RELATIONSHIPS BETWEEN HIGH SCHOOL PHYSICS TEACHER CHARACTERISTICS AND TEACHER-STUDENT ATTITUDES TOWARD PHYSICS

by

Walter Earl Elliott

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF SECONDARY EDUCATION

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 2

THE UNIVERSITY OF ARIZONA

GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my direction by Walter Earl Elliott entitled RELATIONSHIPS BETWEEN HIGH SCHOOL PHYSICS TEACHER CHARACTERISTICS AND TEACHER-STUDENT ATTITUDES TOWARD PHYSICS be accepted as fulfilling the dissertation requirement of the degree of Doctor of Philosophy

Dissertation Director — 12-17-71
Date

After inspection of the final copy of the dissertation, the following members of the Final Examination Committee concur in its approval and recommend its acceptance:*

12-17-71

12-23-71

*This approval and acceptance is contingent on the candidate's adequate performance and defense of this dissertation at the final oral examination. The inclusion of this sheet bound into the library copy of the dissertation is evidence of satisfactory performance at the final examination.

STATEMENT BY AUTHOR

This dissertation has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this dissertation are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Walter E. Elliott

ACKNOWLEDGMENTS

I wish to thank Dr. Chester Brown, my dissertation advisor, for his guidance and patience throughout the interim between conception and fruition of this research.

Several other individuals deserve an expression of gratitude. A special thanks to Dr. Paul Allen, a committee member whose moral support and suggestions were especially welcomed. Further, I extend my gratitude to the other members of my committee, Dr. Douglas Donahue, Dr. M. M. Gubser, and Dr. John McCullen.

A special thanks also to Dr. Arnold Strassenburg, Director, Manpower and Education Division, American Institute of Physics, Inc., for his moral support, his technical guidance, and his arranging for partial funding of the research.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

In this age of advanced science and technology, when the democratic citizen faces a myriad of vital science-based societal issues (such as environmental pollution, space exploration funding, and nuclear weaponry) an overwhelming majority of American high school students are avoiding the study of physics, that science considered basic to all of the natural sciences.

Fundamental to the rationale of this study were the tacit assumptions that a significant feature of a viable democracy is that individuals have choices in matters of special concern to them, and that in the field of education a student's choice of school subjects is related somehow to his perceptions of the subject matter of the course, of the possible value of the course to him personally, and of the life-styles incumbent upon the workers or professionals within the subject matter field.

Since American high schools generally afford students latitude in course selection, it seemed appropriate to probe student perceptions of physics for clues to possible reasons why so many students avoid physics. Accordingly, this study is addressed primarily to the determination of such perceptions.

Instruments were designed which gathered anonymous data related to selected characteristics and attitudes of 347 physics teachers, 2,438 non-physics students, and 10,582 physics students in the California public high schools.

Fourteen null hypotheses were tested. Conclusions and recommendations were based upon Chi square, Pearson product-moment, and frequency of response analyses and pertained to physics courses, physics teachers, and physics teaching.

Significant relationships were found to exist between physics enrollments and fear of poor grades, difficulty of physics, anticipated future usefulness of physics, sex of the students, student grade point average, student class standing, student interest in physics, and student image of physics and physics teachers. Significant relationships also existed between student perceptions of physics and the inclusion of social, political, and historical aspects of physics in course objectives, the teacher's subject matter preparation, teacher time spent in classroom preparation, teacher identification with other physics teachers, teacher feeling of course success, teacher commitment to physics teaching, and teacher attitudes toward physics.

Recommendations included offering courses with greater appeal to girls, to average and below-average

students, to "terminal" students, and to people-oriented students; encouraging employment only of qualified teachers; "selling" physics to counselors, students, non-physics teachers, and the community; and, teaching physics more in terms of behavioral objectives.

CHAPTER I

THE PROBLEM AND HYPOTHESES

Introduction

Among scientists and educators it is generally agreed that today's democratic citizen needs some knowledge of physics if he is to understand and to react intelligently to such myriad, pressing societal issues as environmental pollution, space exploration, and nuclear weaponry. Yet, an overwhelming majority of American high school students are avoiding the study of physics.[1] Moreover, this avoidance phenomenon permeates our colleges and universities as well.

Germane to any analysis of student avoidance of physics in our schools is the democratic philosophy that students ought to be relatively free to choose their own careers, and that the needs of the community and the aspirations of the individual be optimally reconciled to insure maximum benefits to both.

And fundamental to the rationale of this study is the tacit assumption that a student's choice of school subjects is related somehow to his perceptions of the subject matter content of a given course, to his perceptions of the possible

---

1. Gerald Holton, "Harvard Project Physics," Physics Today, XX (March, 1967), pp. 31-34.

value of the course to him personally, and to his perceptions of the life-styles incumbent upon the workers or professionals devoted to a given subject matter field.

Since our high schools generally afford students latitude in course selection, it seemed appropriate to examine student perceptions of physics and physics teachers for clues to possible reasons why so many students elect not to study physics. Accordingly, this study is addressed primarily to the determination of such perceptions.

Statement of the Problem

It was the purpose of this study to seek answers to the question: In what ways were selected characteristics, attitudes, and other qualities of California public high school students and physics teachers related to their perceptions of high school physics, and of physics as a field of study?

Significance of the Problem

There were numerous alarms sounded to warn of the decline in enrollments in physics and of the varied, negative implications of this decline. Susanne Ellis, Supervisor of Manpower Studies, American Institute of Physics, Inc., warned that while physics enrollments in public high schools increased steadily from about three hundred thousand to almost five hundred thousand over the decade 1955 to 1965, the fraction of physics students in the twelfth grade decreased from twenty-four per cent to less than twenty per cent.[2] Ellis further stated that although the college population had increased steadily over the past decade, and that although a greater number of institutions were offering physics courses, enrolling physics majors, and granting physics degrees, the number of physics majors in our colleges and universities had declined. As a consequence, the National Science Foundation, in 1967, funded a two-year study of the causes of attrition for physics majors from their junior year at college through the doctoral level.[3]

Dr. Gerald Holton, Professor of Physics at Harvard University and Director of the Harvard Physics Project, informed the American Association for the Advancement of Sciences that he considered the problem of low physics enrollments to be a national emergency.[4] He pointed out that eighty per cent of our high school seniors take no physics. Holton believed that trying to reverse the enrollment trend had social and individual implications outside the purely professional ones; i.e., that some acquaintance with science

---

2. Susanne D. Ellis, "Enrollment Trends," Physics Today, XX (March, 1967), pp. 75-79.

3. Arthur A. Strassenburg, "Proposal for Studies of Problems in the Education and Employment of Physicists" (submitted to the National Science Foundation by the Office of Education and Manpower, American Institute of Physics, Inc., New York, 1967).

4. Holton, *op. cit.*, p. 31.

and scientific thinking was essential in our technologically-oriented society, and that without this acquaintance, young people would find it difficult to become adequate wage earners and effective citizens. Holton discussed also those students who go to college and study humanities or social sciences, but avoid the physical sciences. He declared that it was both important and possible to reach more of these kinds of students in high school, and to show them that:

> Physics is neither an isolated bloodless body of facts and theories with mere vocational usefulness nor a glorious entertainment restricted to an elite of specialists. We can and must show them that physics now lies, in the words of I. I. Rabi, "at the core of the humanistic education of our time."[5]

A complement to Dr. Holton's thesis was offered by Gatewood and Obourn.[6] Their thesis was that there ought to exist a deepening awareness of the basic role of science and technology in the present and future welfare and security of the free world. To safeguard the free world, they declared that quality education in the sciences was mandatory. They listed the following as guidelines for science teaching in the United States:

> (a) To provide an education in science for all citizens that will insure a scientific literacy commensurate with the demands placed on the society by science and technology.

---

5. Ibid., p. 33.

6. Claude W. Gatewood and Ellsworth S. Obourn, "Improving Science Education in the United States," Journal of Research in Science Teaching, I (1963), pp. 355-399.

(b) To provide specialized education in science for those who will constitute the creative scientific and engineering manpower for the future.

(c) To provide full educational opportunities for the pursuit of science as a humane endeavor in a society in which it plays a significant role.[7]

Arthur A. Strassenburg, Professor of Physics at State University of New York, Stony Brook, and Director of the Education and Manpower Division, AIP, stressed repeatedly both the urgency and the significance of the enrollment problem and suggested methods of attacking it. In 1967, Strassenburg submitted this statement to the National Science Foundation:

> As a result of previous studies, a number of seemingly undesirable trends in the education and employment of physicists have been discovered which, if no corrective action is taken, could have serious consequences for the future of science in this country.[8]

Strassenburg pointed out that one such trend was the nation-wide decrease in physics enrollments. One of his suggested methods of attack was to search for significant relationships between the characteristics of high school physics teachers and selected qualities of high school students.[9]

In summary of the significance of the problem, the nation-wide decline in physics enrollments was perceived as having negative implications for the future scientific

---

7. <u>Ibid</u>., p. 375.

8. Strassenburg, "Proposal for Studies of Problems in the Education and Employment of Physicists," <u>op</u>. <u>cit</u>., p.1.

9. <u>Ibid</u>., pp. 8-9.

literacy of the general population and for the future development of adequate numbers of research scientists and physics teachers. A suggested method for seeking clues to declining physics enrollments was to examine student perceptions of physics and physics courses.

Assumptions

Because this study was of an exploratory nature and because the study probed the attitudes and feelings of both students and teachers, several assumptions had to be considered.

It was assumed that teachers and students held certain attitudes and feelings toward physics as a field of study and toward physics teaching.

It was assumed that relations between attitudes, feelings, and other teacher or student qualities could be determined from analysis of their scaled-choice responses to certain questionnaire items.

Limitations

The nature of the study assumed several recognized limitations which are presented below:

1. The study was limited to California public school teachers and students.

2. The questionnaire formats forced closed-type responses. Respondents were required to sense-mark answer choices on answer sheets that could be read by machine and scored automatically on data processing cards.

3. The validity and reliability of the instruments were established by modeling them after similar instruments of closely related investigations, through critique by high school physics teachers and college physics teachers, by pilot tests with selected students, by critique of the staff, Division of Education and Manpower, American Institute of Physics, Inc., and by submission to the researcher's graduate committee. Because this normative study was conducted entirely by mail, the researcher had no personal contact with any of the respondents. (See Chapter III, Design of the Study.)

4. Teachers who volunteered for the study exhibited a motivation not evidenced by those who chose not to participate; therefore, a limiting bias was caused by the non-participants.

5. The statistical analyses utilized probability distributions for testing certain of the null hypotheses. Thus, possibilities of making Type I and Type II errors in data analysis existed.[10]

Definition of Terms

Definition of these terms seemed necessary:

A. I. P.--The American Institute of Physics, Inc., commonly referred to as AIP, is a non-profit,

---

10. N. M. Downie and R. W. Heath, Basic Statistical Methods (New York: Harper and Row, Publishers, 1965), p. 129.

privately financed federation of the extant physics societies in the United States. The stated purpose of this federation is the advancement and diffusion of the knowledge of physics and its application to human welfare (Appendix A).

Attitude-- An attitude of a teacher or student was revealed by a closed-type, scaled-choice response to those questionnaire items relevant to the respondent's "predisposition to think, feel, perceive, or behave toward some cognitive object" presented him by the questionnaire.[11]

Non-physics student-- A non-physics student was any California public high school student who had senior class status during the academic year 1967-68 and who did not elect to study physics in high school.

Perception-- Perception was used to mean the overall manner in which a respondent was aware of a cognitive object. For example, those qualities which a respondent could consciously ascribe to physics, as a field of study, would be expressions of his perception, or total awareness, of the cognitive object, physics.

Physicist-- A physicist was any person having a baccalaureate or more advanced degree with a major in physics.

---

11. Fred N. Kerlinger, Foundations of Behavioral Research, Educational and Psychological Inquiry (New York: Holt, Rinehart, and Winston, Inc., 1965), p. 483.

Physics student-- A physics student was any California public high school student enrolled in a course of study for which the State of California gave high school physics credit during the academic year 1967-68.

Physics teacher-- A physics teacher was any teacher who taught at least one course of study during the academic year 1967-68, for which the State of California gave credit as constituting a high school physics course.

Population-- A population was a group defined arbitrarily for purposes of statistical sampling. In this study, three populations were sampled: (1) California public high school physics teachers, (2) California public high school physics students, and (3) California public high school non-physics students.

Quality-- Quality was any personal characteristic or attribute or feature of a teacher or of a student, such as: sex, age, education, feelings, experiences, attitudes, etc. Quality was considered to be the universal set of which all the foregoing examples were sub-sets.

Hypotheses Tested

This study sought answers to this question: In what ways were selected characteristics, attitudes, and other qualities of California public high school students related to their perceptions of high school physics teachers and of physics as a field of study?

From the statement of the problem, null hypotheses were developed to give order and direction to the study. These fourteen null hypotheses have been numbered for easy reference:

1. There would be no significant relationship between high school physics student attitudes toward physics and the academic preparation of high school physics teachers.

2. There would be no significant relationship between high school physics student attitudes toward physics and the extent to which the physics teachers identified with the physics profession.

3. There would be no significant relationship between high school physics student attitudes toward physics and the physics work experiences of the teachers.

4. There would be no significant relationship between high school physics student attitudes toward physics as a field of study and teacher expressions of long-term commitments to physics teaching.

5. There would be no significant relationship between the attitudes of high school physics students toward physics as a field of study and the attitudes of high school physics teachers toward physics.

6. There would be no significant relationship between high school physics student identification of a successful physics course and high school physics teacher identification of a successful physics course.

7. There would be no significant relationship between high school physics student attitudes toward physics and the time which high school physics teachers spent in preparation for classroom and laboratory teaching.

8. There would be no significant relationship between high school physics student attitudes toward physics as a field of study and the extent of the emphasis placed upon teaching the social, political and historical aspects of physics.

9. There would be no significant relationship between high school physics student attitudes toward physics courses and teacher expressions of long-term commitments to physics teaching.

10. There would be no significant relationship between the sex of high school students and enrollments in high school physics courses.

11. There would be no significant relationship between the expressed interest levels of high school students toward physics and the number who enrolled in high school physics.

12. There would be no significant relationship between the degree of difficulty with which high school students regarded physics and the number who enrolled in high school physics.

13. There would be no significant relationship between the occupational choice ranking of <u>physics teacher</u> by

high school physics students and the number who enrolled in high school physics.

14. There would be no significant relationship between the occupational choice ranking of physicist by high school physics students and the number who enrolled in high school physics.

Summary

In an age of lunar exploration, nuclear and atomic power, laser technology, and a geometric progression in the advancement of science and technology, American high school students are avoiding the study of physics--that science considered basic to all of the natural sciences.[12] This avoidance phenomenon permeates our higher institutions of learning as well, and defies the concerted efforts of national physics curriculum groups to arrest it.

Numerous alarms have been sounded warning of the negative implications inherent in the nation-wide decline of physics enrollments. These implications include: a serious inadequacy in the level of scientific literacy of the general population, a future shortage of research scientists, and a continued shortage of qualified physics teachers.

---

12. Oscar L. Brauer, "Attempts to Improve High School Physics Education," *Science Education*, XXXXVII (October, 1963), pp. 372-376.

It was suggested that a study of relationships between selected qualities of high school physics teachers and pupil perceptions of physics might yield clues to the solution of the enrollment problem.

This research sought answers to the particular question: In what ways were selected characteristics, attitudes, and other qualities of California public high school students and physics teachers related to their perceptions of high school physics and of physics as a field of study?

Certain assumptions and limitations were inherent in the study. A fundamental assumption was that relations between attitudes, feelings, and other teacher or student qualities could be ascertained from numerical analysis of closed-type, scaled-choice responses to selected items of teacher and student questionnaires.

In Chapter II will be found a review of literature pertinent the study. Chapter III describes the design of the study. Chapter IV presents the findings of the study. Chapter V consists of the study's summary, conclusions, and recommendations.

CHAPTER II

REVIEW OF THE LITERATURE

This review of literature is presented in two major sections: an overview of science education in America, and an evaluation of the nation-wide decline in physics enrollments. These sections were further subdivided into: an historical background of American science education, recent national curriculum efforts, the need for science courses in the education of modern man, the fundamental nature of physics, the nature of the problem of declining physics enrollments, reasons for declining enrollments, and suggested remedies for low enrollments in physics.

Because of the quantity of material in this chapter, the larger sections are preceded by a synthesis of section contents.

An Overview of Science Education in America

This section contains a review of the evolution of science education in America, and a statement of the need for science and physics in the education of modern man.

The evolution of American science education has resulted in three major effects pertinent to this study. Science has become an integral part of the American high school curriculum, secondary public school students have relative freedom to choose their careers and courses of study, and secondary public school students have a variety of science course offerings from which they can choose. However, although students have elected to study physical science, biology, and chemistry in increasing numbers, physics class enrollments have declined steadily for several years.

Historical Background

Prior to 1635, there was no formal science education in the then religion-oriented American schools. In the century which followed, both the Latin grammar school and the college were founded and both became established American institutions. The Latin grammar school offered no science courses, but the colleges (such as Harvard and Yale) usually offered non-laboratory courses in natural history, astronomy, and surveying.[13]

With the advent of the technological and industrial revolutions in the United States (circa 1750), a need soon developed for yet another kind of school to bridge the educational gap between the Latin grammar schools and the

---

13. Orval L. Petersen, "A Brief Look at the History of Science Education in America: Its Past, Present, and Future," Science Education, XXXXIII (December, 1959), pp. 427-435.

colleges.[14] This third type of school was the academy, from which the modern high school evolved. The academy schools soon offered non-laboratory studies related to those areas of science which were destined to become courses in their own right later in the evolution of American science education--namely, biology, astronomy, physical geography, geology, and chemistry. But it was not until 1865 that the first laboratory science course was introduced into American schools at any level, and this was a high school chemistry class for girls only.[15]

By 1894, the concept of a free high school education for all young people had become an integral part of our educational system. The Report of the Committee of Ten, in 1894, proposed a universal curriculum for the public high schools.[16] This curriculum found ready acceptance, enhanced greatly the popularity of the public high schools, and raised the academic standards of these schools to levels comparable with those of the private high schools. Because the committee believed that the curriculum which best served both the

---

14. Stewart A. Street, "Trends in the Physics Curriculum," The Physics Teacher, V (October, 1967), pp. 319-321.

15. Petersen, op. cit., p. 429.

16. Bernard Mehl, "The Conant Report and the Committee of Ten: A Historical Appraisal," Educational Research Bulletin, XXXIX (February, 1960), pp. 29-38.

terminal and the college-bound student was a college preparatory one, it recommended that all students receive a general education concentrated in one of four areas: languages, mathematics, history, or science. Each area of concentration required five years of science, including a course in physics. This recommended physics course followed chemistry, was offered at the senior class level, encompassed a minimum of two hundred hours of instruction, and devoted one-half of the instructional time to laboratory work.[17]

In the short span of twenty years, 1910 to 1930, the high school population more than quadrupled in the United States.[18] Phenomena responsible for this rapid rise in enrollments included: the 1874 Michigan Supreme Court ruling that free, tax-supported high schools could legally be instituted by citizens; the compulsory attendance laws; the child labor laws; and the over-all societal effects of profound economic and social changes which incorporated the twin American ideal of equality of opportunity and equality of status.[19,20] Nearly 266,000 students

---

17. Street, op. cit., p. 320.

18. Gatewood and Obourn, op. cit., p. 358.

19. Claude W. Gatewood, "The Science Curriculum Viewed Nationally," The Science Teacher, XXXV, No. 8 (November, 1968), pp. 18-21.

20. James B. Conant, The American High School Today (New York: McGraw-Hill, 1959), p. 7.

were in high school by 1900, and college preparatory science courses had become entrenched firmly in the American high school. Enrollments grew to nearly 2,500,000 by the year 1920, and the contents of high school science courses began to change.[21]

The curriculum of the schools of the 1920's bore little resemblance to the rigorous, textbook-oriented, college preparatory curriculum of the late nineteenth and early twentieth centuries.[22] Instead, efforts had been made to alter the rigorous curriculum to better meet the cultural needs of the changing society. However, the effect on secondary school science was that although it became somewhat more oriented toward a kind of life-adjustment education, it remained based largely upon a traditional, textbook-dominated memory-oriented approach.[23] During the 1920's, groups of science educators began to seek further reform. Educational principles most often used by these groups as bases for reform were those set forth in 1918 by the National Education Association Committee on the Reorganization of Secondary School Education (The Cardinal Principles of Secondary Education).[24]

---

21. Petersen, op. cit., pp. 428-433.
22. Gatewood, op. cit., p. 19.
23. Street, op. cit., p. 320.
24. Gatewood, op. cit., p. 18.

In the 1930's, secondary school enrollments swelled to over seven million; then, in the 1940's enrollments shrank to a 1949 low of about six and one-half million. The trend was reversed in 1950, when enrollments again surged upward and have continued so ever since. Figure 1 depicts general trends in enrollments in public and private high schools from 1880 to 1960.[25] Enrollments since the time depicted (Fig. 1) show a continued rise and public secondary school figures for 1969-70 were 17,432,000, and for 1970-71 they were 17,726,000. Further, no marked decline was expected within a decade.[26]

While over-all school enrollments rose during the 1930's and the 1950's, high school science programs consisted mostly of obsolescent versions of what science had been many years before. But limited efforts were made early in the 1950's to reform the outdated science education of the 1930's and 1940's. For example, in 1956, the National Science Foundation funded the Physical Science Study Committee and charged it with the development of a modern high school physics curriculum.[27] But the major impetus to rapid

---

25. Chris A. DeYoung and Richard Wynn, American Education, Fifth Edition (New York: McGraw-Hill Book Company, 1964, p. 172), shown in Claude Gatewood, "The Science Curriculum Viewed Nationally," The Science Teacher, XXXV, No. 8 (November, 1968), pp. 18-21.

26. "Public School Statistics, 1967-8 and 1968-9," NEA Research Bulletin, XXXXVII (March, 1969), p. 29.

