



An investigation of Montanas Public High School Physics Program During the 1972-73 School Year
by Alexander Kane Dickison

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
DOCTOR OF EDUCATION

Montana State University

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Abstract:

It was the purpose of the study to determine the status of physics teaching in the public high schools of Montana during the 1972-73 school year. The results of this investigation were compared to earlier studies to determine the progress that had been made in physics since 1959. The study concentrated on teaching objectives and "external factors". "External factors" included the enrollment in physics, teaching assignments, teacher preparation in physics, and laboratory and supplemental materials available.

Data were collected from three main sources. These were: 1)the Fall Reports submitted by the school districts to the State Department of Public Instruction; 2)questionnaires sent to all Montana high school physics teachers; 3)a visitation to twenty-two randomly selected high schools in Montana. The return of the "High School Physics Questionnaire" which emphasized the "external factors" was 81 percent. The return of the "Teachers' Objectives Questionnaire" was 84 percent. The major conclusions of the study were: 1)high school physics in Montana was mainly for the better students. Mathematics and problem solving were emphasized; 2)the teaching objectives of Montana physics teachers could be generalized to have been "traditional"; 3)"traditional" textbooks were used most often. P.S.S.C. Physics and Project Physics were used by some teachers as supplementary textbooks. P.S.S.C. Physics had greatly influenced the laboratory; 4) the academic preparation of Montana physics teachers had improved in the sciences and mathematics.

There were still many teachers, however, with 15 or less quarter hour credits in physics; 5)on the average the laboratory facilities had improved, but there were still many schools with inadequate physics laboratories.

The recommendations of the study were; 1)Montana colleges and universities should offer in-service and summer courses for high school physics teachers; 2)A program designed to increase communications between all physics teachers should be implemented. A State Coordinator of High School Physics should be created; 3)The undergraduate program in preparing physics teachers should be examined; 4) Programs such as summer physics institutes and the Science Curriculum Center, at Montana State University, should not only continue, but expand their services.

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ALEXANDER KANE DICKISON

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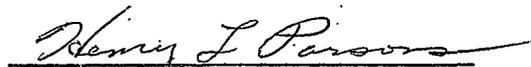
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ABSTRACT

It was the purpose of the study to determine the status of physics teaching in the public high schools of Montana during the 1972-73 school year. The results of this investigation were compared to earlier studies to determine the progress that had been made in physics since 1959. The study concentrated on teaching objectives and "external factors". "External factors" included the enrollment in physics, teaching assignments, teacher preparation in physics, and laboratory and supplemental materials available.

Data were collected from three main sources. These were: 1) the Fall Reports submitted by the school districts to the State Department of Public Instruction; 2) questionnaires sent to all Montana high school physics teachers; 3) a visitation to twenty-two randomly selected high schools in Montana. The return of the "High School Physics Questionnaire" which emphasized the "external factors" was 81 percent. The return of the "Teachers' Objectives Questionnaire" was 84 percent.

The major conclusions of the study were: 1) high school physics in Montana was mainly for the better students. Mathematics and problem solving were emphasized; 2) the teaching objectives of Montana physics teachers could be generalized to have been "traditional"; 3) "traditional" textbooks were used most often. P.S.S.C. Physics and Project Physics were used by some teachers as supplementary textbooks. P.S.S.C. Physics had greatly influenced the laboratory; 4) the academic preparation of Montana physics teachers had improved in the sciences and mathematics. There were still many teachers, however, with 15 or less quarter hour credits in physics; 5) on the average the laboratory facilities had improved, but there were still many schools with inadequate physics laboratories.

The recommendations of the study were: 1) Montana colleges and universities should offer in-service and summer courses for high school physics teachers; 2) A program designed to increase communications between all physics teachers should be implemented. A State Coordinator of High School Physics should be created; 3) The undergraduate program in preparing physics teachers should be examined; 4) Programs such as summer physics institutes and the Science Curriculum Center, at Montana State University, should not only continue, but expand their services.

CHAPTER I

THE PROBLEM

Introduction

In the mid 1950's, the United States was in a position to think about its future. World War II and the Korean War were over. With the death of Stalin in 1953, the fear of Communism, which was displayed in the McCarthy hearings, had dissipated to a rational level. This was a time for planning for the future, even though well defined goals were not yet established.

In 1950, Congress established the National Science Foundation (NSF). By charter, this Foundation was expected to develop "a national policy for the promotion of basic research and education in the sciences."¹ World War II and the Korean War had convinced Congress that a strong science program in the United States was necessary for the national defense.²

During the early years of the Foundation, most money

¹Paul E. Marsh, and R.A. Gartner, Federal Aid to Science Education: Two Programs, Syracuse University Press, New York, 1963, p. 15.

²Ibid., p. 17.

received from Congress went to support basic scientific research.³ It was not until 1956, that the Foundation became concerned about the quality of science education in the nation's high schools. It felt that in order to encourage youngsters to prepare for a scientific career, it was necessary to have challenging, modern high school science courses taught by first-rate teachers.⁴ The National Science Foundation felt that both of these ingredients were lacking in many of the high schools in the United States. NSF prepared to tackle the problem of teacher preparation first. It sponsored summer and academic year institutes for university study in science and mathematics for high school teachers.⁵ This program was intended to up-date and build onto the science preparation the high school teachers already had.

Independently in 1956, the Physical Science Study Commission (P.S.S.C.) was formed at the Massachusetts Institute of Technology. This group applied to NSF for a grant to develop a high-quality physics curricula that could be

³Ibid., p. 18.

⁴Ibid., p. 18.

⁵Ibid., p. 18.

taught by a teacher with a poor physics background.⁶ They were awarded the grant, and started their work unaware of the importance physics would have in the American educational system in the very near future.

On October 4, 1957, Sputnik I was launched by the U.S.S.R. It was not until February 1, 1958, that the United States' space program was able to put a satellite into orbit. This Russian achievement created a strong feeling of competitiveness among the American people. The United States was going to try to be the first to land a man on the moon. The goals now had been set for the next ten years. The United States had entered the Space Race.

The American people were demanding to know why the American Space Program was not first, and one area which came under close scrutiny was the field of Education. A total re-evaluation of the American educational system was undertaken.⁷ One of the first, and perhaps most important, aspect to be studied was the different kind of teaching methods used in the classroom. Leading educators began criticizing the "traditional" methods employed by most class-

⁶Gilbert C. Finley, "Secondary School Physics: P.S.S.C.", American Journal of Physics, 28:286-93, March, 1960.⁷

Marsh and Gartner, op. cit., p. 44.

room teachers. These "traditional methods" emphasized the teaching of facts rather than processes. They felt that if this could be changed, an improved American educational system would follow. As a result of this movement, a number of new teaching programs were developed.

It soon became apparent that in order to have a successful space program, a strong physics program was also needed.⁸ With this new public attitude, the National Science Foundation and the Physical Science Study Commission gained momentum. The Physical Science Study Commission planned and wrote the P.S.S.C. physics curriculum. Since that time, a number of new programs in physics have been written by various agencies. These programs vary in grade level from elementary school through the college level. Among these programs developed were Introductory Physical Science, Harvard Project Physics, Berkeley Physics, Physical Science for Nonscientists, Science Curriculum Improvement Study, and Elementary Science Study.

The development of these new programs in physics was made possible in many cases by NSF grants. These grants allowed many of the leading scientists and educators in the field of physics to be assembled together to work on the

⁸Ibid., p. 45.

curricula. They arrived at many new ideas and techniques on how to teach physics students at the high school and also the college level.

Statement of the Problem

During the 1958-59 school year, two studies were conducted on science teaching in Montana at the secondary school level. Orlich's study⁹ concentrated on the methods of teaching science. He prepared and administered a questionnaire covering six areas of emphasis. These divisions were: 1) administrative factors, 2) methods and procedures of the science teachers, 3) audio-visual aids, 4) library and related facilities, 5) testing and evaluation, and 6) recommendations of the Montana senior high school science teachers. Gebhart¹⁰ concentrated his study more on "external factors" rather than classroom methods. He determined sizes of schools, sciences taught, enrollment in the

⁹Donald C. Orlich, "An Appraisal of the Methods of Teaching Science In the Senior High Schools of Montana," (unpublished Master's thesis, University of Utah, Salt Lake City, 1959).

¹⁰James W. Gebhart, "The Teaching of Science In the Secondary Schools of Montana", (unpublished Doctorate thesis, Ohio State University, 1960).

various sciences, teaching assignments, teacher preparation in the sciences, and teacher salaries.

Both of these studies were done soon after the initial impact of Sputnik. They, therefore, served as a basis for what physics teaching in the secondary schools of Montana was like before the development of the new curricula and the renewed emphasis on the upgrading of the educational system.

This dissertation deals with the status of teaching physics in the public high schools of Montana during the 1972-73 school year. The results of this investigation were compared to earlier studies to determine the progress that has been made in physics education during the past fourteen years. An analysis was made of the new programs in physics to determine which have been of the most benefit, and have been used by the most high school physics teachers in Montana. This study concentrated on the teaching methods and the "external factors" now being used in the high schools.

"External factors" included the enrollment in physics, teaching assignments, teacher preparation in physics, and laboratory equipment available. Programs were developed and carried out during the 1960's to try to influence these statistics. Institutes such as the National Science Foundation Teacher Institutes were conducted throughout the United

States to upgrade the teacher's preparation in physics. New curricula were developed, such as Harvard Project Physics, which had as one of their major goals, to increase the number of high school students enrolled in physics. The National Defense Educational Act (NDEA) provided money for science equipment in the public schools. By comparing the data developed by this study with those compiled by Gebhart, it can be determined if there has been any significant change in these factors in Montana.

The second area investigated was the teaching methods employed by the high school teachers of Montana. These methods included course objectives, laboratory use, and organization of subject material. Although the techniques to be used by this investigator were not the same as Orlich used in his study, it was still possible to compare these findings. Changes should have occurred if the goals of NSF, NDEA, and curricula written since 1956 have had any impact on the physics teaching in Montana.

