.

(77) School Mathematics Study Group. Mathematics for High School, Introduction to Matrix Algebra, Revised Edition. New Haven: Yale University Press, 1961.

(78) School Mathematics Study Group. Mathematics for High School, Elementary Functions, Revised Edition. New Haven: Yale University Press, 1961.

(79) Seabrog, Glenn T. "New Currents in Chemical Education." Chemical and Engineering News, XXXVIII (October 17, 1960), 97-109.

(80) Steel, Robert G.D., and James H. Torrie. Principles and Procedures of Statistics. New York: McGraw-Hill Book Company, Inc., 1960.

(81) Strong, Lawrence E. "Facts, Students, Ideas." Journal of Chemical Education, XXXIX (March, 1962), 126.

(82) Strong, Lawrence E., and M. Kent Wilson. "Chemical Bonds: A Central Theme for High School Chemistry." Journal of Chemical Education, XXXV (February, 1958), 56.

(83) Suchman, J. Richard. "Inquiry Training in the Elementary School." The Science Teacher, XXVII (November, 1960), 42-7.

(84) Wert, James E., Charles O. Neidt, and J. Stanley Ahmann, Statistical Methods in Educational and Psychological Research. New York: Appleton-Century-Crofts, Inc., 1954

APPENDIX A

COPY OF STUDENT QUESTIONNAIRE

COPY OF STUDENT QUESTIONNAIRE

Name ______________________ Age ______ Birthdate ____________________
     Last   First

City ______________________ School ____________ Grade 10 11 12

Teacher's Name ______________________ Class Period ____________________

Mathematics Courses, Completed or Present Enrollment: Circle the appropriate courses or add others if necessary.

Grade Nine	Grade Ten	Grade Eleven	Grade Twelve
Algebra	Geometry	Adv. Algebra	______________
SMSG Math.	SMSG Math.	SMSG Math.	SMSG Math.
______________	______________	______________	______________

Science Courses, Completed or Present Enrollment: Circle the appropriate courses or add others if necessary.

Grade Nine	Grade Ten	Grade Eleven	Grade Twelve
General Science	Biology	Chemistry	Physics
Physical Science	BSCS Biology Version	CBA Chemistry	PSSC Physics
______________	______________	CHEMS Chemistry	______________
		______________	

INSTRUCTIONS FOR COMPLETING QUESTIONNAIRE

All of the blanks in the first three lines should be completed. Either pencil or ink may be used to complete the questionnaire.

The following may need special attention:

Name Line Age of student on the day that the questionnaire is completed.

City Line Circle the grade for each student; 10, 11, or 12.

Teacher's Name Line Class period means first, second, third, etc.

Mathematics Courses

It is necessary to obtain the mathematical background of each student for grades nine through the present year of enrollment. They may circle the courses which they have had and if a course does not appear it may be added.

Science Courses

It is necessary to obtain the science background of each student for grades nine through the present enrollment. They may circle the courses which they have had and if a course does not appear it may be added.

Thanks a lot !!

Paul B. Ackerson

APPENDIX B

SCHOOLS AND TEACHERS PARTICIPATING IN THE STUDY

SCHOOLS AND TEACHERS PARTICIPATING IN THE STUDY

Letter Ident.	Name of School	Location	Teacher
A	North High School	Omaha, Nebraska	E. Schroer H. Dally
B	Benson High School	Omaha, Nebraska	L. Kallemeyn
C	Lawrence High School	Lawrence, Kansas	R. Hunt
D	Hale High School	Tulsa, Oklahoma	R. Dunham
E	Northwest Classen High School	Oklahoma City, Oklahoma	J. Conger
F	John Marshall High School	Oklahoma City, Oklahoma	J. Sparks
G	Harding High School	Oklahoma City, Oklahoma	J. Shull

APPENDIX C

DATA COLLECTED ON ALL STUDENTS INCLUDED IN THE STUDY

DATA COLLECTED ON ALL STUDENTS INCLUDED IN THE STUDY

School A

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
1	M	16	11	3-4	1-2	1	-	-	-	-	-	65	10	11	21
2	M	16	11	5-6	-	1	-	1	-	-	-	78	12	9	21
3	M	17	11	5-6	-	1	-	1	-	-	-	69	15	15	30
4	M	16	11	5-6	-	1	-	-	-	-	-	79	10	11	21
5	F	17	11	5-6	-	1	-	1	-	-	-	88	13	12	25
6	F	17	11	5-6	-	1	-	-	-	-	-	72	6	10	16
7	M	17	11	3-4	1-2	1	-	-	-	-	-	79	10	9	19
8	M	17	11	3-4	1-2	1	-	1	-	-	-	76	15	11	26
9	M	18	11	3-4	1-2	1	-	-	-	-	-	96	19	11	30
10	F	17	11	5-6	-	1	1	-	-	-	-	96	11	11	22
11	M	16	11	5-6	-	1	1	-	-	-	-	79	10	7	17
12	M	16	11	5-6	-	1	-	-	-	-	-	76	15	14	29
13	M	17	11	3-4	1-2	1	-	1	-	-	-	88	14	16	30
14	M	17	11	3-4	1-2	1	-	-	-	-	-	83	13	10	23
15	F	17	11	5-6	-	1	-	1	-	-	-	62	8	-	-
16	M	17	11	3-4	1-2	1	-	-	-	-	-	100	20	14	34
17	M	17	11	3-4	1-2	1	-	1	-	-	-	71	10	16	26
18	F	17	11	3-4	1-2	1	1	1	-	-	-	90	8	17	25
19	M	16	11	3-4	1-2	1	-	-	-	-	-	80	18	9	27
20	M	17	11	3-4	1-2	1	-	1	-	-	-	73	5	14	19
21	M	17	11	3-4	1-2	-	-	-	1	-	-	98	16	19	35
22	M	16	11	5-6	-	1	-	-	-	-	-	73	11	10	21
23	M	16	11	3-4	1-2	1	-	-	-	-	-	82	12	15	27
24	F	16	11	5-6	-	1	-	1	-	-	-	73	16	10	26
25	M	17	11	5-6	-	1	-	1	-	-	-	68	12	12	24
26	M	16	11	3-4	1-2	1	1	-	-	-	-	89	20	13	33
27	M	17	11	3-4	1-2	1	1	-	-	-	-	78	16	13	29
28	M	17	11	3-4	1-2	1	1	-	-	-	-	101	19	11	30
29	M	16	11	3-4	1-2	1	1	-	-	-	-	88	14	14	28
30	M	16	11	3-4	1-2	1	1	-	-	-	-	97	16	15	31
31	F	17	11	3-4	1-2	1	1	-	-	-	-	95	10	8	18
32	M	17	11	5-6	-	1	1	-	-	-	-	72	11	11	22
33	F	17	11	3-4	1-2	1	1	-	-	-	-	101	16	11	27
34	M	17	11	3-4	1-2	1	1	-	-	-	-	89	20	12	32