27. Gatewood, op. cit., p. 19.

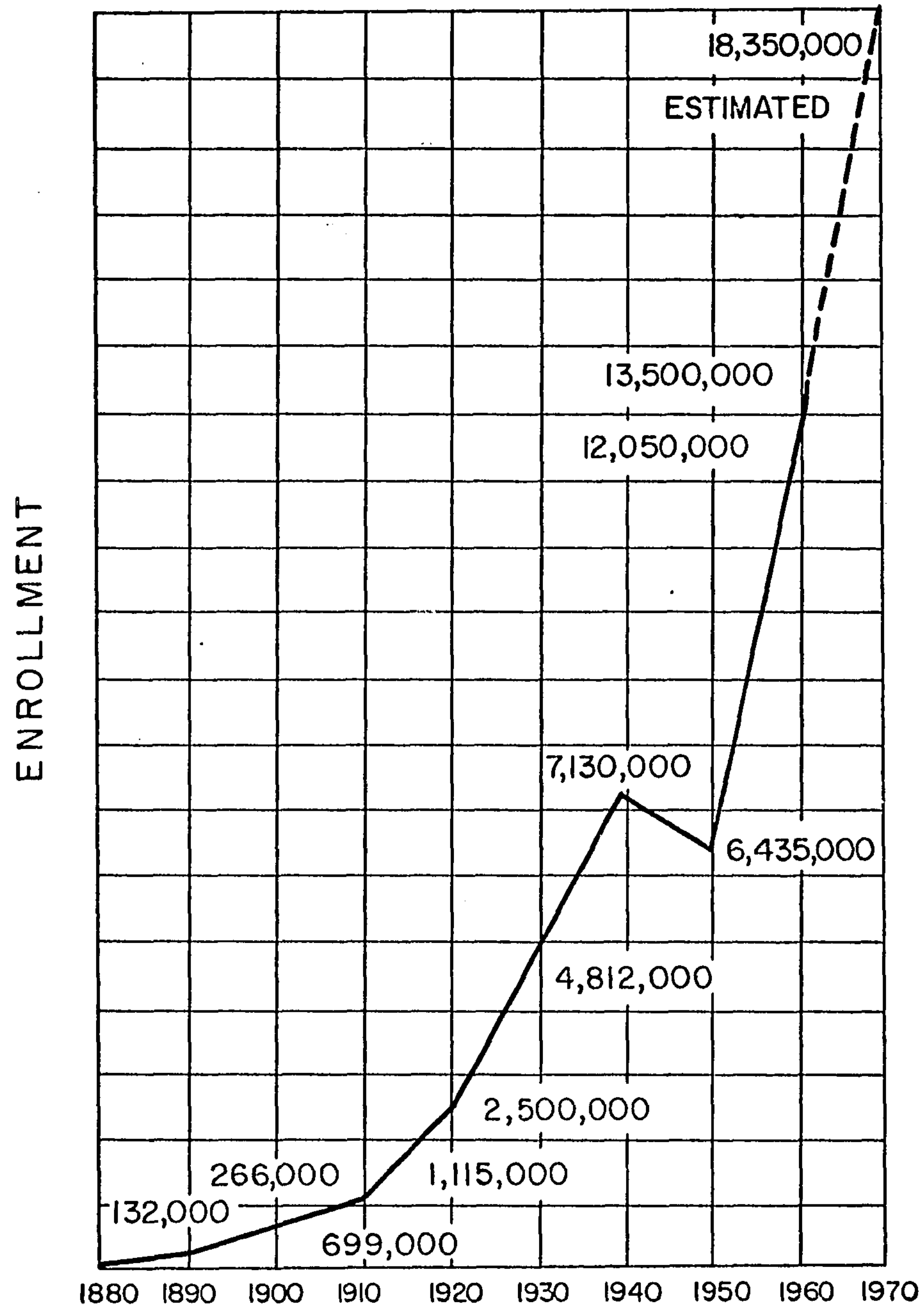

Fig. 1. Public and Private High School Enrollments, 1880 to 1960.

Source: Chris A. DeYoung and Richard Wynn, American Education, Fifth Edition (New York: McGraw-Hill Book Company), p. 172.

and widespread changes in high school science curricula was provided in the 1950's by (1) the launching of Sputnik in 1957, and (2) the publishing of the Conant Report in 1959. Sputnik shocked Congress into providing the large sums of money necessary for national curriculum reforms, and thereby helped usher in the current era of science curriculum improvements. The Conant Report advocated a basic, general, "minimum" curriculum for high school students which included one year of science.[28] For the academically talented, Conant deviated from the "minimum" curriculum and recommended three years of science, including physics. For the nonscience oriented students of average ability, Conant suggested two years of science, including a course which he alluded to as "practical physics."

Recent National Curriculum Efforts

Two significant features of the teaching philosophy of the secondary schools of the middle 1950's through the late 1960's was that students be free to choose their own careers, and that the needs of the community be reconciled with the aspirations of the individual. These two pivotal concepts challenged science educators to develop national science curricula relevant to both student and community

---

28. Street, <u>op</u>. <u>cit</u>., p. 320.

needs so that adequate numbers of students might be motivated to study science.

The first of these updated, elite kinds of science curricula characteristic of the late 1950's and early 1960's was the high school physics course produced by the Physical Science Study Committee (hereinafter referred to as PSSC).[29] These so-called elite curricula were written primarily for college-bound science students and were designed to provide a basis for further studies in a given science field.[30] PSSC efforts were followed quickly by science course improvement projects designed to reach educational levels from kindergarten to high school. The National Science Foundation alone sponsored over one hundred such efforts. Some examples of these nation-wide, first-generation high school science improvement projects were the Chemical Bond Approach Project in 1957 (hereinafter referred to as CBA), the Biological Sciences Curriculum Study in 1959 (hereinafter referred to as BSCS), and the Chemical Materials Study in 1959 (hereinafter referred to as CHEMS). By 1962, approximately one million students were using curricula and materials produced by PSSC, CBA, BSCS, and CHEMS.[31]

---

29. Gatewood and Obourn, op. cit., p. 363.

30. Gatewood, op. cit., p. 19.

31. Ibid.

By the mid-1960's, it was realized that the new curricula were not appealing to large segments of the high school population. To further improve science curricula and to reach those population segments left unmotivated by first-generation curricula, the following second-generation curricula were produced: (1) PSSC Advanced Topics, an elite type, (2) BSCS Special Materials, for less able students, (3) Introductory Physical Science (hereinafter referred to as IPS), an elite type for preparing bright students for PSSC physics, (4) CBA Supplements, an elite type, (5) CHEMS Supplements, another elite type, (6) Harvard Physics Project (hereinafter referred to as HPP), for college-bound, non-science oriented students and for non-college bound students, (7) Engineering Concepts Curriculum Project (hereinafter referred to as ECCP), for students who found PSSC too difficult or too irrelevant, and (8) Earth Science Curriculum Project (hereinafter referred to as ESCP), a ninth grade science course for all students.

The Need for Science Courses

The literature abounded with arguments supporting the need for science courses and supporting the inclusion of physics in science offerings. These supporting arguments were founded principally upon the need for a scientifically literate citizenry as an essential element for survival of a modern democratic society, and upon physics as the fundamental natural science.

Charles Reich, in his 1970 bestseller, The Greening of America, discussed the need for modern man's understanding of science in terms of our "uncontrolled technology and the destruction of the environment" and the "loss of basic values of life" which have accompanied the non-thinking adoption of certain scientific techniques.[32]

Milton O. Pella, professor of science education, University of Wisconsin (Madison), commented upon the significance of science in the education of modern man:

> The number and complexity of the decisions involving understanding of the products, processes, and ethics of science, and the relationships of science to society are ever increasing. Will the masses continue to be involved in making these decisions, or will the decisions be made by a "scientific elite"?[33]

Dr. Elmer Hutchisson, editor of the Journal of Applied Physics, argued that one of the great intellectual achievements of the twentieth century was the confirmation of an immense body of knowledge regarding the physical world. He stressed that to understand and to appreciate something of this knowledge was the foremost reason why every high school student should study physics, and that to be illiterate of

---

32. Charles A. Reich, The Greening of America (New York: Bantam Books, Inc., 1971), pp. 5, 27.

33. Milton O. Pella, "Science Needed by All," The Science Teacher, XXXII (September, 1965), pp. 51-52.

the fundamental work of Galileo, Newton, Maxwell, Einstein, or Bohr was certainly just as great an academic sin as to be ignorant of the contributions of Plato, Shakespeare, Beethoven, or Michelangelo.[34]

C. P. Snow discussed the dichotomy between literary intellectuals and physical scientists, and the manifest "two cultures." He contended that the literary intellectuals shaped and predicted the moods of the non-scientific culture, and thus they influenced, paradoxically, the major decisions within our science and technology-oriented society. Snow felt that the very survival of Western civilization depended upon bridging the gap between science and society, thus bringing the "two cultures" to a condition of viable communication.[35]

Professor David Halliday, co-author of a record best-seller physics text, said in an interview with a representative of the San Francisco Examiner and Chronicle, "People who study physics should be humanists and poets."[36]

Clifford E. Swartz, in a 1968 Physics Today editorial, postulated that sociological changes resulting from

---

34. Elmer Hutchisson, "Physics in our High Schools--A National Problem," The Physics Teacher, II (November, 1964), pp. 385-386.

35. Charles P. Snow, The Two Cultures and a Second Look (Cambridge, England: Cambridge University Press), 1964.

36. Israel Shenker, "'The Great Eggplant,' or Physics as a Best Seller," San Francisco Examiner and Chronicle (August 29, 1971), p. 20.

the maneuverings of politicians and revolutionaries were insignificant compared to those produced by new technology. The student who really wants to contribute to the Peace Corps, or who desires to be a captain of industry, or who aspires to the seminary to soul-search, must learn first about the nature of the universe, because that is where the power is and that is where the lasting changes in the world come from eventually:

> There is no magic wand that will make our "alabaster cities gleam, undimmed by human tears." The pickets and emotional confrontations can trigger action if the times are right, but the real changes in this world will come about, as they always have, from technological changes. Some of these are under the control of man, and some are not. Those that we can control can transform our world for good or evil, and there is no way to escape the need to control that choice. A know-nothing attitude of flight from reality will lead only to disaster. We cannot avoid the power of technology by denying it but only by mastering it.[37]

The literature contained many assertions that a polarization had occurred between the scientific community and the rest of society, and that this condition was to be abhorred.[38] Michael Smith of Howard University submitted that alienation or partial polarization of physicists with

---

37. Clifford E. Swartz, "We Have a World-view," The Physics Teacher, VI (November, 1968), p. 393.

38. Canadian Association of Physicists, A Report of the Activities of the CAP Study Group on Student Attitudes towards Science and Technology (Ottawa, Ontario, Canada: Canadian Association of Physicists, 1971); H. William Kock, "An Age of Change," Physics Today, XXIII (January, 1970), p. 31; Gerald Holton, "Issues for the Seventies," an editorial, The Physics Teacher, VIII (May, 1970), pp. 229-232; Philip H. Abelson, "Troubled Times for Academic Science," an editorial, Science, CLXVIII (May, 1970), p. 525; Ernest C. Pollard, "Physics for the Nonscientist," The Physics Teacher, VIII (January, 1970), pp. 11-15; Barnaby C. Keeney, "The Bridge of Values," Science, CLXIX (July, 1970), pp. 26-28.

the rest of society might be due to the physicist's inability to communicate with society. He implied that a great opportunity for communication was lost because non-physics majors in colleges and high schools were discouraged from taking physics courses by the very nature of these courses.[39]

Harold L. Davis editorialized in the June, 1971, issue of Physics Today that "as things stand now almost any movie star or television personality enjoys greater esteem in the public eye than the most renowned of our Nobel-prizewinning physicists."[40] And in his March, 1971, editorial of Physics Today, Davis wrote, "It is especially disheartening to see an antirational and antiscience movement taking hold among our young people."[41]

President of the National Academy of Sciences, Philip Handler, in an address at The University of Houston, stated that the disappearing blind faith in the utility of science by a public which never did appreciate the beauty of the intellectual structure of science was one of the phenomena

---

39. Michael J. Smith, letter to the editor, Physics Today, XIX (November, 1966), p. 14.

40. Harold L. Davis, "Physics Forty Years from Now," an editofial, Physics Today, XXIV (June, 1971), p. 80.

41. Harold L. Davis, "Drugs versus Science," an editorial, Physics Today, XXIV (March, 1971), p. 88.

combining to generate a rising sense of apprehension in the scientific community.[42]

Bentley Glass, John Hopkins University biology professor, discussed the scientist, the science teacher, and their respective roles in society.[43] He felt that the reflective scientist was overwhelmed by the rapid changes science effected on modern society, and somewhat conscience-stricken over the incumbent evils science had rained upon society. Glass contended that the search for truth about nature had opened a veritable Pandora's box exemplified by: nuclear energy and its ever present threat to annihilate civilization; antibiotics to conquer disease and thereby perpetrate overpopulation; vehicles to provide man with mobility and versatility but whose noxious residues pollute the atmosphere and turn sunny lands dark; and burgeoning industrial technology to supply the wants of man but whose effluents make the fish die and the land stink and the waters unfit to drink. Dr. Glass asked whether a democratic civilization could long endure if, based upon a scientific technology, its populace grew increasingly complacent in its

---

42. Philip Handler, "Science and Scientists: Obligations and Opportunities," an address at The University of Houston, October 21, 1970, in Science, CLXX (November, 1970), p. 837.

43. Bentley Glass, "The Scientist and the Science Teacher," The Physics Teacher, III (March, 1965), pp. 123-124.

ignorance of science, and grew more superstitious about scientific methods.

The Fundamental Nature of Physics

Delegates from twenty-nine nations met in Paris in 1960 to confer on the teaching of precollege physics. Included in the summary report of that conference was this statement: "Physics, the most exact and fundamental of the sciences, is a vital part of modern culture and, as such, a necessary element in the education of all children."[44]

Richard P. Feynman, Nobel laureate in physics and professor of theoretical physics, California Institute of Technology (Pasadena), said that physics is the most fundamental and all-inclusive of the sciences, and that physics has a profound effect on all scientific development. He added that students of many disciplines study physics because of its basic role in all natural phenomena.[45]

But the literature review showed that despite their inherent social, political, educational, and scientific value, students avoided taking physics courses.

An Evaluation of the Nation-wide Decline in Physics Enrollments

A nation-wide decline in physics enrollments has alarmed physicists and educators. This section presents the

---

44. Brauer, *op. cit.*, p. 373.

45. Richard P. Feynman, "The Relation of Physics to other Sciences," *The Physics Teacher*, II (March, 1964), p. 111.

nature of the declining enrollment problem, and suggested remedies for alleviating it.

The Nature of the Problem

Surveys have shown that although high school students were choosing physical science, biology, and chemistry in increasing numbers, nation-wide enrollments in physics classes were declining steadily (relative to the total school population) from a peak established in 1961.[46] This decline has been evidenced not only in the secondary schools but in the colleges and universities as well.[47] Declining enrollments have been noted with concern by scientists and science educators, some of whose statements are reported in the following paragraphs.

In 1964, Fred Boercker reported on a statistical study conducted for the Education and Manpower Division, AIP, and showed that for over thirty years physics has ranked last numerically as a secondary school science choice.[48]

---

46. American Institute of Physics, Physics Manpower, 1969 (New York: American Institute of Physics), 1969.

47. "Manpower Studies Show Physics Leveling Off, in State and Society," Physics Today, XXII (September, 1969), p. 72; Gerald Holton, "The Relevance of Physics," Physics Today, XXIII (November, 1970), pp. 40-47; John S. Rigden, "Reshaping the Image of Physics," Physics Today, XXIII (October, 1970), pp. 48-53; Harold L. Davis, "Teaching Physics in the Corridors," an editorial, Physics Today, XXIV (August, 1971), p. 88.

48. Fred Boercker, "Education and Manpower in Physics," Physics Today, XVII (September, 1964), pp. 42-50.

Figure 2 shows enrollment trends in biology, chemistry, and physics for the public high schools during 1948 to 1965.[49] Figure 3 is a graphic representation illustrating that while twelfth grade enrollments increased by 600,000 students between 1962-63 and 1964-65, the increase in physics enrollments was only 100,000. In other words, the percentage of twelfth grade students taking physics declined during this period, reflecting a trend dating from 1948.[50] Fletcher Watson, Director, Harvard Physics Project, used Figure 4 to demonstrate the almost steady decline in physics students since 1948.[51]

An AIP preliminary survey for academic year 1966-67 showed that at the same time when fewer and fewer students were electing physics as a college major, the attrition from freshman year physics majors to bachelor degree physicists was increasing from year to year.[52] The proportion of college students earning the B.A. degree in physics dropped from 1.2 per cent in 1962 to 0.7 per cent in 1969.[53] Since 1969,

---

49. Fletcher G. Watson, "Why Do We Need More Physics Courses?" The Physics Teacher, V (May, 1967), pp. 212-214.

50. Ibid., p. 213.

51. Ibid.

52. American Institute of Physics, Physics Manpower, 1966 (New York: The American Institute of Physics), 1966.

53. William H. Stiles, "Harvard Project Physics--Review of a National Program for Development of a Humanistically Oriented High-School Physics Course 1964-1970," an unpublished report of Harvard University Program for the Science Development Office, p. 3.

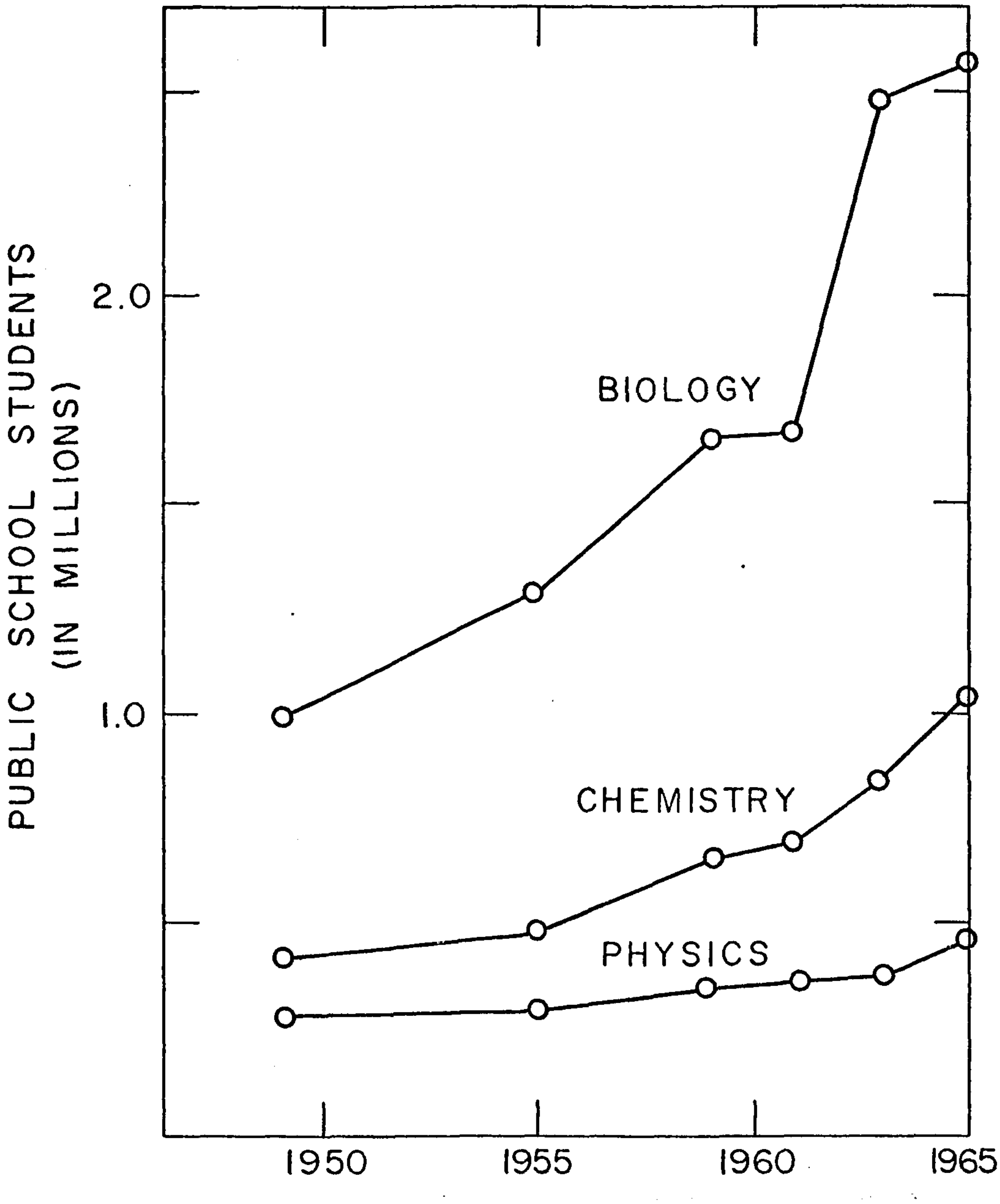

Fig. 2. Science Enrollment Trends, 1948 to 1965.

Source: Fletcher G. Watson "Why Do We Need More Physics Courses?" The Physics Teacher, V (May, 1967), p. 212.

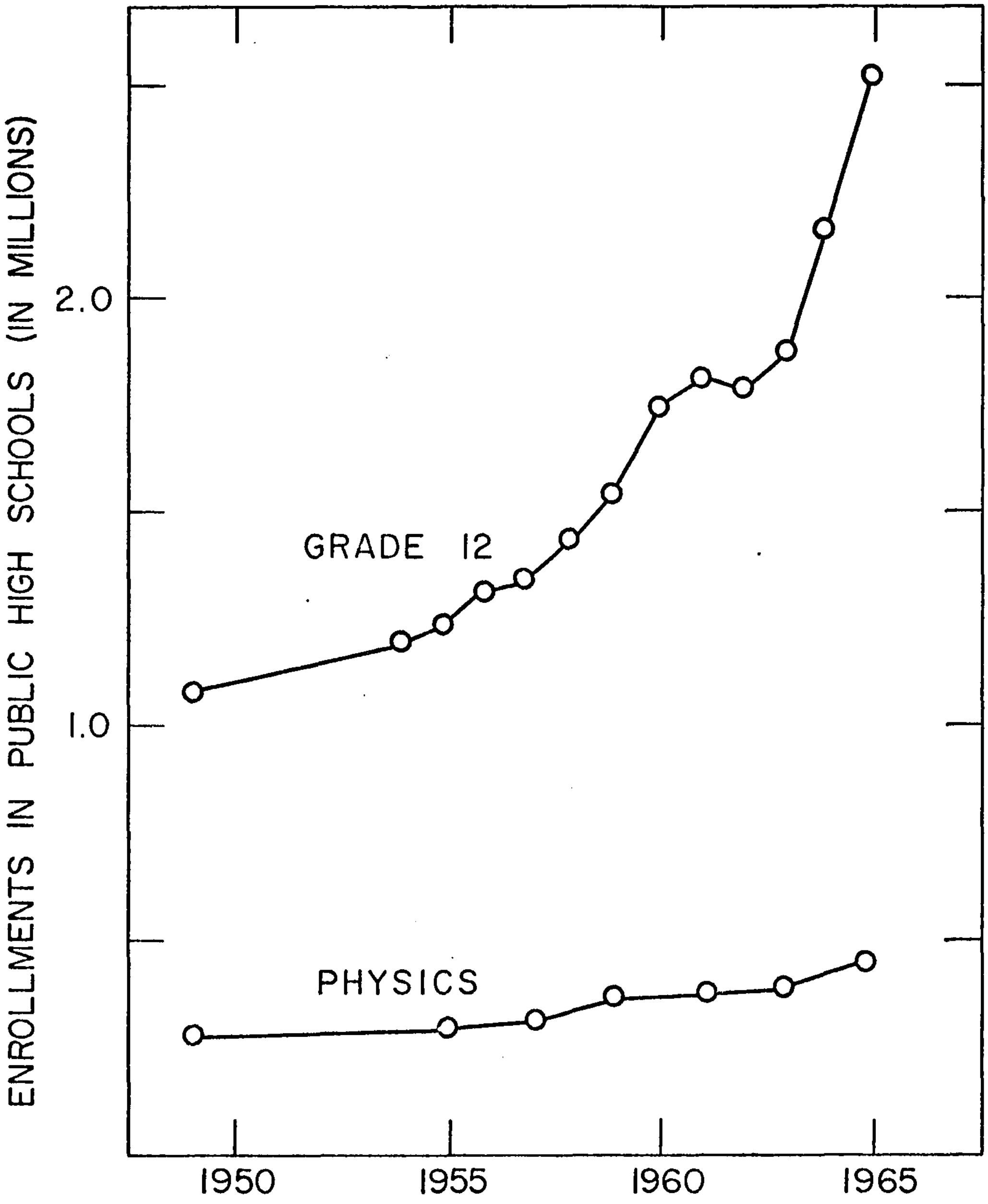

Fig. 3. Physics Enrollment Trends, 1948 to 1965.

