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DIEHL, Tenneson Handley Thomas, 1925-
A STUDY OF ATTITUDE AND THOUGHT PATTERN CHANGES RESULTING FROM THE USE OF A PHYSICAL SCIENCE COURSE FOR NONSCIENCE MAJORS,

The Ohio State University, Ph.D., 1967
Education, general

University Microfilms, Inc., Ann Arbor, Michigan
A STUDY OF ATTITUDE AND THOUGHT
PATTERN CHANGES RESULTING FROM THE
USE OF A PHYSICAL SCIENCE COURSE
FOR NONSCIENCE MAJORS

DISSERTATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by
Tennieson Handley Thomas Diehl, B.A., M.S.

* * * * * *

The Ohio State University
1967

Approved by

[Signature]
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ACKNOWLEDGMENTS

My gratitude and appreciation are extended to all who offered words of encouragement and assistance during this study.

My deepest expression of gratitude is offered my adviser, Dr. John S. Richardson, whose encouragement and guidance have been so vital to this study. The understanding of related problems and his kind suggestions have been a source of inspiration.

I wish also to acknowledge the helpful guidance of other members of my committee, Dr. Frederick R. Cyphert, Dr. Earl W. Anderson (deceased), and Dr. Kenneth Arisman.

My thanks are extended to Dr. Lewis G. Bassett of Rensselaer Polytechnic Institute and Dr. Elizabeth Wood of Bell Telephone Laboratories for the privilege of working with and evaluating the Physical Science for Nonscience Majors project.

Appreciation is given to Dr. James M. Hagedard, now of the University of Michigan, for his counselling in the various statistical problems and to Mr. Arthur Fiser for his assistance on the computer.

Appreciation is extended to Dr. C. Neale Bogner, Dean of the School of Education, and Dr. H. I. Von Haden, Chairman of the Department of Instruction, both of Miami University for their encouragement.

Special thanks is due Dr. Charles E. Teckman, Assistant Dean of the Graduate School of Miami University, for his many hours of guidance in the preparation of the final draft.
Acknowledgment is made to Dr. Alice Barter and Mr. James Eby for proof reading the manuscript.

Deep appreciation is extended to my wife for her many hours and fine work in typing the final manuscript. Also to my wife, Barbara, and my two sons, Eddie and Eric, my deepest love and appreciation for their patience, encouragement, and sacrifice through the years of my graduate study.
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CHAPTER I

INTRODUCTION

Background of PSNS Development

A few chemists and physicists have recognized that deficiencies exist in their introductory college courses. These deficiencies are concerned with the ability to relate science, its methods and processes to the understanding required of the layman in the everyday world.

The Advisory Council on College Chemistry and the Commission on College Physics called a conference in September, 1963, to study course work available in the physical sciences in general education. Specifically they were concerned about the science course offerings available for nonscience majors and more particularly the science course offerings available for the pre-service elementary teacher. From this conference a recommendation was made that a one-year unified course of chemistry and physics be designed.

The recommendation stimulated two further conferences. The first of these was held at Rosemont, Pennsylvania, in October, 1963. The discussion from the Rosemont conference on physical science for nonscience majors was continued at Boulder, Colorado\(^1\), in July, 1964.

From these conferences, held in September, 1963, October, 1963, and

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and July, 1964, grew a fourth conference which was called in September, 1964, at Rensselaer Polytechnic Institute. This fourth conference met for the purpose of requesting aid for the development of such a unified physical science course. The proposal for development of this course was accepted and the resultant project funded by the National Science Foundation.

The proposal at the outset was designed to provide a terminal course in the physical sciences. Emphasis in the unified physical science course was "... to develop in the student a sympathetic attitude toward science and an understanding of the nature of physical science." Ample time for reflective thought, however, was to be provided within the framework of scientific experimentation. This concept led to several themes which were planned to demonstrate principles of conservation and quantification. The proposed course was not designed to be a course in methodology.

Between September, 1964, and May, 1965, a unified course outline was developed by PSNS leaders. The course outline was designed in part to meet some of the objectives stipulated in the proposal to the National Science Foundation. Also by May, 1965, a writing staff had been obtained which met at Rensselaer Polytechnic Institute for orientation to the writing task to be accomplished during the summer of 1965. At the time of the orientation meeting this author was invited to participate in the project. By then the project had

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acquired the title, Physical Science for the Non-Scientist and was abbreviated, PSNS.

Materials suggested for the project during the winter of 1964-65 were used in the summer, 1965, writing conference held at Rensselaer Polytechnic Institute. At the summer writing conference seventeen teaching units were written and later printed and distributed to eight colleges and universities including Miami University. Each of these schools participated in the trial program of the project during the academic year 1965-66. The schools which participated in the initial trials of the PSNS curriculum materials, were Ball State University, Earlham College, Miami University, Montana State College, State University College of Geneseo, Webster College, Western College for Women, and West Chester State College. For location of these schools the reader should refer to the map in Appendix I.

Instructors from the colleges and universities involved in the trial use of the PSNS materials during the fall of 1965 met in New York City in January, 1966, to evaluate and to assess the program. This conference, which had been stipulated in the National Science Foundation proposal, dealt with problems of manuscript and laboratory manipulation. Participants compared notes at the subjective level on methods of teaching. Since the conference was quite subjective in nature, little objective evidence was obtained to allow for a concrete appraisal of the use of the PSNS materials.

Instructors from the eight schools met again at Rensselaer Polytechnic Institute at the end of the academic year in June, 1966.
Further evaluation of the curriculum materials was undertaken at that time. Evaluation at this conference was based upon the subjective judgment of each instructor involved in the trial use of the PSNS materials during the academic year 1965-66. Primary attention of this conference centered on the technical matters of manuscript rather than on the effectiveness of the project in creating positive attitudes toward science in the participating students.

The Use of PSNS Curriculum Materials at Miami University

The initial trial of the PSNS materials at Miami University was undertaken as a "dry-run" which involved no objective testing. The "dry-run", which took place during the fall trimester of 1965, utilized the services of elementary teacher candidates enrolled in Education 181. Although each elementary teacher candidate involved in the "dry-run" had a copy of the PSNS curriculum materials, only the longer laboratory experiments were used with this group. The "dry-run" was conducted under the guidance of this instructor as well as under the guidance of graduate assistants. The "dry-run" enabled this researcher to familiarize himself with manuscript and technical interpretations required to teach such a physical science course adequately. This "dry-run" of the PSNS curriculum materials also afforded an opportunity to learn the interpretations that students may give these materials.

The "dry-run" of the PSNS materials was designed so that a comparable level of competency on the part of this instructor could be
maintained between an experimental trial of the PSNS materials and a control situation using the conventional course materials.

The actual research situation, which involved objective testing, was undertaken during the winter and spring of 1966. Two groups were subjected to objective test measures. One of these two groups was designated experimental. The experimental group utilized the PSNS curriculum materials during the trimester. The second of these two groups was designated control. The control group utilized materials normally employed in the general education course at Miami University. The two groups used in this research were not selected by any pre-course criteria. Rather, the experimental and control groups were selected solely on the basis of chance factors related to registration procedures of Miami University.

Even though no pre-course criteria was utilized to organize either experimental or control samples, it was recognized by this researcher that students usually come to such physical science courses with varying attitudes and thought patterns. Objective evaluation in both the pre-course and post-course situations in this research tested for rigidity of thought and the understanding of the role of science in society. Both rigidity of thought and the understanding of the role of science in society were considered as attitudes in this research. It is these attitudes, which may be developed through the use of the PSNS materials, that the elementary teacher candidate may carry into the elementary classroom. This research is specifically concerned with the resultant attitudes that a student may acquire through the use of the PSNS curricular materials.
Statement of Problem

This study was concerned with the attitudes of elementary teacher candidates toward science, specifically whether the use of PSNS curricular materials would positively influence the attitudes of elementary teacher candidates toward science.

Hypotheses

The following hypotheses were tested in this study:

1. The use of PSNS pervasive laboratory experiences provide a better attitude of open-mindedness toward science than the use of traditional procedures in the teaching of college physical science.

2. The use of PSNS curricular materials provide a greater understanding of the role of science in contemporary society.

Importance of Problem

A general education course at the college level is herein defined as a course designed for all students. The PSNS course, limited to elementary teacher candidates in this research, is considered to be a facet of science in general education.

The need to teach science within the sphere of general education has been recognized by scientists for many years. This researcher suspected that science courses taught for the purpose of general education in many institutions of higher learning fall short of the goal of interesting the future elementary teacher in science and the
teaching of science. The PSNS project was designed with objectives which led to the development of materials that would convey the enjoyment of science to the future elementary teacher and the nonscience major. Since no objective measure was established in the initial PSNS project, evaluation of the effectiveness in conveying the enjoyment of science to the elementary teacher candidate and the nonscience major needs to be undertaken. Such evaluation would attempt to understand objectively whether the efforts of this project have been fully realized.

The efforts of this project were guided by a set of goals established by the PSNS leaders. These goals were to be accomplished in a unified physical science course to be developed at Renssalaer Polytechnic Institute during the summer of 1965. Unfortunately, however, no adequate objective method of measurement had been included in the proposal to the National Science Foundation. Such objective measurement admittedly is difficult to obtain. When no attempt is made to measure these goals objectively, however, the relative worth of the project can only be judged upon assumptions subjectively measured which would be unable to stand the test of objective scrutiny.

Objective measurement, it was believed by this researcher, might determine the direction and/or the emphasis of the PSNS project during revision. Such measurement might also act as a guide to future writing ventures of this nature. Objective measurement of the entire scope of the PSNS project, however, would be a monumental task. Such
comprehensive measurement of the PSNS project would objectively evaluate each of the stated as well as the implied goals which were to have been incorporated in the PSNS curriculum materials. A comprehensive measurement of this nature would also have involved many parallel studies each dwelling upon a limited area of interest, such as, academic achievement, the development of scientific concepts, the ability to apply science, the ability to analyze data, the ability to interpret data, the ability to ask sensible questions about science, the ability to create a positive "open-minded" attitude toward science, and the ability to create a greater understanding of the role of science in society. The investigation of the PSNS curricular materials engaged in by this researcher was limited to a few areas involving open-mindedness and the understanding of the role of science in contemporary society. The limited goals tested in this research are stipulated in the hypothesis on page 6.

Scope of the Study

This experiment was performed in Education 181, a general education science course at Miami University. All students in the class were elementary teacher candidates. Although the course is not required, students take this course in lieu of two years of physical science from the specific academic subject areas. Frequently, students have no other college physical science, although a few do enroll in the two year physical science alternative.

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3 Minutes of the Faculty of the School of Education, Miami University, March 9, 1965.
Two sections of the Education 181 general education science course, each with twenty-five students, were utilized in this research. One section was designated experimental and the other control. The two sections kept their identity in both the "lecture" and the laboratory experiences. This researcher taught both the experimental and the control groups in both the lecture and the laboratory sessions to minimize differences which might be attributed to the individual instructor rather than to the program being tested. The experimental group was exposed to laboratory experiences almost constantly, although many were of short duration. Longer laboratory experiences for the experimental group were reserved for the two-hour block of time normally scheduled each week within the course for the purpose of laboratory work. The laboratory experiences used with the experimental group were those devised at Renssalaer Polytechnic Institute during the summer writing conference of 1965. The laboratory time for the control sample was limited to the two-hour block of time scheduled per three fifty-minute lecture periods. No laboratory experiences for the control group were used during the three fifty-minute lecture periods. The laboratory exercises utilized by the control group were those devised primarily by the physical science staff of Miami University. None of the laboratory experiments in either the control or experimental situations were devised by this researcher.