<u>School A (Continued)</u>

Stu	Sex	Age	Grad	Semesters Mathematics: Conv	Semesters Mathematics: SMSG	Years Science: Biol	Years Science: Chem	Years Science: Othe	Years Science: BSCS	Years Science: CHEM	Years Science: CBA	SCAT	PSSC Tests: 5	PSSC Tests: 10	PSSC Tests: T
35	M	16	11	3-4	1-2	1	1	-	-	-	-	101	15	14	29
36	M	16	11	3-4	1-2	-	1	-	1	-	-	103	16	18	34
37	M	16	11	5-6	-	1	1	-	-	-	-	98	15	13	28
38	M	17	11	3-4	1-2	-	1	-	1	-	-	93	16	12	28
39	M	16	11	3-4	1-2	1	1	-	-	-	-	104	14	13	27
40	M	16	11	3-4	1-2	1	1	-	-	-	-	99	12	16	28
41	M	16	11	3-4	1-2	1	1	-	-	-	-	99	25	19	44
42	F	17	11	3-4	1-2	1	1	-	-	-	-	106	20	19	39
43	M	17	11	3-4	1-2	1	1	-	-	-	-	100	22	13	35
44	F	17	11	3-4	1-2	-	1	-	1	-	-	98	13	12	25
45	M	16	11	3-4	1-2	1	1	-	-	-	-	89	14	9	23
46	M	16	11	3-4	1-2	1	1	-	-	-	-	107	21	9	30
47	M	17	11	3-4	1-2	1	1	-	-	-	-	97	22	17	39
48	M	17	11	3-4	1-2	1	1	-	-	-	-	86	16	12	28
49	M	16	11	3-4	1-2	-	1	-	1	-	-	100	19	17	36
50	M	16	11	3-4	1-2	1	1	-	-	-	-	92	20	17	37
51	M	17	11	5-6	-	1	1	-	-	-	-	88	11	17	28
52	M	16	11	5-6	-	1	1	-	-	-	-	99	18	19	37
53	M	17	11	3-4	1-2	1	1	-	-	-	-	106	17	19	36
54	M	16	11	5-6	-	1	1	-	-	-	-	87	20	19	39
55	M	17	11	3-4	1-2	-	1	-	1	-	-	94	15	14	29
56	M	17	11	5-6	-	1	1	-	-	-	-	96	22	11	33
57	M	17	11	3-4	1-2	1	1	-	-	-	-	82	9	13	22
58	M	17	11	3-4	1-2	1	-	1	-	-	-	45	15	10	25
59	F	16	11	3-4	1-2	1	-	-	-	-	-	97	14	10	24
60	M	16	11	3-4	1-2	1	1	1	-	-	-	86	17	9	26
61	M	17	11	5-6	-	1	-	-	-	-	-	79	12	7	19
62	M	17	11	3-4	1-2	1	1	-	-	-	-	89	20	10	30
63	M	17	11	5-6	-	1	-	1	-	-	-	80	12	14	26
64	M	16	11	3-4	1-2	1	-	1	-	-	-	93	13	7	20
65	M	17	11	3-4	1-2	1	-	-	-	-	-	91	14	15	29
66	M	16	11	5-6	-	1	-	1	-	-	-	86	9	8	17
67	M	17	11	3-4	1-2	1	-	1	-	-	-	89	19	9	28
68	M	17	11	5-6	-	1	1	-	-	-	-	85	12	6	18
69	M	17	11	3-4	1-2	-	1	-	1	-	-	92	13	17	30
70	F	17	11	3-4	1-2	1	-	-	-	-	-	97	10	10	20
71	M	17	11	5-6	-	1	-	-	-	-	-	83	13	6	19
72	M	16	11	5-6	-	1	-	-	-	-	-	64	11	14	25
73	F	17	11	3-4	1-2	1	1	-	-	-	-	105	17	18	35
74	M	16	11	5-6	-	1	-	-	-	-	-	78	9	10	19
75	M	17	11	3-4	1-2	1	-	-	-	-	-	82	5	8	13
76	M	17	11	5-6	-	1	1	-	-	-	-	81	16	13	29
77	M	16	11	5-6	-	1	-	-	-	-	-	84	11	14	25

School A (Continued)

Stu	Sex	Age	Grad	Semesters Mathematics: Conv	SMSG	Years Science: Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	PSSC Tests: 5	10	T
78	M	17	11	5-6	-	1	-	-	-	-	-	64	6	8	14
79	M	16	11	5-6	-	1	-	-	-	-	-	95	15	13	28
80	M	16	11	5-6	-	1	-	1	-	-	-	67	8	8	16
81	M	16	11	3-4	1-2	1	-	1	-	-	-	63	17	14	31
82	F	17	11	3-4	1-2	1	1	-	-	-	-	90	9	11	20
83	M	17	11	5-6	-	-	1	-	1	-	-	102	20	14	34
84	M	15	11	5-6	-	1	-	-	-	-	-	74	16	8	24
85	M	16	11	5-6	-	1	-	1	-	-	-	58	10	9	19
86	M	17	11	3-4	1-2	1	-	-	-	-	-	71	13	12	25
87	M	18	11	5-6	-	1	-	-	-	-	-	74	10	11	21
88	F	17	11	5-6	-	1	-	-	-	-	-	62	8	5	13
89	M	16	11	5-6	-	1	-	1	-	-	-	74	12	8	20
90	F	16	11	5-6	-	1	-	-	-	-	-	74	12	8	20
91	M	16	11	3-4	1-2	1	-	-	-	-	-	70	11	6	17
92	F	16	11	5-6	-	1	-	-	-	-	-	77	13	12	25
93	M	17	11	5-6	-	1	-	-	-	-	-	82	14	9	23
94	M	17	11	5-6	-	1	1	-	-	-	-	78	16	9	25
95	M	17	11	5-6	-	1	1	-	-	-	-	100	20	16	36
96	M	17	11	5-6	-	1	-	-	-	-	-	81	13	4	17
97	M	16	11	5-6	-	-	-	-	-	-	-	60	8	14	22
98	F	17	11	5-6	-	1	-	-	-	-	-	80	11	8	19
99	F	17	11	3-4	1-2	-	1	-	1	-	-	94	12	9	21
100	M	16	11	3-4	1-2	1	-	-	-	-	-	98	21	13	34
101	M	17	11	3-4	1-2	1	-	-	-	-	-	67	16	14	30
102	M	18	11	5-6	-	1	-	1	-	-	-	60	16	12	28
103	M	17	11	5-6	-	1	-	1	-	-	-	76	10	9	19
104	M	17	11	5-6	-	1	-	1	-	-	-	71	10	11	21
105	F	17	11	5-6	-	1	-	-	-	-	-	93	10	11	21
106	M	17	11	5-6	-	1	1	-	-	-	-	83	9	10	19
107	M	17	11	5-6	-	1	-	1	-	-	-	62	9	9	18
108	M	16	11	5-6	-	1	1	-	-	-	-	81	12	14	26
109	M	17	11	5-6	-	1	-	-	-	-	-	88	12	8	20
110	M	16	11	5-6	-	1	-	-	-	-	-	62	17	11	28
111	M	17	11	3-4	1-2	1	1	1	-	-	-	76	14	14	28
112	M	16	11	5-6	-	1	-	-	-	-	-	97	15	9	24
113	F	17	11	3-4	1-2	1	-	1	-	-	-	86	13	12	25
114	M	17	11	5-6	-	1	-	-	-	-	-	58	13	9	22
115	F	17	11	5-6	-	1	-	-	-	-	-	62	9	9	18
116	M	17	11	5-6	-	1	1	-	-	-	-	96	27	17	44
117	M	16	11	5-6	-	1	-	-	-	-	-	80	11	21	32
118	M	17	11	3-4	1-2	1	-	-	-	-	-	78	18	18	36
119	M	16	11	3-4	1-2	1	-	-	-	-	-	57	12	14	26
120	M	16	11	3-4	1-2	1	-	1	-	-	-	68	10	9	19