Source: Fletcher G. Watson "Why Do We Need More Physics Courses?" The Physics Teacher, V (May, 1967), p. 213.

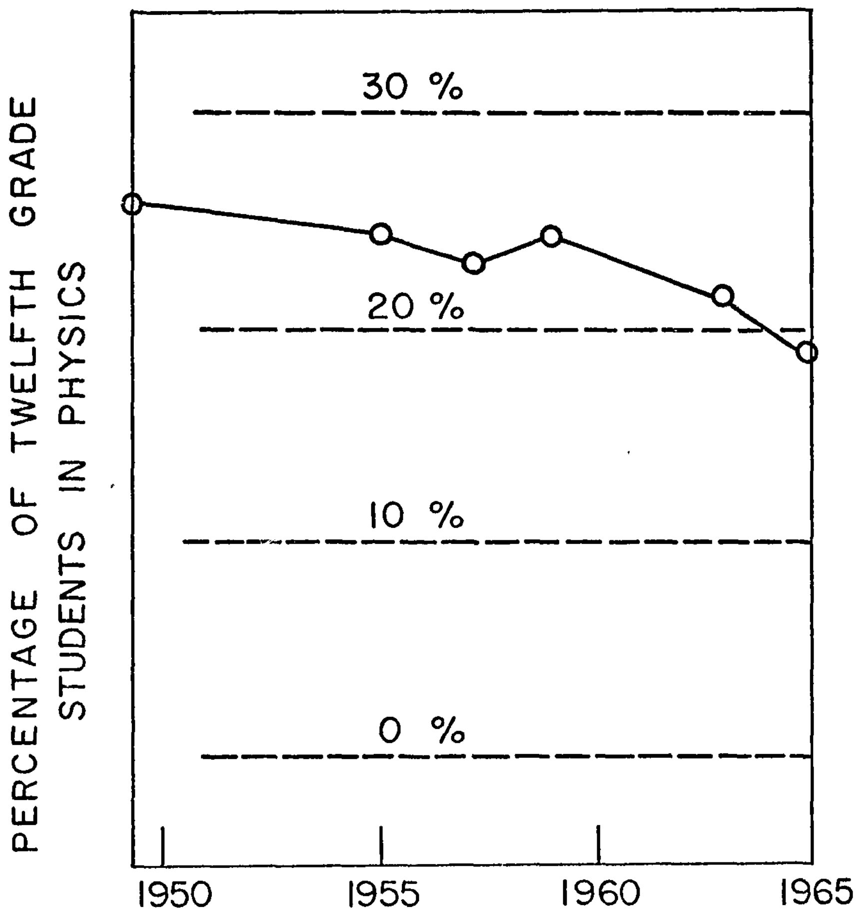

Fig. 4. Public School Twelfth Grade Physics Enrollments, 1960 to 1965.

Source: Fletcher G. Watson "Why Do We Need More Physics Courses?" The Physics Teacher, V (May, 1967), p. 213.

the fraction of bachelor's degree candidates in physics has continued its downward trend.[54]

William H. Stiles, in a 1970 Review of the Harvard Project Physics Program, summarizes the situation as follows:

> A vicious circle seems to have set in; having fewer college physics majors threatens the supply of competent high school physics teachers, which in combination with the dearth of attractive physics courses, plays a role in pushing enrollment in high school physics even lower.[55]

Reasons for Declining Physics Enrollments

An examination of the literature dealing with suggested reasons for declining enrollments revealed several factors reappearing with sufficient consistency and number to warrant further attention. The following paragraphs review publications dealing with factors of the difficulty of physics, physics pedagogy, negative images of physics and physicists, and physics curricula and materials. Most of the reasons published reflected individual experiences as biases, rather than inferences based upon statistical studies.

Susanne Ellis, author of Physics Manpower, 1966, AIP, offered a rather comprehensive statement of reasons for low enrollments. She stated that high school students did not

---

54. American Institute of Physics, Physics Manpower, 1969, *op. cit.*, pp. 77-79.

55. Stiles, *op. cit.*, p. 3.

take physics because physics teachers and counselors created the impression of physics as being a tough course, because physics was offered usually at the twelfth grade when grade point average was a sensitive and critical student concern, and because high school physics teachers were usually inadequately prepared. Ellis added that lower enrollments at the college level might be due either to a poor image of physics at the high school level, a shift of interest among college students toward the humanities and away from the sciences, the long-term commitment required of physics students (physics majors were generally expected to pursue advanced degrees), difficulty with mathematics, degree requirements in the major field and in mathematics were greater for physics majors than for most other majors, and poor college teaching at the undergraduate level.[56]

A 1968 Report of the Panel on the Preparation of Physics Teachers, Commission on College Physics, attributed the problem of low enrollments to these factors: the need for better high school physics courses, the need for better texts and equipment, and the need for more and better college level courses for non-science majors.[57]

---

56. Susanne D. Ellis, "Enrollment Trends," Physics Today, XX, No. 3 (March, 1967), pp. 75-79.

57. Commission on College Physics, Preparing High School Physics Teachers: Report of the Panel on the Preparation of Physics Teachers of the Commission on College Physics (University of Maryland: Department of Physics and Astronomy, 1968).

The literature abounded with references attesting to the difficulty of physics, and to the reputation physics had with both college and high school students as being a difficult subject. The April, 1966, Physics Today editorial was entitled, "Is Physics Too Tough?" Editor Ellis stated that low physics enrollments stemmed from a number of factors and that the reputation physics had as being a difficult course was the foremost of these.[58] Among others who took the view that physics courses were too difficult were Mauri Gould, Assistant Director, Lawrence Hall of Science, Berkeley (California);[59] and physics professor V. G. Drozin of Bucknell University.[60]

In an AIP Survey conducted by Victor J. Young in 1965, Allen L. King, at Dartmouth College (Hanover, New Hampshire), speculated that perhaps physics education was not started early enough in the educational scheme, as in the fields of English or mathematics. As a result of its being offered late in the public school curriculum, King

---

58. R. Hobard Ellis, Jr., "Is Physics Too Tough?" an editorial, Physics Today, XIX (April, 1966), p. 152.

59. Mauri Gould, "Double or Triple Your High School Physics Enrollment," The Physics Teacher, IV (November, 1966), pp. 371-372.

60. V. G. Drozin, "What Should be Done to Increase the Enrollment in Physics," The Physics Teacher, IV (January, 1966), pp. 23-27.

speculated that most high school students avoided physics because it was unfamiliar.[61]

Others who attacked the order of presentation of material and pedagogical methods as contributing to low high school physics enrollments included: Drozin at Bucknell University;[62] high school physics teacher, science coordinator, and physics textbook author Alexander Efron;[63] Jerrold Zacharias, physics professor at Massachusetts Institute of Technology;[64] and, N. H. Frank, professor of physics at Massachusetts Institute of Technology.[65]

In an article by Allen J. Schwartz in The Physics Teacher, B. F. Skinner, professor of psychology, Harvard University, suggested that high school students avoided science because science teachers lacked effective pedagogical skills; namely, science teachers had not been trained to teach in terms of behavioral objectives. Skinner's implication was that the teacher did not know what he did when he taught nor what the student did when he learned.[66] Robert

---

61. Allen L. King, a contributor to Victor J. Young's "Survey on Enrollment in Physics," The Physics Teacher, III (March, 1965), pp. 117-122.

62. Drozin, loc. cit.

63. Alexander Efron, "Physics--Phooey?" The Physics Teacher, VII (April, 1969), pp. 191-192.

64. Jerrold R. Zacharias, "Pre College Physics," an editorial, The Physics Teacher, IV (May, 1966), pp. 227-235.

65. Nathaniel H. Frank, "Physics and Vocational Education," The Physics Teacher, VI (November, 1968), pp. 409-412.

66. Allan J. Schwartz, "A Report on a Dissenting View of Science Education," The Physics Teacher, VI (May, 1968), pp. 222-223.

MacCurdy of Centenary College, who researched personal characteristics of winners of the National Science Talent Search, also took an assenting view.[67]

Fletcher Watson, Co-director of Harvard Project Physics, indicated that "people-centered" students often avoided traditional physics in high school and in college since they were interested primarily in art, music, history, languages, literature, and the other humanities.[68]

Lewis M. Branscomb, Chairman, Joint Institute for Laboratory Astrophysics, National Bureau of Standards, and Professor Adjoint at the University of Colorado, in an address to the Committee on Physics and Society of the American Institute of Physics, conjectured that the disappointing response of high school students to the study of physics was due in part to the public conception of the role of physics in society.[69]

Finally, the Commission on College Physics reported: "Despite the intense interactions between physics and society, the understanding of the aims and content of physics by the public is generally very poor."[70]

---

67. Robert D. MacCurdy, "Engineer or Scientist?" Journal of Counseling Psychology, VIII (Spring, 1961), pp. 79-81.

68. Watson, op. cit., p. 213.

69. Lewis M. Branscomb, "Physics and the Nation in a Crystal Ball," Physics Today, XXI (August, 1968), pp. 23-28.

70. Commission on College Physics, 1968, loc. cit.

Claude Gatewood, from the Educational Research Council of America, postulated that the majority of students elected to study only as much science as was required because of the irrelevancy of science curricula to their daily lives.[71] Assenting views were taken by Dr. Alexander Efron, high school physics text author,[72] and by Dr. LeRoy Kallemeyn at The University of Nebraska.[73]

In summation, the literature review indicated that low enrollments in high school physics derived principally from the shortage of qualified high school teachers, the difficulty associated with physics courses, the ineffective pedagogical skills of science teachers, the negative images of physics and physicists, and the utilization of curricula which lacked relevance for many students.

Suggested Remedies for Low Enrollments in Physics

Many of those who complained of the low enrollments also suggested remedies. In the literature there were proposed five principal means for arresting declining enrollments in physics. These were integrated courses, better teachers and teaching conditions, better course design,

---

71. Gatewood, op. cit., p. 20.

72. Efron, loc. cit.

73. LeRoy W. Kallemeyn, "An Analysis of Subject Matter Content of High School Physics Courses in Selected Schools of Nebraska," a dissertation for the University of Nebraska Teacher's College, 1968.

student recruiting and "selling" of physics, and counselor assistance. The details of these proposals follow.

The literature revealed an emphasis on the desirability of unified science courses. The basic premise underlying unified science curricula was that science was not created in separate disciplines and, therefore, there should be an effort to develop science programs into meaningful and logical integrated sequences.[74] Approximately twenty-five unified course projects across the nation are confederated loosely by the Federation for the Unification of Science Education.[75]

While only limited research data on unified courses could be found in the literature, the over-all impression was favorable. An example of reported unified course success, and some of the implications, was reported by Gatewood.

> From 1963 until the school was closed in the spring of 1967, graduating seniors had had only Science I, II, III, and IV, instead of the traditional general science, biology, chemistry, and physics. USOE-supported research established that the students in this unified high school science sequence attained a greater interest in science and greater scientific literacy than did their counterparts in conventional programs. They also elected college science to a significantly higher degree. Further,

---

74. Lowell G. Herr, "Unified Science: A Solution to Physics Enrollment," The Physics Teacher, IX (May, 1971), pp. 248-252.

75. Gatewood, op. cit., p. 20.

> these gains were not achieved at the expense of less effective preparation for college science . . . science should be "meaningful to the living experience of man." It would seem that an integrated science curriculum could more closely approach this goal than does the series of unconnected courses on selected disciplines that now make up our offerings.[76]

Gatewood, in The Science Teacher, November, 1968, contended that curricula were largely irrelevant and ought to be redesigned to better meet student needs. He suggested that an integrated curriculum, interdisciplinary, be offered on a longitudinal basis, beginning with kindergarten and progressing through grade twelve. His unified science course would "also deal with the interfaces between science, mathematics, social science, technology, and the humanities."[77] Supporting the unified science course concepts discussed by Gatewood were a number of high school science educators, such as high school physics teacher, J. Lawrence Dunlap, in Arizona,[78] and Gladys Francis and Casper Hill, high school science teachers in New Jersey.[79]

---

76. *Ibid.*, p. 21.

77. *Ibid.*

78. J. Lawrence Dunlap, "Predicting Performance in High School Physics," *The Physics Teacher*, IV (October, 1966), pp. 303-313.

79. Gladys M. Francis and Casper W. Hill, "A Unified Program in Science for Grades Nine through Twelve," *The Science Teacher*, XXXIII (January, 1966), pp. 34-36.

Milton Pella, professor of science education, University of Wisconsin, offered similar proposals for improving science teaching and for attracting students to science. High schools of five hundred or more students should offer three or more levels of physics, should emphasize both applied and pure science, should offer unified courses in chemistry and physics for students electing not to study conventional physics (these might be junior level earth science courses or senior level chemistry-physics courses), and should offer a four-year integrated science program presented at three or more levels of sophistication. Pella preferred the last proposal, especially if it were founded upon an integrated program initiated in kindergarten and continued through grade twelve.[80]

Lester G. Paldy, editor of The Physics Teacher, proposed that attempts to reverse the declining enrollment trend begin with the acquisition of qualified high school physics teachers and the fostering of better teaching conditions. His specific solutions included adequate production of trained teachers, provision for adequate teaching facilities and equipment, establishment of salaries and working conditions comparable with those of research physicists, and such teacher self-determination as a voice

---

80. Pella, *op. cit.*, p. 52.

in tenurial processes, selection of administrators, selection of texts, and the like.[81]

The Commission on College Physics considered the high school physics teacher shortage as perhaps the most pressing problem in physics and one which affected adversely the enrollments in physics. The commission found that few colleges and universities were doing much to alleviate the teacher shortage and presented the following criteria for building a physics teacher training program: include teaching preparation in at least one subject area other than physics, construct a teacher preparation program different from the usual undergraduate research-oriented one so as to better meet the needs of prospective teachers, design a sequential training program to permit recruitment of several desirable types of students at different undergraduate levels, provide for experience in explaining physics to others, include a strong course in the history and philosophy of physics, and include appropriate follow-up courses for in-service teachers.[82]

In the February, 1969, issue of The Physics Teacher, the panel on the Preparation of Physics Teachers of the

---

81. Lester G. Paldy, "Physics Teachers and the Schools," an editorial, The Physics Teacher, V (October, 1967), p. 333.

82. Commission on College Physics, "The Most Pressing Problem in Physics?" The Physics Teacher, IV (January, 1966), pp. 33-34.

Commission on College Physics is reported as recommending that college and university departments of physics accept increasing responsibility for establishing realistic academic programs for prospective high school teachers.[83]

It seemed that instructional problems related to work loads of high school teachers focused on the multiple teaching assignments usually required of them and the incumbent number of daily preparations. Most schools did not have enough students enrolled in physics in sufficient numbers to warrant a full-time teacher; therefore, the physics teachers taught additional subjects and only rarely taught physics exclusively.[84]

The literature revealed that the question, how relevant to student needs is the physics being taught in our schools, concerned a large segment of science educators. The trend seemed to be that attention to relevance of courses was assuming an increasingly significant role in curriculum evaluation and development.

The editor of The Physics Teacher asked, in 1967, "What can . . . teachers extract from PSSC, Harvard Physics,

---

83. Melba Phillips, "The Continuing Education of Physics Teachers," The Physics Teacher, VII (February, 1969), pp. 88-92.

84. John Stanley Shrader, "An investigation of Instruction Problems Encountered by Beginning Secondary School Science Teachers in the Pacific Northwest," Science Education, XXXXV (March, 1961), pp. 143-148.

or any other existing course that is relevant to the life of a teenager in the ghetto?"[85]

N. H. Franks, professor of physics at the Massachusetts Institute of Technology, said that public education failed to serve effectively the larger segment of the student body because college-bound education had dominated the public education processes.[86]

I. I. Rabi addressed the Educational Policies Commission, American Association for the Advancement of Science, in December, 1966, on the teaching of science. He stated that we need to teach science "in a way which would be understood and appreciated and felt by the students."[87] In a Harvard Project Physics report, Stiles quotes Rabi as saying:

> . . . science be taught at whatever level, from the lowest to the highest, in a humanistic way. By which I mean it should be taught with a certain historical understanding in the sense of the biography, the nature of the people who made this construction, the the triumphs, the trials, the tribulations.[88]

Clifford Swartz, in a guest editorial for The Physics Teacher, November, 1968, editorialized in part as follows:

> Today's students demand relevance. They want to rebuild our cities, but we physics teachers talk to them about the structure of the atom. . . . They are

---

85. Paldy, *loc. cit.*

86. Frank, *op. cit.*, p. 409.

87. I. I. Rabi, excerpts from his address at the AAAS meeting of Educational Policies Commission, December 27, 1966, Washington, D. C., in The Physics Teacher, V (May, 1967), p. 197.

88. Stiles, *op. cit.*, foreword.

> concerned with sociological crusades and the need for human empathy, but they think that we offer them only cold technology.[89]

A. A. Strassenburg subscribed to the theory that the downward trend in physics enrollments did not have as much to do with the styles of teaching as with students' concerns for social and world problems; concerns for which physics appeared to offer no solutions. Accordingly, he thought it necessary to convey to students that physics was fundamentally relevant to social progress.[90] Assenting views were expressed by Vincent Parker, Dean, California State Polytechnic College,[91] and by physics student Katherine Swartz in her invitational paper before the American Association for the Advancement of Science in 1968.[92]

Watson, of Harvard Project Physics, reasoned that more students would enroll in physics if different kinds of physics courses were offered, courses that would appeal to the needs of different student abilities, interests, and different socio-economic backgrounds. He argued that a course with less mathematics, with appeal to girls, with

---

89. Swartz, loc. cit.

90. Arthur A. Strassenburg, "Baccalaureate Trend Downward: More Take PSSC in High School," Physics Today, XXI (February, 1968), p. 63.

91. Vincent E. Parker, "The Decline in Physics Majors--What Can We Do about It?" An unpublished reprint of address to the Southern California Section, American Association of Physics Teachers, December 7, 1968.

92. Katherine Swartz, "The Flight from Science--A Student's View," an editorial, The Physics Teacher, VII (April, 1969), p. 195.

historical and cultural emphases, and with a humanist flavor would lure the college-bound non-science oriented student to enroll.[93] The need for courses with greater feminine appeal was stressed repeatedly in the literature, further confirming Watson's position regarding the male selectivity of physics courses.[94]

Supporting Watson's views on the new kinds of physics courses were President Donald A. Cowan, University of Dallas,[95] and Wayne Welch and Arthur Rothman of Harvard University.[96]

Approaches to increasing high school enrollments which incorporated the rationale of Watson's theses were reported by high school physics teacher F. Darrell Goar,[97]

---

93. Watson, op. cit., pp. 212-214.

94. Harold L. Davis, "No More Brains to Train?" an editorial, Physics Today, XXIV (April, 1971), p. 84; Gloria B. Lubkin, "Women in Physics" Physics Today, XXIV (April, 1971), pp. 23-27; Donald Daniel and Judith Wood-Kyrala, "Women in Physics," letters to the editor, Physics Today, XXIV (July, 1971), pp. 9-10.

95. Donald A. Cowan, "Physics and the Future of Teaching," The Physics Teacher, VI (March, 1968), pp. 115-117.

96. Wayne W. Welch and Arthur I. Rothman, "The Success of Recruited Students in a New Physics Course," Science Education, LII (April, 1968), pp. 270-273.

97. F. Darrell Goad, "All-girl Physics Course Makes Converts in Illinois," Physics Today, XXII (April, 1969), p. 80.

and by high school physics teachers Buel C. Robinson and Thomas E. Keefe.[98] Watson (Table 18) reviewed public high school science enrollments in terms of course types and sex of students to further substantiate the need for new kinds of physics courses.[99]

More effective utilization of counselors was another suggestion for improving high school physics enrollments. James B. Conant[100] and George McClary[101] emphasized that the combined efforts of physics teacher and counselor could exert a powerful force for increasing physics enrollments. McClary advised physics teachers to seek out the school counselors and acquaint them with physics and physics courses.

Summary

In summation, the review of literature focused on science education in America, the nation-wide decline in physics enrollments, and suggested remedies for arresting this decline.

---

98. Buel C. Robinson and Thomas E. Keefe, "Found: The Missing Physics Students," The Science Teacher, XXXV (January, 1968), pp. 67-69.

99. Watson, op. cit., p. 212.

100. Conant, op. cit., pp. 47-56.

101. George O. McClary, "A New Force--Physics Teacher and Counselor," The Physics Teacher, IV (October, 1966), pp. 300-313.

TABLE 1

Enrollments in Public High School Science, 1964-65

Type of course	Number of students enrolled 1964-65 Boys	Girls	Total
General Science, total	1,143,000	1,032,900	2,175,000
9th grade gen. sci.	1,087,400	990,000	2,077,400
Advanced gen. sci.	55,600	42,900	98,500
Biology, total	1,333,400	1,361,000	2,694,400
Tradl. biol. (gr. 9)	135,600	165,300	300,900
Tradl. biol. (gr. 10)	974,900	961,000	1,935,900
BSCS	161,300	167,100	328,400
Advanced biol.	61,600	67,600	129,200
Chemistry, total	606,100	478,500	1,084,600
Tradl. chemistry	499,200	402,900	902,100
CBA	14,200	9,200	23,400
CHEM STUDY	72,600	55,500	128,100
Advanced chemistry	20,100	10,900	31,000
Physics, total (Introductory and Advanced)	382,200	144,000	526,200
Tradl. physics	281,800	102,900	384,700
PSSC	74,900	25,000	99,900
Advanced physics	25,500	16,100	41,600
Physical Science	167,000	123,700	290,700
Earth Space Science	138,800	106,000	244,800

TABLE 1--*Continued*. Enrollments in Public High School Science, 1964-65

Type of course	Boys	Girls	Total
Physiology	6,400	7,700	14,100
Research Science Seminar	4,000	2,700	6,700
All other sciences	111,200	95,000	206,200
Totals	3,892,100	3,351,500	7,243,600

Source: Fletcher G. Watson, "Why Do We Need More Physics Courses?" *The Physics Teacher*, V (May, 1967), p. 212.

The need for physics courses in the education of modern man was founded principally upon the argument that physics constituted the fundamental natural science and that scientifically literate citizens were essential elements of a modern, democratic society.

Declining physics enrollments were attributed primarily to the difficulty of physics courses, the negative image of physics and physicists, and the methods, curricula, and media used in teaching physics.

Suggested remedies for low physics enrollments included adoption of integrated courses, hiring only qualified physics teachers, improving teaching conditions and teaching materials, designing more relevant courses, actively recruiting students, and "selling" physics to students, to non-physics teachers, and to the community in general.

Chapter III presents the design of the study.

CHAPTER III

DESIGN OF THE STUDY

The study was designed to gather data relative to selected characteristics, attitudes, and other qualities of California public high school students and physics teachers, and to determine whether significant relationships existed between certain of these selected items.

The normative survey method was employed. Teachers and students submitted anonymous responses by mail. These responses were machine-read, stored automatically on data cards, and then computer-evaluated for significance of relationships and for frequency of responses to selected questionnaire items.

Included in this chapter are the general procedures used for collecting, processing, and evaluating the data; descriptions of the instruments employed to gather the data; and descriptions of the populations sampled by the study.

Populations Sampled

Three populations within the California public secondary schools were sampled: physics students, non-physics students, and physics teachers within these schools.