Need for and Benefit of the Study

Due to the increased pressure on education to account for its role and mission in society, it is important that studies be made of the current practices in specific subject

areas. These studies can then serve as a basis to determine if an upgrading and reformation would be needed for any methods and standards now used in the classrooms. It is important that if any changes are made, that they be based on factual information and not speculation. This research project provides data on Montana's current physics program in the secondary schools.

This study provides a standard of comparison for secondary level physics programs in Montana. The results are stratified according to high school population. Individual teachers or entire school districts can compare their own programs with schools similar to theirs throughout the state.

Institutions that train physics teachers for the secondary level should also benefit from this study. It is important that they know the current state of the physics programs in the secondary schools. This is necessary so that future teachers can be taught what to expect out on the job, and how these present conditions can be improved. The teacher-training schools have also been given the responsibility of updating and retraining the experienced teacher. Federal funding is available to support programs such as in-service institutes and instructional resource centers. If these programs are going to be of maximum benefit, a

knowledge of the current state of physics teaching should be obtained in order to gear them to the proper level.

Another reason for undertaking this research project was to determine the effect of past attempts in changing the physics program. A great deal of money, talent, and energy was expended in the United States during the past fourteen years to change the direction of the physics program at the secondary level. Perhaps by studying the present state of the physics program in Montana, it can be determined which of these changing forces have succeeded, and which have not.

In summary, the most important function of this study was to serve as a basis for initiating change. This study will, hopefully, serve as a basis for determining what, if any changes should be undertaken to improve the overall physics program in Montana.

General Questions to be Answered

This study will answer a number of questions about the physics program in the high schools in the state of Montana. A list of these questions include:

1. What was the enrollment in physics in Montana high schools during 1972-73? How does this enrollment compare to that of 1958-59?

2. What formal training in physics (and other disciplines) did the physics teachers in the secondary schools of Montana during 1972-73? How did this compare to the 1958-59 school year?
3. What were the teaching assignments of the high school physics teachers in Montana during 1972-73? How did this compare to 1958-59?
4. To what extent had Federal monies been used in Montana for updating high school physics facilities, or in upgrading the teacher's knowledge of physics?
5. What was the number and availability of courses in physics in the high schools of Montana during 1972-73?
6. What was the availability of physics laboratory equipment in the high schools of Montana?
7. What was the extent of library facilities related to physics in the high schools in Montana?
8. What were the audio-visual facilities related to physics that were available to the physics teachers and students in Montana?

9. What were the prerequisites that a student must fulfill in order to enroll in a physics course in the high schools of Montana?
10. What type of courses (i.e. P.S.S.C., Harvard Project Physics, "traditional", etc.) were being taught in the high schools of Montana?
11. What course objectives did the physics teachers in Montana hold to be most important?
12. Were the objectives of the physics teachers of Montana in harmony with the type of courses being taught?
13. What was the academic ability of the students enrolled in physics courses in the high schools of Montana?
14. What, if anything, could be done to improve the high school physics being taught in Montana within the resources available?

General Procedures

In order to answer these questions, data had to be collected from three main sources. These were: 1) the fall reports submitted by the school districts to the State Department of Public Instruction; 2) a questionnaire sent to

all high school physics teachers in Montana; and 3) a visitation to twenty-two randomly selected high schools in Montana. (List in Appendix A, page 247).

Initially a visit was made to the State Department of Public Instruction. This was done so the fall reports for 1971-72 could be examined. These reports contained information on school enrollment, sciences taught, enrollment in the sciences, teaching loads of the physics teacher, and the college hours of preparation the physics teacher had in various subject areas. The 1970-71 fall reports had to be used for the college preparation of physics teachers due to a change in form of the fall reports starting with the 1971-72 school year. Because this data was older and perhaps, less reliable, this information was asked for again in the questionnaire.

From the fall reports it was ascertained which high schools offered a physics course during the past three years. All of these schools were sent a "High School Physics Questionnaire". (copy in Appendix D, page 250). A randomly selected stratified group of physics teachers received, in addition, a "Teachers' Objectives Questionnaire". (copy in Appendix E, page 256). Three weeks after mailing these questionnaires, they were mailed again to the teachers who

did not respond. Six weeks after the initial mailing phone calls were made to the non-respondent schools to determine if anyone at the school was qualified to fill out the questionnaire. At some schools there was no physical science teacher employed during the year, and they were eliminated from this study.

From the questionnaires returned, information about the teachers' objectives in teaching physics, the teachers' college preparation, the teachers' opinions about how various agencies could help their physics program, and finally factual information about their physics programs was obtained. The factual information included prerequisites needed for a student to take physics, text used, extent new curricula were used, adequacy of laboratory, library, and audiovisual facilities, and whether or not their school had participated in any Federal Aid to high school physics.

Finally, due to the researcher's opinion that the most reliable method of obtaining data was through personal visits to the schools and with the teachers, as many of these trips were undertaken as resources permitted. Altogether twenty-two randomly selected schools were visited. For each visit, a uniform interviewing procedure was used. (copy in Appendix F, page 260).

The results of this study were broken down into four categories. These were: schools with student enrollment over 800; schools with enrollment between 300 and 800; schools with enrollment between 100 and 300; and schools with enrollment under 100. For this reason, the random selection of schools to be visited was also stratified. The stratification was based on the number of students enrolled in each of the above categories.

The data resulting from this investigation was analyzed and presented, utilizing descriptive statistical analyses.

Definition of Terms

P.S.S.C. Physics Curricula. A physics curriculum developed by the Physical Science Study Committee after a thorough analysis of the physics being taught in the high schools during the late 1950's. Included is a textbook, special laboratory equipment, and films. The P.S.S.C. objectives are explained below.

P.S.S.C. Objectives. The Physical Science Study Committee never formulated objectives for the P.S.S.C. course besides those of trying to develop a better curricula. The P.S.S.C. objectives will therefore be taken as

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The data resulting from this investigation was analyzed and presented, utilizing descriptive statistical analyses.

Limitation

It was the purpose of this study to determine the status of physics teaching in the public high schools of Montana during the 1972-73 school year. In order to completely understand why students take or do not take high school physics or how much knowledge the students learn about physics in a high school class, information should be gathered from the high school students. This study, however, concentrated on teaching objectives and "external" factors. "External factors" included the enrollment in physics, teaching assignments, teacher preparation in physics, and laboratory and supplemental materials available.

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P.S.S.C. Objectives. The Physical Science Study Committee never formulated objectives for the P.S.S.C. course besides those of trying to develop a better curricula. The P.S.S.C. objectives will therefore be taken as those which were developed by Trowbridge.¹¹ These objectives are listed on pages 149, 150 and 151.

"Traditional" Physics Course. The "traditional" physics curricula is a composite of high school courses made from a variety of textbooks, workbooks, laboratories, and supplementary material usually written during the 1940's or the early 1950's. The "traditional" course is defined by this researcher as having the objectives described next.

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Leslie W. Trowbridge, "A Comparison of the Objectives and Instructional Materials in Two Types of High School Physics Courses," Science Education, 49:117-119, March, 1965.

"Traditional" Physics Course Objectives. The objectives of the "traditional" physics course are those determined by "Trowbridge."¹² These objectives are listed on page 149.

Harvard Project Physics. A physics curriculum developed by a team of physicists and educators at Harvard University beginning in 1964.

Harvard Project Physics Objectives. The long term objectives of Harvard Project Physics as described by Holton¹³ and Rutherford.¹⁴ The four main objectives were:

1. to create a coherent, tested course for use on a national scale alongside the others that have been developed previously. This course accentuates those aspects of physics not prominently incorporated into high school physics, although they are widely held desirable.
2. to help stem the decline in proportionate enrollment in physics at the high school level - a decline which is now reaching into the college years.

¹²Ibid., pp. 118-119.

¹³Gerald Holton, "Project Physics: A Report on Its Aims and Current Status", The Physics Teacher, 5:198-211, May, 1967.

¹⁴F. James Rutherford, "Flexibility and Variety in Physics," The Physics Teacher, 5:215-221, May, 1967.

3. to provide teachers with all the necessary aids for teaching good physics in realistic classroom situations.
4. the course development requires thinking entirely afresh through quite basic questions such as the role of the teacher and his involvement with the class, the new desire to allow greater diversity and flexibility, and the new opportunities opened up by the developing technology of education.

External Factors. The factors that influence the success of a teaching situation not related to personality factors or the teaching methods used by the teacher. Examples would be: teacher training, classroom size, teacher assignments, and equipment available.

Methods of Teaching. The techniques and methods used by the physics teacher to transfer knowledge, attitudes, appreciations, and/or methods of thinking to the students.

Other Curricula or Approaches. All physics curricula excluding P.S.S.C. and Project Physics that have been developed since 1957 to be used in high school physics classes.

Science Teaching Assistance Center. This center was located at Montana State University, Bozeman, Montana. The center was designed "to provide aid to teachers in their efforts to improve the teaching of the Earth, Life, and Physical Sciences in the elementary and secondary schools of

Montana".¹⁵ At the center were textbooks, laboratory manuals, laboratory equipment, and supplementary reading materials from different science courses and curricula. University staff was also available for consultation.

Organization of the Study

The organization of the balance of the dissertation is as follows:

Chapter II gives a historical review of the literature and presents a survey of related studies.

Chapter III describes the procedures used in conducting the study, an explanation of the instruments used, and the methods used in analyzing the data.

Chapter IV presents the objective data and findings of this research project.

Chapter V contains the subjective findings of the researcher concerning the teaching of high school physics in Montana.

Chapter VI summarizes the main findings, conclusions, and gives recommendations for further research.

¹⁵Nathaniel Kutzman, "Science Teaching Assistance Center", Handout available at Montana State University, Bozeman, Montana, 1973.

CHAPTER II

REVIEW OF RELATED LITERATURE

Historical Background

Before one begins an analysis of the current state of physics teaching in Montana, a historical perspective is needed. The following is a brief introduction which discusses only the highlights in the history of physics teaching in the high schools of America. For a more comprehensive account of the historical basis for physics education, the reader is referred to the many sources which treat this area in depth. To mention a few there are: Marshall,¹ Fowler,² Street,³ de H. Hurd,⁴ and Brandwein.⁵

¹J. Stanley Marshall and Ernest Burkman, Current Trends in Science Education, The Center for Applied Research In Education, Inc., New York, 1966.