School A (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
121	F	16	11	5-6	-	1	-	-	-	-	-	96	19	16	35
122	M	16	11	5-6	-	1	-	-	-	-	-	69	13	11	24
123	M	17	11	3-4	1-2	1	-	-	-	-	-	74	16	11	27
124	F	17	11	5-6	-	1	-	1	-	-	-	80	13	-	-
125	M	16	11	5-6	-	1	-	1	-	-	-	81	9	13	22
126	M	16	11	3-4	1-2	1	-	1	-	-	-	64	10	12	22
127	M	17	11	5-6	-	1	-	1	-	-	-	51	9	12	21
128	M	17	11	3-4	1-2	1	-	1	-	-	-	76	10	9	19
129	M	17	11	3-4	1-2	1	-	-	-	-	-	93	14	17	31
130	M	17	11	3-4	1-2	1	-	1	-	-	-	82	13	10	23
131	F	17	11	1-2	3-4	1	-	1	-	-	-	81	17	10	27
132	F	17	11	5-6	-	1	-	-	-	-	-	86	20	9	29
133	M	16	11	5-6	-	1	-	1	-	-	-	65	7	9	16
134	M	17	11	5-6	-	1	1	-	-	-	-	80	11	10	21
135	M	16	11	5-6	-	1	-	-	-	-	-	78	11	12	23
136	M	16	11	5-6	-	1	-	-	-	-	-	81	14	7	21
137	M	18	11	3-4	1-2	1	-	1	-	-	-	74	12	4	16
138	M	16	11	5-6	-	1	-	-	-	-	-	81	12	10	22
139	F	17	11	5-6	-	1	-	-	-	-	-	81	8	9	17
140	M	17	11	3-4	1-2	1	-	-	-	-	-	84	13	12	25
141	M	17	11	3-4	1-2	1	1	-	-	-	-	84	13	15	28
142	M	16	11	5-6	-	1	-	1	-	-	-	62	15	11	26
143	F	16	11	5-6	-	1	-	-	-	-	-	77	13	10	23
144	M	18	11	5-6	-	1	-	-	-	-	-	79	15	12	27
145	F	17	11	3-4	1-2	1	-	-	-	-	-	79	6	5	11
146	M	16	11	3-4	1-2	1	1	-	-	-	-	87	7	12	19
147	M	16	11	5-6	-	1	1	-	-	-	-	90	13	9	22
148	M	17	11	5-6	-	1	-	1	-	-	-	54	6	12	18
149	M	16	11	5-6	-	1	-	1	-	-	-	54	13	11	24
150	M	17	11	3-4	1-2	-	-	-	1	-	-	99	19	19	38
151	M	17	11	3-4	1-2	1	1	-	-	-	-	106	18	13	31
152	M	17	11	5-6	-	1	-	1	-	-	-	75	16	17	33
153	M	16	11	5-6	-	1	-	-	-	-	-	81	15	15	30
154	M	17	11	5-6	-	1	-	-	-	-	-	83	9	10	19
155	M	16	11	3-4	1-2	-	-	-	1	-	-	78	15	11	26
156	M	16	11	5-6	-	1	-	-	-	-	-	87	13	9	22
157	M	17	11	5-6	-	1	-	-	-	-	-	60	9	11	20
158	M	16	11	3-4	1-2	1	-	-	-	-	-	77	15	10	25
159	M	16	11	5-6	-	1	1	1	-	-	-	78	7	11	18
160	M	16	11	5-6	-	1	-	1	-	-	-	56	6	5	11
161	F	17	11	5-6	-	1	-	-	-	-	-	102	8	10	18
162	M	17	11	5-6	-	1	-	-	-	-	-	58	10	9	19
163	F	16	11	3-4	1-2	1	1	-	-	-	-	79	15	12	27

School A (Continued)

Stu	Sex	Age	Grad	Semesters Mathematics Conv	SMSG	Years Science Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	PSSC Tests 5	10	T
164	M	16	11	5-6	-	1	-	1	-	-	-	76	10	11	21
165	F	16	11	5-6	-	-	-	-	1	-	-	90	16	12	28
166	M	17	11	3-4	1-2	1	1	-	-	-	-	88	19	17	36
167	F	17	11	3-4	1-2	1	1	-	-	-	-	95	22	15	37
168	M	17	11	5-6	-	1	-	-	-	-	-	83	10	8	18
169	M	16	11	3-4	1-2	1	-	1	-	-	-	77	11	15	26
170	M	16	11	5-6	-	1	-	-	-	-	-	77	14	9	23
171	F	16	11	3-4	1-2	1	-	-	-	-	-	91	18	12	30
172	M	16	11	5-6	-	1	-	1	-	-	-	88	10	15	25
173	M	16	11	5-6	-	1	-	-	-	-	-	81	12	14	26
174	M	17	11	3-4	1-2	1	-	-	-	-	-	92	10	13	23
175	M	17	11	3-4	1-2	1	1	-	-	-	-	98	24	16	40
176	M	17	11	3-4	1-2	1	-	1	-	-	-	96	16	10	26
177	M	17	11	5-6	-	1	-	-	-	-	-	72	18	10	28
178	M	17	11	5-6	-	1	-	-	-	-	-	92	18	17	35
179	M	16	11	3-4	1-2	1	-	-	-	-	-	97	14	-	-
180	M	17	11	3-4	1-2	1	-	-	-	-	-	83	18	12	30