For academic year 1967-68, California had approximately 728 public secondary schools.[102] An estimated 650 of these schools offered some kind of physics course. These 650 schools constituted the secondary school population for this study. Private and parochial schools did not contribute to the population sampled.

Three hundred forty-seven secondary schools, representing approximately 52-1/2 per cent of the total California public secondary school population, participated in the study on a voluntary basis. These schools reflected a heterogeneity of ethnic, cultural, economic, and geographical backgrounds.

Physics Student Population

An estimated 26,000 physics students, within the 650 California public secondary schools described above, constituted the physics student population studied.[103] Over 10,500 physics students (42 per cent of the total physics student population) participated in the study.

The general geographic distribution of the schools from which the physics student population sample was drawn is presented in Figure B.1 (Appendix B).

---

102. Weynard Bailey, Consultant, Bureau of Reference Services, Department of Education, California; a personal letter to the researcher, dated September 15, 1969.

103. Ibid.

Non-physics Student Population

The non-physics student population consisted of all California public secondary school seniors, academic year 1967-68, who had elected not to study physics during their high school careers. The non-physics student population sample was comprised of 2,438 senior students in schools selected by the researcher so as to represent a diversity of geographic, cultural, ethnic, and economic backgrounds.

The total non-physics student population was estimated at 200,000.[104] Thus, slightly over one per cent of the total population was in the sample obtained.

Figure B.1 exhibits the general geographic distribution of schools from which the non-physics student population sample was drawn.

Physics Teacher Population

An estimated 650 California public secondary school teachers taught at least one physics course during academic year 1967-68; these teachers made up the physics teacher population.

There were 347 volunteers who constituted the physics teacher population sample. This sample constituted 53-1/2 per cent of the total physics teacher

---

104. Weynard Bailey, Consultant, Bureau of Reference Services, Department of Education, California; a personal letter to the researcher, dated September 3, 1969.

population and was drawn from the 650 schools whose general geographic locations are given in Figure B.1.

Instruments Employed

The principal instruments employed were questionnaires and sense-mark answer sheets.

The instruments were designed and then reproduced on IBM 529 format paper, so that all responses could be sense-marked with a lead pencil, could be machine-read by an IBM 1230 Optical Reader, and could be stored automatically on computer punch cards by an on-line IBM 514 Card Punch Machine.

Two different questionnaires and two different IBM sense-mark answer sheets were developed. In Appendix C are facsimiles of the questionnaire instruments. For the reader's convenience, certain features of the questionnaires are described next.

Non-physics students responded to the first twenty-five items of the student questionnaire, Part I (Appendix C). Physics students responded to the sixty-eight items of the student questionnaire, Parts I and II (Appendix C). Physics teachers responded to the 120 items of the teacher questionnaire (Appendix C).

Responses to both the teacher and the student questionnaires were closed-type. The respondents had no choices other than those offered by the instruments.

Procedures Employed

Administration of the teacher and the student questionnaires was carried out by mail. The collected data were evaluated in terms of significant relationships and frequency responses to selected items. A brief description of these procedures follows.

Administration of Questionnaires

Student volunteers distributed, administered, collected, and then returned the student answer sheets directly to the researcher in unmarked, sealed envelopes.

Teacher answer sheets were mailed directly from the teachers to the researcher in sealed, unmarked envelopes.

Methods of Data Analysis

Null hypotheses numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 13, and 14 (Chapter I, pp. 10-12) were Chi square tested for no significant differences between observed frequencies and expected frequencies. This nonparametric Chi square statistic was selected because the populations could not be assumed to have normal distributions. The .05 level of confidence was the criterion of acceptance or rejection of these null hypotheses.

Because of the nature of the data and because of the large N, the null hypothesis 2-s (Chapter IV, Secondary Findings) was Pearson product-moment tested for no significant differences between observed and expected frequencies. Again, the .05 level of confidence was the criterion for acceptance or rejection.

Because the nature of the data statistically precluded either Chi square or Pearson product-moment analysis, null hypotheses 10, 11, and 12 and the suggested null hypothesis 1-s were subjectively evaluated in terms of percentages and frequencies of responses.

Chi Square Analyses

The Chi square contingency tests for null hypotheses numbers 1, 2, 3, 4, 7, 8, 9, and 11 employed 2 x 5 matrices.

Null hypotheses 13 and 14 were Chi square tested using the same general method for the 2 x 5 arrays above, except that these were 2 x 6 arrays.

Null hypothesis 10 was tested by means of a 2 x 2 Chi square matrix, with correction formula.

Pearson Product-moment Analyses

The Pearson product-moment correlations were obtained from computer analyses of teacher responses to selected questions. Certain of the teacher questions were designed to force responses onto a graduated ten-step scale. These ten-step scale responses were dichotomized as either *Lower five steps* or *Upper five steps*, and then Pearson product-moment evaluations were performed by the computer, and the resultant correlations presented to the researcher for interpretation.

Summary

This study was designed to gather data concerning California public high school physics teachers and students. The researcher attempted to determine whether significant relationships existed between selected characteristics and attitudes of teachers or students, and their perceptions of physics.

The normative method was employed. All responses were sense-marked to permit machine reading and automatic data storage. The data were computer analyzed and the resultant frequencies, percentages, Pearson product-moment correlations, and Chi square correlations presented to the researcher for interpretation.

The data consisted of responses submitted by 2,438 California public high school seniors who elected not to study physics during their high school careers, by 10,582 California public high school physics students, and by 347 California public high school physics teachers.

The findings of the study were based upon the data collected and treated as described in this chapter. These findings follow in Chapter IV.

CHAPTER IV

FINDINGS

Introduction

It was the purpose of this study to seek answers to the question of how certain attitudes and characteristics of California public high school students were related to their perceptions of physics and physics teachers.

The findings were divided into three general areas: first, the tabulation and summary of the data gathered by the questionnaires; second, the results of the tests of the null hypotheses; and third, the secondary findings of the study. This was essentially a statistical study; therefore, these findings are suggestive, rather than definitive.

Wherever reported percentages do not total 100 per cent, differences were due to failure of all participants to respond or were due to rounding-off of fractional values, or both. The reader has been apprised of significant failure-to-respond or rounding-off errors, and whether the rounding-off was to the nearest whole or to the nearest one-half per cent.

Results of the Questionnaires

The results of non-physics student responses, physics student responses, and physics teacher responses are presented separately. These results were based upon samples drawn from the following California public high school populations: 650 physics teachers, 26,000 physics students, and 200,000 seniors who had elected not to study physics in high school (non-physics students).

Non-physics Students

The number of non-physics students who constituted the population sample of all California public high school non-physics students was 2,438. However, because each student did not respond to every questionnaire item, the percentages reported in this section were not per cent responses for an N of 2,438, except where indicated as such. In general, the percentages reported were the per cent of total responses which any given item constituted within a particular category of the questionnaire, and were rounded off to the nearest one-half per cent. A synthesis of these findings follows.

Sex of Respondents. The non-physics students sample was about evenly divided on the basis of sex: 46 per cent male and 53-1/2 per cent female. N was 2,438.

Grade Average of Respondents. The non-physics respondents reported high school grade point averages as: 8 per cent A, 43 per cent B, 45 per cent C, and 4 per cent D. N was 2,330. Thus, approximately 88 per cent of the non-physics student sample reported themselves as B or C students.

Class Rank of Respondents. The self-ranking of these senior class non-physics students was: 36 per cent in the upper third of their graduating class, 55 per cent in the middle third of the class, and 9 per cent in the lower third. N was 2,189. Therefore, 91 per cent of the non-physics student population ranked themselves in the upper two-thirds of their graduating class.

Future Plans of Respondents. The immediate post-graduate plans of the non-physics student respondents were: 29 per cent college or university matriculation, 45 per cent junior college matriculation, 9-1/2 per cent employment, 4-1/2 per cent trade or business school matriculation, and 4 per cent military service. Six per cent indicated that they had no plans after graduation, and 3 per cent reported plans other than those listed. Further academic work was planned by 74 per cent of the non-physics student sample and 4-1/2 per cent planned further vocational training.

Reasons Respondents Avoided Physics. The non-physics student respondents were presented with fifteen choices of reasons for their not having enrolled in a physics course during their high school careers. Because students generally selected more than one reason for not enrolling in physics, the N for this questionnaire category was 6,774.

For greater clarity, these data are presented in tabular form in Table 2. For greater emphasis, the last column in the table reports the per cent of responses for the population sample. N was 2,438.

The two predominant reasons selected by students for not enrolling in physics were that physics did not appear to them to be an interesting subject, and that physics appeared to them to be too difficult a subject. The reasons ranked next for not enrolling in physics were: lack of time, fear of the mathematics required, and fear of lowering grade point average.

Occupational Preferences of Respondents. The non-physics student respondents were presented with a list of sixteen occupations and the following directions: "Assume you have both the finances and the ability to become successful at any of the following sixteen occupations. Select the FIVE you would like most to become and rank these FIVE." Over-all occupational rankings by the non-physics student respondents are presented in Table 3, highest-ranked occupation first and lowest-ranked occupation last.

The four most preferred occupations of the non-physics student sample were social worker, high school teacher, artist, and explorer, in that order. Physicist

TABLE 2

Why Non-physics Students Avoided Physics

Reason for not Enrolling	Number of Responses	Per cent of Responses	Per cent of 2,438
Disinterested	1,197	17-1/2	49
Too difficult	872	13	36
No time in schedule	647	9-1/2	26-1/2
Too much math needed	647	9-1/2	26-1/2
Not enjoyable	626	9	25-1/2
Afraid of failing physics	558	8	23
Might lower grade average	475	7	19-1/2
Not useful	414	6	17
Lacked prerequisites	345	5	14
Not ambitious enough	327	5	13
Advice of counselor	225	3	9
Advice of friend	159	2	6-1/2
Dislike the teacher	112	1-1/2	4-1/2
Advice of parent	98	1-1/2	4
Advice of teacher	72	1	3

TABLE 3

Occupational Preferences of Non-physics Students

Rank	Occupation	Number of Responses
1	Social worker	1,216
2	High school teacher	1,107
3	Artist	1,086
4	Explorer	1,015
5	Business executive	901
6	Architect	878
7	Musician	815
8	College professor	659
9	Sales manager	643
10	Professional athlete	638
11	Engineer	480
12	Ship's commander	472
13	Salesman	398
14	CPA (Certified Public Accountant)	343
15	Physicist	263
16	Physics teacher	130

and <u>physics</u> <u>teacher</u> were ranked fifteenth and sixteenth, respectively, as occupational preferences.

Physics Students

The number of physics students who constituted the population sample of all California public high school physics students was 10,582. Each student did not respond to every questionnaire item; therefore, the percentages reported in this section were not per cent responses for an N of 10,582, except where indicated as such. In general, the percentages reported were the per cent of the total responses which any given item constituted within a particular category of the questionnaire. For the convenience of the reader, percentages were rounded to the nearest one-half per cent.

<u>Sex of Respondents</u>. Almost all of the physics student respondents were males. The respondents were divided as follows: 81-1/2 per cent male, and 18-1/2 per cent female. N was 9,639.

<u>Grade Average of Respondents</u>. The physics student sample reported high school grade point averages as follows: 27-1/2 per cent A, 55-1/2 per cent B, 16 per cent C, 1 per cent D. N was 9,651. Eighty-three per cent of the physics student respondents reported themselves as A or B students and 71-1/2 per cent reported themselves to be B or C students.

Class Rank of Respondents. The self-ranking of these senior class physics students was: 72 per cent in the upper third of their graduating class, 21 per cent in the middle third, and 7 per cent in the lower third. N was 9,286. Thus, 93 per cent of this physics student sample ranked themselves in the upper two-thirds of their graduating class.

Future Plans of Respondents. The immediate post-graduate plans of the physics student respondents were reflected as: 62-1/2 per cent college or university matriculation, 30 per cent junior college matriculation, 2-1/2 per cent military service, one per cent employment, and one per cent trade or business school matriculation. One and one-half per cent reported no plans after graduation and one per cent reported plans other than those listed. Further academic work was planned by 92-1/2 per cent of the physics student sample, and one per cent planned further vocational training.

Reasons Respondents Enrolled in Physics. The physics student respondents were presented with ten choices of reasons for their having enrolled in a physics course in high school. Because students generally selected more than one reason for enrolling in physics, the N for this questionnaire category was 27,382. These data are presented in Table 4 in tabular form for greater clarity. For greater emphasis, the last column shows the per cent response for the population sample of N equals 10,582.

TABLE 4

Reasons Students Enrolled in Physics

Reason for Enrolling	Number Responses	Per cent of Responses	Per cent of 10,582
Useful in college (anticipated need)	7,323	26-1/2	69
Just interested	5,447	20	51-1/2
Advice of counselor	3,586	13	34
Advice of parent	3,315	12	31-1/2
Required for college entrance	2,467	9	23-1/2
Advice of teacher	1,514	5-1/2	14-1/2
Like the teacher	1,405	5	13-1/2
Advice of friend	1,140	4	11
Required by high school	615	2-1/2	5-1/2
To be with friend(s)	568	2	5-1/2

The predominant reason chosen by students for enrolling in physics was "useful in college (anticipated need)." "Just interested" was the students' second-ranked reason for enrollment.

Occupational Preferences of Respondents. The physics student respondents were presented with the same list of sixteen occupations and set of instructions as were presented to the non-physics student sample. These instructions included these directions: "Assume that you have both the finances and the ability to become successful at any of the following sixteen occupations. Select the FIVE you would like most to become and rank these FIVE." Over-all occupational ranking by the physics student sample are presented in Table 5, highest-ranked occupation first and lowest-ranked occupation last.

The two most preferred occupations of the physics student sample were engineer and architect. Physicist was ranked sixth, and physics teacher was ranked fifteenth.

Physics Student Perceptions of Selected Aspects of Physics. The physics student population sample was presented with twenty-three questions pertinent to selected aspects of physics. These questions placed special emphasis on student perceptions of physics teachers and physics courses. To respond to a question, students were forced to choose from a five-step scale: Not at all, Less than average, Average, More than average, Very much.

TABLE 5

Occupational Preferences of Physics Students

Rank	Occupation	Number of Responses
1	Engineer	6,371
2	Architect	5,775
3	Explorer	5,381
4	Business executive	5,218
5	College professor	4,798
6	Physicist	4,619
7	High school teacher	4,589
8	Professional athlete	4,146
9	Artist	3,662
10	Musician	3,628
11	Social worker	3,564
12	Ship's commander	3,391
13	CPS (Certified Public Accountant)	2,907
14	Sales manager	2,623
15	Physics teacher	2,395
16	Salesman	1,831

For greater clarity, the twenty-three questions have been grouped into eight sub-sets. The frequency of responses to each of the five choices for any given question within a sub-set is presented in this section. Also, for any given sub-set, the percentage of the total responses to that sub-set is reported:

Sub-set 1 --To what extent do you feel that physics, as a field of study, is:

	Number of Responses	Per cent of Responses
STIMULATING?		
Not at all	666	7
Less than average	1,435	15-1/2
Average	2,826	31
More than average	2,614	28-1/2
Very much	1,631	17-1/2
	9,172	
DIFFICULT?		
Not at all	389	4
Less than average	1,362	14-1/2
Average	2,803	30
More than average	3,102	33-1/2
Very much	1,573	17
	9,229	
PERSONALLY USEFUL		
Not at all	616	6
Less than average	1,899	20-1/2
Average	2,731	29-1/2
More than average	2,369	25-1/2
Very much	1,635	17-1/2
	9,250	

Sub-set 2 -- To what extent do you feel that your physics course lectures are:

	Number of Responses	Per cent of Responses
STIMULATING?		
Not at all	1,789	19-1/2
Less than average	2,419	26
Average	2,543	27-1/2
More than average	1,679	18
Very much	802	8-1/2
	9,232	
DIFFICULT TO UNDERSTAND?		
Not at all	1,315	14
Less than average	2,544	28-1/2
Average	2,803	30
More than average	1,735	19
Very much	827	9
	9,224	
PERSONALLY USEFUL?		
Not at all	1,342	13
Less than average	2,610	25
Average	3,268	31-1/2
More than average	2,131	20-1/2
Very much	966	9-1/2
	10,317	

Sub-set 3 -- To what extent do you feel that your physics laboratory experiences are:

	Number of Responses	Per cent of Responses
STIMULATING?		
Not at all	1,152	11-1/2
Less than average	1,810	17-1/2
Average	2,572	25
More than average	2,769	27
Very much	1,921	19
	10,224	
DIFFICULT TO UNDERSTAND?		
Not at all	1,803	17-1/2
Less than average	2,987	29
Average	2,930	28-1/2
More than average	1,873	18
Very much	750	7
	10,343	

	Number of Responses	Per cent of Responses
PERSONALLY USEFUL?		
Not at all	1,535	15
Less than average	2,747	26-1/2
Average	3,059	29
More than average	1,984	19
Very much	1,017	10
	10,342	

Sub-set 4 -- To what extent do you feel that your physics teacher:

	Number of Responses	Per cent of Responses
ENJOYS TEACHING PHYSICS?		
Not at all	376	4
Less than average	524	5-1/2
Average	1,090	11-1/2
More than average	2,137	22
Very much	5,487	57
	9,614	
MAKES DIFFICULT IDEAS SEEM EASIER?		
Not at all	1,063	11
Less than average	1,537	16
Average	2,533	26
More than average	2,962	30-1/2
Very much	1,647	16-1/2
	9,742	
GIVES YOU CONFIDENCE IN HIS KNOWLEDGE OF PHYSICS?		
Not at all	930	9-1/2
Less than average	1,208	12-1/2
Average	1,896	20
More than average	2,622	27
Very much	2,954	30-1/2
	9,610	

	Number of Responses	Per cent of Responses
FITS YOUR IMAGE OF A PHYSICS TEACHER?		
Not at all	1,258	13
Less than average	1,360	14-1/2
Average	2,053	21-1/2
More than average	2,053	21-1/2
Very much	2,789	29
	9,513	
FITS YOUR IMAGE OF A PROFESSIONAL PHYSICIST?		
Not at all	2,049	21-1/2
Less than average	1,960	20-1/2
Average	2,350	24-1/2
More than average	2,010	21
Very much	1,152	12
	9,521	
IS INTERESTED IN YOU AS A STUDENT?		
Not at all	706	7
Less than average	1,198	12-1/2
Average	2,406	24-1/2
More than average	2,896	30
Very much	2,545	26
	9,751	
IS INTERESTED IN YOU AS A PERSON?		
Not at all	1,161	12
Less than average	1,699	18
Average	2,702	28
More than average	2,240	23-1/2
Very much	1,732	18
	9,534	
UNDERSTANDS YOUR SCHOOL-RELATED PROBLEMS?		
Not at all	1,502	16
Less than average	1,865	20
Average	2,493	26-1/2
More than average	2,060	22
Very much	1,460	15-1/2
	9,380	

	Number of Responses	Per cent of Responses
UNDERSTANDS YOUR PERSONAL PROBLEMS?		
Not at all	2,824	29-1/2
Less than average	2,382	25
Average	2,364	24-1/2
More than average	1,193	12-1/2
Very much	806	8-1/2
	9,569	
IS FAIR?		
Not at all	511	5
Less than average	602	6
Average	1,579	16
More than average	2,505	26
Very much	4,436	46
	9,630	

Sub-set 5 -- To what extent do you feel that physics is important to your future professional and vocational goals?

	Number of Responses	Per cent of Responses
Not at all	771	8
Less than average	1,341	14
Average	2,082	22
More than average	2,368	25
Very much	2,827	30
	9,389	

Sub-set 6 -- To what extent do you feel that your physics course lecture objectives are personally useful?

	Number of Responses	Per cent of Responses
Not at all	923	10
Less than average	2,081	22
Average	3,322	35-1/2
More than average	2,286	24
Very much	756	8
	9,368	

Sub-set 7 --To what extent do you feel that your physics course laboratory objectives are achieved?

	Number of Responses	Per cent of Responses
Not at all	927	9-1/2
Less than average	1,941	20
Average	3,131	32
More than average	2,734	28
Very much	927	9-1/2
	9,660	

Sub-set 8 --To what extent do you feel that your physics laboratory and your physics lecture supplement one another?

	Number of Responses	Per cent of Responses
Not at all	647	7
Less than average	1,214	12-1/2
Average	2,367	24-1/2
More than average	3,083	32
Very much	2,256	23-1/2
	9,567	

Physics Teachers

The number of physics teachers who constituted the population sample of all California public high school physics teachers was 347. These physics teachers were presented with 120 items pertinent to their personal characteristics, the characteristics of their schools, and their perceptions of selected aspects of physics, physics students, and physics courses.

Teacher questionnaire data have been divided into three principal subsections: data pertinent to the personal characteristics of the teachers, data pertinent to the schools in which the teachers were teaching, and data pertinent to the teachers' perceptions of selected aspects of physics, physics students, and physics courses.

Percentages have been presented to the nearest whole per cent, unless otherwise indicated.

Personal Characteristics of the Teachers. This subsection is devoted to the following selected personal characteristics of the California public high school physics teacher population sample: sex and age, degrees earned, semester hours earned in physics, recency of academic work in physics, and orientation of physics courses taken by teacher, salaries, years of teaching experience, physics-related work experience, and professional affiliations and professional publications read regularly. The data reported were as follows:

Sex of the Teachers: Ninety-two per cent of the respondents were males, 6 per cent were females and 1 per cent omitted the item; 1 per cent error was due to rounding.

Age of the Teachers: The ages of the teachers were distributed as follows: 5 per cent under twenty-five; 33 per cent twenty-five to thirty-four; 37 per cent thirty-five to forty-four; 16 per cent forty-five to fifty-four; and 8 per cent over fifty-five. One per cent error was due to rounding. Approximately 70 per cent of the physics teachers were in the twenty-five to forty-four years of age range.

Degrees Held by the Teachers: Table 6 presents percentages of the types of degrees held by the physics teacher sample and the kinds of institutions where these degrees were earned.

Recency of Academic Work in Physics: The teachers reported recency of the last physics course taken for academic credit as follows: 47 per cent one to three years; 28 per cent four to six years; 19 per cent seven to twelve years; 3 per cent thirteen to nineteen years; and 3 per cent over nineteen years.

Seventy-five per cent of the physics teacher population sample reported academic work in physics within the six years preceding the study.

Institutionally-supported Academic Work: The physics teachers were asked to report the kind and frequency of their academic work supported by the National Science Foundation, Atomic Energy Commission, or other organizations. For example, if a teacher had had two NSF Summer Institutes, entry was made under column 2, row 3 (Table 7). The types of programs and their respective percentages are presented in Table 7.

The number of supported academic programs totaled 286. The programs in which most participated were NSF or AEC Summer Institutes.

TABLE 6

Degrees Held by Physics Teachers

Type of Degree	Unafilliated teacher's college	Liberal arts college	College (school) of education in a university or state college	Other college (school) in a university or state college
	(in per cent)			
Bachelor's	5	30	23	39
Master's (Education)	1	3	26	6
Master's (Physics)	-	2	1	7
Other Master's	-	4	6	18
Ed.D.	-	-	-	1
Ph.D. (Physics)	-	1	-	1
Other Ph.D.	1	1	-	-

TABLE 7

Institutionally-supported Academic Work Undertaken by Physics Teachers

Kind of Program	None	Number of Participations per Teacher (in per cent) 1	2	3	4	5
NSF Academic Year Institute	79	18	1	1	-	-
NSF In-service Institute	73	14	8	4	-	-
NSF or AEC Summer Institute	39	17	14	12	12	5
NSF or AEC Summer Participation	88	6	3	1	-	-
Other Academic Year Institute	97	1	1	1	-	-
NSF or AEC Summer Conference	97	2	-	1	-	-
Other Summer Participation	88	9	2	1	1	-
Other Summer Conference	96	2	1	-	-	-
Government Fellowship	97	2	1	-	-	-
Other Fellowship	92	6	2	1	-	-

Semester Hours Earned in Physics: The physics teachers listed their undergraduate and graduate semester hours earned in physics as shown in Table 8.