²H. Seymour Fowler, Secondary Science Teaching Practices, The Center for Applied Research In Education, Inc., New York, 1964.

³Stewart A. Street, "Trends in the Physics Curriculum", The Physics Teacher, 5:319-321, October, 1967.

⁴Paul de H. Hurd, "The Case Against High School Physics", School Science and Mathematics, III:439-449, June, 1953.

⁵Paul F. Brandwein, Paul E. Blackwood, and Fletcher G. Watson, Teaching High School Science - A Book of Methods, Harcourt, Brace, and Co., New York, 1958.

In the seventeenth and eighteenth centuries, the scientific awakening which had been developing for several centuries, reached its climax.⁶ It was proposed by some that the discovery of America could be thought of as a major event in the history of science, and that it helped to hasten this awakening. Until this time, the natural sciences were patterned after Aristotle, with the Bible as the source book of natural history. With the discovery of the New World, the Book of Nature had to be brought to terms with the new discoveries. In this search, the moral significance of every find had to be interpreted. Thus, an attempt was made to order and catalogue all previously existing knowledge, as well as the new discoveries.

The universities, at this time, were classically oriented in their courses of study. The science teachers, due to their nonrecognition in the universities, formed groups called "academies". The academies served the purpose of cataloguers of knowledge. Those objects or observations

⁶Elliot Rowland Downing, Teaching Science In the Schools, The University of Chicago Press, Chicago, 1925.

which were inconsistent with the written word were set aside as curiosities.⁷

With the discovery of the New World, came settlers. In America they established colonies based on their experiences in Europe. Universities were soon founded based on the pattern of European schools. Only the classical subjects were taught. This caused many science academies to be founded. These academies offered study in "natural philosophy", or as it is known today, "physics".

The single household in Europe had always been the most important agency in the transfer of culture. In America, however, with its wilderness and the westward migration of each new generation, the total family unit was disrupted.⁸ The colonists, therefore, recognized the need to support public agencies for education. The New England Puritans possessed a high cultural level including a Puritan dependence upon the Bible, concentrated settlements, and town governments. The Puritans transferred the family educational

⁷Robert J. Oppenheimer, "Some Reflections on Science and Culture", Journal of Secondary Education, 41:99-104 41:147-153, March-April, 1966.

⁸Bernard Boilyn, Education In the Forming of American Society, Vintage Books, New York, 1960.

patterns to institutions of learning. In so doing, they defined the schools responsibilities in vocational, cultural, and moral training. This had a profound effect on American science.⁹

The Puritans derived their ideas from the Bible. They believed they could know God better by studying nature.¹⁰ In fact, they felt it a duty to study nature. Thus, research was an important part of their lives and schools. The Puritan science was not the same as modern science. Their science was subservient to theology. They believed that through the pursuit of their science, man could have an experience with the mind of God. The early Puritans believed in a God of Wrath. They, therefore, believed they could not use nature for their own benefit.

During the eighteenth century, the God of Love concept gained favor. Cotton Mather and Newton contributed greatly to this change in beliefs. By 1800, the God of Love was widely accepted. "Man could now use science to control his own future. The responsibility for decision was now his

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David G. Barry, "Early American Science and the Roots of Modern Biology", American Biology Teacher, 27:600-606, 1965.

¹⁰Perry Miller, The New England Mind, New York: 1939.

own".¹¹ Man no longer held a rigid view of the world, but was free to question all processes. On the other hand, it was no longer the responsibility of every person to study science. By the end of the American Revolution, the strong influence of science on the public schools and our society was gone.

During the 19th century, America contributed little to the field of science, but concentrated on Western expansion. As was mentioned earlier, science was not considered worthy of study in the universities prior to 1800. This tradition was maintained, in spite of the Puritan influence, for a long time. As an indication of the acceptance of science in the universities, one can look at entrance requirements. In the classical university, a written and reading knowledge of Latin and Greek was the only requirement for admittance. In 1807, Harvard required geography for admission. Princeton required English grammar in 1819; Yale, geometry in 1856; University of Michigan, United States History in 1870; Harvard, physics in 1872; University of Michigan,

¹¹Melvin Kranzberg, "On Understanding Our Time: The History of Science", Teachers College Record, 64:545-51, April, 1963.

either botany or zoology in 1873. It, therefore, can be seen that not until the middle of the nineteenth century did many of the high school and colleges offer science courses.

During the nineteenth and early twentieth centuries the methods of teaching physics were continually changing. Five distinct periods can be distinguished where different objectives and methods of instruction were popular.¹² These periods may be designated as 1) the descriptive period; 2) the period of systematic organization; 3) the period of principles illustrated with experiments; 4) the college preparatory period; and 5) the reactionary, or practical period.

The descriptive period --- The early objective in natural philosophy, as the subject was called in the 1840's, was to give information regarding physical appliances in everyday use. During this time, mechanical inventions were revolutionizing the economic and social lives of the people. Therefore, people became interested in these new machines and how they worked.

¹²James T. Robinson, "Philosophical and Historical Bases of Science Teaching", Review of Educational Research, October, 1969.

Period of systematic organization -- Gradually the subject matter was systematized. Instead of an understanding of commonplace physical appliances, a comprehension of the principles of science became the chief objective. Instead of the texts having pictures of machines and engines, the illustrations became those of laboratory apparatus.

The period of principles, illustrated with experiments -- In the 1880's the first book appeared which gave directions for experiments which could be done in the classroom. Up to this time, laboratories were not part of the school, and only research scientists had access to them. The introduction of the laboratory method of instruction with special laboratory apparatus spread rapidly. In 1886, Harvard College published the Harvard Descriptive List of Experiments which had a great influence.¹³ This list contained forty experiments which soon became a requirement for admission to most colleges.

The college preparatory period -- In the 1890's, the colleges and universities began to require science courses for entrance, and to prescribe the number and type of

¹³Marshall, op. cit., p. 19.

experiments that must be done by the student for admission. The problems in the texts became more exacting and mathematical. Skill in exact measurements and other manipulatory processes became desirable ends in themselves. The Conference on Physics, Chemistry, and Astronomy reporting to the Committee of Ten on Secondary School Studies in 1894 made recommendations that influence physics teaching even today.¹⁴ These recommendations included: 1) that physics be pursued the last year of high school so the student would have as much mathematical knowledge as possible; 2) that physics be required for admission to college; 3) that physics be taught by a "combination of laboratory work, the textbook, and thoroughly didactic instruction"; 4) that the laboratory be quantitative; and 5) that the teaching should not aim at the "so-called re-discovery of the laws of physics", but the pupils should "determine whether the results agree with the laws."

In 1899, the Committee on College Entrance Requirements of the National Education Association re-enforced these recommendations.¹⁵ These reports standardized the type of

¹⁴C.R. Mann, *The Teaching of Physics*, The Macmillan Co. New York, 1912, p. 29.

¹⁵Ibid., p. 61.

physics courses then being taught in high schools throughout America. To help hasten the standardization even more, the Topical Syllabus in Physics was published in 1905 by the New York State Department of Education.¹⁶ Shortly afterward a topical syllabus for physics was issued by the North Central Association.¹⁷

During this period, the objectives of physics teaching had moved a long way from the interests of the pupils. A reaction was soon to come. This was the start of the "practical period".

The practical period -- In 1910, a committee of the Central Association of Science and Mathematics Teachers studied the fundamental purposes of science teaching in high school.¹⁸ The committee reported that science courses should not be used as a preparation for students to go on to college, but should serve the purpose of introducing the pupils to "new interests and appreciations". They also recommended that physics be a requirement for all students.

At the same time, the National Education Association

¹⁶Ibid., p. 66.

¹⁷Ibid., p. 67.

¹⁸de H. Hurd, op. cit., p. 441.

Committee on the "Reorganization of Science in Secondary Schools" recommended that science teaching should be geared to all students.¹⁹ They also said that physics should place more emphasis on the commonplace manifestations of science, with the main stress on the practical.

These reports allowed steps to be taken to introduce new methods into physics instruction. The hope was to bring physics back to the realm of practical affairs. Following the same reasoning process, a number of other reports were issued recommending that high school physics be designed for general education. These included The North Central Association in 1929,²⁰ The National Society for the Study of Education in 1932,²¹ The National Association for Research in Science Teaching in 1938,²² The Central Association of Science and Mathematics Teachers in 1941,²³ The American Council of Science Teachers in 1942,²⁴ The Harvard Committee in 1945,²⁵ and the Forty-Sixth Yearbook of the National

¹⁹Ibid., p. 442.

²⁰Ibid., p. 442.

²¹Ibid., p. 442.

²²Ibid., p. 443.

²³Ibid., p. 443.

²⁴Ibid., p. 444.

²⁵Ibid., p. 444.

Society for the Study of Education in 1947.²⁶

With all of these reports and studies recommending that high school physics courses be closely related to daily living and concerned with social problems related to physics one would conclude that in the 1950's a typical high school physics course would be very different from those of the 1900's. This was not necessarily the case. There were some external forces that hindered this change.

During the first quarter of the twentieth century, physics had great changes in its structure with the departure from classical physics to that of modern quantum physics. These changes made science a respected discipline, and made teaching "science for the scientists" popular.²⁷

During the 1920's and 30's "workbooks" and "laboratory manuals" were developed.²⁸ These tended to emphasize the "cookbook" approach toward physics and standardized the content to the traditional areas of mechanics, heat, light, sound, magnetism, and electricity. In 1939, the American

²⁶Ibid., p. 444.

²⁷James B. Conant, On Understanding Science, Yale University Press, New Haven, 1947.

²⁸Trowbridge, op. cit., p. 30.

Association of Physics Teachers appointed a committee to study the teaching of secondary school physics and bring about better coordination between the natural sciences and mathematics in the schools.²⁹ They recommended more emphasis on everyday applications of the physics' principles in textbooks. This led to an increase in illustrative material which was from industrial and household applications. The traditional areas of study, however, remained the same.