School B

1	M	16	11	5-6	-	1	-	-	-	-	-	91	14	15	29
2	M	17	11	3-4	1-2	1	1	-	-	-	-	97	25	21	46
3	M	17	11	3-4	1-2	1	1	-	-	-	-	100	17	19	36
4	M	16	11	5-6	-	1	1	-	-	-	-	103	20	20	40
5	M	16	11	5-6	-	1	1	-	-	-	-	89	16	18	34
6	F	17	11	5-6	-	1	1	-	-	-	-	76	14	5	19
7	M	16	11	5-6	-	1	1	-	-	-	-	92	24	19	43
8	M	17	11	5-6	-	1	-	-	-	-	1	105	20	26	46
9	M	16	11	5-6	-	-	-	-	-	-	-	82	15	13	28
10	M	17	11	3-4	1-2	1	1	-	-	-	-	103	22	11	33
11	F	16	11	5-6	-	1	1	-	-	-	-	94	28	22	50
12	M	17	11	5-6	-	-	1	-	1	-	-	91	21	20	41
13	M	16	11	5-6	-	1	1	-	-	-	-	86	10	14	24
14	M	16	11	5-6	-	1	-	-	-	-	1	103	26	26	52
15	M	16	11	3-4	1-2	1	1	-	-	-	-	96	22	19	41
16	F	16	11	5-6	-	1	1	-	-	-	-	96	7	15	22
17	M	17	11	5-6	-	1	1	-	-	-	-	85	14	14	28
18	M	16	11	3-4	-	1	-	1	-	-	-	79	23	14	37
19	M	16	11	5-6	-	1	1	-	-	-	-	102	28	25	53
20	M	17	11	5-6	-	1	1	-	-	-	-	88	20	23	43
21	M	17	11	5-6	-	1	1	-	-	-	-	103	29	22	51

School B (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
22	M	17	11	5-6	-	1	-	-	-	-	-	100	21	20	41
23	M	16	11	5-6	-	1	-	-	-	-	1	97	26	27	53
24	M	17	11	5-6	-	1	-	-	-	-	-	94	20	18	38
25	M	17	11	3-4	1-2	-	-	-	1	-	-	98	21	15	36
26	F	17	11	5-6	-	1	1	-	-	-	-	95	18	25	43
27	M	17	11	5-6	-	1	-	1	-	-	-	97	22	15	37
28	M	18	12	3-4	1-2	-	1	-	-	-	-	63	17	13	30
29	F	18	12	3-4	1-2	1	1	-	-	-	-	96	22	24	46
30	F	18	12	3-4	1-2	1	1	-	-	-	-	100	20	20	40
31	F	17	12	3-4	1-2	1	1	-	-	-	-	68	12	16	28
32	M	17	12	3-4	1-2	-	1	-	1	-	-	95	24	22	46
33	F	18	12	7-8	1-2	1	1	-	-	-	-	94	15	19	34
34	M	17	12	3-4	1-2	-	1	-	-	-	-	87	18	12	30

School C

1	F	16	12	5-6	-	-	1	1	-	-	-	105	19	16	35
2	M	17	11	5-6	-	1	1	-	-	-	-	100	22	20	42
3	M	17	12	7-8	-	2	1	-	-	-	-	109	26	17	43
4	M	16	11	5-6	-	1	1	-	-	-	-	76	18	14	32
5	M	18	12	7-8	-	2	1	-	-	-	-	92	17	18	35
6	M	18	12	5-6	-	1	1	1	-	-	-	81	12	13	25
7	M	17	12	7-8	-	-	1	1	-	-	-	85	23	16	39
8	M	17	12	7-8	-	-	-	-	1	1	-	106	27	15	42
9	F	18	12	5-6	-	1	1	-	-	-	-	97	20	21	41
10	M	17	12	7-8	-	1	1	-	-	-	-	92	20	14	34
11	F	17	11	5-6	-	1	-	-	-	1	-	106	20	15	35
12	M	18	12	7-8	-	1	1	1	-	-	-	87	17	14	31
13	M	17	12	7-8	-	1	1	1	-	-	-	104	21	17	38
14	M	17	12	7-8	-	1	1	1	-	-	-	86	12	12	24
15	M	18	12	7-8	-	-	1	-	-	-	-	100	13	10	23
16	F	17	11	5-6	-	1	1	-	-	-	-	101	18	17	35
17	M	17	12	7-8	-	-	-	-	1	-	-	87	24	-	-
18	M	17	11	5-6	-	1	1	-	-	-	-	87	20	18	38
19	M	18	12	7-8	-	-	1	1	-	-	-	95	13	14	27
20	M	17	12	7-8	-	1	-	-	-	1	-	100	22	10	32
21	M	17	12	7-8	-	1	1	-	-	-	-	84	16	21	37
22	M	18	12	5-6	-	-	-	-	-	1	-	74	11	14	25
23	M	18	12	7-8	-	-	1	1	1	-	-	97	11	9	20
24	M	18	12	5-6	-	1	1	1	-	-	-	94	24	19	43
25	M	18	12	7-8	-	1	1	-	-	-	-	84	16	14	30

School C (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
26	M	16	11	5-6	-	1	-	-	-	1	-	102	19	-	-
27	M	16	11	5-6	-	1	1	-	-	-	-	96	22	17	39
28	M	18	12	7-8	-	1	1	-	-	-	-	84	20	22	42
29	M	17	12	7-8	-	1	-	-	-	1	-	90	16	16	32
30	F	18	12	5-6	-	1	1	1	-	-	-	80	16	13	29
31	F	18	12	7-8	-	1	1	-	-	-	-	93	13	-	-
32	M	17	11	5-6	-	1	-	1	-	-	-	91	16	7	23
33	M	18	12	7-8	-	-	1	1	-	-	-	82	22	14	36
34	M	18	12	7-8	-	1	1	-	-	-	-	87	23	13	36
35	F	17	11	5-6	-	1	-	-	-	1	-	93	14	13	27
36	F	17	11	5-6	-	1	-	-	-	1	-	108	24	13	37
37	M	17	12	7-8	-	1	1	-	-	-	-	95	21	15	36
38	F	17	12	5-6	-	1	-	-	-	-	-	110	24	15	39
39	M	16	10	3-4	-	1	-	-	-	-	-	105	22	18	40
40	M	17	11	5-6	-	1	-	1	-	1	-	89	17	14	31
41	F	17	12	5-6	-	1	1	-	-	-	-	104	23	10	33
42	M	17	12	5-6	-	1	1	1	-	-	-	79	14	7	21
43	M	17	12	7-8	-	-	-	1	-	-	-	104	20	23	43
44	M	17	12	7-8	-	1	1	1	-	-	-	96	20	13	33
45	M	17	12	5-6	-	1	-	-	-	1	-	88	26	20	46
46	F	17	12	5-6	-	1	-	-	-	-	-	98	23	-	-
47	M	17	12	7-8	-	-	1	1	1	-	-	97	23	14	37
48	M	18	12	7-8	-	1	1	1	-	-	-	104	15	14	29
49	M	18	12	5-6	-	1	1	-	-	-	-	96	16	19	35
50	M	18	12	7-8	-	1	-	-	-	1	-	90	15	9	24
51	M	17	12	3-4	-	1	-	1	-	1	-	89	23	10	33
52	M	17	11	5-6	-	1	1	-	-	-	-	99	25	19	44
53	M	17	12	7-8	-	1	1	-	-	-	-	83	12	17	29
54	F	18	12	7-8	-	2	1	-	-	-	-	106	16	18	34
55	M	18	12	7-8	-	1	1	-	-	-	-	94	22	21	43
56	M	17	11	5-6	-	1	-	-	-	1	-	102	20	13	33
57	M	18	12	7-8	-	-	1	1	-	-	-	90	22	18	40
58	M	17	11	5-6	-	1	-	-	-	1	-	103	19	11	30
59	M	17	12	5-6	-	-	-	1	-	-	-	80	14	10	24
60	M	18	12	7-8	-	-	-	1	1	1	-	93	16	16	32
61	F	17	12	7-8	-	-	1	-	-	-	-	107	18	16	34
62	M	17	12	7-8	-	-	1	1	-	-	-	97	19	12	31