Physics-related Work Experiences: The teachers reported the extent of their years of physics-related work experiences, other than teaching, as follows: 49 per cent one to three years; 13 per cent four to six years; 6 per cent seven to twelve years; 2 per cent thirteen to nineteen years; and 2 per cent over nineteen years.

Seventy-two per cent of the physics teacher sample reported physics-related work experiences, other than teaching. Approximately half the teachers had worked one to three years in physics-related work.

Teaching Experience: The years of cumulative teaching experience in all fields, years of physics teaching, years of mathematics teaching, and years of physical science teaching, were reported by the physics teachers. Table 9 shows the percentage of the responses reported for each category.

Orientation of Physics Courses Taken by Teachers: The physics teachers were asked to classify their high school and college physics courses on the basis of whether they had had no physics courses, PSSC, PSSC equivalent, or traditional physics courses. The percentages of responses are given in Table 10.

TABLE 8

Semester Hours Earned in Physics by Physics Teachers

	Number of Undergraduate Hours per Teacher (in per cent)				
	(0-8)	(9-16)	(17-24)	(25-32)	(Over 32)
Per cent of Respondents	10	23	22	18	19
	Number of Graduate Hours per Teacher				
	(0-8)	(9-16)	(17-24)	(25-32)	(Over 32)
Per cent of Respondents	20	19	12	5	5

TABLE 9

Teaching Experience of Physics Teachers

	Years (1-3) (in per cent)	(4-6)	(7-12)	(13-19)	(Over 19)
Total years of teaching	17	20	29	22	12
Physics	32	21	31	10	5
Mathematics	36	17	19	8	2
Any physical science	18	22	27	16	6

TABLE 10

Orientation of Physics Courses Taken by Teachers

	PSSC or Equivalent (in per cent)	Traditional	None
High School	1	80	18
College	7	85	2

Extent of Professional Affiliation: The number of professional physical science societies in which the physics teacher sample held active membership is reported in Table 11.

Professional Publications Read Regularly: The physics teacher population sample indicated the number of professional physical science publications read regularly, in addition to those publications accompanying individual memberships in the societies reported above. These are given in Table 12.

Academic Year Salary: The physics teachers reported their salaries for an academic year as shown in Table 13.

School Characteristics: This sub-section is devoted to selected characteristics of the California public secondary schools encompassed by the study. These characteristics were: grade structure within the schools, school enrollments, physics courses prerequisites, kind of student encouraged to take physics, orientation of the physics courses offered, teaching schedules and pupil loads of physics teachers, and weekly activities of physics teachers. The data were reported as follows.

Grade Structure within Schools: The physics teachers reported that 7 per cent taught in combined junior high and high schools, and that 89 per cent taught in high schools only; 3 per cent omitted this item.

School Enrollments: The physics teachers estimated enrollments within their schools for the following categories:

TABLE 11

Professional Affiliations of Physics Teachers

	Number of Societies per Teacher					
	1	2	3	4	Over 4 (in per cent)	No response
Number of Respondents	41	21	7	3	4	25

TABLE 12

Professional Publications Read Regularly by Physics Teachers

	Number of Publications Read Regularly					
	1	2	3	4	Over 4 (in per cent)	No response
Number of Respondents	29	25	17	5	6	18

TABLE 13

Academic Year Salaries of Physics Teachers

	Annual Salary Ranges (in Dollars)									
	4,000 to 4,999	5,000 to 5,999	6,000 to 6,999	7,000 to 7,999	8,000 to 8,999	9,000 to 9,999	10,000 to 10,999	11,000 to 11,999	12,000 to 12,999	Over 13,000
Per cent of Respondents			3-1/2	5-1/2	6-1/2	8	10-1/2	6-1/2	7	2

One-half of the teachers did not report their academic year salaries.

over-all school enrollment, senior class enrollment, and physics course enrollment. Percentages are to the nearest one-half per cent of all the participating teachers. These are reported in Table 14.

The average-size, any-combination-of-grade school had an enrollment within the range of 701 to 1,500 students. The average size high school had an enrollment over the same range, 701-1,500 students. The senior class size mean was approximately 150 students, and the mode for senior class size was the range 351 to 450 students. Most physics classes had enrollments within the range of sixteen to fifty students.

Physics Course Prerequisites: The physics teachers were asked: "What prerequisites must a student fulfill to enroll in physics courses in your school?" The per cent of total responses was as follows: 8 per cent no prerequisites; 1 per cent grade point average; 6 per cent teacher approval; 12 per cent counselor approval; and 59 per cent course requirements or class standing (i.e., sophomore, junior, senior).

Approximately 86 per cent of the public high schools were reported as having some kind of high school physics course prerequisites. The two extant prerequisites were: class standing and/or specific course(s), 59 per cent; and counselor approval, 12 per cent.

TABLE 14

Enrollments in Schools where Physics Teachers Worked

(in per cent)

Estimated No. of Students:	1-25	26-100	101-250	251-400	401-700	701-1000	1001-1500	1501-2000	2001-2500	Over 2500
Entire School	-	-	1	1-1/2	4	4	8	10	8	7
High School	-	1/2	1-1/2	2-1/2	4	4	9-1/2	12-1/2	8-1/2	4-1/2

Estimated No. of Students	1-25	26-100	101-150	151-250	251-350	351-450	451-550	551-750	751-1000	Over 1000
Senior Class	1/2	4-1/2	4	5	8	9	8-1/2	5	3	1/2

Estimated No. of Students:	1-15	16-50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	Over 400
Taking Physics	20	51	21	4	-	-	-	-	-	-

Physics for Everyone? The physics teachers were asked, "Are 'poor' students at your school discouraged from taking physics?" Nearly three-fourths of the physics teachers reported that their schools discouraged "poor" students from taking physics.

Orientation of Physics Courses Taught: The physics teachers gave the orientation of their lectures and laboratories as shown in Table 15.

Teaching Schedules and Pupil Loads: Physics teachers reported their hours per week teaching physics, teaching mathematics, teaching physical sciences, and teaching other courses (Table 16). Also reported were the pupil loads for these courses. Fifty-five per cent of the participants taught physics five or more hours per week.

Weekly Activities of Physics Teachers: The teachers sampled were asked to estimate the number of hours of a typical twenty-four-hour day of a seven-day-work week which they devoted to teaching, teacher preparation, and to related activities. The percentage who failed to respond to a given item is reported in Table 17, along with the per cent of response to that same item, based upon N equal to 347.

Most of the respondents spent 4-1/2 to 5 hours per week at classroom teaching, and 1-1/2 to 2 hours per week at laboratory teaching. Most respondents spent 1-1/2 to 2 hours per week at classroom teaching preparation, and one hour or less per week at laboratory teaching preparation.

TABLE 15

Orientation of Physics Courses Taught

	PSSC or Equivalent	Some Combination of PSSC and Traditional (in per cent)	Traditional
Laboratories	55	26	15
Lectures	56	24	19

TABLE 16

Class Hours per Week and Number of Students
Taught per Week
(Physics, Mathematics, Physical Sciences, and other Classes)

	Physics	Mathematics	Physical Sciences	Other
		(in per cent)		
Class Hours per Week:				
3 to 3-1/2	6	5	7	5
4 to 4-1/2	5	2	3	2
5 to 5-1/2	22	8	12	5
6 to 6+	33	20	30	16
Number of Students per Week:				
1 to 20	8	6	7	5
21 to 40	35	13	17	10
41 to 80	23	10	18	10
81 to 125	6	10	13	5
126 to 200	1	2	2	2
201+	-	-	-	1

Rounded to the nearest 1/2%

TABLE 17

Weekly School-related Activities of Physics Teachers

Estimated Hours of 24-hour Day, 7-day Week, Devoted to:	0 to 1	1-1/2 to 2	2-1/2 to 3	3-1/2 to 4	4-1/2 to 5	5-1/2 to 6	6-1/2 to 7	7-1/2 to 8	8-1/2 to 9	9-1/2+	Not Reporting
					(in per cent)						
Classroom Teaching	1/2	2	6	9	16	5-1/2	2	1	1	5-1/2	3
Laboratory Teaching	15	18	7	3	1-1/2	1	1/2	1/2	-	2	2
Preparation for Classroom Teaching	7	19	10-1/2	4	2-1/2	1	1	1-1/2	1/2	2-1/2	1
Preparation for Laboratory Teaching	23-1/2	15	4-1/2	2	1-1/2	1/2	1/2	1/2	-	1/2	3
Related (lunch duty, clubs, records, etc.)	30	11	3	1	2	1/2	-	-	-	1/2	4
Professional Meetings, Journals, etc.	32-1/2	11-1/2	2-1/2	1	1/2	1/2	-	-	-	-	3
Advanced Study (courses for credit):											
Physics	39-1/2	2-1/2	1	1/2	1/2	1/2	-	-	-	-	11
Mathematics	40	1-1/2	1/2	1/2	-	-	-	-	-	-	15
Physical Sciences (astronomy, earth science, chemistry, etc.)	25-1/2	4	1-1/2	1	1/2	1/2	-	-	-	1/2	33
Education	38	3	1/2	-	1/2	-	-	-	-	1/2	15

Per cent not responding is that fraction of the 347 participants who failed to respond to item.

Rounded to the nearest 1/2%

Most respondents spent one hour or less per week at the following: related duties such as lunch duty, clubs, school records, etc.; professional meetings, journals, etc.; and advanced studies in physics, mathematics, education, or the physical sciences.

Four and one-half per cent of the participants spent one and one-half or more hours per week studying physics courses taken for credit.

Teacher Perceptions of Physics, Physics Students, and Physics Courses: This sub-section is devoted to the physics teachers' perceptions of selected aspects of physics, physics students, and physics courses.

Seventy-eight questions were posited. Findings are presented as per cent of responses for N equals 347; percentages are to the nearest whole per cent.

For greater clarity, the set of seventy-eight questions has been grouped into the following eighteen subsets:

Sub-set 1-- To what extent do you feel that students find your physics laboratory experiences:

	Per cent of Participants
STIMULATING?	
Not at all	2
Less than average	12
Average	39
More than average	36
Very much	9

	Per cent of Participants
INTERESTING?	
Not at all	1
Less than average	7
Average	32
More than average	45
Very much	12
PERSONALLY USEFUL?	
Not at all	5
Less than average	39
Average	43
More than average	10
Very much	-
DIFFICULT TO UNDERSTAND CONCEPTUALLY?	
Not at all	5
Less than average	27
Average	34
More than average	27
Very much	4
SUPPLEMENT AND CLARIFY YOUR LECTURES?	
Not at all	1
Less than average	8
Average	36
More than average	37
Very much	15

Sub-set 2-- To what extent do you feel that students find your physics course has:

	Per cent of Participants
SOCIAL VALUE?	
Not at all	20
Less than average	39
Average	22
More than average	15
Very much	2

	Per cent of Participants
POLITICAL VALUE?	
Not at all	45
Less than average	35
Average	11
More than average	5
Very much	1
HISTORICAL VALUE?	
Not at all	12
Less than average	33
Average	34
More than average	17
Very much	2
SCIENTIFIC VALUE?	
Not at all	1
Less than average	1
Average	11
More than average	44
Very much	40

In general, teachers felt that students found their physics courses to be relatively high in scientific value; relatively low in political value; and somewhere between these two extremes in both social and historical values.

Sub-set 3 -- To what extent do you feel your physics course:

	Per cent of Participations
LOWERS YOUR STUDENTS' GRADE POINT AVERAGES?	
Not at all	18
Less than average	36
Average	22
More than average	18
Very much	3

Sub-set 4-- To what extent do you feel that the physics course you teach prepares your students for:

	Per cent of Participants
PHYSICS MAJOR COURSES?	
Not at all	2
Less than average	7
Average	18
More than average	44
Very much	27
SCIENCE MAJOR COURSES?	
Not at all	-
Less than average	3
Average	13
More than average	47
Very much	34
GENERAL COLLEGE COURSES (NON-SCIENCE)?	
Not at all	1
Less than average	10
Average	34
More than average	39
Very much	14
UNDERSTANDING SCIENCE'S ROLE IN SOCIETY?	
Not at all	3
Less than average	14
Average	33
More than average	33
Very much	14

Sub-set 5-- To what extent do you feel that your students:

	Per cent of Participants
HAVE CONFIDENCE IN YOUR KNOWLEDGE OF PHYSICS?	
Not at all	1
Less than average	6
Average	24
More than average	44
Very much	22

Sub-set 6— To what extent do you feel that you:

	Per cent of Participants
MEET YOUR COURSE OBJECTIVES?	
Not at all	1
Less than average	8
Average	29
More than average	51
Very much	9

Sub-set 7 — To what extent do you feel that you include in your course objectives:

	Per cent of Participants
SOCIAL ASPECTS OF PHYSICS?	
Not at all	11
Less than average	33
Average	29
More than average	16
Very much	5
POLITICAL ASPECTS OF PHYSICS?	
Not at all	24
Less than average	37
Average	26
More than average	9
Very much	2
HISTORICAL ASPECTS OF PHYSICS?	
Not at all	77
Less than average	19
Average	-
More than average	-
Very much	1

Sub-set 8 — To what extent do you feel:

	Per cent of Participants
ENCOURAGED TO BETTER PHYSICS TEACHING BY YOUR ADMININSTRATORS?	
Not at all	24
Less than average	19
Average	19
More than average	16
Very much	8

	Per cent of Participants
YOUR WORK LOAD PREVENTS BETTER PHYSICS TEACHING?	
Not at all	11
Less than average	12
Average	18
More than average	31
Very much	27
YOUR NEEDS FOR PHYSICS TEACHING MATERIALS ARE MET?	
Not at all	5
Less than average	20
Average	25
More than average	29
Very much	20

Sub-set 9-- To what extent do you feel there exists the following:

	Per cent of Participants
PUPIL INTEREST IN PHYSICS?	
Not at all	3
Less than average	28
Average	41
More than average	24
Very much	3
COMMUNITY INTEREST IN PHYSICS?	
Not at all	18
Less than average	44
Average	27
More than average	9
Very much	1
NON-PHYSICS TEACHER INTEREST IN PHYSICS?	
Not at all	21
Less than average	53
Average	21
More than average	3
Very much	1

Sub-set 10-- To what extent do you feel that you understand your students':

	Per cent of Participants
SCHOOL-RELATED PROBLEMS?	
Not at all	1
Less than average	6
Average	33
More than average	44
Very much	14
PERSONAL PROBLEMS?	
Not at all	2
Less than average	21
Average	39
More than average	29
Very much	7
PROBLEMS IN LEARNING PHYSICS?	
Not at all	-
Less than average	2
Average	19
More than average	50
Very much	27

Sub-set 11-- To what extent do you feel that, for yourself, physics is the following:

	Per cent of Participants
STIMULATING?	
Not at all	-
Less than average	1
Average	13
More than average	32
Very much	53
INTERESTING?	
Not at all	-
Less than average	1
Average	6
More than average	28
Very much	63

	Per cent of Participants
PERSONALLY USEFUL (OTHER THAN TEACHING)?	
Not at all	-
Less than average	5
Average	17
More than average	41
Very much	35
DIFFICULT TO UNDERSTAND CONCEPTUALLY?	
Not at all	12
Less than average	32
Average	23
More than average	26
Very much	4
SOCIALLY SIGNIFICANT?	
Not at all	3
Less than average	16
Average	31
More than average	30
Very much	18
POLITICALLY SIGNIFICANT?	
Not at all	9
Less than average	23
Average	27
More than average	26
Very much	12
HISTORICALLY SIGNIFICANT?	
Not at all	3
Less than average	11
Average	22
More than average	37
Very much	24

<u>Sub-set 12</u> -- To what extent do you feel that for yourself, physics laboratory experiences are:

	Per cent of Participants
STIMULATING?	
Not at all	1
Less than average	7
Average	20
More than Average	35
Very much	35

	Per cent of Participants
DIFFICULT TO UNDERSTAND?	
Not at all	16
Less than average	38
Average	24
More than average	15
Very much	4
SIGNIFICANT SUPPLEMENTS TO THEORY?	
Not at all	1
Less than average	4
Average	15
More than average	35
Very much	42

Sub-set 13-- To what extent do you feel that you:

	Per cent of Participants
LIKE TEACHING YOUNG PEOPLE?	
Not at all	-
Less than average	-
Average	4
More than average	23
Very much	71
ENJOY TEACHING PHYSICS STUDENTS?	
Not at all	-
Less than average	1
Average	5
More than average	20
Very much	71
IDENTIFY WITH PHYSICISTS?	
Not at all	10
Less than average	24
Average	35
More than average	21
Very much	8
IDENTIFY WITH PHYSICS TEACHERS?	
Not at all	4
Less than average	13
Average	21
More than average	38
Very much	23

	Per cent of Participants
HAVE RAPPORT WITH YOUR PHYSICS STUDENTS?	
Not at all	-
Less than average	1
Average	13
More than average	44
Very much	39

Sub-set 14-- To what extent do you feel that for your first year of physics teaching you were prepared academically to:

	Per cent of Participants
TEACH THE PHYSICS-ORIENTED PUPIL?	
Not at all	12
Less than average	31
Average	26
More than average	16
Very much	14
TEACH THE AVERAGE PHYSICS PUPIL?	
Not at all	3
Less than average	18
Average	39
More than average	26
Very much	14
ATTRACT THE ABLE PUPIL TO PHYSICS?	
Not at all	9
Less than average	27
Average	35
More than average	22
Very much	5

Sub-set 15-- To what extent do you feel that you are currently prepared academically to:

	Per cent of Participants
TEACH THE PHYSICS-ORIENTED PUPIL?	
Not at all	-
Less than average	7
Average	15
More than average	40
Very much	35
TEACH THE AVERAGE PHYSICS PUPIL?	
Not at all	-
Less than average	3
Average	15
More than average	37
Very much	43
ATTRACT THE ABLE PUPIL TO PHYSICS?	
Not at all	1
Less than average	8
Average	26
More than average	41
Very much	21

Sub-set 16--To what extent do you feel a long-term commitment to the following:

	Per cent of Participants
TEACHING?	
Not at all	2
Less than average	3
Average	8
More than average	18
Very much	67
PHYSICS TEACHING?	
Not at all	4
Less than average	7
Average	12
More than average	24
Very much	51

	Per cent of Participants
ADDITIONAL FORMAL TRAINING IN PHYSICS?	
Not at all	8
Less than average	14
Average	17
More than average	27
Very much	33

Sub-set 17 -- To what extent do you feel that you would leave teaching for a monthly:

	Per cent of Participants
10 PER CENT SALARY INCREASE?	
Not at all	80
Less than average	12
Average	3
More than average	1
Very much	1
25 PER CENT SALARY INCREASE?	
Not at all	44
Less than average	32
Average	13
More than average	6
Very much	2
50 PER CENT SALARY INCREASE?	
Not at all	19
Less than average	15
Average	26
More than average	23
Very much	15
75 PER CENT SALARY INCREASE?	
Not at all	13
Less than average	8
Average	14
More than average	22
Very much	40

Sub-set 18 --To what extent do you feel the following contribute to low physics marks in high school?

	Per cent of Participants
PHYSICS IS HARD	
Not at all	3
Less than average	15
Average	41
More than average	27
Very much	9
PHYSICS REQUIRES MATHEMATICS	
Not at all	1
Less than average	12
Average	30
More than average	34
Very much	20
STUDENTS LACK AMBITION	
Not at all	12
Less than average	27
Average	27
More than average	22
Very much	10
STUDENTS FEAR PHYSICS	
Not at all	6
Less than average	20
Average	22
More than average	33
Very much	17
PHYSICS COURSES DO NOT RELATE TO STUDENTS' EXPERIENCES	
Not at all	14
Less than average	30
Average	29
More than average	17
Very much	6
PHYSICS COURSES DO NOT RELATE TO STUDENT IMMEDIATE NEEDS	
Not at all	9
Less than average	23
Average	24
More than average	29
Very much	12

Tests of the Fourteen Null Hypotheses

The fourteen null hypotheses listed in Chapter I were tested for significance; Chapter III described the statistical tests employed. This section of Chapter IV presents each null hypothesis, the results of its statistical tests, and how the results were arrived at. A succeeding section presents tests and results for two null hypotheses suggested by the data (secondary findings), and the last section is a summary of the chapter.

Chi Square Tests

Null hypotheses 1, 2, 3, 4, 5, 6, 7, 8, 9, 13, and 14 were Chi square tested for possible significant relationships, as described in the following sub-sections.

Null Hypothesis 1--The null hypothesis that there would be no significant relationship between high school physics student attitudes toward physics and the academic preparation of high school physics teachers was rejected at the .05 level of confidence, as determined by tests using teacher question 99 and student questions 46, 47, and 48.

> For student questions 47 and 48, no significant relationship existed between teacher semester hours earned in physics and pupil feeling that physics as a field of study was difficult or personally useful.
>
> A significant relationship (.05 confidence level) was found between teacher question 99 and student question 46; therefore, a significant relationship did exist between teacher semester hours earned in physics and pupil feeling that physics as a field of study was stimulating.

Null Hypothesis 2--The null hypothesis that there would be no significant relationship between high school student attitudes toward physics and the extent to which the physics teachers identified with the physics profession was rejected at the .05 level of confidence, as determined by tests using teacher questions 83 and 84, and student questions 46, 47, and 48.

> No significant relationship existed between the extent that the teachers felt they identified with physicists and the extent that students found physics stimulating, difficult, or personally useful (teacher question 83 and student questions 46, 47, and 48).
>
> No significant relationship existed between the extent that teachers identified with other physics teachers and the extent that students found physics stimulating (teacher question 84 and student question 46).
>
> A significant relationship (.05 confidence level) was found to exist between teacher question 84 and student questions 47 and 48; therefore, a significant relationship existed between teacher identification with other physics teachers and the extent that students found physics difficult and personally useful.

Null Hypothesis 3--The null hypothesis that there would be no significant relationship between high school physics student attitudes toward physics and the physics work experiences of the teachers was accepted, as determined by tests using teacher question 11 and student questions 46, 47, and 48.

> No significant relationship was found between the physics work experiences of the teacher and the extent to which students found physics stimulating, difficult, or personally useful.

Null Hypothesis 4--The null hypothesis that there would be no significant relationship between high school physics student attitudes toward physics as a field of study and teacher expressions of long-term commitments to physics teaching was rejected at the .01 level of confidence, as determined by tests using teacher question 92 and student questions 46, 47, and 48.

> No significant relationship existed between teacher long-term commitment to physics teaching and student feeling that physics was difficult or personally useful (teacher question 92 and student questions 47 and 48).
>
> A significant relationship (.01 confidence level) was found to exist between teacher question 92 and student question 46; therefore, a significant relationship existed between teacher long-term commitment to physics teaching and the extent that students felt physics was stimulating.