Subject matter in the experimental sample was used to the extent that similar material was studied in the control sample.
Principles generally related to physics were studied in both samples during the one trimester. Extension of the study beyond one trimester was not feasible, since the cases in the sample would again be rearranged through the chance factors of registration. Such rearrangement would have destroyed the experimental design.

Sampling of the cases within this investigation was dependent upon the chance factors of registration at Miami University. Since all students registering for the Education 181 physical science course were elementary teacher candidates, it was thought that pre-course environmental factors might be similar between the experimental and control groups. Nevertheless, the small samples involved in this research necessitated careful scrutiny of a variety of aspects which might exist between two populations. These aspects were statistically treated to minimize differences which may have been initially or concurrently existent at the time of this research.

**Overview of the Study**

The PSNS project from the embryonic to the experimental stage of development has been traced in this chapter. The summer writing conference of 1965 and the relationship of the role of Miami University to the experimental phase of the project was indicated. The problem was stated and hypotheses to be tested have been presented. A discussion of the importance of the problem was followed by the scope of the study that explained the boundaries of the research.

Chapter two will present an historical background to general education with an emphasis on science as a part of general education.
Research on science in general education and particularly research of laboratory usage will be reported. In conclusion, the research on attitudes relevant to science will be presented.

Chapter three will describe and analyze the sample used in this study and will give a description of the measuring instruments utilized. The general design of the study and its scope will be presented. The controls of the experiment will be explained.

Chapter four will offer the data and will state analysis through mathematical computation. In addition, student and instructor reactions will be summarized for both experimental and control samples.

Chapter five will summarize the study and will offer conclusions and submit recommendations that might be explored in other ESNS programs as well as in science education generally.

Summary

The Advisory Council on College Chemistry and the Commission on College Physics jointly considered the plight of college physical science for nonscience majors. The funding by the National Science Foundation made a writing conference in the summer of 1965 a reality. At this writing conference physical science curricular materials for the nonscience major were produced. These were later tried in eight colleges during the academic year, 1965-66.

The use of these curricular materials was evaluated in order to answer the question of what influence this course may have had on a limited area of participating student attitudes. The problem of this research is directly concerned with positive attitudes and the
understanding of the role of science in society. These positive attitudes, that may be created by the PSNS approach, are thought by this researcher to be important since those enrolled in this physical science course will be teaching in the elementary school. The attitudes and the understandings acquired through the use of the PSNS curricular materials will perhaps have an effect on their elementary teaching.

Miami University participated in the experimental use of the PSNS curricular materials and evaluated their usage relative to attitude and understanding during one trimester. Specifically, the evaluation attempted to measure whether the use of the PSNS materials would provide a better open-mindedness toward science and whether it would provide a greater understanding of the role of science in contemporary society.

There is recognition of the importance of the problem involving attitude and understanding of physical science in that present physical science courses fall short of interesting elementary teacher candidates in the physical sciences. As a recognition of this need, the PSNS leaders set up some goals to be accomplished in the course. Adequate objective method of measuring these goals, however, was not provided.

Objective measurement was made in this research on two limited goals stipulated in the hypothesis. The classes upon which the testing was performed were designated experimental and control. Both experimental and control groups were small, but pre-course
environmental factors, which may have altered the outcomes, were statistically treated to minimize such factors.
CHAPTER II

HISTORICAL BACKGROUND AND RELATED RESEARCH

Development of Physical Science in General Education

Earliest accounts of general education, according to Mayhew, appeared in 1837\(^1\) as a representation of man's need to keep abreast of technological and cultural changes. Moosnick\(^2\) found in his search of the literature that the beginning of a general education course evolved from Columbia College's course, "Contemporary Civilization," first offered about 1919. This he indicated was a milestone in course change. The University of Chicago, Colgate, and Dartmouth College\(^3\) in the 1920's developed courses in general education for the nonscience major. This development was a part of an emerging pattern in course innovation and experimentation in higher education.

These early accounts of course innovation were reflected in a speech on general education given by Krauskopf at Florida University in 1950. According to a transcription of this talk, Krauskopf


\(^2\) Monroe Moosnick, "An Exploration of General Education in the Natural Sciences" (unpublished Ph.D. dissertation, School of Education, Indiana University, 1962.)

stated ". . . dissatisfaction with science training afforded non-
science majors in the elementary courses first became acute in the
1920's."^4 Meikeljohn, considered a pioneer in general education be-
cause of his work at Amherst and then the University of Wisconsin,^5
also tried to develop courses in this area. Although Meikeljohn may
have been a little precocious in his thoughts on the matter, the de-
velopment of general education courses gained momentum. Generally
the development of experiments in general education were in three
forms: (1) Newer methods of conducting laboratory and lecture pre-
sentation; (2) survey courses covering several sciences; and
(3) watered down versions of the traditional course. Much later the
rigorous treatment of a few subject matter blocks was tried.

Development and experimentation of general education, according
to Krauskopf,^6 continued through the 1930's and spread to other in-
stitutions, gaining momentum in the 1940's. As an outgrowth of this
experimentation, many university leaders reassessed their outlook on
general education.

James B. Conant, President of Harvard University, gave impetus
to the general education movement through his leadership with a facul-
ty committee there in the widely heralded report, General Education

^4Konrad B. Krauskopf, "Science in General Education at Mid-


^6Krauskopf, loc. cit.
in a Free Society. This report proposed a definitive science course in general education, by way of contrast to work done at Colgate. Such a course, he believed, should have a core of physics and include chemistry, astronomy, and geology. He indicated, however, that descriptive astronomy and chemistry would probably be omitted. The following quotation explains the thought that he had in conceiving such a course:

The emphasis on historical development in this course is in no sense to constitute merely a humanistic garnishing of its factual material. On the contrary, it is introduced to illuminate and vitalize the content with which it is integrated. The attempt should be made in this course to teach science as part of the total intellectual and historical process, of which, in fact, it has always been an important part. The student should gain thereby an insight into the principles of science, an appreciation of the values of the scientific enterprise; and he should also learn much of the subject matter of the physical sciences.

An earlier re-evaluation of science in general education at Colgate was led by Sidney French, Dean of Faculties in 1944. This committee arrived at the following conclusion: "In assessing the college's pre-war experience of more than 15 years with general education, the committee on the Post-War College came to the conclusion early in 1944 that general

8Ibid., p. 227.
education was not only worth keeping but worth improving and extending."

The parallel between the Colgate and Harvard general education science courses is indicated by a quotation from French. "The resemblance of the new Colgate course in Problems of Natural Science to that proposed by Mr. Conant at the Conference on the Natural Sciences in the Liberal Arts College, held at Princeton late in 1944 is striking—but entirely coincidental. Ours was on paper before we knew of his."  

The University of Chicago also developed an analogous curriculum to those of Harvard and Colgate. This development was reported by Smith in Science in General Education.  

Even though these three institutions developed these programs along parallel lines, other institutions which did not are reported both by McGrath  and Haun.  Although a wide variety of general education courses developed, Krauskopf was able to note a number of areas of agreement in 1951. In course content these were:

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10Ibid., p. 201.


(1) Development of the favorable emphasis toward the scientific method and scientific attitude; (2) the belief that presentation of blocks of subject matter was better than the superficial survey or the diluted traditional science course; and (3) physical science is best taught separately from the biological science. In methods of instruction he found agreement on the following: (1) The lecture should be under one man for the entire term and should not be divided according to individual specialty; (2) small discussion sections are helpful to students in addition to the regular lecture; (4) individual laboratory experience is very desirable; and (5) movies and other visual aids to instruction are helpful, but must be used with care. He found disagreement on subject matter in the following areas: (1) The teaching of the scientific method in an elementary course; (2) the quantity of mathematics, history of science, philosophy of science, practical application of science within the course; and (3) the single science course versus several sciences fused within a course. Other areas of disagreement in teaching methods as found by Krauskopf are listed as follows: (1) The relative emphasis placed on lecture, laboratory demonstrations, discussion groups, visual aids, and original writings; (2) the use and emphasis of the objective versus the essay exam; and (3) the measuring of the goals of education.  

Patterns of instruction were developed from the experiments in science in general education. These are reported by a number of

14 Krauskopf, loc. cit.  
15 Ibid., p. 60.
authorities. Among these approaches listed are the following:
(1) Block and gap courses, a term given to those courses that treat representative topics from the various disciplines of science which are treated in some depth; (2) survey courses, a term given to those courses which omit depth by giving an overview of several related disciplines; (3) problem-solving courses, a term given to those courses in which the student tries to solve problems that are posed by the instructor during the school year; (4) great issues courses designed around big ideas of science; and (5) case histories. To this can now be added the PSNS pervasive laboratory approach.

If the reported research is an indication of the amount of activity in science in general education, it would appear as though general education achieved its maximum growth shortly after World War II. Research is still being carried on, it is true, but the development of new curricula appears to be almost nil as shown by the decreased reporting of such development in the literature. What is amazing is that such a mammoth job of curricular development in this area should have occurred over a period of thirty years with virtually no government support.

**Historic Purpose of Science in General Education**

Education for centuries has attempted to educate for the needs of society. The need for the understanding of science by the educated man was recognized when Harvard taught its first science course in 1690.

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16 McGrath, *op. cit.*, pp. 11-19.
In the late 1940's Eric Rogers wrote, "Administrators in business and in governments, even heads of governments themselves, all have to meet scientists and formulate policies and make decisions which depend upon scientific judgments; yet they find themselves ill prepared to understand the scientist's point of view or to assess their statements." The cultural lag between the educated individual and his need to know science has been ever increasing. To overcome the cultural lag the survey course in science was introduced. The survey course did not completely achieve its mission, but rather led to the development of such courses as those promoted by President Conant at Harvard, Dean French at Colgate, Dean Taylor at Princeton, Professor Zens Smith and others at Chicago, which tended to look less at facts and more carefully toward an approach that would include more depth and understanding of science. These later attempts were instrumental in fostering many of the present approaches to science in general education today.

Many of these general education courses were based upon the idea that transfer of training is possible, at least to a limited degree. Although some psychologists warn this may not be so, others believe it does occur to a limited extent. This is particularly true where the elements in each given situation are more nearly similar. Rather than to "train-the-mind" for specific tasks, suggests Rogers, general

education attempts to encourage critical thinking, give some understanding of science, and by leading students through a variety of scientific methods help them create an appreciation for science.  

As a result, subject matter in general education appears to be based upon the transfer of training concept, while the methods of teaching appear to be based upon the process of science.  

Eric Rogers also discussed some of the purposes of science in general education as he saw them in the 1940's. These were listed as follows: (1) Teaching the scientific method by showing how scientists attack a problem, gather data, and sort data. In short, teaching the mode of scientific investigation, both in science and in the total environment; (2) teaching for creative work by giving students time, opportunity and encouragement; (3) cultivation of general abilities such as creative imagination, effective communication, and responsible citizenship; (4) the teaching of a few basic principles, the choice of which "... leaves time to study the development and interrelations of the chosen topic;" and (5) "... mediate between the scientist and the layman, between classical culture and a scientific civilization."  