School D

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
1	M	18	12	5-6	-	1	1	-	-	-	-	77	18	17	35
2	M	18	12	7-8	-	1	1	1	-	-	-	90	21	15	36
3	M	18	12	5-6	-	1	1	-	-	-	-	99	13	18	31
4	F	18	12	3-4	3-4	1	-	-	-	-	-	97	21	15	36
5	F	17	12	3-4	3-4	-	1	1	1	-	-	91	13	8	21
6	M	18	12	3-4	1-2	1	1	-	-	-	-	101	27	20	47
7	M	17	12	7-8	-	-	1	1	-	-	-	99	23	15	38
8	M	17	12	5-6	1-2	-	1	1	-	-	-	90	18	-	-
9	M	18	12	7-8	-	-	1	-	1	-	-	86	23	16	39
10	F	18	12	3-4	1-2	-	1	-	-	-	-	104	19	16	35
11	M	18	12	7-8	-	1	1	1	-	-	-	82	19	20	39
12	M	18	12	3-4	1-2	1	1	-	-	-	-	106	28	19	47
13	M	17	12	5-6	1-2	1	1	1	-	-	-	100	23	19	42
14	M	18	12	5-6	1-2	1	1	-	-	-	-	99	19	16	35
15	M	17	12	5-6	1-2	1	1	1	-	-	-	94	17	-	-
16	F	17	12	7-8	-	-	1	2	1	-	-	98	21	18	39
17	M	19	12	7-8	-	1	1	1	-	-	-	85	13	13	26
18	M	18	12	5-6	-	1	1	-	-	-	-	87	15	11	26
19	M	16	11	3-4	1-2	-	1	-	-	-	-	106	26	21	47
20	M	18	12	7-8	-	1	1	1	-	-	-	86	8	-	-
21	M	18	12	7-8	-	1	1	1	-	-	-	81	16	15	31
22	M	18	12	7-8	1-2	-	1	2	1	-	-	107	18	12	30
23	M	18	12	5-6	1-2	-	1	1	1	-	-	93	16	15	31
24	F	18	12	3-4	3-4	-	1	-	-	-	-	100	21	15	36
25	M	18	12	5-6	1-2	-	1	-	-	-	-	109	33	21	54
26	M	17	12	7-8	-	1	1	-	-	-	-	99	19	15	34
27	M	18	12	7-8	-	1	1	1	-	-	-	91	10	-	-
28	M	17	12	7-8	-	1	1	1	-	-	-	107	25	13	38
29	M	17	12	5-6	-	-	1	-	1	-	-	92	14	10	24
30	M	18	12	7-8	-	-	1	1	1	-	-	106	22	20	42
31	M	18	12	7-8	-	1	1	1	-	-	-	70	10	-	-
32	M	17	12	5-6	1-2	-	1	-	1	-	-	98	19	10	29
33	M	18	12	5-6	1-2	1	1	-	-	-	-	105	23	19	42
34	M	17	12	7-8	-	1	1	-	-	-	-	96	15	11	26
35	M	16	12	5-6	1-2	-	2	-	-	-	-	109	27	18	45
36	M	17	12	5-6	1-2	1	1	-	-	-	-	106	23	16	39
37	M	17	12	7-8	-	1	1	-	-	-	-	96	23	20	43
38	M	17	12	7-8	-	1	1	1	-	-	-	83	18	8	26
39	F	18	12	7-8	-	-	-	-	1	-	-	103	15	13	28
40	M	17	12	5-6	1-2	1	1	1	-	-	-	89	23	18	41
41	M	16	11	5-6	-	-	1	1	-	-	-	98	23	21	43
42	F	17	12	7-8	-	2	1	-	-	-	-	99	16	16	32
43	M	17	12	7-8	-	1	1	1	-	-	-	91	23	18	41

School D (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
44	M	18	12	3-4	3-4	-	2	1	-	-	-	93	26	16	42
45	M	18	12	5-6	1-2	1	1	-	-	-	-	92	15	15	30
46	M	17	12	7-8	-	-	1	-	1	-	-	96	16	8	24
47	M	17	12	5-6	1-2	-	1	1	1	-	-	103	21	11	32
48	M	17	12	7-8	-	-	1	-	1	-	-	95	17	17	34
49	M	17	12	5-6	1-2	1	1	1	-	-	-	107	28	17	45
50	F	18	12	3-4	1-2	1	1	1	-	-	-	105	18	14	32