Null Hypothesis 5--The null hypothesis that there would be no significant relationship between the attitudes of high school physics students toward physics as a field of study and the attitudes of high school physics teachers toward physics was rejected at the .01 level of confidence, as determined by tests using teacher questions 70, 72, and 73 and student questions 46, 47, and 48.

> No significant relationship existed between the extent that teachers found physics stimulating and the extent that students found physics difficult (teacher question 70 and student question 47).
>
> A significant relationship (.05 confidence level) existed between teacher question 70 and student questions 46 and 48; therefore, a significant relationship

existed between the extent that teachers found physics stimulating and the extent that students found physics stimulating and personally useful.

A significant relationship (.01 confidence level) existed between teacher question 72 and student questions 46, 47, and 48; therefore, a significant relationship existed between the extent that teachers found physics personally useful (other than teaching) and the extent that students found physics stimulating, difficult, and personally useful.

A significant relationship (.01 confidence level) existed between teacher question 73 and student questions 46, 47, and 48; therefore, a significant relationship existed between the extent that teachers found physics difficult to understand conceptually and the extent that students found physics stimulating, difficult, and personally useful.

Null Hypothesis 6-- The null hypothesis that there would be no significant relationship between high school physics student identification of a successful physics course and high school physics teacher identification of a successful physics course was rejected at the .01 level of confidence, as determined by tests using teacher question 57 and student questions 65, 66, and 67.

No significant relationship existed between the extent that teachers felt they met their course objectives and the extent that students felt physics was important to their future professional and vocational goals (teacher question 57 and student question 65).

A significant relationship (.05 confidence level) existed between teacher question 57 and student question 66; therefore, a significant relationship existed between the extent that teachers felt they met their course objectives and the extent that students felt their lecture objectives were personally useful.

> A significant relationship (.01 confidence level) existed between teacher question 57 and student question 67; therefore, a significant relationship existed between the extent that teachers felt they met their course objectives and the extent that students felt the objectives of their physics laboratory courses were achieved.

<u>Null Hypothesis 7</u>--The null hypothesis that there would be no significant relationship between high school physics student attitudes toward physics and the time which high school physics teachers spent in preparation for classroom and laboratory teaching was rejected at the .01 level of confidence, as determined by tests using teacher questions 103 and 104 and student questions 46, 47, and 48.

> No significant relationship existed between teacher preparation time for laboratory teaching and the extent that students felt physics as a field of study was stimulating, difficult, or personally useful (teacher question 104 and student questions 46, 47, and 48).

> No significant relationship existed between teacher preparation time for classroom teaching and the extent that students felt physics as a field of study was personally useful (teacher question 103 and student question 48).

> A significant relationship (.01 confidence level) existed between teacher question 103 and student questions 46 and 47; therefore, a significant relationship existed between teacher preparation time for classroom teaching and the extent that students felt physics as a field of study was stimulating and difficult.

<u>Null Hypothesis 8</u>--The null hypothesis that there would be no significant relationship between high school physics student attitudes toward physics as a field of study and the extent of the emphasis placed upon teaching the

social, political, and historical aspects of physics was rejected at the .01 level of confidence, as determined by tests using teacher questions 58, 59, 60, 74, 75, and 76 and student questions 46, 47, and 48.

> No significant relationship existed between the extent that physics teachers found physics socially significant and the extent that students found physics difficult, as a field of study (teacher question 74 and student question 47).
>
> No significant relationship existed between the extent that the physics teachers found physics politically significant and the extent that students found physics as a field of study stimulating, difficult, or personally useful (teacher question 75 and student questions 46, 47, and 48).
>
> No significant relationship existed between the extent that the teachers felt they included the social aspects of physics in their course objectives and the extent that the students felt physics as a field of study was stimulating, difficult, or personally useful (teacher question 58 and student questions 46, and 48).
>
> A significant relationship (.01 confidence level) existed between teacher question 74 and student question 46; therefore, a significant relationship existed between the extent that the physics teachers found physics socially significant and the extent that students found physics stimulating, as a field of study.
>
> A significant relationship (.05 confidence level) existed between teacher question 74 and student question 48; therefore, a significant relationship existed between the extent that the physics teachers found physics socially significant and the extent that the students found physics personally useful, as a field of study.
>
> A significant relationship (.01 confidence level) existed between teacher question 76 and student questions 46 and 47; therefore, a significant relationship existed between the extent that the physics teachers found physics historically significant and the extent that students found physics stimulating and difficult, as a field of study.

A significant relationship (.05 confidence level) existed between teacher question 76 and student question 48; therefore, a significant relationship existed between the extent that the physics teachers found physics historically significant and the extent that students found physics personally useful, as a field of study.

A significant relationship (.05 confidence level) existed between teacher question 58 and student ques- 47; therefore, a significant relationship existed between the extent that the teachers felt they included the social aspects of physics in their course objectives and the extent that the students felt that physics as a field of study was difficult.

A significant relationship (.01 confidence level) existed between teacher question 59 and student questions 46, 47, and 48; therefore, a significant relationship existed between the extent that the teachers felt they included the political aspects of physics in their course objectives and the extent that the students found physics stimulating, difficult, and personally useful.

Null Hypothesis 9--The null hypothesis that there would be no significant relationship between high school physics student attitudes toward physics courses and teacher expressions of long-term commitments to physics teaching, was rejected at the .01 level of confidence, as determined by tests using teacher question 92 and student questions 49, 50, 51, 52, 53, and 54.

No significant relationship existed between the teacher long-term commitment to physics teaching and the extent that the physics students felt their physics course lectures were difficult to understand or personally useful (teacher question 92 and student questions 50 and 51).

No significant relationship existed between the teacher long-term commitment to physics teaching and the extent that the physics students felt their physics laboratory experiences were stimulating, difficult to understand, or personally useful (teacher question 92 and student questions 52, 53, and 54).

A significant relationship (.01 confidence level) existed between teacher question 92 and student question 49; therefore, a significant relationship existed between teacher long-term commitment to physics teaching and the extent that physics students felt their physics course lectures were stimulating.

Frequency Tests

Null hypotheses 10, 11, 12, 13, and 14 did not lend themselves to continuous-variable or dependent-variable tests; therefore, these were evaluated on the bases of ratios of observed frequencies of items, or ratios of percentages of responses.

Null Hypothesis 10--The null hypothesis that there would be no significant relationship between the sex of high school students and enrollments in high school physics courses was rejected.

The non-physics student sample had an N of 2,348 for this item, and was about evenly divided on the basis of sex: 46 per cent male and 53-1/2 per cent female. The physics student sample had an N of 9,639 for this item, and was predominantly male: 81-1/2 per cent male and 18-1/2 per cent female. Therefore, the data revealed that while approximately one-half of the non-physics students were male, about four-fifths of the physics students were male.

Null Hypothesis 11--The null hypothesis that there would be no significant relationship between the expressed interest levels of high school students toward physics and the number who enrolled in high school physics was rejected.

Pages 62, 63, 64, 67, 68, and 69 of this chapter show listings of reasons students gave for not enrolling or for enrolling in high school physics. The most frequent reason given for not enrolling in physics was disinterest (49 per cent of the sample population), and the second most frequent reason given for enrolling in physics was interest (51 per cent of the sample population).

Null Hypothesis 12--The null hypothesis that there would be no significant relationship between the degree of difficulty with which high school students regarded physics and the number who enrolled in high school physics was rejected.

Pages 63 and 64 of this chapter show a listing of reasons students gave for not enrolling in high school physics. The second-ranked reason for not enrolling in physics was that physics appeared to be too difficult (36 per cent of the sample population).

Null Hypothesis 13--The null hypothesis that there would be no significant relationship between the occupational choice ranking of physics teacher by high school physics students and the number who enrolled in high school physics was rejected at the .001 level of confidence.

Students enrolled in physics ranked physics teacher, as an occupational choice, significantly higher than did those who were not enrolled.

Null Hypothesis 14--The null hypothesis that there would be no significant relationship between the occupational choice ranking of physicist by high school physics students and the number who enrolled in high school physics was rejected at the .001 level of confidence.

> Students enrolled in physics ranked physicist, as an occupational choice, significantly higher than did those who were not enrolled.

Secondary Findings

The data were perused for significant relationships not included in the original fourteen null hypotheses. This section expresses two secondary findings in suggested null hypothesis form and discusses the possible significance of each.

Suggested Null Hypothesis 1-s

The suggested null hypothesis that there would be no significant relationship between the occupational preferences of high school physics students and the occupational preferences of non-physics students with regard to physicist and physics teacher as occupational choices was accepted in terms of physicist preference, but rejected in terms of physicist preference.

> Examination of the data on occupational choices of non-physics and physics students given in this chapter on pages 63, 64, 65, 66, 69, and 70, reveals that non-physics students ranked physicist and physics teacher fifteenth and sixteenth, respectively, for sixteen occupational preferences, but physics students ranked physicist and physics teacher sixth and fifteenth, respectively, for the same sixteen occupational preferences.

Suggested Null Hypothesis 2-s

The suggested null hypothesis that there would be no significant relationship between teaching-related activities of the physics teachers and their attitudes toward physics was rejected at the .05 level of confidence.

Null hypothesis 2-s was Pearson product-moment tested using teacher attitude questions 70, 72, and 73 and teacher activities questions 101, 102, 104, 105, and 106. Listed below are teacher attitude items and corresponding teacher activity items with the significantly related items appearing in upper case:

Teacher Attitude Item	Teacher Load Item
Physics is stimulating	Time spent in classroom teaching Time spent in laboratory teaching TIME SPENT IN PREPARING FOR CLASSROOM TEACHING TIME SPENT PREPARING FOR LABORATORY TEACHING Time spent in related, nonteaching duties Time spent in professional meetings, reading professional journals, etc.
Physics is personally useful (other than teaching)	Time spent in classroom teaching Time spent in laboratory teaching Time spent in preparing for laboratory teaching TIME SPENT IN PROFESSIONAL MEETINGS, READING PROFESSIONAL JOURNALS, ETC.

Physics is difficult to understand conceptually	Time spent in classroom teaching Time spent in laboratory teaching
<u>Teacher Attitute Item</u>	<u>Teacher Load Item</u>
	Time spent in preparing for classroom teaching Time spent in preparing for laboratory teaching Time spent in related, non-teaching duties Time spent in professional meetings, reading professional journals, etc.

For teachers who scored high on the attitude item Physics is Stimulating, a significant relationship (.05 confidence level) existed between this attitude item and the teacher load items Time Spent Preparing for Classroom Teaching and Time Spent for Laboratory Teaching.

For teachers who scored high on the attitude item, Physics is Personally Useful (Other than Teaching), a significant relationship (.05 confidence level) existed between Physics is Personally Useful and Time Spent in Professional Meetings, Reading Professional Journals, Etc.

Summary

The findings were fitted into three principal groups: first, a tabulation and summary of the questionnaire data; second, the results of the tests of the fourteen null hypotheses which ordered and directed the study; and third, the two additional null hypotheses suggested by the secondary findings.

Tabulations and Synthesis of the Questionnaire Data

Non-physics Students. California public high school non-physics students were about evenly divided on the basis of sex. Eighty-eight per cent were B or C students, and 91 per cent ranked themselves in the upper two-thirds of their graduating class. Further academic work after graduation was planned by 74 per cent. The two predominant reasons selected for not enrolling in physics were lack of interest and fear that physics was too difficult. The non-physics student group's four most preferred occupations were social worker, high school teacher, artist, and explorer, in that order. Physicist and physics teacher were ranked fifteenth and sixteenth choices, respectively, of sixteen possible occupational choices.

Physics Students. California public high school physics students were predominantly male (81-1/2 per cent). Eighty-three per cent were A or B students, and 71-1/2 per cent were B or C students. Seventy-two per cent ranked themselves in the upper one-third of their graduating class, and 93 per cent ranked themselves in the upper two-thirds. Ninety-two and one-half per cent planned further academic work. The predominant reasons this group gave for enrolling in physics were anticipated need in college, and interest in physics. The two most preferred occupations of the physics students were engineer and architect, in that order; they ranked physicist sixth and physics teacher fifteenth of sixteen possible occupational choices.

Of the physics students, 77 per cent felt that physics as a field of study was stimulating; 51-1/2 per cent felt it was difficult; and 72-1/2 per cent felt it was personally useful. Approximately 77 per cent perceived physics as being important to their future professional and vocational goals.

Approximately 54 per cent felt their physics course lectures were stimulating; 28 per cent felt they were difficult to understand; and 71-1/2 per cent felt they were personally useful. Approximately two-thirds (67-1/2 per cent) perceived their physics lecture objectives as being personally useful.

Some 71 per cent indicated that their physics laboratory experiences were stimulating; 25 per cent indicated that they were difficult to understand conceptually; and 58 per cent indicated that they were personally useful. Also, 69-1/2 per cent indicated that they believed their laboratory objectives were achieved; and nearly 80 per cent indicated that their laboratory experiences and their lectures supplemented one another.

Seventy-seven and one-half per cent of the physics students felt that their teacher enjoyed teaching physics and gave them confidence in his knowledge of physics; 73 per cent felt their teacher made difficult ideas seem easier; 74-1/2 per cent felt their physics teacher was interested in them as students; 69-1/2 per cent felt their physics teacher was interested in them as persons; 88 per cent felt their physics teacher was fair; 64 per cent felt their physics teacher understood their school-related problems; but 54-1/2 per cent felt their physics teacher little understood their personal problems. Seventy-two per cent thought their teacher fitted their image of a physics teacher; and 58 per cent thought he fitted their image of a professional physicist.

Physics Teachers. Ninety-two per cent of the California public high school physics teachers were male; about 70 per cent were twenty-five to forty-four years of age; 78 per cent held master's degrees (of which only 10 per cent were in physics); 75 per cent had completed some academic work in physics within the six years preceding this study; 286 institutionally-supported academic programs had been participated in by the 347 physics teacher respondents. About two-thirds of the physics teachers had earned at least seventeen undergraduate semester hours in physics and approximately two-thirds had earned some graduate credits in physics (41 per cent reported at least nine semester hours of graduate physics credits); 72 per cent reported having physics-related work experiences, other than physics teaching. Over half had taught physics for four to nine years; 75 per cent were affiliated with at least one professional physical science society; 82 per cent read regularly one or more professional, physical science publications other than those published by the societies with which they were affiliated. The average salary was approximately $10,000 per annum.

Eighty-nine per cent of the physics teachers taught in high schools that were not combined with junior high schools. School enrollments were mostly in the 700 to 1,500 student range; average senior class size was about 150 students; and most physics classes had enrollments in the range sixteen to fifty students. Only 55 per cent of these teachers taught physics for five or more hours per week. Most spent one and one-half to two hours per week in physics classroom preparation, and one hour or less per week at laboratory teaching preparation. One hour or less per week was spent at school-related, non-teaching duties.

Eighty-six per cent of the teachers reported their schools had some kind of physics course prerequisite for students. The most prevalent prerequisite (59 per cent) was class standing and/or specific prior course(s). Nearly three-fourths of the schools surveyed actively discouraged "poor" students from enrolling in physics.

Although only 1 per cent of the teachers had taken a PSSC or equivalent high school physics course, and although only 7 per cent had taken a PSSC or equivalent college physics course, approximately four-fifths reported that they incorporated in varying degrees the PSSC approaches to physics teaching in both their laboratory and lecture courses.

Eighty-four per cent of the teachers believed their laboratories to be stimulating to students; 89 per cent believed their laboratories were interesting to students; 53 per cent believed students found their laboratory experiences personally useful; 65 per cent believed their students found their laboratory experiences difficult to understand conceptually; and 85 per cent believed that their students found their laboratory experiences supplemented and clarified the lectures.

The teachers felt their students found their courses high in scientific value, low in political value, and somewhere between these two extremes in social and historical value. Only 21 per cent felt that their course lowered their students' grade point averages more than did any other course; 89 per cent felt their course prepared students for college physics major courses, 94 per cent felt they prepared them for college science major courses, and 97 per cent felt they prepared them for general, non-science college courses.

Low marks in high school physics were attributed by physics teachers as due to physics was hard, 67 per cent; physics required mathematics, 59 per cent; students feared physics, 72 per cent; physics courses did not relate to students' experiences, 52 per cent; and physics courses did not relate to students' immediate needs, 65 per cent.

Although 94 per cent of the teachers perceived their physics course as preparing students for understanding the role of science in society, only 4 per cent reported they included more than a few of the historical aspects of physics in their course. Only 37 per cent reported they included more than a few of the political aspects of physics, and only 50 per cent reported they included more than a few of the social aspects of physics in their course.

Ninety per cent of the teachers felt they inspired student confidence in their knowledge of physics; 94 per cent liked teaching young people; 91 per cent enjoyed teaching physics; 96 per cent felt rapport with their students; and 51 per cent felt they met their course objectives.

Although 43 per cent felt their administrators encouraged them to better teaching, and although 74 per cent felt their needs for physics teaching materials were met, 76 per cent of the teachers felt that their work loads prevented better teaching.

Pertinent to interest in physics, 68 per cent of the teachers perceived that there was student interest in physics, and 37 per cent felt that there was community interest in physics. But only 25 per cent believed that non-physics teachers were interested in physics. Sixty-four per cent of the physics teachers reported they identified with physicists, and 82 per cent identified with physics teachers.

Ninety-one per cent of the physics teachers reported they understood their students' school-related problems, 75 per cent reported understanding their students' personal problems, and 96 per cent reported understanding their students' problems in learning physics.

For themselves, 98 per cent of the physics teachers perceived physics to be stimulating; 91 per cent found it interesting; 92 per cent believed it to be personally useful, other than in teaching; 53 per cent indicated it was difficult conceptually; 79 per cent considered it to be socially significant; 65 per cent considered it politically significant; and 83 per cent felt that it was historically significant. As applied to themselves, they felt that their laboratory experiences had been stimulating (90 per cent), difficult to understand conceptually (43 per cent), and significant supplements to theory (92 per cent).

For their first year of teaching, the percentage of teachers who felt prepared academically to teach the physics-oriented student was 90 per cent; to teach the average physics student was 95 per cent; and to attract the able student to physics was 88 per cent.

Eighty-five per cent of the physics teachers expressed a long-term commitment to teaching, 75 per cent expressed a long-term commitment to physics teaching, and 60 per cent expressed a long-term commitment to additional formal training in physics. Nearly two-thirds indicated that they would not leave teaching solely for financial reasons unless they received a 50 per cent or greater monthly salary increase.

Tests of the Fourteen Null Hypotheses

Significant relationships existed between the following: teacher semester hours earned in physics and pupil feeling that physics was stimulating (.05 level of confidence), teacher identification with other physics teachers and student feeling that physics was difficult and personally useful (.05 level of confidence), teacher long-term commitment to physics teaching and student feeling that physics was stimulating (.01 level of confidence), teacher feeling that physics was stimulating and student feeling that physics was stimulating and personally useful (.05 level of confidence), teacher feeling that physics was personally useful (other than teaching) and student feeling that physics was stimulating, difficult, and personally useful (.01 level of confidence), teacher feeling that physics was difficult conceptually and student feeling that physics was stimulating, difficult, and personally useful (.01 level of confidence), teacher feeling that course objectives were met and student feeling that lecture course objectives were personally useful (.05 level of confidence), teacher feeling that course objectives were met and student feeling that laboratory course objectives were achieved (.01 level of confidence), teacher classroom preparation time and student feeling that physics was stimulating and difficult (.01 level of confidence), teacher feeling that physics was socially significant and student feeling that physics was stimulating (.01 level of confidence), teacher feeling that physics was socially significant and student feeling that physics was personally useful (.05 level of confidence), teacher feeling that physics was historically significant and student feeling that physics was stimulating and difficult (.01 level of confidence), teacher feeling that physics was historically significant and student feeling that physics was personally useful (.05 level of confidence), teacher inclusion of social aspects of physics in the course and student feeling that physics was difficult (.05 level of confidence), teacher inclusion of political aspects of physics in the course and student feeling that physics was stimulating, difficult, and personally useful (.05 level of confidence), and teacher long-term commitment to physics teaching and student feeling that physics lectures were stimulating (.01 level of confidence). No significant relationships existed between physics work experiences of the teachers (other than teaching) and student feeling that physics was stimulating, difficult, or personally useful.

Significant relationships existed between: sex of high school students and the number of students who enrolled in physics, interest levels of students toward physics and the number of students who enrolled in physics, and the degree of difficulty students associated with physics and the number who enrolled in physics.

Secondary Findings

Significant relationships existed between the occupational preferences of physics students and the occupational preferences of non-physics students with regard to physicist and physics teacher. Significant relationships also existed between: teacher feeling that physics was stimulating and teacher time spent at classroom teaching preparation (.05 level of confidence), teacher feeling that physics was stimulating and teacher time spent at preparation for laboratory teaching (.05 level of confidence), and teacher feeling that physics was personally useful, other than in teaching, and teacher time spent at professional meetings, reading professional journals, etc. (.05 level of confidence).

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter is divided into three main parts. The first part is comprised of a brief summary of the study. The second part examines conclusions obtained from analysis of the data. The third part contains recommendations and suggestions for further studies.

Summary of the Study

In the most scientifically and technologically advanced age of man, American high school students are avoiding the study of physics, the science considered basic to all of the natural sciences.

Four facets of American science education in the public secondary schools appeared pertinent to the phenomenon of low enrollments in high school physics classes. Science study had become an integral part of the curriculum. Secondary school students had relative freedom to choose their own careers and courses of study. Students had an increasing variety of choices of science course offerings. Students elected to study courses in physical science, biology, and chemistry in increasing numbers, but physics class enrollments declined steadily for well over the decade preceding this study.

As a consequence, many science educators and scientists showed concern for possible future shortages of qualified high school physics teachers and of well-trained research scientists. In addition, they warned of possible future deficiencies in the level of the scientific literacy of the general population. It was these concerns which motivated this study: "In what ways were selected characteristics, attitudes, and other qualities of California public secondary school students and physics teachers related to their perceptions of high school physics and of physics as a field of study?"

Design of the Study

This study focused on possible relationships between characteristics of California public high school physics teachers and high school pupil perceptions of physics teachers and of physics as a field of study.

Certain assumptions and limitations were inherent in the study. A fundamental assumption was that relationships between attitudes, feelings, and other selected qualities of teachers or students could be ascertained from analyses of closed-type, scaled-choice, anonymous responses collected by a normative survey.

Questionnaires and sense-mark response sheets were constructed for sampling the non-physics student, the physics student, and the physics teacher populations. Data collected on the response sheets were evaluated by a computer and used by the researcher for interpretation.

Machine-readable responses were submitted by 10,582 physics students, by 2,438 non-physics students, and by 347 physics teachers.

Findings of the Study

The following synthesis of findings was based upon frequency of responses to selected questionnaire items, and are numbered so that they are easily referred to later in the conclusions, recommendations, or interpretations sections:

1. Most high school physics students were males.

2. Most physics students had a higher grade point average and a higher class ranking than did non-physics students.

3. More physics students planned further academic work after high school than did non-physics students.

4. Non-physics students avoided physics mostly because it did not appear interesting, and because it appeared too difficult.

5. Students enrolled in physics mostly because it seemed interesting.

6. Non-physics students ranked social worker and high school teacher as most preferred occupations,

and ranked physicist and physics teacher as sixth and fifteenth, of sixteen possible choices.