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19. Ibid., pp.6-11.  
20. Ibid., p. 9.
The Allerton House Conference on Education focused its attention on science in college general education in 1957. The conference concluded that:

The enrollment in broad courses in the physical and biological sciences designed for general education is one means of providing basic science instruction for the prospective elementary teacher... It is our belief that a good elementary school program in science could be developed around the topics listed below:
(a) living things (b) the earth (c) matter and energy (d) the universe (e) the use of science.

A later idea expressed by Philip Morrison, as well as Conant and French, indicated that perhaps science courses were still trying to teach too much, and therefore students did not have time to think about the sciences they were studying. It was upon this premise that the PSNS program based its approach.

A contemporary effort to design a new course is being carried on by Parsegian at Rensselaer Polytechnic Institute. In attempting to fuse the sciences and the humanities into one two-year course, Parsegian has enlisted the aid of outstanding educators from a variety of campuses and has obtained funds through the Kettering Foundation. In his own words he says, "The basic course is designed to require two lectures and one three-hour work session each week for


sixty weeks. The work sessions are with small groups, and combine recitation with laboratory experiments. There are no formal reports required. He describes the course as follows:

The sequence begins with a brief introduction to geologic time, to the beginnings of life on earth, and to early civilizations. The intent is to develop a sense of time and of history. Starting with the Sumerian period the lectures briefly trace the observations and experimental methods that led to Newtonian concepts. The introduction ends with a glimpse at current ideas of cosmology as seen by the space scientist and the astronomer.

Four themes are pursued along parallel lines throughout the two years of study. These are as follows:

(1) The capabilities and limitations of science and of scientific methodology.

(2) The statistical and probability characteristics of natural phenomena.

(3) The "systems," or interrelated cooperative and engineering aspects of nature (including cyclic phenomena, feedbacks, control, and cybernetic concepts).

(4) The knowns and unknowns of the science of nature, and their changeability, as well as trends in scientific development.

Dewey indicated many years ago that science was part of the human environment, "... but I am afraid that science is still taught

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24 Ibid., p. 269.

25 Ibid.
largely as a separate and isolated subject and that there are still those, including many scientists themselves, who think that the wonderful thing 'pure' science would be contaminated if it were brought into connection with social practice." It is interesting that a few scientists have begun to realize the need of the social side of science after almost thirty years since John Dewey.

**Criteria and Objectives in General Education**

Spafford has listed three criteria for selecting materials for physical science studies as follows: "(1) Does the material contain practical information?; (2) is it of general interest? and (3) does it demonstrate a way of thinking?"\(^{27}\)

In 1954 a committee on science in general education\(^{28}\) set up a group of objectives of evaluation of such courses. The seven suggestions of that committee are as follows:

1. Evaluation of the ability to apply science . . .
2. Evaluation of the ability to analyze set data . . .
3. Evaluation of the ability to read and evaluate news articles
4. Evaluation of the understanding of the role . . . of science
5. Evaluation of the willingness to face fact, to revise . . .
6. Evaluation of the understanding of a point of view . . .
7. Evaluation of the recognition of the need for additional science knowledge . . .

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\(^{27}\)Ivol Spafford et al., *Building a Curriculum for General Education* (Minneapolis, Minnesota: The University of Minnesota Press, 1943), p. 267.

Washton decried the lack of use of such criteria in general education when he said, "For all college students in a liberal arts program who do not intend to specialize in the sciences, no research is done to determine how to teach science and its social and economic implications. A few studies have provided us with some criteria in the selection of scientific principles for purposes of general education. Nevertheless, one seldom finds college science instruction which is based primarily on the development of the objectives of such criteria."²⁹

Criteria Used in Writing PSNS Materials

The PSNS proposal to the National Science Foundation indicated that the laboratory should: (1) enhance the art of asking sensible questions; (2) involve the collection of data; (3) encourage the describing of observations; (4) encourage the interpretation of results, and (5) encourage the student's ingenuity in designing techniques to support conclusions.³⁰ In addition, a group of verbal criteria were used during the summer 1965 writing conference. Such questions as, "Does the experiment contribute to the 'over-all' direction of the course?", "Does it create 'a need to know'?",


and "Will it broaden a student's thinking?" were constantly used to evaluate the contributions of the writers. Further, a test was written by the PSNS staff to determine the background of elementary teacher candidates in the physical sciences. The response to this test was used as a criteria of the academic level to which the materials were to be written. (See Appendix II.)

**Development of PSNS Materials**

The PSNS proposal to the National Science Foundation in February, 1965, stipulated a set of criteria which are stated above. The proposal indicated that the student should be more actively involved with experiment planning so that he would have an opportunity to learn to support conclusions from the evidence gathered in his data. Laboratories were to be designed to give direct experience with chemistry and physics. These direct experiences were to be provided through six approaches as follows: (1) **In-lab experiments**—experiments normally performed in a conventional laboratory; (2) **at-home experiments**—experiments involving little or no apparatus, using materials easily available or in kit form; (3) **chair-arm experiments**—experiments to be done during the lecture class under the direction of the instructor; (4) **sub-group experiments**—experiments done by small groups of students for analysis and study by all; (5) **instructor experiments**—experiments set up and operated by the instructor (commonly called demonstration experiments in most literature); and (6) **no-lab lab experiments**—experiments based only on tabulated data.
These six areas of laboratory experience given in the FSNS proposal and submitted to the National Science Foundation could be summarized under three general categories: (1) **Lecture-laboratory** experiments—experiments done by individuals or groups of students during the lecture class; (2) **outside assignment laboratory**—experiments done by groups or individuals as part of a long or short term outside assignment which may take several days or a few weeks to complete; and (3) **conventional laboratory**—experiments done within a specified block of time other than lecture where students may work individually or in groups under the guidance of an instructor.

None of the time of a conventional laboratory is devoted to lecture. The block of time allocated would be approximately two hours in length. These three categories are the bases for the experimentation carried on by this researcher at Miami University.

Unfortunately, the initial trial draft of the FSNS project did not include specifically the sub-group experiments or no-lab lab experiments. The initial trial draft did include, however, approximately 9 chair arm, 34 conventional laboratory, 21 home experiments, and 2 instructor experiments. A number of the experiments in the initial trial draft could be used in more than one way, however, so that the distribution of experiments could vary with the instructor. For example, some chair-arm experiments could be used as home experiments or as in-laboratory experiments. Flexibility was deliberately built into the program for the instructor involved or for the facilities available. It appears from the above distribution of experiments
that there was not as broad an approach to the variety of laboratory experiments as originally envisioned by the PSNS directors. If, however, the laboratory experiences are categorized according to the suggestion of this investigator (into three broad areas), it can be seen that this yields better distribution of experiences than has been customarily considered in general education.

The scope of the PSNS materials made available an opportunity for a pervasive laboratory experience. The materials were written for a "programmed" experience which would raise questions to which additional laboratory experience would be required to answer these questions. This, in turn, it was hoped, would raise more questions. Laboratory experiences were therefore an integral part of the course.

Summary of the PSNS Syllabus

The preliminary edition of the PSNS text was written in seventeen chapters. The introduction discusses the world of science, the place of adequate observation through an illustration borrowed from Sherlock Holmes, and the way an investigation is undertaken. The memorization of facts, the text suggests, is a poor way to learn science. The pace of the course, it is indicated, should permit leisurely exploration of the subject. Within this chapter two experiments are recommended. One experiment involves a mixture of chemicals in a jar to be taken home where the chemicals are dissolved in water.

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31 An Approach to Physical Science (Troy, New York: Rensselaer Polytechnic Institute, 1965).
The directions are to observe what happens as the days go by and the water evaporates. The crystals formed are observed and discussion is encouraged. The second experiment involves a flask, stopper, and tubing designed to acquaint students with a sensitive means of measuring volume change, temperature change, and the effect of dissolving a substance in a solvent, such as water, related to volume and/or temperature change. The need for careful observation is shown by these experiments.

The investigation of crystal properties is the next topic to be studied. Classification is added an another concept in science. The idea of measurement follows with the idea of need for a standard. It is suggested that rulers be compared to illustrate the error that may be involved in measurement. Although the pendulum was not used in the initial trial, it is used in a later edition to illustrate that a standard interval can be obtained by its use. The measurement of temperature is also investigated again with the flask full of water, stopper, and glass tube. Temperature by way of experimentation is compared to heat as a quantity. The ideas of heat input versus heat output are investigated with moth balls as the melting solid and an expanded styrofoam cup for a calorimeter.

Light is studied based upon the idea of color. A "chair-arm" experiment involves the use of color filters and color pencils. Red writing on white paper, for instance, disappears when viewed through a red filter. The question asked is why. The spectrum and wave
motion are introduced. Experiments with rope waves, water waves, and the reaction of light with silver chloride are recommended.

Interference and diffraction are studied from the standpoint of Newton's corpuscular theory of light, the work of Huygen, and Young. Interference of light from a point source when viewed through a double slit is explained. After discussion of the interference of light based upon the wave theory, a detailed analysis of double slit interference involving geometric concepts and finally some basic trigonometry (only to the extent of fundamental relationships) leads the student to the reasoning about diffraction and the Bragg equation for measuring small distances. A short section on indirect measurement leads to an experiment on the measurement of thin films.

Crystal growth and the observation that as the crystal grows the angles on its faces remain the same are important concepts in the course structure. The growth of the crystal is performed as a "chair-arm" experiment earlier or at this point to increase student interest. The process of dissolving materials in a solvent is discussed along with the experimentation which is designed to illustrate that dissolving occurs only on the face of a crystal, not throughout simultaneously. The melting of ice is used as a means of illustrating this process in crystals. Two ice cubes of approximately the same size, one crushed the other whole, are compared in relationship to the time that is required for each to melt. A unique experiment on the packing of spheres is done with glass beads in a plastic box. By permitting the beads to run together in the box at the student's chair
in the lecture the student observes the concept of packing. Crystals that were started from the beginning of the course are now harvested and examined. The relationship of natural crystal formation in rocks and minerals is given cursory attention.

The trial version of the course gives an interesting biographical account of Max Von Loue and his experiment with x-rays and crystalline structure. The diffraction of x-rays is discussed with reference to previous investigation of diffraction patterns of light.

The idea of matter in motion is used to tie previous concepts together by stating that matter can move and collide, as do billiard balls. Simple motion is investigated by sliding a block of wood and an air puck over a desk top. Consideration is given to the interaction of forces which produce uniform velocity and acceleration. "Rubber band" forces are calculated according to Newton's Laws and the concept of mechanical energy explored through the use of a pendulum.

The behavior of molecules in motion introduces the kinetic molecular theory which is developed along with several alternative "models" for a gas. These "models" are applied to Boyle's and Charles' Law. The question of the relatedness of gas laws to solids then arises. To illustrate translatory motion and the breakdown of crystal structure, a "chair-arm" experiment is suggested using the plastic box and the beads. This demonstration, it was believed, illustrates the relationship between diffraction patterns and temperature.
The student's attention is then directed toward the differences in matter by drawing attention to such solids as glass, a rubber band, and a piece of wood. Wood splints are baked in a test tube, the liquid from the heating collected, and the gas ignited. The question following the experiment is indicative of the reason for the experiment. "Could you predict, just by looking at and handling wood, that all these gases and liquids could be obtained from it?" Moth crystals are again used to illustrate the effects of heat on a solid and a melting point is taken. Iodine crystals are heated to show that vapors may be formed directly from a solid. Electrical conductivity of melts is an additional experiment to demonstrate further properties of the solid state. Finally, the heat involved in the fusion of water is investigated to illustrate the part that heat as a quantity and as energy plays in these transformations.