Therefore, in the early 1950's, it was apparent that the physics courses taught in most high schools would have to undergo major changes. An evaluation by Fowler³⁰ sums up the situation in the 1950's:

The basic content of high school physics has not changed appreciably in the last 60 years. A student may well be exposed to topics in 1960 similar to those his grandfather knew. Perhaps the examples chosen to illustrate the concepts developed may be different, but the content would be very similar. In spite of the fact that the 1900 and 1960 textbooks are similar, the 1960 version is much thicker, a result of the inability of authors and curriculum-makers to discard anything. As time passed, more and more current examples from technology were added to high school physics. For example, each so-called "new age" contributed

²⁹K. Lark-Horavitz, "Physics in the Secondary School", Review of Scientific Instruments, XIII, April, 1942, pp. 137-39.

³⁰Fowler, op. cit., p. 70.

something to the textbook authors and curriculum-makers for inclusion in their revisions: The 'air age' added the airplane; the 'atomic age' added more about nuclear energy, both for peacetime uses and for war; the 'jet age' added jet propulsion; and the 'space age' added satellites. Seldom, however, has any topic been deleted.

The rejection of this type of course by the students was apparent in the enrollment figures for high school physics. The national figures for enrollment in high school can be compared below.³¹

<u>Year</u>	<u>Percent of All U.S. High School Students Enrolled in Physics</u>
1895	22.77 %
1905	15.66
1915	14.23
1928	6.85
1940	5.60
1947	5.49

Due to the growing dissatisfaction over the high school curricula, informal groups of high school and university teachers began to meet. These groups were established at Cambridge, Massachusetts; Bell Laboratories in New Jersey; the California Institute of Technology; Cornell University; and the University of Illinois. Several tentative outlines

³¹Philip O. Johnson, "The Teaching of Science in Public High Schools", Bulletin 1950, No. 9, Federal Security Agency, Washington, D.C., p. 6.

for physics courses were drawn at these meetings.³²

In 1956, the Physical Science Study Commission was formed. Its goal was to review and make recommendations about the current state of high school physics in the United States. This commission was funded primarily by the National Science Foundation. It quickly decided that a new physics curriculum was needed.

In December, 1956, a meeting was held at the Massachusetts Institute of Technology for interested educators across the country to bring together ideas about a new physics curriculum. Most of the people involved in the informal groups mentioned above, attended this meeting. A general agreement was reached on a broad outline for the new course. This was the beginning of P.S.S.C. Physics.³³

The goals of P.S.S.C. Physics have been stated by Haber-Schaim:³⁴

a) to present physics as a unified, yet living and ever-changing subject.

³²Street, op. cit., p. 320.

³³Ibid., p. 321.

³⁴Uri Haber-Schaim, "The P.S.S.C. Course", Physics Today, 20:3, March, 1967, p. 26.

b) to demonstrate the interplay between experiment and theory in the development of physics.

c) to have the students learn the basic principles and laws of physics by interrogating nature itself, thus learning not only the laws, but also the evidence for them as well as their limitations.

d) to extend the student's ability to read critically, to reason and to distinguish between the essential and the peripheral, thereby improving his learning skills in general.

e) to provide a sound foundation for those students who plan to study science at the college level.

No behavioral or more detailed goals or objectives were ever developed.

The immediate reaction to the P.S.S.C. curriculum was mixed. In almost every issue of any science education magazine, one could find articles both for or against this curriculum. Poorman³⁵ and Brauer³⁶ were leaders in the opposition, while Finlay³⁷ strongly advocated the use of P.S.S.C.

Soon after these arguments, came research papers on the achievement of students taking "P.S.S.C." compared to "tra-

³⁵Lawrence G. Poorman, "Indiana Physics Teachers React to P.S.S.C.", Science Education, 49:171-2, March, 1965.

³⁶Oscar L. Brauer, "Something Dangerously New In Physics Teaching", Science Education, 47:365-72, October, 1963.

³⁷D. Finlay, "Summary of Judgements Made By Teachers About P.S.S.C. Physics", Science Teacher, 26:579-81, December, 1959.

ditional" physics. Heath,³⁸ Wosik,³⁹ and Hudek,⁴⁰ are just a few of the many studies done. When these are viewed together, several conclusions can be reached:

1. with conventional achievement tests no difference can be measured.

2. no difference in achievement in college classes can be determined between students who took the "traditional" physics or the P.S.S.C. physics.

As a reaction to these findings, the Physical Science Study Commission argued that their course had different objectives than the traditional courses. The P.S.S.C. course tried to teach higher level thought processes as well as teaching a better appreciation of physics.⁴¹ No research has yet proved this statement false. This may be due to the difficulties in constructing proper measuring instruments.

³⁸Robert W. Heath, "Comparison of Achievement In Two Physics Courses", Journal of Experimental Education, 32:347-54, Summer, 1964.

³⁹John L. Wosik, "A Comparison of Cognitive Performance of P.S.S.C. and Non-P.S.S.C. Physics Students", Journal of Research In Science Teaching, 8:85-90, 1971.

⁴⁰Albert D. Hudek, "The Relative Effects of P.S.S.C. Physics and Traditional Physics on Achievement In College Physics", (unpublished thesis, University of South Dakota, 1969).

⁴¹Haber-Schaim, op. cit., p. 26.

It was never a stated goal of P.S.S.C. Physics to increase enrollment in high school physics,⁴² but educators hoped this might occur. The percent of enrollment of students in high school physics compared to the enrollment among all twelfth grade students still dropped. The following figures show this:⁴³

<u>Year</u>	<u>Percent of All U.S. Twelfth Grade Students Enrolled in Physics</u>	<u>Total Number of Students Enrolled in Physics</u>
1948	25.8 %	291,000
1954	24.3	303,000
1958	24.6	379,000
1960	21.2	385,000
1964	19.6	485,000

This differs from the previously given enrollment figures on page 31, for this is the percent of twelfth graders and not of all high school students. This means that in 1964 less than 20 percent of the students were taking physics during their high school years. This is compared to over 95 percent for biology, and over 40 percent for chemistry. It was soon apparent that P.S.S.C. Physics was very selective, and mainly geared for the college bound student.

⁴²Ibid., p. 27.

⁴³Fletcher G. Watson, "Why Do We Need More Physics Courses?", The Physics Teacher, 5:213, May, 1967.

In 1962, with the support of the Carnegie Corporation in New York, Holton, Watson, and Rutherford started working on a new physics curriculum geared to reverse the trend of decreasing high school physics enrollment. In 1964, the project became national in scope, and was funded by the National Science Foundation and the United States Office of Education. The center of activity was moved to Harvard University. This was the start of The Project Physics Course.⁴⁴

The specific goals of The Project Physics Course were given in their first published resource book:

1. to help students to increase their knowledge of the physical world by concentrating on the ideas that characterize physics as a science at its best (for example, the conservation laws), rather than concentrating on isolated bits of information (such as the lens formula).

2. to help students see physics as the many-sided human activity that it really is. This means presenting the subject in historical and cultural perspective, and showing that the ideas of physics have not only a tradition but methods of adaption and change.

3. to increase the opportunity for each student to have immediate rewarding experiences in science while gaining knowledge and skill that will be useful throughout life.

⁴⁴Gerald Holton, F. James Rutherford, and Fletcher G. Watson, About the Project Physics Course, Holt, Rinehart, and Winston, Inc., New York, 1971.

4. to make it possible for teachers to adapt the physics course to the wide range of interests and abilities among their students.

5. to recognize the importance of the teacher in the educational process, and the vast spectrum of teaching situations that prevail.⁴⁵

Specific behavioral objectives were not given for this curriculum.

Project Physics was not fully developed until around 1970. For this reason, the impact of this curriculum was only beginning to be felt. Whether it increased the physics enrollments in the high schools has not yet been established. In measuring the achievement of students taking this course, the problem of adequate measuring devices was again encountered. This curriculum, much like P.S.S.C., tried to teach higher level thought processes. Testing instruments in physics have not been developed yet to measure this type of behavior.

The hope of many physics educators^{46,47,48} was that high

⁴⁵ Ibid., p. 5.

⁴⁶ R.W. Detenbeck, and P. Di Lavore, "Harvard Project Physics", The Physics Teacher, 5:223, May, 1967.

⁴⁷ F. James Rutherford, "Flexibility and Variety in Physics", The Physics Teacher, 5:215-24, May, 1967.

⁴⁸ Editorial: "Need for Multiplicity of Physics Courses", The Physics Teacher, 3:371-72, November, 1965.

schools, whenever feasible, will develop more than one track of physics. "P.S.S.C.", "traditional", or a modification of either could be used for the science-oriented college bound student. "Project Physics" or a modification could be used for the majority of other students who now seem to elect not to take physics.

It would now seem important to determine where we are in reaching these goals in the high schools. The next section of this research paper deals with research done in assessing what type of physics was being taught in the high schools.

Review of Related Studies

Most of the research to determine the status of physics teaching in the senior high schools was carried out before the development of the new curricula. Many of these studies served as the basis for determining the different approaches taken by these new programs. In this review only the studies most pertinent to Montana will be discussed. There has been, however, a very limited amount of research completed recently to determine the new trends in physics education. In this review, the literature will be organized into four categories. These are: 1) research done prior to the develop-

ment of the new curricula, 2) research done since the development of the new curricula, 3) criteria for determining the present status of physics teaching in the high schools, and 4) Piaget's Theory of Learning and Related Studies.

Research done prior to the development of the new curricula.

In 1953, Lefler,⁴⁹ reported on the current status of physics teaching in the American high schools. Both the outstanding features and problem area were discussed. Attention was given to textbooks, workbooks, classroom demonstrations, laboratory experiments, physics apparatus, audio-visual aids, library resources, community resources, and physical layout of rooms for instruction of high school physics.

Concerning these areas, Lefler found the following information:

a) the textbook had changed little since 1856, except for the addition of modern aspects of physics. Emphasis was still placed on rote memory, and even then it was very difficult to cover all the material in the text.