School E

1	M	17	12	5-6	1-2	1	-	-	-	-	-	79	17	21	38
2	M	17	12	5-6	-	-	1	1	-	-	-	78	13	9	22
3	M	17	12	5-6	1-2	1	1	1	-	-	-	85	12	12	24
4	F	17	11	-	5-6	-	1	1	-	-	-	102	22	18	40
5	M	17	12	3-4	3-4	-	-	-	-	-	1	101	19	18	37
6	M	18	12	1-2	5-6	1	1	-	-	-	-	97	24	24	48
7	F	16	11	-	5-6	1	1	-	-	-	-	102	21	17	38
8	M	16	11	1-2	3-4	-	1	1	-	-	-	94	21	21	42
9	M	17	11	3-4	1-2	-	1	1	-	-	-	79	12	13	25
10	M	17	12	5-6	1-2	-	1	-	-	-	-	78	19	12	31
11	M	17	12	1-2	5-6	-	1	2	-	-	-	65	14	12	26
12	M	17	11	-	5-6	1	-	-	-	-	-	104	20	15	35
13	M	17	11	1-2	3-4	1	1	-	-	-	-	95	17	17	34
14	M	18	12	3-4	3-4	1	1	-	-	-	-	98	26	21	47
15	M	16	11	3-4	1-2	1	-	1	-	-	-	88	10	12	22
16	M	17	12	3-4	1-2	1	-	-	-	-	1	61	17	11	28
17	M	17	12	7-8	-	1	1	-	-	-	-	103	20	15	35
18	M	17	12	3-4	3-4	1	1	-	-	-	-	90	22	11	33
19	M	18	12	1-2	5-6	1	1	-	-	-	-	99	15	17	32
20	M	17	12	3-4	3-4	1	1	-	-	-	-	104	20	19	39
21	M	17	12	-	7-8	-	-	1	-	-	-	101	23	17	40
22	M	17	11	-	5-6	-	1	1	-	-	-	102	19	20	39
23	M	18	12	-	7-8	1	1	-	-	-	-	76	20	14	34
24	M	18	12	5-6	1-2	1	1	-	-	-	-	80	16	15	31
25	M	17	11	1-2	3-4	-	1	-	-	-	-	95	21	18	39
26	M	17	12	7-8	-	-	1	-	-	-	-	61	18	12	30
27	M	17	11	-	5-6	-	-	-	-	-	-	104	22	21	43
28	M	18	12	1-2	5-6	-	1	-	-	-	-	84	13	9	22
29	M	17	12	3-4	3-4	-	1	1	-	-	-	83	15	13	28
30	F	16	11	-	5-6	1	1	-	-	-	-	103	22	18	40
31	M	17	12	3-4	3-4	1	-	-	-	-	-	68	11	9	20

School E (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
32	M	16	11	-	5-6	1	1	-	-	-	-	96	19	13	32
33	F	17	11	-	5-6	-	1	1	-	-	-	102	21	15	36
34	M	18	12	3-4	-	1	1	-	-	-	-	65	5	10	15
35	M	18	12	5-6	1-2	1	1	-	-	-	-	91	13	14	27
36	M	17	11	1-2	3-4	-	1	1	-	-	-	85	14	17	31
37	M	17	11	1-2	3-4	-	1	1	-	-	-	84	17	16	33
38	M	17	12	7-8	-	-	1	1	1	-	-	92	22	21	43
39	M	18	12	5-6	1-2	1	-	1	-	-	-	76	17	18	35
40	M	17	12	3-4	1-2	1	-	-	-	-	-	92	12	14	26
41	M	16	11	1-2	3-4	-	1	1	-	-	-	85	18	13	31
42	M	18	12	3-4	3-4	-	-	1	-	-	1	92	20	16	36
43	M	17	12	1-2	5-6	1	1	-	-	-	-	91	16	8	24
44	M	16	11	-	5-6	1	1	-	-	-	-	101	22	20	42
45	M	18	12	1-2	5-6	1	1	1	-	-	-	101	28	17	45
46	M	18	12	3-4	3-4	-	1	-	-	-	-	95	21	17	38
47	M	18	12	1-2	5-6	1	-	1	-	-	1	91	23	16	39
48	F	17	12	1-2	5-6	1	1	-	-	-	-	101	18	17	35
49	M	17	11	3-4	1-2	-	-	1	-	-	1	77	8	17	25
50	M	18	12	-	7-8	1	1	-	-	-	-	103	18	17	35
51	M	16	11	1-2	5-6	1	1	-	-	-	-	96	23	17	40
52	M	16	11	1-2	3-4	-	1	-	-	-	-	101	20	17	37
53	M	17	11	1-2	3-4	-	1	1	-	-	-	96	22	14	36
54	M	18	12	3-4	3-4	1	-	-	-	-	1	84	12	14	26
55	M	17	12	1-2	5-6	1	1	-	-	-	-	98	16	18	34
56	M	16	11	-	5-6	-	1	-	-	-	-	105	16	18	34
57	M	18	12	3-4	3-4	1	-	1	-	1	-	87	16	16	32
58	M	17	11	1-2	3-4	-	1	1	-	-	-	94	20	23	43
59	M	18	12	1-2	5-6	-	1	-	-	-	-	94	22	12	33
60	F	17	11	-	5-6	-	1	1	-	-	-	98	20	15	35
61	M	17	12	1-2	5-6	-	-	-	-	-	1	96	21	17	38
62	M	18	12	1-2	5-6	-	1	-	-	-	-	95	25	18	43
63	M	18	12	1-2	5-6	1	-	-	-	-	1	107	24	24	48
64	M	17	12	1-2	5-6	1	1	-	-	-	-	94	20	19	39
65	M	17	11	-	5-6	1	1	-	-	-	-	89	20	19	39
66	F	16	11	-	5-6	-	1	1	-	-	-	92	18	11	29
67	M	18	12	-	7-8	1	1	-	-	-	-	103	26	17	43
68	M	17	12	1-2	5-6	-	1	-	-	-	-	107	28	22	50
69	F	17	12	1-2	5-6	1	1	-	-	-	-	108	32	31	63
70	M	18	12	3-4	3-4	1	1	1	-	-	-	102	21	18	39
71	M	17	11	1-2	3-4	1	-	-	-	-	1	83	17	15	32
72	M	17	12	1-2	5-6	-	-	3	-	-	1	82	18	11	29
73	M	17	12	1-2	5-6	1	1	-	-	-	-	97	14	14	28
74	M	17	12	1-2	5-6	1	1	-	-	-	-	79	16	17	33

School E (Continued)

Stu	Sex	Age	Grad	Semesters Mathematics Conv	SMSG	Years Science Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	PSSC Tests 5	10	T
75	M	17	12	1-2	5-6	1	1	-	-	-	-	96	21	17	38
76	M	17	12	1-2	5-6	1	1	-	-	-	-	91	17	12	29
77	M	18	12	1-2	5-6	1	1	-	-	-	-	101	28	22	40
78	M	18	12	1-2	5-6	1	1	1	-	-	-	91	20	13	33
79	M	17	12	1-2	5-6	-	1	4	-	-	-	88	18	10	28
80	F	17	12	1-2	5-6	1	1	-	-	-	-	100	17	-	-
81	M	18	12	1-2	5-6	1	1	-	-	-	-	102	17	17	34
82	M	17	12	3-4	1-2	1	1	-	-	-	-	94	16	14	30
83	F	17	11	1-2	5-6	1	1	-	-	-	-	107	18	21	39
84	M	17	12	1-2	5-6	1	1	-	-	-	-	99	24	13	37
85	F	18	12	-	7-8	1	1	-	-	-	-	93	19	10	29
86	M	19	12	5-6	-	1	-	1	-	-	-	72	9	-	-
87	M	17	12	5-6	1-2	1	1	1	-	-	-	96	15	19	34
88	M	17	12	1-2	5-6	1	1	-	-	-	-	99	18	-	-
89	M	17	12	3-4	1-2	1	-	-	-	-	1	99	21	17	38
90	M	18	12	1-2	5-6	1	1	1	-	-	-	108	31	33	64