Attention is then directed toward forces inside matter. Salt is used as an example of a crystal that has a degree of hardness which resists crushing by a fingernail. Forces that hold such crystals together are carefully examined in light of previous work. Forces that are suggested as being involved are gravitational and electrical. The gravitational forces have been investigated experimentally earlier in relationship to concepts of motion. Now they are treated mathematically. The electrical forces are examined with the aid of an improvised electroscope and pith balls.

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Ibid., Chap. 9, p.6.
The units of electric current are defined on the basis of electric charges in motion. The way the electricity is thought to move through a conductor is discussed. Forces, energy, and current are used in the development of the idea of potential. The only experiment in this chapter encourages students to "play" with a flash light bulb, battery, and paper clip until it lights. A final question states, "What would happen inside the house if a typical day's supply of current entered and more left?" 33

The atomic view and the development of the present day model are discussed. After introduction to Rutherford's nuclear atom, an experiment using marbles as targets and bombarding particles illustrates the method used by Rutherford to conclude that the mass of an atom was concentrated in the nucleus and to estimate its size. Then the Bohr atom is discussed as well as energy levels and ionization potential.

The electrolysis of melts is used to illustrate that charges do move through melts and that ions do move through gels. The properties of atoms and ions are studied by replacement reactions and the production of an electric current from a modified Daniel Cell.

A review of the nature of the salt crystal looks back at the ideas of classification, observation, measurement, temperature, heat, and diffraction. From this the structure of a crystalline solid is more closely examined. Crystals of sodium chloride and cesium chloride

33 Ibid., Chap. 11, p. 12.
are grown on a microscope slide in the lecture classroom. A moderate attempt at cleavage is attempted with the aid of a magnifying glass and a pin. The identification of sodium, and cesium ions is accomplished by means of flame tests and the plastic diffraction gratings. By the use of the Bragg equation the planes within a crystal are investigated and models of cesium chloride and sodium chloride crystals are constructed from polystyrene balls. Finally, the dipole moment of water and the relationship of this to hydrated ions are discussed.

The concept of combining volumes of gases is illustrated through the electrolysis of water and its recombination. In addition, Avogadro's Number and diatomic molecules are discussed.

H. H. Sisler's book, Electronic Structure, Properties and the Periodic Law, is used to relate covalent molecules and their relation of properties to bond types.

Chemical reactions are illustrated with concepts of the combination of gases, the effect of temperature on a reaction, combustion, catalysts, oxidation and reduction.

Finally, there is an attempt to relate the entire course to the student's own environment.

Research on Science and Thought Pattern Rigidity

Rigidity of thought patterns is defined by Milton Rokeach as the inability to change one's set when the objective

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conditions demand it, as the inability to restructure a field in which there are alternative solutions to a problem in order to solve that problem more effectively. 35

Rokeach believed that "... the ethnocentric prejudiced person's solution of social problems is not an isolated phenomenon, but is rather an aspect of a general rigidity factor which will manifest itself in solving any problem, social or nonsocial in nature." 36

Rokeach designed some test problems to evaluate rigidity of thought patterns of individuals. Some of the problems he designed with several solutions; others had only one solution. An example of a problem with one solution follows: Three jars of 31, 61, and 4 quart capacities are given to a subject. The problem is to obtain 22 quarts of water by using these three jars. Such problems were interspersed with others which have a variety of solutions, a few of which were quite complex. The critical problems, those with more than one solution, were thought to demonstrate the degree of rigidity of individual thinking. Subjects more rigid in their thinking frequently would use a more complex means of solution.


36 Ibid., p. 276.
In the 1950's Solomon's studies on mental rigidity and the scientific method used a hypothesis set forth earlier by Rokeach. A summary of the hypothesis follows: Individuals who are inflexible in their outlook on life will not be limited to this outlook to things of a social nature, but inflexibility will be characteristic throughout those problems which lack social content. A scientific method test was set up by Solomon to test this hypothesis. From this he found the following relationships:

1. Relationships exist between non-rigidity and comprehensive cognitive structures.
2. Relationships exist between rigidity and narrowness of cognitive structure.
3. Rigid individuals seem to show an inability to go beyond the mere factual information and react on the basis of each individual fact separately.
4. Rigid groups do not indicate the ability to see a relationship of one piece of factual information to others.
5. Rigid groups may refuse to consider some of the facts that are at their command.

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6. The "non-rigid individual, . . . has the ability to see and to state relationships existing and necessary for the complete solution to a problem."\(^40\)

7. The "non-rigid group can take individual facts and organize them into a single unified structure."\(^41\)

8. "The thought processes are broad and integrated and take pertinent facts into consideration in arriving at a solution."\(^42\)

Behavioral rigidity and its relationship to success in college physical science was studied by Shockley in 1962. His study concluded that ". . . extremely flexible individuals are more successful than extremely rigid individuals in applying principles of physical science to new situations after having completed the one semester physical science course, when adjustments are made to offset differences in ability to handle quantitative relationships."\(^43\) Extremely flexible persons excelled over extremely rigid ones, Shockley noted in an aside to his study, when the two groups were compared by the analysis of covariance. The areas of significant difference were as follows:

1. knowledge of elementary math
2. over-all scholastic aptitude
3. quantitative aptitude

\(^{40}\)Ibid., p. 269. \(^{41}\)Ibid. \(^{42}\)Ibid. \(^{43}\)James T. Shockley. "Behavioral Rigidity in Relation to Student Success in College Physical Science," Science Education, XLVI (February, 1962), p. 70.
4. reading proficiency
5. skill in critical thinking
6. skill in applying principles of physical science to new situation
7. course grades

Little has been done, it appears from this study of the literature, to understand the rigidity of thought and the belief pattern of individuals. Further, the pedagogy of science teaching has contributed little, if anything, to the understanding of such belief systems, attitudes, and the thought pattern rigidity of the science instructor. The impetus of this study was derived from the few cited examples of the relationship of science to the rigidity of thought patterns.

Research on the Laboratory in General Education

A review of research revealed a number of studies involving the role of the science laboratory in general education. Many of the studies used academic achievement as a criterion in the evaluation of the worth of a particular laboratory method of instruction. One study used the rather nebulous criterion of scientific information and attitude relative to the laboratory performance. It was based upon objectives of general education. Two other studies examined students' abilities to interpret data. One of these two studies tested the ability of students to design an experiment. The other tested the ability of the student to avoid hasty generalizations and to suspend judgment. Yet another study looked at the problem of scientific reasoning and understanding.
The work of Alterman in 1958 is an example of research which involved the measurement of recall of facts, ability to solve mathematical problems, and application. He used a deductive approach with a control group starting with the statement of principle then presented the application through illustration. With the experimental group he developed a principle by analysis of applications and demonstration. This was termed the inductive approach. On the basis of recall of facts, ability to solve mathematical problems, and application he found that the inductive method of teaching produced significantly better results only with those students rating low in their initial background and only with the application of principles to new situations as shown by that test.

Matheis's approach used the laboratory to determine what effect two different approaches would have on the general subject matter competency. The control group used the conventional "cookbook" laboratory experiences while the experimental group worked on science projects during their laboratory time. He found that neither experience was superior in the development of scientific interest.

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He also found that there was a substantial gain in science knowledge for those in the control group with low science interest and knowledge over the rest of the group. The experimental group, however, demonstrated a gain in science knowledge for those who already had a high interest and knowledge in science, before the experiment, over the rest of the group. He also found, by way of interest, that ". . . prospective elementary teachers were more interested and knew more about the biological sciences than the physical sciences before and after college courses in science although they did not receive better grades in the biological science course." 46

Sandler 47 made a study between a fused course in mathematics and science and the two courses in separate subjects. He found the fused course to be significantly higher on scores as far as knowledge of physics facts, terms, principles, and ability to solve mathematics and physics problems.

Balcziak 48 set up three teaching methods: (1) The lecture alone, (2) the lecture plus the laboratory, (3) the laboratory alone. The experimental evidence on tests of science information, scientific

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46 Ibid.


attitude, and laboratory performance illustrated that none of the three instructional methods proved superior in achieving the objectives of general education.

Bradley made an exhaustive study to determine differences between lecture demonstration and individual laboratory work. At the conclusion of his experiment he had to accept the null hypothesis that there is no difference between subject matter achievement of college students who undergo instruction in physical science for general education (1) by either the lecture demonstration method or the individual laboratory method, (2) on the basis of the sex of the students taking the course, (3) on the basis of instructors, (4) on the basis of those who had previous laboratory science versus those who did not, and (5) on the basis of an above median group and below median group.

The most significant study reviewed by this researcher was that by Lahti. He made an extensive study of the effectiveness of the laboratory in developing the student's ability to use the scientific method. He designed three instruments—Interpretation of Data, Design and Experiment, and Performance. Each of these were found to be reliable at the 1% level or less. The methods employed for

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laboratory teaching were the historical, standard, and inductive-deductive. In all cases he found the inductive-deductive method of laboratory teaching significantly greater than other methods of laboratory teaching.

Ward\(^1\) made a study of two teaching methods which he termed "group study" and "lecture demonstration." While his study did not involve the laboratory, mention is made here because it did involve a more flexible approach to education as advocated by the PSNS program. The experimental inquiry involved two methods each using the same subject matter and audio-visual aids, but with the lecture demonstration group having topics treated by the instructor only. The group method treated topics in class by a group of students with the instructor present. Neither method was significant even at the 5\% level.

Perlman\(^2\) wondered whether scientific thinking could be learned specifically or whether there would be a significant gain in scientific attitudes and abilities through laboratory use. He also explored problem-solving outcomes and contemporary problem-solving uses of the laboratory. In addition he explored the differences between problem-solving outcomes and subject matter achievement of the problem-solving method against a good lecture demonstration method.


and found no significant differences between the experimental and control groups on measures of interpretation of data, associated attitudes of hasty generalizations, suspended judgment, and over caution.

Robinson\(^{53}\) followed the ideas of Dressel and Mayhew\(^{54}\) by teaching an experimental physical science class in general education from fifteen articles in the *Scientific American*. He compared this group with those who only studied the text. Robinson found a moderate correlation of .48 between science understanding and reasoning and a correlation of .33 between interest in science articles and the attitude toward the science course. The experimental and control groups demonstrated almost equal science reasoning ability as judged from the scores of *A Test of Science Reasoning and Understanding*.

**Studies Related to Research Sample**

A few studies have analyzed the science backgrounds of elementary teacher candidates. One study of this nature was made at Iowa State Teachers College in 1952 by McCollum. His purpose was to find if a relationship existed between the high school science background of the students and the work that they did in the college level general education course in physical science. His findings follow:

1. A majority of . . . students had two or more high school science courses.
2. General science and biology were the two high school sciences most

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commonly taken by these students. (3) There appeared to be a positive relationship between the amount of high school science work and the grade received . . ., but it was not of enough significance to be of a predictive value. (4) High school physics appeared to be of more value in achieving success in the course than high school chemistry. (5) Correlation between scholastic aptitude and reading ability and achievement . . . were consistent, in general, with correlations between these abilities and scholastic achievement in other areas. (6) Previous high school training in science and achievement in . . . [general education science] did not appear to be as closely related as scholastic aptitude and reading ability and achievement.\textsuperscript{55}

Gaides and Diehl\textsuperscript{56} made an informal study during the winter of 1964 to determine the influences of high school science background on students in a general education science course at Miami University. The results were that the high school science background of the student was not as good a predictor of grades in the physical science course as the student's high school grade point average, although it was recognized that students with higher grade point averages usually took high school science.