⁴⁹R.W. Lefler, "Trends in High School Physics," National Association of Secondary-School Principals, January, 1953, pp. 74-83.

b) the workbook which possessed blanks to be filled in by locating appropriate phrases in the text was used frequently. The author did indicate that leading educators were questioning this practice.

c) the teacher demonstration in place of individual laboratories for pupils was also a frequently used technique. The reasons given for its use were lack of enough time, lack of enough equipment, and observation of skilled persons doing experiments.

d) laboratories were used in addition to the teacher demonstration. In most cases workbooks went with the laboratories. For this reason, many experiments had a "cookbook" nature to them.

e) high school physics equipment was in need then. It was estimated that to have the proper equipment for a class of twenty-four pupils, an inventory of \$3,200 of apparatus was needed. Many schools did not have this much equipment.

f) the potential of audio-visual aids was just being realized. Film loops and transparencies were just being developed. Films were in use, but not to any great extent.

g) the use of library materials was not extensive.

h) recently the use of community resources in the physics classes was given greater emphasis.

i) most new physics classrooms contained room for both class and laboratory activities. Many older schools had separate classrooms and laboratories, but this was no longer popular.

j) the staffing of physics classrooms with adequately prepared teachers was a grave problem. Even with the minimum of twenty semester hours in physics for a physics teacher, most schools did not meet this recommendation. To improve this situation, in-service training and "workshops" were being established to upgrade teacher preparation.

During the 1958-59 school year two studies were done involving the status of physics education in the Montana

high schools. Orlich⁵⁰ appraised the methods of teaching science in the high schools of Montana during the 1958-59 school year. By means of a questionnaire, he obtained information about the science program in six areas. These were: 1) administrative factors, 2) methods and procedures of the science teachers, 3) audio-visual aids, 4) library and related facilities, 5) testing and evaluation, and 6) recommendations of the Montana senior high school science teachers. In each of these areas the responses were analyzed and recommendations made. Several of the more significant generalizations cited were these:

1. the teachers had to teach too many different classes.
2. at many schools the laboratory was seldom used or not used at all due to lack of equipment.
3. audio-visual aids were used infrequently.
4. the libraries were inadequately stocked in at least one-third of the schools.
5. there was a need to offer different levels of science, especially in the physical sciences in order to satisfy the different types of students wanting to enroll in these courses.

Gebhart's study⁵¹ complemented Orlich's findings by

⁵⁰Donald C. Orlich, "An Appraisal of the Methods of Teaching Science In the Senior High Schools of Montana," (unpublished Master's thesis, University of Utah, Salt Lake City, 1959).

⁵¹James W. Gebhart, "The Teaching of Science in the Secondary Schools of Montana", (unpublished Doctorate thesis Ohio State University, 1960).

placing emphasis on statistical data such as school size, sciences taught, enrollments, teaching assignments, degrees held by teachers, salaries, and years of service. This data was primarily obtained from the State Department of Public Instruction, and individual teachers' college transcripts. Comparisons were then made with similar studies in Ohio and Wisconsin.

Gebhart concluded that the percent of students enrolled in high school physics in Montana did not differ greatly from the nation as a whole. He noted, however, that the preparation of the high school physics teachers in Montana was not sufficient. The mean number of quarter hours of physics taken by the high school physics teachers of Montana was 10.1. This was compared to a mean of 20.2 quarter hours in Wisconsin, and a median of 16-20 quarter hours in Ohio.

The reason for this problem was credited to the proliferation of small schools in Montana and the low salary paid to secondary school teachers. It was found that 75 percent of Montana's secondary schools had fewer than 300 pupils, and 93 percent enrolled fewer than 500 pupils. A teacher in a small school was paid a low salary (mean of \$4924 per year) due to the district's small tax base. The teachers in the small schools also had to teach many differ-

ent subjects. Only four teachers in the state of Montana taught physics exclusively. The most popular areas to be taught outside of physics were the other science and mathematics. On the whole, it was discovered that the average physics teacher was better prepared to teach in outside areas (mean quarter hours in chemistry of 18.4, in biology of 27.0).

This trend was also found in Ohio and Wisconsin, but not to the same extent it was in Montana. In Wisconsin, the physics teacher was better prepared in physics than biology, (a mean of 20.2 quarter hours in physics compared to a mean of 19.0 quarter hours in biology) and a little better prepared in chemistry where the mean was 23.8 quarter hours. In Ohio, the physics teacher was better prepared in both biology and chemistry compared to physics (a median of 26-30 for both areas, compared to a median of 16-20 in physics).

To improve these conditions Gebhart made the following recommendations:

1. consolidate schools into fewer, larger districts.
2. establish a national curriculum center.
3. require five year training for science teachers.
4. improve summer programs.
5. reorganize high school science curriculum into two broad areas of physical science and biological science.

Research done on the status of high school physics since the development of the new curricula.

Several surveys of high school physics have been made in the United States since the development of the new curricula. Most of these studies concentrated on certain aspects of the high school physics program, and thus failed to give a total picture of the status of high school physics in the state that was studied.

During the spring of 1970, Hale and Smith⁵² conducted a survey of the high school physics programs in Wisconsin. In this study, they concerned themselves with physics texts used, tests administered, enrollment trends, grading practices and teacher-time allocation. They found that Modern Physics by Dull et. al. was used by 58.3 percent of the teachers in Wisconsin, while 21.1 percent used P.S.S.C. Physics. Project Physics was listed down the list along with other less used textbooks, with only 3.9 percent using it.

The teachers were then asked about their own physics class enrollment trends. These answers were correlated with

⁵²Henry E. Hale IV, and John R. Smith, "Trends in High School Physics - A Survey In Wisconsin", The Science Teacher, February, 1971, pp. 33-34.

the textbook used by the teacher. It was found that those classes where Project Physics was used indicated an increase in enrollment in 37.5 percent of the cases, while 40 percent showed no change. This can be compared to the mean response in which only 26.4 percent of the teachers indicated an increase in enrollment. A question was raised by the investigators, however, concerning the validity of the small sample of teachers using Project Physics that responded to the questionnaire.

It was found that final examinations and chapter tests were used as the main determining factor for grades. Following in importance were laboratory notebooks and homework. Very little self evaluation was indicated. Author-prepared tests were used by 60 percent of the responding teachers. In P.S.S.C. Physics, this figure went up to 79 percent.

As far as what activities the high school physics student actually participated in, the teachers responded as follows: 44 percent of the time was spent in class lecture, discussion, demonstration observation, testing, or other teacher-centered activities; 29 percent in problem solving and 27 percent in laboratory activities. Little time was spent in topics chosen by the students.

A study on secondary science curriculum trends in Iowa

was done by Tweeten and Yoger.⁵³ Part of their study was concerned with the high school physics in Iowa. The data was collected from data sheets filled out annually by all Iowa public school teachers for the Iowa Department of Public Instruction. A comparison was made between the results of the 1958-59 school year to that of the 1964-65 school year. The following conclusions were drawn:

1. general science is on the decline as shown by the number of schools offering it and the number of students enrolled.

2. physical science is on the increase as shown by the number of schools offering it and the number of students enrolled.

3. physics is the only basic science with an actual decrease in the number of students enrolled. This is in spite of an overall increase in the number of high school students.

4. physics teachers on the whole, have the poorest background in college physics courses when compared to all other science teachers, and their college preparation in the courses they teach.

5. the science curriculum has begun to change at a faster rate than years past. More experimentation with science offerings is taking place in Iowa.

A third study on the state level was conducted by Van Koevering⁵⁴ in Michigan. This paper concentrated totally on

⁵³Paul W. Tweenten, and Robert E. Yoger, "Science Curriculum Trends in Iowa", School Science and Mathematics, 67:32-36, January, 1967.

⁵⁴Thomas E. Van Koevering, "High School Physics and Chemistry Enrollments in Michigan", School Science and Mathematics, 72:379-83, May, 1972, pp. 379-383.

enrollment statistics. Altogether data from 308 schools from a sample of 372 schools was reported. Figures for enrollments in high school physics in Michigan were given for the class A, B, C, and D high schools. The table which follows gives the data that Van Koevering found.

TABLE I
HIGH SCHOOL PHYSICS ENROLLMENT IN MICHIGAN IN 1968

High School	No. of Schools	Mean Percent of Seniors	Median Percent of Sen.	Standard Deviation
Class A	77	15.8%	12.9%	12.7%
Class B	97	15.4	13.3	9.4
Class C	81	20.2	16.5	14.4
Class D	53	24.4	22.2	13.7

The last study done on a state level to be discussed was done by Elliott.⁵⁵ Elliott conducted a questionnaire research project in 1968 among California's high school teachers and students. The students were divided into those taking, and those not taking a physics course. In this study, he asked the teachers to evaluate themselves as teachers, and the physics courses they were teaching. He

⁵⁵Walter E. Elliott, "Perceptions of High School Physics and Physics Teaching," The Physics Teacher, 9:33-38, January, 1971.

then asked the students taking the physics course to answer the same questions about the course and the teacher. The results were compared. The students not taking physics completed questions pertaining to why they did not take the course. Based on the answers received, Elliott made several recommendations for improving the physics program:

1. for larger schools to offer a variety of physics courses for a broader spectrum of students.
2. for smaller schools to offer a course designed to meet a broader spectrum of students, interests, abilities, and needs.
3. course prerequisites for physics should be reconsidered.
4. schools should consider integrated science courses as a means of exposing students to the concepts of physics.
5. physics teachers should strive for lighter teaching loads to allow for more preparation time.

In addition to the five studies mentioned previously on the state level, several national studies on high school physics have been undertaken. A national study of enrollments in high school physics during the 1964-65 school year was made by Watson.⁵⁶ The data for these comparisons was collected by the U.S. Office of Education. In this study, he reported that 19.6 percent of the high school seniors had

⁵⁶Fletcher G. Watson, "Why Do We Need More Physics Courses?" The Physics Teacher, 5:212-14, May, 1967.

taken physics in 1965, down from 24.6 percent in 1958. Watson blamed this enrollment drop on not having physics courses designed for the majority of the students. It was reported that Harvard Project Physics was one attempt to fill this void.

Thompson⁵⁷ learned that specific topics were taught in a typical high school physics class. Thompson needed this information to determine what changes were needed in the College Entrance Examination Board's achievement tests for college admission to make them concur with the present physics curriculum in the secondary schools.