School F

Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
1	M	16	11	1-2	3-4	1	-	1	-	-	1	96	17	6	23
2	M	19	12	3-4	3-4	1	-	2	-	-	-	94	16	5	21
3	M	16	11	1-2	1-2	1	1	2	-	-	-	99	20	16	36
4	M	17	11	1-2	3-4	1	-	-	-	-	1	107	18	14	32
5	M	16	11	1-2	3-4	1	-	3	-	-	-	92	22	15	37
6	M	16	11	3-4	1-2	1	1	-	-	-	-	103	20	12	32
7	M	17	11	1-2	3-4	1	1	-	-	-	-	98	22	14	36
8	M	17	11	1-2	3-4	1	-	-	-	-	1	100	21	10	31
9	M	16	11	1-2	3-4	1	1	1	-	-	-	101	19	8	27
10	F	17	11	1-2	3-4	1	1	-	-	-	-	98	22	16	38
11	M	17	12	3-4	3-4	1	1	1	-	-	-	85	13	11	24
12	M	18	12	5-6	3-4	1	-	-	-	-	1	87	21	13	34
13	M	17	11	1-2	3-4	1	1	-	-	-	-	98	17	16	33
14	M	17	11	3-4	1-2	1	-	1	-	-	1	105	20	12	32
15	M	17	11	3-4	1-2	1	1	1	-	-	-	99	19	14	33
16	M	17	12	7-8	-	1	1	1	-	-	-	93	19	16	35
17	M	18	12	3-4	3-4	1	1	1	-	-	-	78	12	6	18
18	F	16	11	1-2	3-4	1	-	1	-	-	1	55	19	12	31
19	F	17	11	1-2	3-4	1	-	-	-	-	1	108	23	10	33
20	F	17	11	1-2	3-4	1	1	-	-	-	-	103	21	16	37
21	M	16	11	3-4	3-4	1	-	-	-	-	1	98	18	9	27
22	M	16	11	1-2	3-4	1	1	-	-	-	-	85	17	15	32

School F (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
23	F	16	11	3-4	1-2	1	1	-	-	-	-	102	19	-	-
24	F	17	11	3-4	1-2	1	1	-	-	-	-	95	19	9	28
25	M	18	12	-	3-4	1	-	1	-	-	1	86	12	9	21
26	M	18	12	3-4	3-4	1	1	1	-	-	-	80	7	10	17
27	F	18	12	3-4	3-4	1	1	1	-	-	-	99	17	14	31
28	M	18	12	5-6	1-2	1	1	1	-	-	-	82	13	8	21
29	M	17	11	1-2	3-4	1	1	-	-	-	-	103	20	16	36
30	M	17	12	3-4	3-4	1	-	-	-	-	1	109	22	14	36
31	M	17	12	3-4	3-4	1	-	1	-	-	1	98	24	14	38
32	M	18	12	3-4	3-4	1	1	1	-	-	-	67	15	9	34
33	F	17	12	1-2	3-4	1	-	1	-	-	-	84	10	9	19
34	M	17	12	5-6	1-2	1	1	4	-	-	-	82	17	8	25
35	M	17	12	5-6	1-2	-	1	1	-	-	-	71	20	14	34
36	M	18	12	3-4	3-4	1	1	1	-	-	-	98	17	15	32
37	F	18	12	3-4	1-2	1	1	1	-	-	-	97	13	12	25
38	M	18	12	3-4	3-4	1	1	1	-	-	-	86	16	12	28
39	M	16	11	5-6	-	1	-	1	-	-	-	75	21	18	39
40	F	17	12	5-6	-	1	1	2	-	-	-	67	8	14	22
41	F	17	12	7-8	-	1	1	-	-	-	-	83	13	7	20
42	M	18	12	3-4	3-4	1	1	1	-	-	-	93	19	17	36
43	M	17	11	3-4	1-2	1	1	-	-	-	-	84	21	20	41
44	M	17	12	3-4	1-2	1	1	1	-	-	-	91	11	7	18
45	M	17	11	1-2	3-4	1	-	-	-	-	1	87	17	8	25
46	M	16	11	1-2	3-4	1	1	-	-	-	-	100	20	12	32
47	M	16	11	3-4	1-2	1	-	1	-	-	1	99	22	21	43
48	M	17	12	5-6	1-2	1	1	1	-	-	-	95	15	6	21
49	M	18	12	3-4	3-4	1	-	2	-	-	-	83	20	17	37
50	M	18	12	3-4	3-4	1	1	1	-	-	-	85	17	16	33
51	M	17	11	1-2	3-4	1	1	-	-	-	-	106	30	20	50
52	M	17	11	1-2	3-4	1	1	-	-	-	-	79	16	8	24
53	M	18	12	5-6	1-2	1	-	1	-	-	1	104	19	15	34
54	M	17	11	1-2	3-4	1	1	-	-	-	-	104	26	18	44
55	M	18	12	3-4	1-2	1	1	1	-	-	-	95	15	9	24
56	M	17	12	3-4	3-4	1	1	1	-	-	-	92	18	15	33
57	M	17	12	3-4	3-4	1	1	1	-	-	-	93	24	12	36
58	M	18	12	3-4	3-4	1	1	1	-	-	-	98	19	12	31
59	F	17	12	3-4	3-4	1	1	1	-	-	-	83	18	8	26
60	M	17	11	1-2	3-4	1	1	-	-	-	-	100	19	18	37
61	M	17	12	5-6	-	1	1	-	-	-	-	98	21	15	36
62	M	17	12	5-6	-	1	-	1	-	-	1	49	17	13	30
63	M	17	11	5-6	-	1	-	1	-	-	1	85	13	13	26
64	M	17	11	1-2	5-6	1	1	-	-	-	-	99	18	15	33
65	M	18	12	3-4	3-4	1	-	4	-	-	1	83	22	16	38