The high school science background of elementary teacher candidates was also scrutinized by Iddings.\textsuperscript{57} He found that students


\textsuperscript{56}Glen E. Gaides and T. Handley Diehl, "Report to the Students in Physical Science and to the Dean of the School of Education of Miami University," (1964).

\textsuperscript{57}Roger Iddings, "A Comparison of the Effectiveness of Selected Physical Science Courses for Non-science Majors" (unpublished Ph.D. dissertation, The Ohio State University, 1966).
in elementary education had approximately two years of high school science. He also found that the relationship between high school science courses taken and the academic growth in general education science courses was not significant.

The two formal studies by McCollum and Iddings and the informal study by Gaides and Diehl appear to concur in their conclusions regarding the number of high school science courses completed by elementary teacher candidates.

Summary

Mayhew indicates that general education began as early as 1837, while Moosnick has traced the present approach to general education to Columbia College. Meiklejohn is credited with being precocious in the development of general education at Amherst and the University of Wisconsin.

It appears as though general education was slow in its development through the 1930's, but gathered momentum during the 1940's, and crystallized during the 1950's. Conant at Harvard, and Sidney French at Colgate, among others, were part of this movement in the 1940's and 1950's in their own institutions. Although Harvard and Colgate developed general education along parallel lines, a variety of programs in general education developed throughout the colleges and universities of this country. Methods of instruction as well as course content were a part of this variation.

The historic purpose of education has been to meet the needs of society. Eric Rogers attempted to remind those concerned of this aim
and of the cultural lag between the theory and practice of education. In the 1940's, Eric Rogers saw the purposes of general education involving the teaching of the scientific method, teaching for creative work, cultivation of a creative imagination, teaching of basic principles, and mediation between the scientist and layman. Several educators expressed the idea that the problem with education of the day was insufficient time for students to think about the science they were studying.

Course innovation at the freshman-sophomore levels is in evidence in the work of Parsegian. His course attempts to fuse the sciences and humanities. The course seems to follow the ideas set down by Eric Rogers to "... mediate between the scientist and the layman, between classical culture and scientific civilization."  

Objectives of general education were enumerated by Dressel and Mayhew as well as Spafford. Washton is noted for his lamentation over the lack of research to determine what should be taught in science so that students meet with some realization of the social and economic problems of life.

The leaders of the PSNS project enumerated several criteria and objectives in their proposal to the National Science Foundation. The criteria established guidelines for the summer 1965 writing conference. They appeared to be influential in the development of the course outline.

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58 Rogers, loc. cit.
A wide range of pervasive laboratory activity was included in the PSNS materials. This is illustrated by the variety of laboratory experiences recommended not only for the customary lecture classroom, but also for experimentation in the dormitory room. Flexibility was evident in the structure of course work to a limited degree in subject matter, but more in the types of laboratory activity that was suggested.

The PSNS program was designed to convey the enjoyment of science to the elementary teacher candidate. One of the PSNS course objectives was to encourage the interpretation of the results of an experiment. The fact that the relationship between science and social outlook may be related to the interpretation of the results of an experiment was suggested in work by Rokeach and Solomon.

The research, which is related to the laboratory in general education, has covered a limited range of investigations. Many of these investigations have been concerned with a particular method of instruction. Other studies have been concerned with the ability of students to interpret data, design experiments, and avoid hasty generalizations with the suspension of judgment.

The survey of the literature extended to other studies which indicated that the nature of the sample of elementary teacher candidates was not necessarily unique to Miami University.
CHAPTER III

DESIGN OF THE STUDY

Description of the Sample

The experiment was conducted in Physical Science, Education 181, at Miami University, during the spring of 1966. The course carries three trimester credit hours. It meets for three fifty-minute lectures and one 110-minute laboratory each week for 14 weeks. The fifteenth week is designated as exam week. Students were assigned to this class by change factors related to registration procedures of Miami University. All students in this study are elementary education majors who are pursuing the Bachelor of Education degree.

Within the total group studied one sample was designated experimental and the other control. The experimental group had full use of the PSNS curricular material, while the control group utilized the material normally used in the conventional course taught at Miami University. There were twenty-five students initially enrolled in the experimental sample, all of whom were girls. Twenty-two of the original twenty-five were included in the data of this research. The data from three students had to be omitted since one student was withdrawn from the University, and the records on two others were insufficient as a result of their transfer from another institution.
The students in both the experimental and the control groups were aware that they were involved in research before the experiment was begun. Students involved in this research were almost entirely from Ohio high schools. (See Appendix III.)

**Analysis of the Sample**

All students in the total experiment had no less than two years of high school science coursework to their credit. Three students in the experimental sample had taken a course in high school physics. Sixteen students had taken a course in high school chemistry. Two students had taken courses in both chemistry and physics during high school. In addition to courses in chemistry and/or physics, students frequently had taken a course in biology and/or general science.

The high school percentile rank for the experimental sample ranged from 40 to 95 while the chronological age for the sample ranged from 231 months to 275 months. The natural science scores for the sample in the American College Testing Program ranged from 5 to 81. (See Appendix III.)

In the control sample only one student had taken a course in high school physics. Seven students had taken a course in high school chemistry. No students had taken courses in both chemistry and physics during high school. Frequently the second course in science for the control sample had been either general science, biology, or both. The high school percentile rank for the control sample ranged from 52 to 99 while the chronological age for the sample ranged from 218 to 269
months. The students in the control sample had natural science scores in the American College Testing Program which ranged from 3 to 84. (See Appendix III.)

**Description of Tests**

Five objective measurements were employed in this research. These were obtained from a dogmatism scale perfected by Rokeach, the natural science scores from the American College Testing Program, and the *Facts About Science Test* from the Educational Testing Service. In addition, the students' chronological age and high school percentile rank were used in the statistical analysis.

The dogmatism scale was used to measure individual differences in open and closed belief systems. The scale is designed to measure general authoritarianism and general intolerance. Statements in the scale were so arranged by Dr. Rokeach that higher scale readings indicate a more rigid or dogmatic attitude than low scale readings.

The natural science scores from the American College Testing Program measured the student's ability to reason and to understand written material on natural science content.

The *Facts About Science Test* was "... designed to measure the understanding students have of the role science plays in contemporary society and of the way scientists as a group differ from

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people in general." In addition "... the test is meant to indicate how the student perceives the implications of these facts and techniques for society and for his life." 

The chronological age was introduced since it was realized that there was a broad range in many of these physical science classes. It was thought that such a range might introduce some factors that would be difficult to control unless recognized.

The high school percentile rank has been shown to be a good predictive factor in college achievement; therefore, these scores were used in the statistical analysis.

Teaching Procedures

The experimental sample was taught in accordance with the non-directive teaching technique stipulated by the PSNS staff in a pre-teaching orientation conference in August, 1965. Students were encouraged to progress at their own rate according to their ability, but were prodded if they lagged in favor of more pressing work from other courses. Materials produced at the writing conference in the summer of 1965 were used in the sequence suggested. Laboratory time, although indicated on the University time schedule, was not always

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3 Ibid.

used for laboratory work. Likewise, lecture classes were not always used for discussion. Rather, laboratory or discussion was utilized as the need arose or was dictated by the PSNS curricular materials or by student progress in class.

Equipment for "take-home" experiments was loaned to students in the experimental sample. Equipment was loaned from the scheduled laboratory because of the ease of record keeping. This was based upon anticipation of student progress in the PSNS syllabus. During each laboratory exercise students frequently worked in groups of two. This apparently was also true of the "take-home" experiments which were done in the dormitories.

Class discussion in the experimental sample centered around the experiments performed by the students and generalizations that might be obtained from the experimental data.

The control sample was taught in the conventional pattern of college science teaching. The class schedule was arranged for 150 minutes of lecture per 110 minutes of laboratory. This pattern was rigidly followed. The curriculum was designed in a cooperative effort three years previously by the instructors involved. The course syllabus follows closely the suggestions of President Conant of Harvard in the book which he edited, General Education in a Free Society. Lectures were illustrated by overhead slides or by demonstration. Demonstrations were of the "show-tell" variety. They did not involve

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scientific exploration beyond the illustration of points in the lecture itself. Laboratory was conducted at the scheduled time with the experiments geared to demonstration of principles rather than being exploratory in nature. No effort was made to encourage students to design an experiment. Rather, the emphasis was on the manipulative exercise. Variations in student data provided a focal point for further experimentation or at times encouraged formulation of further hypotheses to be tested. Through this procedure students arrived at their own conclusions. This technique was used to develop self-confidence in the students with a minimum of guidance from the instructor.

**General Plan**

This research falls within the area of general education. Further, it is involved with science within this broad area. More specifically, it has been limited to the sub-area of physical science in college general education. The particular facet explored in this research is related to student attitudes that may have been influenced in a positive direction toward science by materials written under a grant of the National Science Foundation at Renssalaer Polytechnic Institute in the summer of 1965, the PSNS course.

The mode of attack in this research consisted of the following techniques: The use of (1) an experimental and a control group, (2) pre-course and post-course testing, and (3) the statistical analysis of data obtained from the test instruments employed.
The attack can be considered a self-contained experiment since it satisfied the requirements of randomization, replication, and control.

**Randomization**

The selection of the samples in this research drew upon a population based upon chance factors of registration at Miami University. The only restriction placed upon this sample required that students registering for Education 181 be elementary teacher candidates. This type of sampling, known as cluster sampling, is made up of relatively small groups of individuals. This type of sampling is most advantageous if there is great heterogeneity within the group. For this reason the selection of the sample based upon registration procedures was assumed to have proceeded on a random basis.

**Replication**

The research technique used to achieve replication employed each individual student as a separate unit. Five measures or predictor variables were used for each individual. These were (1) a dogmatism score, (2) a *Facts About Science Test* score, (3) a natural

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7Johnson says, "If a random method of selection can be developed, then a random sample can be simply defined as a sample which has been obtained by a random method." Ibid., p. 199.

8"A great advantage of carrying out an experiment in this way . . . is that differences between persons are eliminated from the comparisons among elements of the experiment. Another advantage is that fewer cases are needed . . . ." Helen M. Walker and Joseph Lev, *Statistical Inference* (New York: Henry Holt and Company, 1953), p. 363.
science score from the American College Testing program, (4) the chronological age, and (5) the high school percentile rank of the student upon graduation from high school. These measures were correlated and the correlations taken into account in the subsequent calculations.

The information from these five measures for each student were combined through the use of a multiple regression equation so that errors of prediction would be as small as possible. The mean value for all predictor variables under these conditions is identical for the experimental and control groups. Thus the correlation between each predictor variable can be found. In addition, the correlation between each predictor variable and the criterion can be determined. These correlations were found for experimental and control groups based upon a pooled sample.

**Pre-course and Post Course Testing**

Almost all the students, in the total sample studied, had taken the natural science test as part of a battery of tests given within the American College Testing program. The natural science test scores were obtained from the Student Counseling Service of Miami University. The chronological age and the high school percentile rank were obtained from high school transcripts deposited in the office of the Registrar. These three scores were obtained under pre-experimental conditions.