A question might be raised concerning the validity of the results of Thompson's study which was supposed to represent the whole nation. This was due to how the sample was drawn. The sample was stratified into geographical regions. The number of questionnaires to be sent into each region was based on that region's use of their achievement tests. This meant that over 60 percent of the respondents came from New England. However, some of the data was broken down into the geographical regions from which they were obtained. For

⁵⁷Raymond E. Thompson, A Survey of the Teaching of Physics in Secondary Schools, Educational Testing Service, Princeton, New Jersey, 1969.

this reason, this study was still useful as a comparison.

Modern Physics by Dull, et. al., was found to be used by forty-two percent of the seniors taking physics in the United States. P.S.S.C. Physics was used by twenty-eight percent of the seniors. Harvard Project Physics had just come out at the time of the study, so the percentage of students using this curriculum was only one percent.

The topics or areas of physics Thompson found taught in P.S.S.C. and non-P.S.S.C. classes were listed. It was discovered that many of the topics taught in these two courses were different. It was concluded by Thompson that the two courses emphasized different objectives.

In 1969-70, the National Assessment of Educational Progress⁵⁸ (N.A.E.P.) conducted a study designed to measure educational progress in science across the country. A science test was given during the 1969-70 school year to 88,000 randomly selected individuals in the United States. Approximately one-fourth of the people were in the four age groups of nine, thirteen, seventeen year olds, and adults. No individual results were given. The statistics were

⁵⁸ _____, "Science and Writing Assessment - Facts and Figures", National Assessment of Educational Progress, 4: No. 3:1-4, May-June, 1971.

broken down into age category, geographical regions of the United States, and size of community.

The objectives⁵⁹ of the science test were stated as follows:

1. know fundamental facts and principles of science.
2. possess the abilities and skills needed to engage in the process of science.
3. understand the investigative nature of science.
4. have attitudes about and appreciations of scientists, science, and the consequences of science that stem from adequate understandings.

Iona⁶⁰ raised the question, after reviewing the test, whether more than the first objective was really assessed. He further claimed that most exercises were based on memorization rather than experience.

Soon after the 1969 assessment of Science, an extensive process of review and revision began.⁶¹ This resulted in two major changes. The first change was the alteration of the structure of presentation in order to obtain a more

⁵⁹Ibid., p. 2.

⁶⁰Maria Iona, "Physics Teaching and the National Assessment of Educational Progress", The Physics Teacher, November, 1970, pp. 445-448.

⁶¹_____, Science Educators, "Consultants Revise Science Objectives", N.A.E.P. Newsletter, Vol. 3:5-6, May, 1972.

accurate assessment of the objectives. In addition, the objectives were stated behaviorally. Each of the previously stated objectives were broken down into more than forty-five descriptions of behaviors that each age level must meet to complete the objective.

The second science assessment tests were given⁶² between October, 1972, and July, 1973. A comparison of the results of this test with that of the 1969 test should indicate whether citizens in the United States have more knowledge, skills and attitudes toward science now than they did in 1969, (the date of the first assessment).

Because the 1973 data was not yet available, and the 1969 data was of questionable value except for the first objective, this work was not used to any great degree in this paper.

The last, and probably most significant recent study on current practices in the high schools was done in the Northeastern states during the 1971-72 school year.⁶³ In this

⁶² _____, "Second Round for Science Assessment", N.A.E.P. Newsletter, V:6:4, October, 1972.

⁶³George Ivany, Richard Mullaney, Douglas Huegal, Russell Faust, and A.A. Strassenburg, High School Physics Teaching: A Report on Current Practices, American Institute of Physics, New York, 1972.

study, 107 high schools were randomly selected from the eleven Northeastern States. From the number, 42 participated in the study. The schools were classified as being urban, suburban, rural, or small city. Out of the 42 schools, six were urban, 22 were suburban, eight were rural, and six were small city. These schools were visited for up to a week by the researchers. During these visits extensive data was collected on both the "external factors" and the teachers', students', and administrations' attitudes toward physics.

The most popular curriculum in use was found to be the "traditional", with Modern Physics by Williams, Metcalf, et. al., the most popular text. The second most popular curricula was "P.S.S.C." followed by "Project Physics".

Enrollment of 12th grade students in physics varied according to classification of school. Among the urban schools 12.0 percent of the 12th grade students took physics. In small city schools 13.5 percent took physics, while 18.8 percent of the rural 12th graders studied physics. In suburban schools 23.4 percent, or the largest percentage, took physics. This meant that for the entire sample, 20.9 percent of the seniors studied physics.

The authors reported that enrollment went up only one

percent over the previous year. This gain was made in schools just changing to the Project Physics curriculum. Schools that used this curriculum for more than one year, showed no growth in the number of students.

Out of the 42 schools visited, the researchers collected data from 32 teachers on the number of semester hours they had completed in the various sciences. They found the teachers averaged 41.7 hours in physics, 23.4 hours in mathematics, 18.9 hours in chemistry and 10.2 hours in biology.

Another aspect of the study was to ask the teachers six questions dealing with their philosophy of physics teaching. These questions gave an indication of the teachers' objectives. The first question asked the teachers concerned changes in students' attitudes toward studying physics. Of the forty-two teachers asked, twenty-seven felt the students attitudes were changing. Fourteen felt the attitudes were becoming more positive, while the rest felt that the students were turning away from physics.

The second question asked was which type of physics curricula, (none, applied, traditional, experimental, or cultural-historical), was best for each of the following specific student groups: science, arts, technical, terminal.

By far the greatest number of teachers (22) felt an experimental physics course was best for the science student. For the art student the same overwhelming number (22) felt a cultural-historical physics course was best. A cultural-historical course was felt best (19) for the technical student, and only seven teachers felt an applied course should be implemented for this type of student. Finally, for the terminal student there was mixed reaction. Fourteen teachers felt a cultural-historical course was best, while eleven favored no physics course at all.

Question three listed eight objectives and had the teachers list them in the order they strive to reach them. The following list is the rank order the objectives were listed in by the composite of teachers.

1. A verbal and mathematical understanding of the topics covered in physics.
2. Knowledge of the methods physicists use to discover and validate knowledge in physics.
3. Ability to use some general techniques of data analysis such as: consideration of errors, numerical statistics and graphical display.
4. Increased interest in physics as evidenced by outside reading and discussion about topics in physics.
5. Skills derived from laboratory manipulation of common physics apparatus.
6. Possession of knowledge about important facts, laws, and theories of physics.
7. Knowledge of the cultural and historical aspects of physics.
8. Increased understanding and approval of the role of the scientist in our culture.

Question four tried to have the teachers classify the classroom organization and the teacher-student relationship. The majority of the teachers (28) picked the category "rationally prescribed" which is defined as, "behavior is justified by some understood, logical, enlightened system; authority and standards function for the teacher and the student through the control of the logical system."

Question five determined the teachers' attitudes on the role of the laboratory. Twenty-two of the teachers felt the proper role of the laboratory was primarily to demonstrate concepts, laws, etc. Eight teachers believed in open-ended laboratory investigations. Thirty-one teachers required a written lab report, and twenty-seven of these had a special laboratory report format.

The last question asked the teacher to list in order of difficulty the constraints imposed, which prevented or hindered effective teaching. In order of popularity the four responses that received more than ten responses were Space (19), Schedule (18), Budget (14), and Administrative Policy (12).

In addition to the above aspects of the study, other information was collected. This included a complete listing of equipment available, a detailed questionnaire given to

the physics students, followed up by an interview with a randomly selected number of students. Finally, a detailed breakdown was made on what the physics teacher did in the classroom.

Criteria for determining the present state of physics teaching in the high schools.

The studies in this section were used as a basis for determining what conditions are necessary for good physics teaching in the high schools. In an analysis of these studies, three problem areas were often repeated. These areas are as follows:

1. The professional status and continuing education of the high school physics teacher.
2. The facilities necessary for effective high school physics teaching.
3. The decision of who should take high school physics.

The first four studies reported were conducted by groups or committees on a national or international scope. They were included in this review to insure a thorough analysis of previous studies of high school physics programs.

The European Economic Cooperation Report⁶⁴ analyzed the current status of physics education in Europe in 1960 and made recommendations for improving the situation. This committee found the main defect in European secondary physics was the small enrollment. Only the very best students took physics. To try and correct this, a physics course for general education was recommended. The main differences in this course were:

1. to relate physics to other sciences and to the environment whenever possible.
2. to be more practical and less abstract.
3. to not teach mechanics at the start of course, but start with atomic physics. Introduce mechanics only when needed.
4. laboratories should be included, but not all at once. Introduce them progressively.
5. try to avoid mathematics, but when needed, actually teach them the mathematics they can see use for.
6. on exams do not emphasize numerical exercises.

The committee felt the major hurdle in implementing these recommendations would be the lack of well-trained teachers in physics. Most teachers did not have enough physics background.

In July 1960, more than one hundred delegates from

⁶⁴European Economic Cooperation, Physics Today, 14:31-38, January, 1961.

twenty-nine nations met at The Paris Conference,⁶⁵ to discuss problems in physics education. As a result of this conference, three recommendations were made pertaining to high school physics being taught throughout the world.

These were:

1. in secondary schools, physics should be taught by a person who has had professional training in physics. Teachers must be encouraged to keep their professional experience up to date. The experimental nature of physics places an added burden on the teacher and this must be recognized and adequately compensated by a reduction of teacher hours and in other suitable ways.

2. improvement of salary and status are necessary, but most important are better conditions of work. Apparatus, better facilities and, when needed, technical assistance should be easily available.

3. universities should accept the responsibility to establish close relations with secondary schools and provide refresher courses. These courses would require extended periods of study-leave for teachers.

The U.S. Office of Education conducted a study in 1967 headed by Rogers⁶⁶ on the teaching of science in the public junior high schools. This study used a questionnaire which

⁶⁵Paris Conference, "Physics Education," Physics Today, 14:28-30, January, 1961.