School F (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
66	M	17	12	3-4	1-2	1	1	1	-	-	-	87	15	9	24
67	M	17	12	5-6	1-2	1	1	1	-	-	-	96	20	9	29
68	F	17	12	3-4	3-4	1	1	1	-	-	-	97	18	9	27
69	M	17	11	1-2	3-4	1	1	-	-	-	-	93	20	12	32
70	M	17	12	5-6	1-2	1	1	1	-	-	-	100	18	15	33
71	M	17	12	7-8	-	1	1	1	-	-	-	85	16	9	25
72	M	17	11	3-4	-	1	-	1	-	-	-	57	12	8	20
73	M	17	11	1-2	3-4	1	1	-	-	-	-	99	16	13	29
74	M	17	12	3-4	3-4	1	-	1	-	-	1	98	20	14	34
75	M	18	12	5-6	1-2	1	1	-	-	-	-	84	20	17	37
76	M	18	12	1-2	3-4	1	1	1	-	-	-	98	18	12	30
77	M	17	12	3-4	3-4	1	1	1	-	-	-	70	12	15	27
78	F	16	11	1-2	3-4	1	1	-	-	-	-	102	17	9	26

School G

1	F	18	12	1-2	5-6	1	1	1	-	-	-	106	18	19	37
2	M	17	11	-	5-6	1	-	-	-	-	-	100	15	18	33
3	M	17	12	1-2	5-6	1	-	1	-	1	-	109	26	28	54
4	M	16	11	-	5-6	1	1	-	-	-	-	100	18	16	34
5	M	16	12	1-2	5-6	1	1	-	-	-	-	100	19	20	39
6	M	17	12	3-4	3-4	-	-	1	-	1	-	96	21	13	34
7	M	17	11	-	5-6	1	-	-	-	1	-	105	19	18	37
8	M	17	12	1-2	1-2	-	-	3	-	1	-	104	21	-	-
9	F	18	12	1-2	5-6	1	-	-	-	-	-	101	18	17	35
10	M	17	12	3-4	3-4	1	-	1	-	1	-	92	22	16	38
11	M	18	12	3-4	3-4	1	-	1	-	1	-	92	10	19	29
12	M	19	12	5-6	1-2	1	-	1	-	1	-	59	10	11	21
13	F	17	12	3-4	1-2	-	-	-	-	1	-	80	18	22	40
14	M	18	12	1-2	5-6	1	1	1	-	-	-	98	23	12	35
15	M	17	11	1-2	3-4	1	-	1	-	1	-	107	30	28	58
16	M	17	12	1-2	5-6	1	-	1	-	1	-	98	24	14	38
17	M	18	12	3-4	3-4	-	-	1	-	-	-	101	19	16	35
18	M	17	11	3-4	1-2	-	-	3	-	-	-	99	7	12	19
19	M	17	12	1-2	5-6	-	-	1	-	1	-	105	19	16	35
20	M	18	12	1-2	5-6	-	1	1	-	-	-	108	13	-	-
21	M	18	12	5-6	1-2	1	-	-	-	1	-	96	16	19	35
22	M	18	12	1-2	5-6	-	-	3	-	-	-	108	21	16	37
23	M	18	12	3-4	3-4	1	-	-	-	-	-	92	15	15	30
24	M	17	12	3-4	3-4	1	-	-	-	-	-	98	15	18	33
25	M	17	11	1-2	5-6	1	-	-	-	1	-	101	18	-	-

School G (Continued)

				Semesters Mathematics		Years Science							PSSC Tests		
Stu	Sex	Age	Grad	Conv	SMSG	Biol	Chem	Othe	BSCS	CHEM	CBA	SCAT	5	10	T
26	M	18	12	3-4	1-2	1	-	-	-	-	-	84	14	18	32
27	M	18	12	1-2	5-6	1	-	-	-	1	-	102	30	20	50
28	M	18	12	3-4	3-4	-	-	1	-	1	-	90	19	19	38
29	F	18	12	3-4	3-4	1	-	1	-	1	-	106	18	22	40
30	M	18	12	1-2	5-6	1	1	-	-	-	-	100	15	15	30
31	M	17	12	3-4	3-4	1	-	-	-	1	-	90	11	4	15
32	M	17	12	3-4	3-4	-	-	3	-	1	-	92	17	15	32
33	M	17	12	1-2	5-6	1	-	1	-	1	-	87	8	11	19
34	F	16	11	3-4	1-2	1	-	-	-	-	-	79	12	10	22
35	M	17	12	5-6	1-2	1	-	1	-	1	-	109	22	20	42
36	M	17	12	5-6	1-2	1	1	-	-	-	-	86	15	13	28
37	M	17	12	3-4	3-4	1	-	-	-	1	-	97	11	14	25
38	F	17	12	7-8	-	1	-	-	-	1	-	104	12	15	27
39	M	18	12	3-4	3-4	-	-	1	-	1	-	99	22	20	42
40	M	17	12	3-4	3-4	-	-	4	-	-	-	90	8	17	25
41	M	18	12	3-4	1-2	1	-	-	-	-	-	60	19	15	34
42	M	18	12	5-6	1-2	1	-	-	-	1	-	100	18	-	-
43	M	18	12	1-2	5-6	1	-	1	-	-	-	93	10	18	28
44	F	18	12	1-2	3-4	-	-	-	-	-	-	83	7	10	17
45	F	17	12	5-6	1-2	1	-	1	-	1	-	100	13	-	-
46	M	18	12	5-6	1-2	1	-	-	-	1	-	94	10	-	-

VITA

Paul Berndt Ackerson

Candidate for the Degree of

Doctor of Education

Thesis: A STUDY OF THE RELATIONSHIP BETWEEN ACHIEVEMENT IN PSSC PHYSICS AND EXPERIENCE IN RECENTLY DEVELOPED COURSES IN SCIENCE AND MATHEMATICS

Major Field: Higher Education.

Biographical:

Personal Data: Born near Funk, Nebraska, October 10, 1919, the son of Bert E. and Johanna C. Ackerson.

Education: Attended elementary school at Funk and Mead, Nebraska; graduated from Wahoo High School, Wahoo, Nebraska, in 1936; graduated from Luther Junior College, Wahoo, Nebraska, in 1938; received the Bachelor of Science degree from the University of Omaha, with a major in Education, in 1947; received the Master of Science degree from the University of Omaha, with a major in Education, in 1952; selected as a participant in the Academic Year Institute for High School Science Teachers at the Oklahoma State University, in 1958; received the Master of Science degree from the Oklahoma State University, with a major in Natural Science, in 1959; awarded National Science Foundation Summer Fellowship for Secondary School Teachers for 1959 through 1964; completed the requirements for the Doctor of Education degree in May, 1965.

Professional Experience: Appointed superintendent in the Memphis, Nebraska Public Schools in 1938; enlisted in the United States Naval Reserve in 1941; served on active duty on the USS DENVER; discharged in 1945; appointed as science teacher at Benson High School, Omaha, Nebraska, in 1945; appointed as part-time instructor at the University of Omaha in 1955; appointed as science department head at North High School, Omaha, Nebraska, in 1959; appointed part-time instructor in the Department of Education at the Oklahoma State University in 1962; member Omaha Education Association, Nebraska State Teachers Association, National Education Association, National Science Teachers Association, and Phi Delta Kappa.