At the beginning of the study, the dogmatism scale designed by Milton Rokeach and the Facts About Science Test were administered at the initial class meeting. This technique guaranteed that initial
testing was done under pre-experimental conditions. During the final class meeting the dogmatism scale and the Facts About Science Test were again administered.

Statistical Analysis

The statistical treatment of the data from this research utilized a multiple regression technique by the DuBois method of reduction of criterion variance. Multiple regression is a method of predicting one variable from several others. This technique uses the values obtained from the correlation matrices to produce a Beta weight for each variable and a multiple correlation coefficient.

The correlation coefficient was obtained for the dogmatism scale using a pooled sample as the base and the predicted trait for the experimental and the control groups. The pooled sample consisted of the combined experimental and control groups. A correlation coefficient was obtained for the Facts About Science Test by the same technique. These coefficients were used to determine whether the statistical treatment was statistically significant to continue the mathematical analysis. The process of pooling the sample provided a broad statistical base of operation. It also provided a means for control of extraneous variables.

9 A number to be computed from the sample data indicating the weight given the observed score of a sample.

10 "The coefficient of correlation between observed scores on a certain trait and scores predicted for that trait by a multiple regression equation . . . ." Walker and Lev, op. cit., p. 321.
A residual score was obtained for each individual from the Facts About Science Test. The residual score was determined from the difference between the predicted score obtained through the multiple regression equation and the actual post-course score. A residual score was also obtained for each individual from the dogmatism scale by the same technique.

These residual scores, pooled independently for the control group and for the experimental group, were compared by means of the t test.

Teaching Variables Controlled

Every effort was made to use the PSNS materials in the manner suggested by the PSNS staff during a final conference in August of 1965. Demonstrations were performed as prescribed in order to explore an idea. Take-home laboratory work was assigned and the chair-arm experiments were performed as suggested. Although some experiments were listed as "in-lab," they were actually used as take-home experiments. It was believed that the take-home assignments of the in-lab experiments did not alter the concept of the pervasive laboratory experience.

In the control situation direct effort was made to teach the course on as traditional a basis as possible. No outside laboratory work was assigned. Demonstrations for the control group were intended to illustrate a principle or fact and did not explore an idea.
Laboratory time was scheduled according to the University time schedule. Experiments performed during this period were of the verification variety with a completely prescribed organization.

Summary

Two groups were studied in this research: One was an experimental group that made exclusive use of PSNS materials, and the second, a control group, was taught in a conventional college science classroom pattern. Both groups were selected from a larger group of elementary teacher candidates based upon the chance factors of registration. A wide range of experience and background was found for the total sample studied. This variation was treated in a statistical analysis to minimize differences in the total mathematical treatment.

The basic difference of instruction centered on the use of the PSNS curricular materials and the non-directive teaching technique suggested for their use. This approach was compared to the conventional college science teaching approach with rigid laboratory and lecture experiences.

The research is considered to fall within the area of general education under the facet of science for the elementary teacher candidate. The design of the experiment can be considered self-contained in that it provides for randomization, replication, and control. Final statistical analysis rested upon the use of the t test.
CHAPTER IV

FINDINGS

Subjective Reactions to the Study

Many evaluative reactions and suggestions were gained during the period of this study. In part, such evaluations were direct. The direct reactions were those offered by the participating students to this researcher. Likewise, there were evaluations which were indirect. These indirect evaluations were reflections of the words and actions of others, such as could be obtained through the graduate assistants. The principal direct reactions were recorded in a daily log. Once rapport was established with the class, both negative and positive reactions were freely forthcoming. Such reactions are admittedly subjective and could not stand the test of objective scrutiny. The evidence, however, is believed by this researcher to be relative to the problem of this research and is therefore included. A summary of such evaluations of the PSNS materials, both direct and indirect, follows.

Generally, the students in the experimental group had mixed feelings with regard to the worth of the course. Initially the students felt that the course began on a level and with a vocabulary that was beneath their intelligence. In other words, the students initially
felt intellectually insulted. As the course progressed into more abstraction students became more and more confused. Since the course was based upon experimentation, many students performed some experiments several times, not for the purpose of achieving right answers, but rather from an effort to understand what they were doing. Students performed the take-home experiments fairly well when loaned equipment to work with, but frequently neglected those that were suggested using materials they had in their rooms. In some cases the students felt the directions for the activity suggested were not clear or were entirely misleading. Many of these criticisms are understandable, however, in view of the fact that it was the first trial of these materials. A number of students expressed disdain for the non-directive technique of teaching that was employed.

While some did not particularly like the non-directive technique, since it required them to be more prepared for class discussion, they did adjust themselves to the occasion. Most expressed a feeling of fun at the beginning of the course, after the initial insult period, because the class had more "doing" than "listening" in it. However, students did find that the "doing" began to be more and more burdensome as the course progressed. This expression apparently stemmed from the increase in pressure in course work from other classes.

The laboratory instructors (graduate assistants) who pre-tried many of the experiments performed by the experimental group in multiple laboratory experience prior to a treatment with an experimental group did not generally like the experiments. A few of the experiments
they thought were good, but the over-all pattern they rated as mediocre, because they felt it misguided students in the true purpose, or that the vocabulary was inadequate. The graduate assistants were glad when the experiment was terminated.

Evaluative reactions and suggestions for the conventional course were gained over a period of three years. Specifically, however, these reactions were recorded at the conclusion of the class used in the control situation. The evaluations for this group were also of direct and indirect origin. The direct reactions were those offered by the participating students to this researcher. The indirect reactions were those offered by the graduate assistants. A summary of such evaluations of the conventional course materials, both direct and indirect, follows.

In the control group there was constant pressure on the students. Generally students expect the pressure and ordinarily do reasonably well academically. The general opinion of the control group was that the course was challenging and required work at the peak of their efficiency. Material, they said, was well thought out and presented in a logical pattern. However, the material was presented to them at such a pace that at times they found it difficult to assimilate and to see various relationships. Many students disliked the laboratory, since a written report on the experiment was required. The logical development of the student's thought patterns increased the course difficulty for many, particularly those who were not accustomed to expressing themselves in writing. Students generally
appreciated the development of science presented as a unified whole. Many expressed that they had seen scientific relationships that they had never dreamed existed even though they may have taken several high school science courses.

Objective Results of the Study

The dogmatism scale and the Facts About Science Test final scores were predicted on the basis of multiple regression equations through the use of the DuBois technique. Five predictor variables were used for each prediction which were thought to be good indicators of the student's progress. These variables were: (1) the preliminary (pre-course) scores on the Facts About Science Test, (2) the age in months of each of the 41 cases used in the study, (3) the natural science scores from the American College Testing Program tests, (4) the high school percentile rank of the cases in the sample, and (5) the preliminary (pre-course) score on the dogmatism scale.

The cases for both the experimental sample and control sample were pooled so that the mean value for all predictor variables would be identical for each sample. The variables in this treatment were then controlled by balancing. As a result, the linear correlation between any controlled variable and any experimental variable initially should be zero. Because of the possibility of removing too much criterion variance, only pre-course scores for all variables were used in the prediction of the final scores.

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These variables predicted both the Facts About Science and dogmatism scores with a high degree of accuracy. For the Facts About Science Test the multiple correlation between the predictor variables and the final scores were checked as each predictor variable was added to the equation. With only the pre-course Facts About Science scores being used in the DuBois equation a correlation of +.658 was obtained between the predicted and the real scores. With all variables used in the equation the multiple correlation between predicted and real became +.735. The correlation matrix for the predictor variables and post-course Facts About Science score as a criterion variable will be found in Appendix V.

For the dogmatism scale multiple correlations were found between the predicted and final scores. With only the pre-course score for dogmatism being used in the DuBois equation a correlation of +.526 was obtained between the predicted and real scores. With all variables used in the equation the multiple correlation between predicted and real scores became +.609. The correlation matrix for the predictor variables and post-course dogmatism scores as a criterion variable will be found in Appendix V.

Having obtained multiple regression equations predicting post-course scores on the two criteria from the five pre-course variables, residual scores (the difference between the real and predicted post-course scores) were obtained for each member of the pooled samples for each of the criteria. For each criterion variable, the significance of the difference in mean residual scores for the two groups
(experimental and control) was tested via the t test. The actual t values for the Facts About Science Test and the dogmatism scales were .2140 and .2189, respectively, with 39 degrees of freedom. These values are considered insignificant. (See Appendix VI.)

Were these between-group differences the actual differences to be obtained if all possible students were divided and exposed to the differing teaching procedures, samples of more than a thousand students each would be required to obtain statistical significance. The results obtained, in the absence of other evidence, suggest there is no significant difference between the two samples on these post-course measures.

Summary

Students in the experimental group generally expressed the feeling that the course began on a level and with a vocabulary beneath their intelligence. Very quickly, however, it appeared to progress to a level of abstraction without adequate transition. After the initial period of adjustment to the new program, students in the experimental group did seem to enjoy some aspects of the course, but found it rather burdensome when pressed with course work from other classes.

Graduate assistants who pre-tried many of the experiments generally did not like them. They placed the over-all pattern as mediocre. In some cases they felt the language used to guide students in experiments was inadequate.
The general opinion of the control group was that the course was challenging. Material, they said, was presented logically, but at times came too fast to assimilate sufficiently to see adequate relationships. Laboratory was not generally appreciated because of the report that was required. Students have expressed gratitude that the conventional course was presented as a unified whole.

The dogmatism scale and the Facts About Science Test were used as the measuring instruments. A multiple regression equation was used to predict the post-course scores on both the dogmatism scale and the Facts About Science Test. For each criterion variable, the significance of the difference in mean residual scores for the experimental and control groups was tested via the t test. The results obtained, in the absence of other evidence, suggest there is no significant difference between the two samples on these post-course measures.
CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was concerned with attitudes of elementary teacher candidates toward science, especially whether the use of PSNS curricular materials would positively influence the attitudes of elementary teacher candidates toward science.

The investigation was conducted at Miami University and involved students enrolled in Education 181, a general education science course limited to elementary teacher candidates. The investigation was limited to the use of curricular materials during one trimester. One group, designated as the "experimental" group, was subjected to the use of the PSNS curricular materials which involved a pervasive laboratory approach and a non-directive teaching technique. The other group, designated as the "control" group, used the conventional curricular materials previously designed for the course and a conventional lecture-laboratory teaching technique.

The investigation satisfied the requirements of a self-contained experiment through the use of (1) randomization, (2) replication, and (3) control. Students were assigned randomly according to the chance factors of registration at Miami University. Replication was
accomplished by treating each student as an independent unit within the statistical treatment. Control was obtained by having two groups involved in the study, one of which was a control group and the other was an experimental group. In addition, statistical tests of the hypotheses were accomplished through the use of a multiple regression technique based upon the DuBois method of reduction of criterion variance and the t test. Every effort was made to control the two teaching situations, the first as suggested by the PSNS project leaders, the second as performed in the conventional course.

An evaluation of the investigation was executed by pre-course and post-course testing of all students involved. Pre-course evaluation utilized five measures. These were (1) a dogmatism scale, (2) the Facts About Science Test, (3) the natural science test from the American College Testing Program, (4) the chronological age, and (5) the high school percentile rank. These pre-course measures were used as predictor variables in the statistical analysis. Post-course evaluation utilized two measures: the first, a dogmatism scale, and the second the Facts About Science Test, both of which were identical to test instruments used in the pre-course evaluation. The dogmatism scale was used to measure individual differences in open and closed belief systems. The scale is designed to measure general authoritarianism and general intolerance. The Facts About Science Test measures the understanding of the role of science in society.
Two hypotheses relating to the data collected were tested.