7. Students felt their physics laboratory and lecture experiences generally supplemented one another.

8. Physics teachers were predominantly male, were relatively young, had taught physics for a relatively short time, were better prepared academically than the national norm, were undertaking and/or were planning to undertake further academic work in physics, had some physics-related work experiences other than teaching, and earned an average annual salary of approximately $10,000.

9. Few of the teachers had taken a PSSC (or equivalent) high school or college physics course, yet most incorporated some degree of non-traditional approaches to physics teaching in both their laboratory and lecture courses.

10. Most teachers taught in schools having prerequisites for physics enrollment, and which actively discouraged "poor" students from enrolling in physics.

11. Only a few teachers taught physics exclusively; more than half the teachers taught fewer than five hours of physics per week.

12. Teachers felt that their students found physics laboratory work stimulating, interesting, personally useful, supplemental to the lecture course, but difficult to understand conceptually.

13. Teachers felt that their students perceived their physics courses to be high in scientific value, low in political value, and intermediate in both social and historical value.

14. Teachers did not feel that their physics courses lowered the students' grade point averages significantly.

15. Teachers felt that their physics courses prepared students for college physics major courses, for college science major courses, and for general non-science college courses. Further, the teachers felt that their courses prepared students for understanding the role of science in society.

16. Teachers felt that students had confidence in their teachers' knowledge of physics.

17. Teachers felt that they usually met their course objectives.

18. Teachers included more of the historical aspects of physics in their course objectives than they did the social and political aspects of physics.

19. Teachers felt that although their needs for for physics teaching materials were met, their work loads prevented better physics teaching.

20. Teachers perceived that their students were interested in physics, but that neither their

communities nor their non-physics teacher colleagues were much interested in physics.

21. Teachers felt they usually understood their students' school-related, personal, and physics-learning problems.

22. Teachers liked teaching young people, enjoyed teaching physics, felt rapport with their students, and identified with both physicists and physics teachers.

23. Teachers felt a long-term commitment to physics teaching and to additional formal training in physics.

24. In their first year of teaching, the teachers felt prepared academically to teach both the physics-oriented pupil and the average physics pupil, and to attract the able pupil to physics.

25. For themselves, the physics teachers perceived physics to be stimulating; interesting; useful other than in teaching; socially, politically, and historically significant; and difficult to understand conceptually.

26. For themselves, the physics teachers perceived laboratory experiences to be stimulating and to be significant supplements to theory.

27. Teachers indicated they would not leave teaching solely for higher pay, unless the pay increase was fifty per cent or greater.

Thirteen of the fourteen null hypotheses which ordered and directed the study were rejected. In addition, two null hypotheses suggested by the secondary findings yielded significant relationships. Conclusions and interpretations resulting from tests of these null hypotheses are reported under conclusions of the study.

Conclusions of the Study

The conclusions were divided into three sections. The first section was devoted to conclusions drawn from statistical analyses of the null hypotheses which ordered and directed the study. The second section consisted of conclusions resulting from statistical analyses of the five null hypotheses suggested by the secondary data. The third section was made up of interpretations based upon a composite of the findings of the study.

Conclusions Related to the Null Hypotheses

The following conclusions were based upon Chi square and frequency-of-response tests of the fourteen null hypotheses which ordered and directed the study. Interpretations of these conclusions are presented at the end of this section. These items are numbered for easier referral in the interpretations and recommendations sections.

1. There was no significant relationship between physics student attitudes toward physics and the physics-related work experiences of the teachers.

2. Teachers who reported having completed a greater number of semester hours in physics stimulated their students to a greater degree than did their colleagues with fewer semester hours in physics (.05 level of confidence).

3. Teachers who spent comparatively more time in classroom teaching preparation stimulated students more than did their colleagues who spent less time (.01 level of confidence).

4. Students of teachers who spent more time in preparation for classroom teaching felt that physics, as a field of study, was less difficult (.01 level of confidence).

5. Physics teachers who identified least with other physics teachers had students who felt that physics as a field of study was less useful personally (.01 level of confidence) and was more difficult (.05 level of confidence).

6. Teachers who felt less strongly that physics was <u>socially</u> significant stimulated their students less about physics as a field of study than did their colleagues (.01 level of confidence). Paradoxically, these same teachers had students who felt that physics as a field of study was more personally useful than did the students of their colleagues who attached

greater significance to the social aspects of physics (.05 level of confidence).

7. Teachers who felt less strongly that physics was <u>historically</u> significant stimulated their students less about physics as a field of study (.01 level of confidence). However, these same teachers had students who felt physics was less difficult (.01 level of confidence) and who felt physics was more useful personally (.05 level of confidence).

8. Teachers who included more of the <u>social</u> aspects of physics in their course objectives had students who felt that physics was less difficult (.05 level of confidence).

9. Teachers who included more of the <u>political</u> aspects of physics in their course objectives had students who felt that physics as a field of study was more stimulating (.01 level of confidence), more difficult (.01 level of confidence), and, oddly enough, more useful personally (.01 level of confidence).

10. Physics teachers who felt less strongly that physics was stimulating had students who felt physics was less stimulating (.05 level of confidence), and was less useful personally (.05 level of confidence).

11. Teachers who felt less strongly that physics was useful personally (other than in teaching) had students who felt that physics was less stimulating (.01 level of confidence), more difficult (.01 level of confidence), and less useful personally (.01 level of confidence).

12. Teachers who felt a greater long-term commitment to physics teaching had students who felt that their physics lectures were more stimulating (.01 level of confidence).

13. Teachers who felt, to a greater extent than did their colleagues, that physics was difficult to understand conceptually had students who felt that physics was less stimulating (.01 level of confidence), more difficult (.01 level of confidence), and less useful personally (.01 level of confidence).

14. Teachers who felt, to a greater degree than did their colleagues, that they met their course objectives had students who felt that physics lecture objectives were more useful personally (.05 level of confidence), and had students who felt more strongly that they had achieved their laboratory objectives (.01 level of confidence).

15. Teachers who felt more strongly that physics was stimulating had a greater classroom teaching load (.05 level of confidence) and had a greater laboratory teaching load (.05 level of confidence).

16. A significant relationship existed between the sex of the students and enrollments in high school physics (greater than .001 level of confidence). Girls virtually excluded themselves from physics courses.

17. A significant relationship existed between student interest in physics and enrollments in high school physics courses (greater than .001 level of confidence).

18. A significant relationship existed between the perceived difficulty of physics and enrollments in high school physics courses (greater than .001 level of confidence). The more difficult physics seemed, the lower the enrollment probability.

Conclusions Related to the Secondary Findings

The following conclusions were based upon frequency-of-response and Pearson product-moment tests of the two null hypotheses suggested by the secondary findings:

1-s. A significant relationship existed between the occupational preferences of physics students and those of non-physics students, particularly insofar as physicist and physics teacher were concerned. Of sixteen possible occupational choices, physics students ranked physicist and physics teacher sixth and fifteenth, respectively; whereas, the non-physics students ranked physicist and physics teacher fifteenth and sixteenth, respectively.

2-s. A significant relationship existed between the teaching-related activities of physics teachers and the attitudes they held toward physics. Physics teachers who felt more strongly that physics as a field of study was stimulating, spent more time preparing for classroom teaching (.05 level of confidence), and spent more time preparing for laboratory teaching (.05 level of confidence). Also, teachers who felt more strongly that physics was useful personally (other than in teaching) spent more time attending professional meetings and reading professional journals than did their colleagues (.05 level of confidence).

Generalized Interpretations of the Findings

These seven interpretations were inferred from the over-all findings of the study. Some unexpected findings appeared inconsistent and resisted clear-cut interpretation. The following statements reflect the more conclusive inferences synthesized from the findings:

Teacher time spent in classroom preparation was significantly reflected in student attitudes toward physics.

Teacher identification with other physics teachers had a significant effect upon student attitudes toward physics.

Inclusion of the social, political, and historical aspects of physics in the physics course objectives had a measurable effect on student attitudes toward physics.

Students exhibited a perception of success when the teacher felt he had successfully met his course objectives.

Teachers who felt a long-term commitment to physics teaching had a positive effect on student impressions of physics as a field of study.

Recommendations of the Study

The first part of this section includes recommendations for high schools, for physics teachers, and for physics teaching. The second part consists of suggestions for further research.

Recommendations for High Schools

Conclusions drawn from the data of this study have many implications for high school physics courses, physics teachers, and physics teaching.

Implications for Physics Courses. High school physics courses appeared highly selective and restrictive in terms of stronger appeal to males with a stronger appeal to students with higher academic records and stronger appeal to students who planned on academic work after graduation. These courses were also selective in that they were perceived by non-physics students to be lacking in interest and to be too difficult. In addition, most physics courses had prerequisites which included school grade and/or specific course requirements. Also, they lacked general appeal to that large segment of the student population whose vocational preferences were people-oriented, such as social worker and teacher.

Although the respondents were from schools of different sizes, diverse socio-economic strata, and varied environmental and geographical backgrounds, they characteristically perceived the following to be primary influences on whether or not they enrolled in physics: interest in physics, difficulty of physics, and anticipated need for physics (future professional, vocational, or educational goals).

In light of the preceding paragraphs, the following recommendations for physics courses seemed appropriate:

1. Larger high schools should offer a greater variety of physics courses designed to appeal to a broader spectrum of student interests, student intellectual abilities, and backgrounds.

2. Smaller high schools offering only a single course in physics should consider a course designed to meet a broad spectrum of student interests, backgrounds, and abilities. For this purpose, an abridged version of the Harvard Project Physics course would appear to be the most suited.

3. Whether the physics course be taught in large or small high schools, special emphasis should be placed upon the inclusion of course objectives with stronger

appeal to girls, to students of average academic ability, to students not planning further academic work after graduation, and to students who tend to be people-oriented. Implied in this recommendation is greater inclusion of the social, historical, and political aspects of physics, and the elimination of course prerequisites which might deter the average, non-college bound student from enrolling.

4. Periodic feedback of student perceptions should be used as one basis for continuous development and modification of the physics curriculum.

5. Schools should consider the possibilities of integrated science courses, such as those piloted by the Federation for the Unification of Science Education and by the Educational Research Council of America, as another means of introducing more students to the concepts of physics.

Implications for Physics Teachers. The study revealed that most high school physics teachers were men, that nearly all had primary teaching assignments other than physics, that most felt their work loads prevented better teaching, that most perceived little community or non-physics teacher interest in physics, and that one-third had fewer semester hours in physics than the minimum number of eighteen semester hours recommended by the Commission on College Physics.

In view of these findings, the following recommendations for high school physics teachers seemed appropriate:

1. Physics teachers should make concerted efforts to "sell" physics to students and to high school counselors. Concurrently, they should strive to stimulate both community and non-physics teacher interest in physics. Programs such as the Moline Plan have indicated directions such efforts can take. In any case, programs to motivate interest in physics should aim to apprise students, teachers, and community of the nature of physics and of its basic relevance to mankind and to all of the natural sciences.

2. A joint teacher-counselor effort should be made to encourage more girls to enroll in physics courses.

3. Teachers should strive to meet the minimum academic requirements set forth by the Commission on College Physics, and should urge that teachers not meeting such requirements not be assigned to teach physics.

4. Physics teachers should consider utilization of paraprofessionals in the laboratory and as classroom teaching assistants.

5. Physics teachers should be aware that their attitudes toward physics can affect student attitudes

toward physics; i.e., teacher attitudes and enthusiasm appear to be infectious.

6. Physics teachers should be aware that a long-term commitment to physics teaching affects positive student attitudes toward physics and that time spent in classroom preparation affects positive student attitudes toward physics; i.e., dedication and industry seem to "pay off" in terms of student attitudes.

7. Physics teachers should be aware that when the teacher feels he successfully meets his course objectives, his students reflect a like identification of course success; i.e., the teacher who carefully defines his objectives is most likely to impart an attitude of successful accomplishment to his students.

Implications for Physics Teaching. Certain qualities of physics teachers and of physics teaching ranked high in terms of student perceptions, motivating the following suggestions:

1. Because teacher identification with other physics teachers correlated with positive student attitudes toward physics, teachers should be active in such professional societies as the American Association of Physics Teachers and the National Science Teachers Association.

2. Because inclusion of social, political, and historical aspects of physics in course objectives was related significantly to student attitudes toward physics, physics teachers ought to be concerned with teaching more than just the purely "scientific" aspects of physics.

3. Because less able students feared the difficulty of physics, and because this study recommends the utilization of physics courses which both attract and appeal to the less able student, teachers should keep in mind that these courses need not be without intellectual challenge. This study indicated that the joy (stimulation) and the grind (difficulty) of physics were not necessarily mutually exclusive.

4. Because when the teacher feels he meets his course objectives, his students reflect a like kind of attitude toward accomplishment, more physics course objectives should be stated in behavioral terms. This implies that students need to be informed in advance what the behavioral objectives are, those conditions under which they must demonstrate having met those objectives, and the levels of performance requisite for a given mark. Such objectives should not constitute the only goals of the physics course; rather, behavioral objectives should serve as a matrix from which student

understanding and appreciation of the nature of physics are generated.

Suggestions for Further Research

This study indicated that enrollments in high school physics were related to student perceptions of physics, especially as these pertained to anticipated need for physics, interest in physics, difficulty of physics, selectivity of males, and lack of relevance to people-oriented students.

This study further indicated that student perceptions of physics were related to certain qualities of physics teachers. These qualities included extent of teacher subject matter preparation, teacher identification with other physics teachers and with physicists, inclusion of historical and social and political aspects of physics in course objectives, and certain teacher attitudes toward physics.

Thus, it seemed appropriate to recommend further research in the following areas:

1. High school physics course content and methodology should be studied, particularly in terms of raising the interest level of the course, better meeting the needs and abilities of a greater diversity of students, and appealing more to the special interests and needs of female students.

2. More attention should be directed to writing and testing behavioral objectives for high school physics courses, so as to transmit more efficiently the skills and concepts of physics and, at the same time, to develop positive student attitudes toward physics as suggested by Mager.[105,106]

3. Examination should be made of the perceptions of physics held by teachers and students in junior colleges, colleges, and universities to determine whether significant correlates exist between such perceptions and those of this study. Further research is particularly suggested by the unexpected, somewhat puzzling results referred to below:

(1) Finding number 25 (p. 136), wherein physics teachers perceived physics as stimulating; interesting; useful other than in teaching; and as socially, politically, and historically significant; but, difficult to understand conceptually.

(2) Conclusion number 6 (p. 138), wherein physics teachers who did not feel strongly that physics was socially significant

---

105. Robert F. Mager, Preparing Instructional Objectives (Belmont, California: Fearon Publishers/Lear Siegler, Inc., 1962).

106. Robert F. Mager, Developing Attitude toward Learning (Belmont, California: Fearon Publishers/Lear Siegler, Inc., 1968).

stimulated their students less about physics, yet, had students who felt physics was more useful personally.

(3) Conclusion number 7 (p. 139), wherein physics teachers who did not feel strongly that physics was historically significant stimulated their students less about physics, yet, had students who felt physics was more useful personally.

(4) Conclusion number 9 (p. 139), wherein physics teachers who did not feel strongly that physics was politically significant had students who felt physics was more useful personally.

APPENDIX A

DESCRIPTION OF AMERICAN INSTITUTE OF PHYSICS, INC.

The American Institute of Physics, Inc., was founded in 1931 as a non-profit, privately financed federation of leading societies in the field of physics. Today its member societies include The American Physical Society, American Association of Physics Teachers, Optical Society of America, Acoustical Society of America, Society of Rheology, American Crystallographic Association, and The American Astronomical Society. Some of its affiliated societies are: The American Association of Physicists in Medicine, American Institute of Aeronautics and Astronautics, American Society for Metals, American Vacuum Society, Electron Microscopy Society of America, The Geological Society of America, Instrument Society of America, and The Society for Applied Spectroscopy.

The stated purpose of The American Institute of Physics is the advancement and diffusion of the knowledge of physics and its application to human welfare.

The institute publishes scientific journals, furnishes the national media with information related to physics, carries on a comprehensive program to strengthen physics education, encourages and assists in the documentation and study of the history and philosophy of physics, and fosters relations between physics and other sciences, the arts, and industry.

Physicists represented by the institute number almost 40,000. Approximately 5,500 students at nearly three hundred colleges and universities are affiliated with student sections of the institute. Industry is represented by some 155 corporations, institutions, and laboratories maintaining corporate associate memberships.

APPENDIX B

GENERAL GEOGRAPHIC DISTRIBUTION OF RESPONDENTS

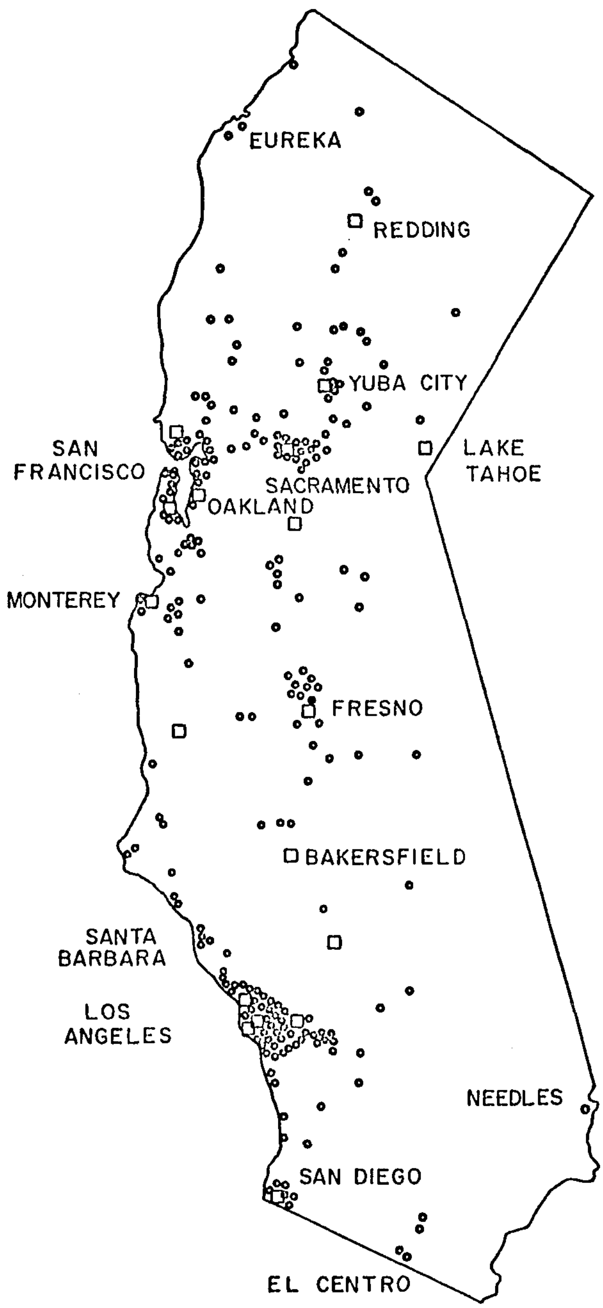

Fig. B.1. Distribution of Respondents.

• Physics student sample
□ Non-physics student sample

APPENDIX C

HIGH SCHOOL PHYSICS STUDY

Student Questionnaire

I

Please mark your answers clearly in the appropriate box on the answer sheet, preferably with a #2 or #3 pencil. Please DO NOT FOLD the answer sheet; this is a confidential study and a machine will read your answers.

1. Sex: (a) Male (b) Female

2. High school grade average: (a) A (b) B (c) C (d) D

3. Plans immediately after graduation:
   (a) College (univ.) (b) Jr college (c) Trade (business) school (d) Military
   (e) Job (f) Don't know (g) Other

4. Your senior class rank: (a) Lower 1/3 (b) Middle 1/3 (c) Upper 1/3

If you have NOT ENROLLED in a high school physics course, indicate your reasons for NOT ENROLLING by MARKING, on the answer sheet, one or more of the items below:

5. (a) Advice of parent
6. (a) Advice of friend
7. (a) Advice of counselor
8. (a) Advice of teacher
9. (a) Might lower my grade
10. (a) Disinterested
11. (a) Too difficult
12. (a) Not enjoyable
13. (a) Not useful
14. (a) No time in my schedule
15. (a) Dislike the teacher
16. (a) Too much math needed
17. (a) Not ambitious enough
18. (a) Afraid of failing
19. (a) School standards for taking physics not met

Assume you have both the finances and the ability to become successful at any of the following sixteen occupations! Select the FIVE you would like most and rank these FIVE. For example: If artist were your first choice (the occupation you prefer most of the FIVE selected), mark (a) in column 1, after Number 24. Artist. If musician were your fourth choice, mark (d) in column 4, after Number 22. Musician. Continue, marking ONLY ONE letter box for each, until you have a single mark after each of five.

	Columns 1	2	3	4	5
20. Sales manager	(a)	(b)	(c)	(d)	(e)
21. College professor	(a)	(b)	(c)	(d)	(e)
22. Musician	(a)	(b)	(c)	(d)	(e)
23. Social worker	(a)	(b)	(c)	(d)	(e)
24. Artist	(a)	(b)	(c)	(d)	(e)
25. Explorer	(a)	(b)	(c)	(d)	(e)
26. Ship's commander	(a)	(b)	(c)	(d)	(e)
27. Physics teacher	(a)	(b)	(c)	(d)	(e)
28. Physicist	(a)	(b)	(c)	(d)	(e)
29. Professional athlete	(a)	(b)	(c)	(d)	(e)
30. Salesman	(a)	(b)	(c)	(d)	(e)
31. CPA (Cert. Publ. Acct.)	(a)	(b)	(c)	(d)	(e)
32. Business executive	(a)	(b)	(c)	(d)	(e)
33. High school teacher	(a)	(b)	(c)	(d)	(e)
34. Architect	(a)	(b)	(c)	(d)	(e)
35. Engineer	(a)	(b)	(c)	(d)	(e)

IF YOU ARE NOT ENROLLED IN A HIGH SCHOOL PHYSICS COURSE, STOP HERE!
(Please turn in your questionnaire. Thank you!)

II

Reasons you enrolled in physics. You may MARK more than one:

36. (a) Advice of parent
37. (a) Advice of teacher
38. (a) Advice of counselor
39. (a) Advice of friend
40. (a) Just interested
41. (a) Like the teacher
42. (a) Useful in college (anticipated need)
43. (a) To be with friend(s)
44. (a) Required by high school
45. (a) REQUIRED for college entrance

Boxes in the columns on the right are numbered 1 through 5. Boxes 2, 3, and 4 permit you to scale your feelings, should they fall somewhere between the two extremes: 1 (Not at all), and, 5 (Very much). Mark the letter (a) thru (e), corresponding to the Column Number 1 thru 5, which most nearly expresses the degree of your feelings about questions 46 thru 68. For example: Suppose you feel that physics is very important if you were an astronaut. Then you would carefully darken (e) in Column 5, across from number 65 on the Answer Sheet.