⁶⁶Lola E. Rogers, Science Teaching In the Public Junior High Schools, (Washington, D.C.: U.S. Office of Education, 1967), Catalog No. 5.229:29067.

was sent to a random group of junior high schools throughout the United States. Even though this study was done on the junior high school level, a number of interesting ideas and methods of approach were revealed. Five areas of investigation were chosen. These were: 1) enrollment and organization of the schools, 2) enrollment and organization of the sciences, 3) instructional resources for science, 4) funds for science, and 5) science clubs and fairs. As a result of the findings, Rogers made several recommendations:

1. to provide in-service training for the teachers.
2. to have a science consultant in many schools.
3. to use the laboratory more extensively.
4. to use newer textbooks.
5. to provide access for more students to science fairs and clubs.

The National Academy of Sciences,⁶⁷ in 1969, appointed a committee to survey the entire United States' physics enterprise. The committee's report was released in July, 1972. This survey was broken down into fourteen areas. These were: 1) origin, objectives and organization, 2) recommendations, 3) the nature of physics, 4) the subfields of physics, 5) priorities and program emphasis in physics, 6) the

⁶⁷D. Allan Bromley, "Physics in Perspective," Physics Today, 25:7:23-35, July, 1972.

consequences of deteriorating support, 7) physics and U.S. society, 8) international aspects of physics, 9) the institutions of physics, 10) the support of U.S. physics, 11) physics in education and education in physics, 12) manpower in physics, 13) dissemination in physics, and 14) policy considerations. Only area eleven dealt with education, and most of this effort, according to Bromley,⁶⁸ dealt with undergraduate and graduate physics programs. Very little time was spent dealing with the problems of high school physics or in the preparation of high school physics teachers.

The committee found that the enrollment in high school physics had been decreasing percentage-wise ever since 1948. This occurred even in the early 1960's when Sputnik created such an interest in physics and engineering. It was reported that one reason for this decline was the lack of "good" teachers. In the 1960's many of the well-trained teachers found more attractive employment outside the high school classroom. Hopefully, the committee concluded, this pattern was reversing itself with the oversupply of physicists.

Several studies on high school physics teaching which

⁶⁸Ibid., p.29.

were of interest to this research have been done by individual researchers. In a study done by Trowbridge,⁶⁹ a list of seventy-two long range objectives for a high school physics class were compiled. These were obtained by consulting with teachers, authors of textbooks, and members of the Physical Science Study Committee. These objectives were then submitted to 200 classroom teachers to allow them to pick the objectives they felt were more important. It was found that sixteen of the objectives were unique to P.S.S.C. teachers, (listed on page 149), seventeen were unique to "traditional" objectives. Trowbridge concluded that these responses differed significantly, and that this was one method of measuring the differences in the two programs.

Kruglak's study^{70,71} consisted of administering the Dunning Physics Test, Form BM, to all entering freshmen at

⁶⁹Leslie W. Trowbridge, "A Comparison of the Objectives and Instructional Materials In Two Types of High School Physics Courses", Science Education, 49:117-122, March, 1965.

⁷⁰Haym Kruglak, "Pre- and Post-Sputnik Physics Background of College Freshmen", Journal of Research in Science Teaching, 6:42-43, 1969.

⁷¹Haym Kruglak, "Pre- and Post-Sputnik Physics Background of College Freshmen - II", Journal of Research in Science Teaching, 7:41-42, 1970.

Western Michigan University in 1958, 1963, and 1968. From the results of this test, a comparison was made with the physics background of college freshmen, pre-Sputnik to post-Sputnik.

The Dunning Physics Test was a standardized test with 75 multiple choice items. It tests the objectives and subject matter which existed before the curricular reforms of the 1950's. There were four subgroups of the test: 1) factual information, 2) understanding concepts, 3) applying principles, and 4) using mathematics.

Kruglak concluded from his investigation that:

1. there was no significant difference in the mean scores of girls in 1958, 1963, and 1968.
2. the mean score of the boys in 1963 was higher than those of 1958 and 1968. There was no difference between the mean scores of 1958 and 1968.
3. the male achievement was higher all three years than the female achievement.
4. school size, method of instruction (traditional vs P.S.S.C.), and students' rating of their physics teacher seemed to have no effect on the physics scores of entering freshmen.
5. the percentage of freshmen entering school with high school physics increased significantly between 1958 and 1963, but then decreased between 1963 and 1968. These trends were independent of school size. Female percentages remained fairly constant, while male enrollments changed.

A chapter devoted to the current trends in high school

physics was included in a book written by Marshall and Burkman⁷² in 1966. This chapter devoted itself almost entirely to giving a historical perspective on the development of P.S.S.C. physics. In the course of doing their study, an overview of the typical "traditional" syllabus and the new syllabus of P.S.S.C. physics was given. The main differences noted by Marshall and Burkman were:

1. P.S.S.C. covers less material, but goes into these areas in more depth.
2. P.S.S.C. develops physical models and uses them much as scientists do.
3. P.S.S.C. physics is unified and an interconnected story.
4. P.S.S.C. places less emphasis on applications.
5. P.S.S.C. integrates the laboratory more closely with the rest of the course.
6. P.S.S.C. provides a more diverse amount of teaching materials.

Existing problems were raised at the end of the chapter. The question of enrollment and the selectivity of P.S.S.C. Physics was discussed. The concern over the proper grade level for physics, as well as the development of a two-year coordinated physics-chemistry course, seemed to indicate that a solution to this problem was being sought by many teachers. In addition, the new elementary science curricula

⁷²J. Stanley Marshall, and Ernest Burkman, Current Trends in Science Education, The Center for Applied Research In Education, Inc., New York, 1966.

were mentioned to point out that in some schools physics was being taught at the elementary level.

Finally, several checklists or listings of conditions necessary for good physics teaching were prepared. A checklist to be used in evaluating a science program has been prepared by the U.S. Office of Education.⁷³ This checklist was developed to be used by school districts to evaluate their science program at all grade levels. A broad participation of teachers, principals, and superintendents was encouraged to obtain the most satisfactory results. Areas of exploration included planning, goals, curriculum, evaluation, staff, administration, finances, and facilities.

The National Science Teacher's Association⁷⁴ has produced a self-inventory for science teachers to help them "judge for themselves the extent they meet reasonable professional standards". The questionnaire followed the format of the recommendations of the 1968 Commission On Professional Standards and Practices of the National Science Teacher's

⁷³U.S. Office of Education, "Suggested Checklist for Assessing a Science Program," Government Printing Office Document OE-29034A, 1964.

⁷⁴National Science Teacher's Association, "The National Science Teacher's Association Annual Self-Inventory for Science Teachers", The Science Teacher, September, 1970.

Association. The questions reflected the 65 conditions for effective science teaching developed by this commission. (listed in Appendix H, page 269). They believed that the professional science teacher:

1. is well educated in science and the liberal arts.
2. possesses a functional philosophy of education and the technical skills of teaching.
3. continues to grow in knowledge and skill throughout his career.
4. insists on a sound educational environment in which to work.
5. maintains his professional status.
6. contributes to the improvement of science teaching.
7. takes a vital interest in the quality of future science teachers.

In Montana, A Study Guide For Physics⁷⁵ was developed in 1961, by the Montana Science Curriculum Committee. This guide listed the physics topics necessary to cover a minimum high school physics course. It also contained additional subject matter which could be used as supplemental material. In an appendix to the guide there were listed films and reference sources that could be used by the high school physics teacher.

The Commission on Professional Standards and Practices

⁷⁵Montana Science Curriculum Committee, The Study Guide in Science, State Superintendent of Public Instr., 1961.

was established in 1968 by The National Science Teacher's Association.⁷⁶ This commission, in 1970, published a list of 65 conditions (listed in Appendix H, page 269), they felt were necessary for effective science teaching to occur. This list was broken down into three sections: 1) Resources for Learning, 2) Conditions for Instruction, and 3) Professional Growth.

This list was very comprehensive, and served as an important document in determining the criteria for good science teaching. The Commission⁷⁷ did point out, however, that it was not possible to specify how to insure good science teaching, but that the conditions listed in this document generally contributed to effective science teaching.

Piaget's Theory of Learning and Related Studies.

Piaget's⁷⁸ theory of learning deals with the psychological development of children. His work has recently been

⁷⁶Commission on Professional Standards and Practices, Conditions for Good Science Teaching in Secondary Schools, National Science Teacher's Association, Washington, 1970.

⁷⁷Ibid., p. 1.

⁷⁸Jean Piaget, The Child's Conception of Physical Curiosity, Littlefield, Adams, Patterson, New York.

recognized as having important consequences to physics education.⁷⁹

Piaget divided a child's mental development into four stages. The first stage occurred during infancy and was called the "sensory motor, preverbal" stage. At this time the child established by a combination of visual and kinesthetic explorations, simple spatial relations, and the permanent existence of objects.

The second stage Piaget called "pre-operational." During this stage, the present appearance of objects can be described by the child, but any changes of the objects can not be comprehended.

In the third stage or "concrete operations" stage, the child is able to reason by using operations such as classification, serial ordering, and time sequencing on objects. He is not yet able to verbally express such operations.

The "formal operation" is the fourth stage, and when this stage is reached, the individual can reason about the relationships and implications of a hypotheses as well as an actual physical operation.

Piaget hypothesized that a person must pass through

⁷⁹Jean Piaget, "Physical World of the Child", Physics Today, 25:6:23-27, June, 1972.

each stage before the next stage can be reached. It is apparent that for high school physics instruction to be successful, as presently taught, all the students need to be in the last stage. Most of the nationally popular curricula have not considered the possibility that some students have not reached the "formal operation" stage.⁸⁰

Tisher⁸¹ tested a questionnaire he developed to determine the Piagetian stage of development for a secondary school student. He compared the results of the questionnaire with those obtained in an interview test with the same students. He found a 77 percent agreement between the two methods.

Table II on page 70, shows the distribution of pupils age, and stage of development. The largest number of students were still in concrete operations. Also, the older the age group, more students in the formal operational stage of development.

⁸⁰J.W. Renner, and A.E. Lawson, "Piagetian Theory and Instruction in Physics", The Physics Teacher, 11:165-169, March, 1973.

⁸¹R.P. Tisher, "A Piagetian Questionnaire Applied to Pupils in a Secondary School", Child Development, 42:1633-6, November, 1971.