These were as follows:

1. The use of PSNS pervasive laboratory experiences provides a better attitude of open-mindedness toward science than the use of traditional procedures in the teaching of college physical science.

2. The use of the PSNS curricular materials provides a greater understanding of the role of science in contemporary society.

Conclusions

The conclusions in this study are based on the objective evidence reviewed in Chapter Five and recorded in the Appendixes. The evidence resulting from this study supports the following conclusions:

1. There was no significant difference between experimental and control groups in providing a better attitude of open-mindedness toward science through the use of PSNS curricular materials as measured on the dogmatism scale.

2. There was no significant difference between experimental and control groups in providing a greater understanding of the role of science in contemporary society through the use of PSNS curricular materials as measured by the Facts About Science Test.

Implications and Recommendations

The following implications and recommendations arise as a result of the findings developed in this study:

1. The conclusions arrived at in this study are based on data gathered in a given situation at Miami University. Extension to other instructors in other environmental situations is tenuous at best. It is not the intent of this study that these conclusions be construed to
apply as a generalization to any situation. Increased validation of this research by other investigators is needed in order to support the evidence beyond all reasonable doubt. The PSNS curriculum materials need to be tested in replica studies with other instructors under varying environmental conditions. Until a substantial quantity of evidence can be amassed, the worth of the PSNS curriculum materials must remain in question.

2. The science background of elementary teacher candidates needs to be concretely known. The PSNS curricular materials do not demonstrate the fact that the elementary teacher candidates may be knowledgeable in science. The findings of McCollum at Iowa State, Gaides and Diehl, and Iddings indicate that these candidates frequently have at least two years of high school science to their credit. In view of the increasing use of new science curricula at the elementary, junior, and senior high school level, a quantity of the science experiences in the PSNS curricular materials appears to be redundant. Future endeavors of this nature would profit by a thorough study of experiences in science that students might be expected to have prior to high school or college. Without this insight students would be bored with the curriculum or would find the PSNS materials assuming too much background. The student response\(^1\) observed during the initial phases of the use of the PSNS materials could be a result of inadequate understanding of elementary teacher candidate background.

\(^1\)See Chapter IV, pp. 59-60.
3. **The reading level of the materials published needs to fall within the range of freshman college students.** Provision should have been made to adequately test the reading materials of the trial edition of the PSNS syllabus. If the assumption is made that elementary teacher candidates have a reading ability that falls outside the range of the average college freshmen, then this assumption should be tested. First, it needs to be tested on a larger sample than was involved in this study. Secondly, subjective observation of the data presented in this thesis demonstrates a wide range of student ability. Materials written for this type of student consumer are extremely challenging and require skill in preparation with repeated testing. The subjective reactions of the students involved in the initial trial of the PSNS syllabus indicate that initial rejection of these curricular materials perhaps was related to the inappropriate reading level. If the materials are to be challenging to the student, the writers of future general education syllabi for elementary teacher candidates need to be cognizant of the reading level selected.

4. **The establishment of course outlines and course criteria should be based upon the needs of the elementary teacher candidate prior to any writing venture.** The PSNS proposal to the National Science Foundation does stipulate course criteria. The PSNS course criteria either inadvertently or purposely incorporated criteria generally believed to be valid for science in general education. The PSNS project leaders did attempt to evaluate elementary teacher candidates prior to the summer writing conference in 1965. The test instrument
used apparently provided a criteria for course difficulty. Unfortunately, only elementary teacher candidates were enlisted in this evaluation and no effort seems to have been expended to learn whether the sample tested was unique to the elementary teacher candidate population. Further, the instrument appears to fall short of various criteria established by the PSNS project leaders, not only in relationship to course criteria, but also in relationship to various criteria reported in the literature on science in general education.

5. The value of the science laboratory in college general education needs to be studied in relationship to criteria established for such science courses. Although science was once taught in colleges without laboratory, a science department in a college today without such a facility would be considered sub-standard by the respective professional science organizations. Yet the science laboratory is not always considered to be a necessary part of college science courses in general education. Research dealing with the laboratory most frequently appears to evaluate academic achievement. A much smaller body of research relative to the laboratory does seem to deal with more subtle aspects of the value of the laboratory in general education. The leaders of the PSNS project did assume that the laboratory should be the heart of a science course in general education. To this end they made a valiant attempt to overcome resistance to the science laboratory in general education. It appears, however, that additional
research is needed in order to present evidence that the PSNS curricular approach to laboratory instruction has merit based upon the PSNS course objectives.

6. There is a need to study further the development of attitudes that individual students acquire toward science. Before an adequate curriculum for a science course in general education can be written, a more thorough understanding of attitude development needs to be studied. Further, the contribution that a science curriculum can make toward achieving less authoritarian and intolerant attitudes needs to be known.

7. The social significance of science needs to be more clearly defined within the PSNS curricular materials. John Dewey recognized the problem of relating science to society and indicated that efforts should be made to bring the two into proper perspective. Many of the present elementary school science curricula are based upon the idea of establishing a balance between the natural sciences and the social sciences. The curricular writing project of Parsegian, reviewed briefly in this thesis, should be compared to the PSNS curricular approach. Parsegian did attempt to create such a course by bringing together the natural and social sciences in one two-year course. The value of PSNS curricular materials for elementary teacher candidates needs to be compared to those of the proposed course by Parsegian. Evaluation concerning the merit of either approach could ultimately lead to the improvement of teaching in the elementary classroom.
8. A thorough evaluation of the achievement of the initial PSNS course objectives needs to be undertaken. The goals of the PSNS program were concretely stated in the proposal to the National Science Foundation. An objective evaluation needs to be made to determine the extent to which these goals were achieved. Such critical evaluation at the conclusion of the course would answer the following questions about the use of the PSNS curricular materials: (1) Are students now able to ask sensible questions about science?, (2) Do students now do a better job of data collection?, (3) Are students now able to describe their observations adequately?, (4) Are students now able to interpret experimental results of an experiment?, (5) Are students better able to design techniques to support conclusions? Not only do these objectives need testing, they also need to be tested in reference to the extent that PSNS materials do this more adequately than general education courses already in use.
APPENDIX I

COLLEGES USING THE EXPERIMENTAL MATERIAL DURING THE ACADEMIC YEAR 1965-1966
APPENDIX II

PRELIMINARY TEST USED BY PROJECT IN THE FALL OF 1965 TO EVALUATE STUDENT BACKGROUND
Questions to Test Background of Students in Physical Science Courses

To the Student: These questions are being given to you by your professor in cooperation with a group of people who are about to design a new course in Physical Science for non-science majors. In order not to make the course too hard or too easy we need to have on record some information about the background preparation of students who take such a course. We are very grateful to your professor and you for giving us this information. If you have any suggestions or comments that you think would be useful to us, please add them at the end.

Whenever you don't know the answer, leave a blank.

A. Vocabulary: Tell as briefly as possible what each of the following means to you:

1. horizontal
2. vertical
3. linear relationship
4. chemical compound
5. viscous
6. permeable
7. normal to
8. precipitate
9. convex side
10. a thermal effect
11. sine
12. cosine

B. Mathematical background:

1. Express each of the following in some other way:
   a. \(10^2\)
   b. \(10^{-2}\)
   c. \(3.251 \times 10^3\)
   d. \(16^{\frac{1}{2}}\)
2. What is the value of x in the following equations?
   a. \(2x = 4\)
   b. \(\frac{2}{3}x = 4\)
   c. \(3 + x = 4\)
   d. \(\sqrt{x + 6} = 4\)
   c. \(\frac{330}{x} = 11\)

3. Express the following functions of a in terms of P, Q, and R: sine, cosine, tangent, cotangent.

4. Plot the values given in the table on the grid shown to the right and connect the plotted points to give a graph.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>x</th>
<th>y</th>
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<tbody>
<tr>
<td>0</td>
<td>2.0</td>
<td>7</td>
<td>8.5</td>
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<td>10</td>
<td>9.8</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Observation: Which weighs more, a pint of milk or a pint of cream? How do you know?

D. Interest: Check the phrase or phrases that describe how you felt about this course before beginning it.

___ I was going to enjoy it and do well in it.
___ I might enjoy it but not do well in it.
___ I would dislike it, but do pretty well in it.
___ I would dislike it and do badly in it.
___ It would be useful to me in my future work.
___ It probably wouldn't be useful, but since it was required there must be some purpose in it.
___ It probably wouldn't be useful but taking it would be worthwhile for my general background as a person.
___ I couldn't see how it could be useful and therefore thought taking it was a waste of time.

PLEASE ADD ANY COMMENTS YOU MAY WISH TO MAKE ON THE BACK OF EITHER SHEET.
APPENDIX III

TABLES ILLUSTRATING THE PRECOURSE AND ENVIRONMENTAL VARIABLES
### TABLE 1
PREVIOUS HIGH SCHOOL SCIENCE COURSES COMPLETED

<table>
<thead>
<tr>
<th>Course</th>
<th>Number Experimental Sample</th>
<th>Number Control Sample</th>
<th>Number Pooled Sample</th>
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<tbody>
<tr>
<td>General Science</td>
<td>9</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>Biology</td>
<td>9</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Chemistry</td>
<td>16</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Physics</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Other High School Science</td>
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<td>3</td>
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</table>

Total years of high school science background:

<table>
<thead>
<tr>
<th></th>
<th>Number Experimental Sample</th>
<th>Number Control Sample</th>
<th>Number Pooled Sample</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>37</td>
<td>43</td>
<td>77</td>
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Average number of years per student of high school science:

<table>
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<tr>
<th></th>
<th>Average years per student of high school science</th>
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<tbody>
<tr>
<td></td>
<td>2.24</td>
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<td>2.21</td>
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### TABLE 2
ENVIRONMENTAL FACTOR OF RESIDENCE

<table>
<thead>
<tr>
<th>Residence</th>
<th>Experimental Sample</th>
<th>Control Sample</th>
<th>Pooled Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>20</td>
<td>14</td>
<td>34</td>
</tr>
<tr>
<td>At Home</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Total:

<table>
<thead>
<tr>
<th></th>
<th>Experimental Sample</th>
<th>Control Sample</th>
<th>Pooled Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
<td>19</td>
<td>41</td>
</tr>
</tbody>
</table>
### TABLE 3

**PRE-COURSE FACTOR OF STUDENT'S HIGH SCHOOL LOCATION**

<table>
<thead>
<tr>
<th>Student Status</th>
<th>Experimental Sample</th>
<th>Control Sample</th>
<th>Pooled Sample</th>
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</thead>
<tbody>
<tr>
<td>Resident of Ohio</td>
<td>20</td>
<td>18</td>
<td>38</td>
</tr>
<tr>
<td>Non-Resident of Ohio</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>19</td>
<td>41</td>
</tr>
</tbody>
</table>

### TABLE 4

**PRE-COURSE FACTOR OF HIGH SCHOOL PERCENTILE RANK UPON GRADUATION**

<table>
<thead>
<tr>
<th>High School Percentile Rank</th>
<th>Experimental Sample</th>
<th>Control Sample</th>
<th>Pooled Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 30</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>31 - 60</td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>61 - 90</td>
<td>13</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>91 - 99</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>19</td>
<td>41</td>
</tr>
</tbody>
</table>
### TABLE 5
PRE-COURSE FACTOR OF CHRONOLOGICAL AGE
AS A REFLECTION OF INDIVIDUAL MATURITY