	1 Not at all	2	3 Range	4	5 Very much
To what extent do you feel that Physics, as a FIELD OF STUDY is:					
46. stimulating?	(a)	(b)	(c)	(d)	(e)
47. difficult?	(a)	(b)	(c)	(d)	(e)
48. personally useful?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that your physics course LECTURES are:					
49. stimulating?	(a)	(b)	(c)	(d)	(e)
50. difficult to understand?	(a)	(b)	(c)	(d)	(e)
51. personally useful?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that your physics LABORATORY experiences are:					
52. stimulating?	(a)	(b)	(c)	(d)	(e)
53. difficult to understand?	(a)	(b)	(c)	(d)	(e)
54. personally useful?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that your physics TEACHER:					
55. enjoys teaching physics?	(a)	(b)	(c)	(d)	(e)
56. makes difficult ideas seem easier?	(a)	(b)	(c)	(d)	(e)
57. gives you confidence in his knowledge of physics?	(a)	(b)	(c)	(d)	(e)
58. fits your image of a physics teacher?	(a)	(b)	(c)	(d)	(e)
59. fits your image of a professional physicist?	(a)	(b)	(c)	(d)	(e)
60. is interested in you as a student?	(a)	(b)	(c)	(d)	(e)
61. is interested in you as a person?	(a)	(b)	(c)	(d)	(e)
62. understands your school-related problems?	(a)	(b)	(c)	(d)	(e)
63. understands your personal problems?	(a)	(b)	(c)	(d)	(e)
64. is fair?	(a)	(b)	(c)	(d)	(e)
65. To what extent do you feel that physics is important to your future professional and vocational goals?	(a)	(b)	(c)	(d)	(e)
66. To what extent do you feel that your physics course LECTURE OBJECTIVES* are personally useful?	(a)	(b)	(c)	(d)	(e)
67. To what extent do you feel that your physics LABORATORY OBJECTIVES* are achieved?	(a)	(b)	(c)	(d)	(e)
68. To what extent do you feel that your physics labs and lectures supplement one another?	(a)	(b)	(c)	(d)	(e)

*OBJECTIVES are defined as those educational goals set for the student in the class and in the laboratory.

Teacher Questionnaire

Please mark your answers clearly in the appropriate box on the answer sheet, preferably using a #2 or #3 pencil. Please DO NOT FOLD the answer sheet; this is a confidential study and a machine will read your responses accurately if the sheet has not been folded.

1. Sex: (a) Male (b) Female

2. Age: (a) Under 25 (b) 25-34 (c) 35-44 (d) 45-55 (e) Over 55

In items 3 thru 9, mark each degree you have earned, and indicate the type of institution granting each degree.

Example: For a BS degree from a liberal arts college, mark b across from #3 on the answer sheet.

	Unaffiliated teacher's college	Liberal arts college	College (school) of Education in a university or state college	Other college (school) in a university or state college
3. Bachelor's	(a)	(b)	(c)	(d)
4. Master's (Education)	(a)	(b)	(c)	(d)
5. Master's (Physics)	(a)	(b)	(c)	(d)
6. Other Master's	(a)	(b)	(c)	(d)
7. Ed.D.	(a)	(b)	(c)	(d)
8. Ph.D. (Physics)	(a)	(b)	(c)	(d)
9. Other Ph.D.	(a)	(b)	(c)	(d)

	1-3	4-6	7-12	13-19	over 19
10. How many years since you completed your last physics course for credit?	(a)	(b)	(c)	(d)	(e)
11. Years of physics-related work experiences (omit teaching)	(a)	(b)	(c)	(d)	(e)

Years teaching experience, including the current academic year:

12. Total years of teaching	(a)	(b)	(c)	(d)	(e)
13. Physics	(a)	(b)	(c)	(d)	(e)
14. Mathematics	(a)	(b)	(c)	(d)	(e)
15. Any physical science	(a)	(b)	(c)	(d)	(e)

Physics course you completed in:

16.	High school	(a) PSSC or equivalent	(b) Traditional	(c) None
17.	College	(a) PSSC or equivalent	(b) Traditional	(c) None

Orientation of the physics course you teach:

18.	Lecture	(a) PSSC or equivalent	(b) Traditional	(c) Combination
19.	Laboratory	(a) PSSC or equivalent	(b) Traditional	(c) Combination

20. What prerequisites must a student fulfill to enroll in physics courses in your school?

(a) None (b) Grade point average
(c) Teacher approval (d) Counselor approval
(e) Course requirements or class (soph., jr., sr.)

21. Are "poor" students at your school discouraged from taking physics? (a) Yes (b) No

Supported academic work [Example: if you had two NSF-SI's, mark #24 (b)]:

	Frequency 1	2	3	4	5
22. NSF Academic Year Institute	(a)	(b)	(c)	(d)	(e)
23. NSF In-Service Institute	(a)	(b)	(c)	(d)	(e)
24. NSF or AEC Summer Institute	(a)	(b)	(c)	(d)	(e)
25. NSF or AEC Summer Participation	(a)	(b)	(c)	(d)	(e)
26. Other Academic Year Institute	(a)	(b)	(c)	(d)	(e)
27. Other Summer Participation	(a)	(b)	(c)	(d)	(e)
28. NSF or AEC Summer Conference	(a)	(b)	(c)	(d)	(e)
29. Other Summer Conference	(a)	(b)	(c)	(d)	(e)
30. Government Fellowship	(a)	(b)	(c)	(d)	(e)
31. Other Fellowship	(a)	(b)	(c)	(d)	(e)

Boxes numbered 2, 3, and 4 permit you to scale your feelings, should they fall somewhere between the two extremes: 1 (Not at all, and, 5 (Very much). Mark the appropriate box on the answer sheet:

Not at all ←—— Range ——→ Very much

	1	2	3	4	5
To what extent do you feel the following contribute to low physics marks in high school:					
32. Physics is hard.	(a)	(b)	(c)	(d)	(e)
33. Physics requires mathematics.	(a)	(b)	(c)	(d)	(e)
34. Students lack ambition.	(a)	(b)	(c)	(d)	(e)
35. Students fear physics.	(a)	(b)	(c)	(d)	(e)
Physics courses do NOT relate to student:					
36. experiences.	(a)	(b)	(c)	(d)	(e)
37. immediate needs.	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that students find your physics LECTURES:					
38. stimulating?	(a)	(b)	(c)	(d)	(e)
39. interesting?	(a)	(b)	(c)	(d)	(e)
40. personally useful?	(a)	(b)	(c)	(d)	(e)
41. difficult to understand conceptually?	(a)	(b)	(c)	(d)	(e)

Check the appropriate box on the <u>answer sheet</u>:

	Not at all		Range		Very much
To what extent do you feel that students find your physics LABORATORY experiences:					
42. Are stimulating?	(a)	(b)	(c)	(d)	(e)
43. Are interesting?	(a)	(b)	(c)	(d)	(e)
44. Are personally useful?	(a)	(b)	(c)	(d)	(e)
45. Are difficult to understand conceptually?	(a)	(b)	(c)	(d)	(e)
46. Supplement and clarify your lectures?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that students find your physics course has:					
47. Social value?	(a)	(b)	(c)	(d)	(e)
48. Political value?	(a)	(b)	(c)	(d)	(e)
49. Historical value?	(a)	(b)	(c)	(d)	(e)
50. Scientific value?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel your physics course:					
51. <u>Lowers</u> your students' grade point average?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel the physics course you teach prepares your students for:					
52. Physics major courses?	(a)	(b)	(c)	(d)	(e)
53. Science major courses?	(a)	(b)	(c)	(d)	(e)
54. General college courses (non-science)?	(a)	(b)	(c)	(d)	(e)
55. Understanding science's role in society?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that your students:					
56. Have confidence in your knowledge of physics?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel you:					
57. Meet your course objectives?	(a)	(b)	(c)	(d)	(e)
Include in your course objectives the:					
58. social aspects of physics?	(a)	(b)	(c)	(d)	(e)
59. political aspects of physics?	(a)	(b)	(c)	(d)	(e)
60. historical aspects of physics?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel:					
61. Encouraged to better physics teaching by your administrators?	(a)	(b)	(c)	(d)	(e)
62. Your work load prevents better physics teaching?	(a)	(b)	(c)	(d)	(e)
63. Your needs for physics teaching materials are met?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel there exists:					
64. Pupil interest in physics?	(a)	(b)	(c)	(d)	(e)
65. Community interest in physics?	(a)	(b)	(c)	(d)	(e)
66. Non-physics teacher interest in physics?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel you understand your students:					
67. School-related problems?	(a)	(b)	(c)	(d)	(e)
68. Personal problems?	(a)	(b)	(c)	(d)	(e)
69. Problems in learning physics?	(a)	(b)	(c)	(d)	(e)

Check the appropriate box on the answer sheet:

	Not at all		Range		Very much
To what extent do you feel that, for YOURSELF, physics is:					
70. Stimulating?	(a)	(b)	(c)	(d)	(e)
71. Interesting?	(a)	(b)	(c)	(d)	(e)
72. Personally useful (other than teaching)?	(a)	(b)	(c)	(d)	(e)
73. Difficult to understand conceptually?	(a)	(b)	(c)	(d)	(e)
74. Socially significant?	(a)	(b)	(c)	(d)	(e)
75. Politically significant?	(a)	(b)	(c)	(d)	(e)
76. Historically significant?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that, for YOURSELF, physics LABORATORY experiences are:					
77. Stimulating?	(a)	(b)	(c)	(d)	(e)
78. Difficult to understand?	(a)	(b)	(c)	(d)	(e)
79. Significant supplements to theory?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that you:					
80. Like teaching young people?	(a)	(b)	(c)	(d)	(e)
81. Enjoy teaching physics students?	(a)	(b)	(c)	(d)	(e)
82. Have rapport with your physics students?	(a)	(b)	(c)	(d)	(e)
83. Identify with physicists?	(a)	(b)	(c)	(d)	(e)
84. Identify with physics teachers?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that, your FIRST YEAR of physics teaching, you were prepared academically to:					
85. Teach the physics-oriented pupil?	(a)	(b)	(c)	(d)	(e)
86. Teach the average physics pupil?	(a)	(b)	(c)	(d)	(e)
87. Attract the potentially able pupil toward physics?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that you are NOW prepared academically to:					
88. Teach the physics-oriented pupil?	(a)	(b)	(c)	(d)	(e)
89. Teach the average physics pupil?	(a)	(b)	(c)	(d)	(e)
90. Attract the potentially able pupil toward physics?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel a long-term commitment to:					
91. Teaching?	(a)	(b)	(c)	(d)	(e)
92. Physics teaching?	(a)	(b)	(c)	(d)	(e)
93. Additional formal training in physics?	(a)	(b)	(c)	(d)	(e)
To what extent do you feel that you would leave teaching for a monthly:					
94. 10% salary increase?	(a)	(b)	(c)	(d)	(e)
95. 25% salary increase?	(a)	(b)	(c)	(d)	(e)
96. 50% salary increase?	(a)	(b)	(c)	(d)	(e)
97. 75% salary increase?	(a)	(b)	(c)	(d)	(e)

98. Which grade arrangement best describes the school in which you teach

Combined elementary, junior high, and high school	Combined junior high and high school	High school only
(a)	(b)	(c)

99. Semester hours earned in physics:

Undergraduate Hours					Graduate Hours				
0-8	9-16	17-24	25-32	Over 32	0-8	9-16	17-24	25-32	Over 32
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

100. Your academic year salary:

4000-4999	5000-5999	6000-6999	7000-7999	8000-8999	9000-9999	10,000-10,999	11,000-11,999	12,000-12,999	Over 13,000
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

Estimated hours of 24-hr. day, 7-day week, you spend on:	0-1	$1\frac{1}{2}$-2	$2\frac{1}{2}$-3	$3\frac{1}{2}$-4	$4\frac{1}{2}$-5	$5\frac{1}{2}$-6	$6\frac{1}{2}$-7	$7\frac{1}{2}$-8	$8\frac{1}{2}$-9	$9\frac{1}{2}$+
101. Classroom teaching	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
102. Laboratory teaching	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
103. Preparation for classroom teaching	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
104. Preparation for laboratory teaching	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
105. Related (lunch duty clubs, records, etc.)	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
106. Professional meetings, journals, etc.	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Advanced study (courses for credit)										
107. physics	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
108. mathematics	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
109. education	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
110. physical sciences (astronomy, earth science, chemistry, etc.)	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

Your teaching schedule:

Subject	Class Hrs/Wk 3–3½	4–4½	5–5½	6–6+	Number of Students 1–20	21–40	41–80	81–125	126–200	201+
111. Physics	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
112. Mathematics	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
113. Physical sciences	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
114. Other	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

Estimated student enrollment:

	1–25	26–100	101–250	251–400	401–700	701–1000	1001–1500	1501–2000	2001–2500	Over 2500
115. Entire school	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
116. High school	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

	1–25	26–100	101–150	151–250	251–350	351–450	451–550	551–750	751–1000	Over 1000
117. Senior class	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

	1–15	16–50	51–100	101–150	151–200	201–250	251–300	301–350	351–400	Over 400
118. Taking physics	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)

	1	2	3	4	Over 4
119. Number of professional physical science societies you now hold active memberships in (AAPT, AAAS, APS, NSTA, etc.).	(a)	(b)	(c)	(d)	(e)
120. Number of professional physical science publications you read regularly, in addition to those accompanying memberships in the societies listed above.	(a)	(b)	(c)	(d)	(e)

If you wish to make a general comment, or if you wish to elaborate on any answer you have given, please do so on a separate sheet of paper. Please DO NOT WRITE ON THE ANSWER SHEET; all answer sheets are secret and are read by machine!

LIST OF REFERENCES

Abelson, Philip H. "Troubled Times for Academic Science," an editorial, Science, CLXVIII (May, 1970), p. 525.

American Institute of Physics. Physics Manpower, 1966. New York: The American Institute of Physics, 1966.

American Institute of Physics. Physics Manpower, 1969. New York: The American Institute of Physics, 1969.

Bailey, Weynard. Bureau of Reference Services, Department of Education for the State of California; a personal letter to the researcher, dated September 3, 1969.

Bailey, Weynard. Bureau of Reference Services, Department of Education for the State of California; a personal letter to the researcher, dated September 15, 1969.

Boercker, Fred. "Education and Manpower in Physics," Physics Today, XVII (September, 1964), pp. 42-50.

Branscomb, Lewis M. "Physics and the Nation in a Crystal Ball," Physics Today, XXI (August, 1968), pp. 23-28.

Brauer, Oscar L. "Attempts to Improve High School Physics Education," Science Education, XXXXVII (October, 1963), pp. 372-376.

Canadian Association of Physicists. A Report of the Activities of the CAP Study Group on Student Attitudes toward Science and Technology. Ottawa, Ontario, Canada: Canadian Association of Physicists, 1971.

Commission on College Physics, "The Most Pressing Problem in Physics?" The Physics Teacher, IV (January, 1966), pp. 33-34.

Commission on College Physics. Preparing High School Physics Teachers: Report of the Panel on the Preparation of Physics Teachers of the Commission on College Physics. University of Maryland: Department of Physics and Astronomy, 1968.

Conant, James B. The American High School Today. New York: McGraw-Hill, 1959.

Cowan, Donald A. "Physics and the Future of Teaching," The Physics Teacher, VI (March, 1968), pp. 115-117.

Daniel, Donald and Wood-Kyrala, Judith. "Women in Physics," letters to the editor, Physics Today, XXIV (July, 1971), pp. 9-10.

Davis, Harold L. "Drugs versus Science," an editorial, Physics Today, XXIV (March, 1971), p. 88.

Davis, Harold L. "No More Brains to Train?" an editorial, Physics Today, XXIV (April, 1971), p. 84.

Davis, Harold L. "Physics Forty Years from Now," an editorial, Physics Today, XXIV (June, 1971), p. 80.

Davis, Harold L. "Teaching Physics in the Corridors," an editorial, Physics Today, XXIV (August, 1971), p. 88.

DeYoung, Chris A. and Wynn, Richard. American Education, Fifth Edition. New York: McGraw-Hill Book Company, 1964, in Claude Gatewood's "The Science Curriculum Viewed Nationally," The Science Teacher, XXXV, No. 8 (November, 1968).

Downie, N. M. and Heath, R. W. Basic Statistical Methods. New York: Harper and Row, Publishers, 1965.

Drozin, V. G. "What Should be Done to Increase the Enrollment in Physics," The Physics Teacher, IV (January, 1966), pp. 23-27.

Dunlap, J. Lawrence. "Predicting Performance in High School Physics," The Physics Teacher, IV (October, 1966), pp. 303-313.

Efron, Alexander. "Physics--Phooey?" The Physics Teacher. VII (April, 1969), pp. 191-192.

Ellis, R. Hobard, Jr. "Is Physics Too Tough?" An editorial, Physics Today, XIX (April, 1966), pp. 152-235.

Ellis, Susanne D. "Enrollment Trends," Physics Today, XX, No. 3 (March, 1967),pp. 75-79.

Feynman, Richard P. "The Relation of Physics to other Sciences," The Physics Teacher, II (March, 1964). III.

Francis, Gladys M. and Hill, Casper W. "A Unified Program in Science for Grades Nine through Twelve," The Science Teacher, XXXIII, No. 1 (January, 1966), pp. 34-36.

Frank, Nathaniel H. "Physics and Vocational Education," The Physics Teacher, VI (November, 1968), pp. 409-412.

Gatewood, Claude W. "The Science Curriculum Viewed Nationally," The Science Teacher, XXXV, No. 8 (November, 1968), pp. 18-21.

Gatewood, Claude W. and Obourn, Ellsworth S. "Improving Science Education in the United States," Journal of Research in Science Teaching, I (1963), pp. 355-399.

Glass, Bentley. "The Scientist and the Science Teacher," The Physics Teacher, III (March, 1965), pp. 123-124.

Goar, F. Darrell. "All-girl Physics Course Makes Converts in Illinois," Physics Today, XXII (April, 1969), p. 80.

Gould, Mauri. "Double or Triple your High School Physics Enrollment," The Physics Teacher, IV (November, 1966), pp. 371-372.

Handler, Philip. "Science and Scientists: Obligations and Opportunities," an address at the University of Houston, October 21, 1970, in Science, CLXX (November, 1970), p. 837.

Herr, Lowell G. "Unified Science: A Solution to Physics Enrollment," The Physics Teacher, IX (May, 1971), pp. 248-252.

Holton, Gerald. "Harvard Project Physics," Physics Today, XX (March, 1967), pp. 31-34.

Holton, Gerald. "Issues for the Seventies," an editorial, The Physics Teacher, VIII (May, 1970), pp. 229-232.

Holton, Gerald. "The Relevance of Physics," Physics Today, XXIII (November, 1970), pp. 40-47.

Hutchisson, Elmer. "Physics in our High Schools--A National Problem," The Physics Teacher, II (November, 1964), pp. 385-386.

Kallemeyn, LeRoy W. "An Analysis of Subject Matter Content of High School Physics Courses in Selected Schools of Nebraska." A dissertation, University of Nebraska Teacher's College, 1968.

Keeney, Barnaby C. "The Bridge of Values," Science, CLXIX (July, 1970), pp. 26-28.

Kerlinger, Fred N. Foundations of Behavioral Research, Educational and Psychological Inquiry. New York: Holt, Rinehart, and Winston, Inc., 1965.

King, Allen L. A contributor to Victor J. Young's "Survey on Enrollment in Physics," The Physics Teacher, III (March, 1965), pp. 117-122.

Kock, H. William. "An Age of Change," Physics Today, XXIII (January, 1970), p. 31.

Lubkin, Gloria B. "Women in Physics," Physics Today, XXIV (April, 1971), pp. 23-27.

MacCurdy, Robert D. "Engineer or Scientist?" Journal of Counseling Psychology, VIII (Spring, 1961), pp. 79-81.

McClary, George O. "A New Force--Physics Teacher and Counselor," The Physics Teacher, IV (October, 1966), pp. 300-313.

Mager, Robert F. Preparing Instructional Objectives. Belmont, California: Fearon Publishers/Lear Siegler, Inc., 1962.

Mager, Robert F. Developing Attitude toward Learning. Belmont, California: Fearon Publishers/Lear Siegler, Inc., 1968.

"Manpower Studies Show Physics Leveling Off in State and Society," Physics Today, XXII (September, 1969), p. 72.

Mehl, Bernard. "The Conant Report and the Committee of Ten: A Historical Appraisal," Educational Research Bulletin, XXXIX (February, 1960), pp. 29-38.

Paldy, Lester G. "Physics Teachers and the Schools," an editorial, The Physics Teacher, V (October, 1967), p. 333.

Parker, Vincent E. "The Decline in Physics Majors--What Can We do about It?" An unpublished reprint of address to the Southern California Section, American Association of Physics Teachers, December 7, 1968.

Pella, Milton O. "Science Needed by All," The Science Teacher, XXXII (September, 1965), pp. 51-52.

Petersen, Orval L. "A Brief Look at the History of Science Education in America: Its Past, Present, and Future," Science Education, XXXXIII (December, 1959), pp. 427-435.

Phillips, Melba. "The Continuing Education of Physics Teachers," The Physics Teacher, VII (February, 1969), pp. 88-92.

Pollard, Ernest C. "Physics for the Nonscientist," The Physics Teacher, VIII (January, 1970), pp. 11-15.

"Public School Statistics, 1967-8 and 1968-9," NEA Research Bulletin, XXXXVII (March, 1969), p. 29.

Rabi, I. I. Excerpts from his address at the AAAS meeting of Educational Policies Commission, December 27, 1966, Washington, D. C., in The Physics Teacher, V (May, 1967), p. 197.

Reich, Charles A. The Greening of America. New York: Bantam Books, Inc., 1971.

Rigden, John S. "Reshaping the Image of Physics," Physics Today, XXIII (October, 1970), pp. 48-53.

Robinson, Buel C. and Keefe, Thomas E. "Found: The Missing Physics Students," The Science Teacher, XXXV (January, 1968), pp. 67-69.

Schwartz, Allan J. "A Report on a Dissenting View of Science Education," The Physics Teacher, VI (May, 1968), pp. 222-223.

Shenker, Israel. "'The Great Eggplant,' or Physics as a Best Seller," San Francisco Examiner and Chronicle (August 29, 1971), p. 20.

Shrader, John Stanley. "An Investigation of Instruction Problems Encountered by Beginning Secondary School Science Teachers in the Pacific Northwest," Science Education, XXXXV (March, 1961), pp. 143-148.

Smith, Michael J. Letter to the editor, Physics Today, XIX (November, 1966), p. 14.

Snow, Charles P. The Two Cultures and a Second Look. Cambridge, England: Cambridge University Press, 1964.

Stiles, William H. "Harvard Project Physics--Review of a National Program for Development of a Humanistically Oriented High-School Physics Course 1964-1970." An Unpublished report of Harvard University Program for the Science Development Office.

Strassenburg, Arthur A. "Proposal for Studies of Problems in the Education and Employment of Physicists" (submitted to the National Science Foundation by the Office of Education and Manpower, American Institute of Physics, Inc., New York, 1967).

Strassenburg, Arthur A. "Baccalaureate Trend Downward: More Take PSSC in High School," Physics Today XXI (February, 1968), p. 63.

Street, Stewart A. "Trends in the Physics Curriculum," The Physics Teacher, V (October, 1967), pp. 319-321.

Swartz, Clifford E. "We Have a World-View," The Physics Teacher, VI(November, 1968), p. 393.

Swartz, Katherine. "The Flight from Science--A Student's View," an editorial, The Physics Teacher, VII (April, 1969), p. 195.

Watson, Fletcher G. "Why Do We Need More Physics Courses?" The Physics Teacher, V (May, 1967), pp. 212-214.

Welch, Wayne W. and Rothman, Arthur I. "The Success of Recruited Students in a New Physics Course," Science Education, LII (April, 1968), pp. 270-273.

Young, Victor J. "Survey on Enrollment in Physics," The Physics Teacher, III (March, 1965), pp. 117-122.

Zacharias, Jerrold R. "Pre College Physics," an editorial, The Physics Teacher, IV (May, 1966), pp. 227-253.