<table>
<thead>
<tr>
<th>Chronological Age (months)</th>
<th>Experimental Sample</th>
<th>Control Sample</th>
<th>Pooled Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>221-233</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>234-245</td>
<td>10</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>246-257</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>258-275</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22</strong></td>
<td><strong>19</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
APPENDIX IV

TABLES ILLUSTRATING CORRELATION MATRICES OF PREDICTION VARIABLES
### TABLE 6

**DOGMATISM SCALE POOLED SAMPLE CORRELATION MATRIX WITH ALL PREDICTOR VARIABLES CONSIDERED**

<table>
<thead>
<tr>
<th>Variables</th>
<th>PRE-FAS</th>
<th>AGE</th>
<th>ACT</th>
<th>H.S. RANK</th>
<th>PRE-DOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>.262</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>.264</td>
<td>-.169</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>.246</td>
<td>.095</td>
<td>.143</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>-.291</td>
<td>-.115</td>
<td>-.015</td>
<td>-.271</td>
<td></td>
</tr>
<tr>
<td>POST-DOG</td>
<td>-.087</td>
<td>-.215</td>
<td>.090</td>
<td>-.090</td>
<td>.526</td>
</tr>
</tbody>
</table>

*a* PRE-FAS: Preliminary FACTS ABOUT SCIENCE TEST  
AGE: Chronological age  
H.S. RANK: Percentile rank at time of high school graduation  
PRE-DOG: Preliminary dogmatism scale  
POST-DOG: Post dogmatism scale  
ACT: American College Testing Program

### TABLE 7

**FACTS ABOUT SCIENCE TEST POOLED SAMPLE CORRELATION MATRIX WITH ALL PREDICTOR VARIABLES CONSIDERED**

<table>
<thead>
<tr>
<th>Variables</th>
<th>PRE-FAS</th>
<th>POST-FAS</th>
<th>AGE</th>
<th>ACT</th>
<th>H.S. RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-FAS</td>
<td>.658</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>.262</td>
<td>.255</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>.264</td>
<td>.208</td>
<td>-.169</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>.246</td>
<td>.270</td>
<td>.095</td>
<td>.143</td>
<td></td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>-.087</td>
<td>-.364</td>
<td>-.215</td>
<td>.090</td>
<td>-.090</td>
</tr>
</tbody>
</table>

*b* PRE-FAS: Preliminary FACTS ABOUT SCIENCE TEST  
POST-FAS: Post FACTS ABOUT SCIENCE TEST  
AGE: Chronological age  
ACT: American College Testing Program  
H.S. RANK: Percentile rank at time of high school graduation  
PRE-DOG: Preliminary dogmatism scale
### TABLE 8

**DOGMATISM SCALE CONTROL SAMPLE CORRELATION MATRIX WITH ALL PREDICTOR VARIABLES CONSIDERED**

<table>
<thead>
<tr>
<th>Variables</th>
<th>PRE-FAS</th>
<th>AGE</th>
<th>ACT</th>
<th>H.S. RANK</th>
<th>PRE-DOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>.079</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>.307</td>
<td>-.086</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>.316</td>
<td>.138</td>
<td>.169</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>-.353</td>
<td>.162</td>
<td>-.066</td>
<td>-.313</td>
<td></td>
</tr>
<tr>
<td>POST-DOG</td>
<td>.016</td>
<td>-.170</td>
<td>.238</td>
<td>-.005</td>
<td>.465</td>
</tr>
</tbody>
</table>

^PRE-FAS: Preliminary FACTS ABOUT SCIENCE TEST
PRE-DOG: Preliminary dogmatism scale
H.S. RANK: Percentile rank at time of high school graduation.
POST-DOG: Post dogmatism scale
ACT: American College Testing Program
AGE: Chronological age

### TABLE 9

**DOGMATISM SCALE EXPERIMENTAL SAMPLE CORRELATION MATRIX WITH ALL PREDICTOR VARIABLES CONSIDERED**

<table>
<thead>
<tr>
<th>Variables</th>
<th>PRE-FAS</th>
<th>AGE</th>
<th>ACT</th>
<th>H.S. RANK</th>
<th>PRE-DOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>.178</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>.111</td>
<td>-.469</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>.082</td>
<td>-.060</td>
<td>.081</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>.167</td>
<td>-.167</td>
<td>.196</td>
<td>-.165</td>
<td></td>
</tr>
<tr>
<td>POST-DOG</td>
<td>-.035</td>
<td>-.058</td>
<td>.015</td>
<td>-.125</td>
<td>.542</td>
</tr>
</tbody>
</table>

dRefer to note c in Table 8 above for definitions of terms.
<table>
<thead>
<tr>
<th>Variables</th>
<th>PRE-FAS</th>
<th>POST-FAS</th>
<th>AGE</th>
<th>ACT</th>
<th>H.S. RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-FAS</td>
<td>.584</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>.079</td>
<td>.138</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>.307</td>
<td>.097</td>
<td>-.086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>.316</td>
<td>.305</td>
<td>.138</td>
<td>.169</td>
<td></td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>.016</td>
<td>-.372</td>
<td>-.170</td>
<td>.238</td>
<td>-.005</td>
</tr>
</tbody>
</table>

PRE-FAS: Preliminary FACTS ABOUT SCIENCE TEST
POST-FAS: Post FACTS ABOUT SCIENCE TEST
ACE: Chronological age
ACT: American College Testing Program
H.S. RANK: Percentile rank at time of high school graduation
PRE-DOG: Preliminary dogmatism scale

<table>
<thead>
<tr>
<th>Variables</th>
<th>PRE-FAS</th>
<th>POST-FAS</th>
<th>AGE</th>
<th>ACT</th>
<th>H.S. RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST-FAS</td>
<td>.649</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>.178</td>
<td>-.054</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>.111</td>
<td>.276</td>
<td>-.469</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>.082</td>
<td>.156</td>
<td>-.060</td>
<td>.381</td>
<td></td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>-.035</td>
<td>-.104</td>
<td>-.056</td>
<td>.015</td>
<td>-.125</td>
</tr>
</tbody>
</table>

Refer to note e in Table 10 above for definitions of terms.
APPENDIX V.

TABLES ILLUSTRATING CORRELATIONS BETWEEN ACTUAL AND PREDICTED SCORES USING THE POOLED SAMPLE AS THE BASE IN THE DUBOIS EQUATION
### Table 12

**Correlation Between the Actual and Predicted Scores for the Facts About Science Test Using the Pooled Sample as the Base in the DuBois Equation**

<table>
<thead>
<tr>
<th>Beta Weight</th>
<th>Control Sample</th>
<th>Experimental Sample</th>
<th>Pooled Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-FAS</td>
<td>(1) .584</td>
<td>(1) .649</td>
<td>(1) .658</td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>(2) .697</td>
<td>(4) .690</td>
<td>(2) .726</td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>(3) .708</td>
<td>(3) .686</td>
<td>(3) .732</td>
</tr>
<tr>
<td>AGE</td>
<td>(4) .708</td>
<td>(5) .695</td>
<td>(5) .735</td>
</tr>
<tr>
<td>ACT</td>
<td>(5) .708</td>
<td>(2) .680</td>
<td>(4) .734</td>
</tr>
</tbody>
</table>

*See Table 10 for definitions of terms used under Beta Weight. Numbers in () parentheses are indicative of the order that the predictor variables were entered into the DuBois equation.*

### Table 13

**Correlation Between the Actual and Predicted Scores for the Dogmatism Scale Using the Pooled Sample as the Base in the DuBois Equation**

<table>
<thead>
<tr>
<th>Beta Weight</th>
<th>Control Sample</th>
<th>Experimental Sample</th>
<th>Pooled Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-FAS</td>
<td>(2) .588</td>
<td>(3) .597</td>
<td>(2) .580</td>
</tr>
<tr>
<td>PRE-DOG</td>
<td>(1) .465</td>
<td>(1) .542</td>
<td>(1) .526</td>
</tr>
<tr>
<td>H.S. RANK</td>
<td>(5) .693</td>
<td>(4) .610</td>
<td>(3) .605</td>
</tr>
<tr>
<td>AGE</td>
<td>(3) .649</td>
<td>(5) .619</td>
<td>(4) .608</td>
</tr>
<tr>
<td>ACT</td>
<td>(4) .693</td>
<td>(2) .573</td>
<td>(5) .609</td>
</tr>
</tbody>
</table>

*See Table 10 for definitions of terms used under Beta Weight. Numbers in () parentheses are indicative of the order that the predictor variables were entered into the DuBois equation.*
APPENDIX VI

TABLE ILLUSTRATING THE LEVEL OF SIGNIFICANT DIFFERENCE BETWEEN EXPERIMENTAL AND CONTROL SAMPLES BASED UPON THE MEASURING INSTRUMENTS USED
TABLE 14

T TEST FOR SIGNIFICANCE BETWEEN EXPERIMENTAL AND CONTROL SAMPLES\textsuperscript{a}

<table>
<thead>
<tr>
<th>t Value</th>
<th>No. Cases Control</th>
<th>No. Cases Experimental</th>
<th>Total Sample</th>
<th>Degrees of Freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOG</td>
<td>.2189</td>
<td>19</td>
<td>22</td>
<td>41</td>
</tr>
<tr>
<td>FAS</td>
<td>.2140</td>
<td>19</td>
<td>22</td>
<td>41</td>
</tr>
</tbody>
</table>

\textsuperscript{a}DOG: Dogmatisn scale  
FAS: Facts About Science Test
BIBLIOGRAPHY

Books


Articles and Periodicals


Rogers, Eric M. "The Good Name of Science: A Discussion of Science Courses for General Education in College," Science, CX (December 9, 1949), 599-604.


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Gaides, Glen E., and Diehl, T. Handley. "Report to the Students in Physical Science and to the Dean of the School of Education of Miami University." (Duplicated.)


Miami University, Oxford, Ohio. Minutes of the Faculty of the School of Education. March 9, 1965. (Mimeographed.)


I, Tennieson Handley Thomas Diehl, was born in Philadelphia, Pennsylvania, on December 2, 1925. My primary and secondary education was received in Moorestown Friend's School, Moorestown, New Jersey. In 1951 Earlham College, Richmond, Indiana, granted me the Bachelor of Arts degree with a concentration in chemistry. I received the Master of Science degree from the University of Delaware, Newark, Delaware, in chemistry in 1954. From 1952 to 1955 I taught science and mathematics at Celina High School, Celina, Ohio. From 1955 to 1959 I taught chemistry in the Cincinnati Public Schools. While with the Cincinnati Public Schools, I served as a science facilities consultant in 1958 to the Finneytown Board of Education. In 1958 I received the outstanding science teacher award from the Ohio Academy of Science. From 1959 to 1960 I was Research Associate and Associate Project Director of a project titled, "The Development of a Mobile Laboratory for the In-Service Education of Teachers of Science and Mathematics," at The Ohio State University. At the termination of this science education research project, I worked part time as a lecture assistant in the Department of Chemistry at The Ohio State University and in science education research for the Title III office of the Ohio State Board of Education. During the summer of 1965, I was a member of the writing staff for the Physical Science
for Nonscience Majors project at Rensselaer Polytechnic Institute at Troy, New York. Since 1961 I have been an Instructor at Miami University, Oxford, Ohio, teaching a course in general education science for elementary teachers and a methods course in high school physical science.