TABLE II
DISTRIBUTION OF PUPILS' AGES AND STAGES OF DEVELOPMENT

Stage of Development	Age (in years)			Total
	12.0-13.4	13.5-14.9	15.0-16.4	
Concrete	74	71	21	166
Formal	7	41	18	66
Total	81	112	39	232

Renner and Stafford⁸² conducted a study in 1971 to determine the Piagetian intellectual level of the students of Oklahoma's secondary schools (grades 7-12). They selected six tasks suggested by Piaget and Inhelder⁸³ for determining the level of the students. A total of 588 students were interviewed. To arrive at this sample, the state of Oklahoma was divided into various sections based upon the type of activity, (agriculture, mining, industrial, etc.), the citizens used to support themselves and the concentrations of population (rural-urban-ghetto). Schools were then randomly selected from the sections, and students were

⁸²J.W. Renner and D.G. Stafford, Teaching Science In the Secondary School, Harper & Row, New York, 1972, pp. 291-300.

⁸³Jean Piaget and Barbel Inhelder, The Psychology of the Child, Basic Books, New York, 1969, p. 99.

randomly selected from the schools.

The results of this study are shown in Table III. This table compares the grade level of the students and the classification of intellectual level. The authors have defined in this study, the post-concrete operational stage as a transitional stage between concrete and formal operational stages.

TABLE III
DISTRIBUTION OF PUPILS' GRADES AND STAGES OF DEVELOPMENT

Grade Level	Pre-operational	Concrete	Post Concrete	Formal
7	5	75	13	3
8	3	81	18	6
9	4	74	7	9
10	4	65	15	10
11	3	65	19	12
12	1	63	15	18
Total	20	423	87	58

The authors felt this data clearly showed that the majority of the students in the secondary schools were functioning at an intellectual level below the formal operational stage.

One implication of this research, according to Renner and Stafford, was that more laboratories and other activities that were meaningful to the concrete operational student

were needed in the science programs of the Oklahoma secondary schools.⁸⁴

⁸⁴J.W. Renner, and D.G. Stafford, op. cit., p. 297.

CHAPTER III

DESIGN OF THE STUDY

The objective of this investigation was to determine the current status of physics teaching in the high schools of Montana. This chapter will outline the procedures that were followed to complete this objective. For clarity and continuity, the steps are organized in chronological order according to when they were done.

Fall Report

Each year the State Department of Public Instruction in Helena, Montana, requires individual school districts to complete a set of forms in order to provide statistical data for planning and evaluating public education in the state. One of these forms is called the "Fall Report". This form contains information about the teachers, the classes they teach, and the size of their various classes. In this study, an analysis of these forms was made to determine basic information about Montana physics teachers. From the "Fall Report", the following data was taken:

1. the number of high schools and their enrollments.
2. the number of physics classes taught.
3. the student enrollment in the physics classes.

4. the number of teachers involved in physics teaching.
5. the degrees, as well as the college quarter hours of credit taken by the teachers in the areas of science and mathematics.
6. the years of teaching experience of the physics teachers.
7. the salaries of the physics teachers.

Altogether the reports from 1970, 1971, and 1972 were studied. In order to get the information needed for items five and six above, the 1970 reports were used. The reason for this was due to a change in the report forms in 1971. The more recent forms no longer require this information. This information was checked again in the questionnaires and interviews. This was done to insure valid data.

It was found that there were 167 public secondary schools in Montana in the fall of 1972. To better understand the distribution of student enrollment in these schools, Table IV, on page 75 categorized the secondary schools according to student population. It should be noted that although 79 percent of the schools have enrollments of less than 300 students, over 67 percent of the public high school students in Montana attend schools with enrollments greater than 300. The data in Table IV does not include students attending ninth grade in a junior high school. If these figures were included, the percentage of students attending schools over 800 would increase. In order to

TABLE IV
ENROLLMENT IN MONTANA SECONDARY SCHOOLS IN 1972

Enrollment Size	No. of Schools	% of Schools	Total No. of Students Attending	% of Total Students Attending
1-100	59	35%	3,285	7.1%
100-300	73	44	11,767	25.3
300-800	21	13	9,763	21.0
OVER 800	<u>13</u>	8	21,683	46.6
	167			

settle this dichotomy between the number of schools and the number of students, it was decided that the sample for this study should be stratified. The four student enrollment categories listed in Table IV were used in collecting and reporting the data.

Development of Questionnaire

The second step in this investigation was to gather information from all the physics teachers in Montana. This was done by means of a mailed questionnaire. Two questionnaires were developed. These were called the "High School Physics Questionnaire" (see Appendix D, page 250), and the "Teachers' Objectives Questionnaire" (see Appendix E, page 256). The "High School Physics Questionnaire" was developed

by the present researcher. It was reviewed by a panel of experts at Montana State University consisting of both educators and physicists. Their recommendations were incorporated and necessary revisions were made.

During the 1971-72 school year the questionnaire was distributed to ten high school physics teachers in Wisconsin. Their comments and recommendations were used to construct the final form of this questionnaire. The areas explored by this questionnaire fell into four main categories. These were:

1. An extension of the "Fall Report" information about the teacher: the degrees earned; the quarter hours completed in physics, mathematics, and other science areas; the years of teaching experience; membership in professional organizations; and participation in financially supported academic work in physics.
2. An extension of the "Fall Report" information on the physics classes themselves. A determination was made of what physics classes were available in the high schools of Montana. The teachers were asked to list the textbooks they used for each class, the prerequisites they set for the students in each class, and, in their opinion, to what extent they

incorporated the P.S.S.C. and Harvard Project Physics material into these classes.

3. The opinions of the physics classroom teachers as to the adequacy of certain factors in their school related to teaching. Areas explored included room facilities, laboratory equipment, audio-visual equipment, library facilities, and rapport between physics teachers and the administration.
4. To determine subjectively with open-ended questions what college courses were missing or were taken and not needed in the physics teacher's college preparation. In addition, inquiry was made as to how the colleges and universities, Federal Government, and/or State Department could be of more service to them in their physics teaching.

The "Teachers' Objectives Questionnaire" was developed by Trowbridge.¹ The same instructions, as well as format that were used by Trowbridge were used in this study. Only the thirty-three most significant objectives determined by Trowbridge were included in the Teachers' Objectives

¹Leslie W. Trowbridge, "A Comparison of the Objectives and Instructional Materials in Two Types of High School Physics Courses", Science Education, 49:117-122, March, 1965.

Questionnaire" used in this study. This questionnaire was also given during the 1971-72 school year to ten physics teachers in Wisconsin. There were several comments about the difficulty in arriving at an answer for some of the objectives. The Wisconsin teachers felt, however, that this was most likely due to the difficulty in thinking out and concretely defining one's teaching objectives.

Mailing of Questionnaire

On September 22, 1972, the questionnaires were mailed. The "High School Physics Questionnaire" was mailed to all 149 physics teachers in Montana. The "Teachers' Objectives Questionnaire" was sent to all physics teachers in schools with enrollments greater than 300, and to half the teachers with enrollments less than 300. This insured an adequate number of returns for the analysis. The teachers in the smaller schools who received the questionnaire were randomly selected. Altogether 93 of these questionnaires were sent. A copy of the cover letter sent with the initial mailing can be found in Appendix B, page 248.

On October 16, 1972, a follow-up letter was sent along with copies of the questionnaire to those teachers who had not replied. A copy of this letter can be found in Appendix C, page 249.

On October 30, 1972, the investigator telephoned those schools who had not replied, and talked to either the secretary or principal to determine if anyone at the school was qualified to fill out the questionnaires. Only schools that had taught physics once during the last two years, or had a physics teacher on the staff, were considered part of the population. The number of useable questionnaires are shown in Tables V and VI on page 80.

The "High School Physics Questionnaire" was returned by 81 percent of the total sample. Altogether 121 of the questionnaires were returned out of the 149 sent. The return from the larger schools was greater than 81 percent. The larger schools had more students enrolled in physics. Therefore, this data represented what over 81 percent of the high school physics students would experience in their high school physics classes.

The response to the "Teachers' Objectives Questionnaire" was 84 percent. Altogether 78 questionnaires were returned out of the 93 sent. Some teachers did not complete the objectives on the back of the first page. These were used for the objectives that were completed. Three questionnaires were returned uncompleted with notes from the teachers, indicating they were too inexperienced.

TABLE V

RETURN OF "HIGH SCHOOL PHYSICS QUESTIONNAIRE"

School Enrollment Size	No. of Schools in Sample	No. of "High School Physics Questionnaires" Mailed	No. Returned	% Returned
1-100	46	46	38	83%
101-300	68	68	52	76%
301-800	21	21	17	81%
OVER 800	<u>14</u>	<u>15</u>	<u>14</u>	<u>93%</u>
	149	150	121	81%

TABLE VI

RETURN OF "TEACHER OBJECTIVES QUESTIONNAIRE"

School Enrollment Size	No. of Schools in Sample	No. of "Teachers' Objectives Questionnaires" Mailed	No. Returned	% Returned
1-100	46	23	20	87%
101-300	68	34	29	85%
301-800	21	21	16	75%
OVER 800	<u>14</u>	<u>15</u>	<u>13</u>	<u>87%</u>
	149	93	78	84%

Personal Visits

A total of twenty-two schools from the sample were randomly selected to visit personally. No school was selected that was not offering physics during the 1972-73 school year. This was necessary because a personal visit was made to each of these schools to study the physics teaching at the school.

Due to the large variations in the high school enrollments, a stratified sampling was made. The stratification used was the same as the overall pattern of this research project. In order to arrive at a result that could be interpreted as what the "average" student in Montana would encounter in high school physics, the size of each stratified sample tried to approximate the total percentage of students attending each size range of schools. However, in order to have a more reliable sample, a greater number of schools were selected in the smaller enrollment categories than the actual percentage of students justified. It was felt that at least four schools should be visited in each school category, even if the percentage of students did not warrant this many. Table VII on page 82, shows the number of schools selected to visit in each school category. (A list of the schools visited is in Appendix A, page 247).

TABLE VII
RANDOM SAMPLE OF HIGH SCHOOLS THAT WERE VISITED

No. of Students Attending	No. of Schools in This Range	% of Montana Students Attending a School of this Size Range	No. of Schools in Random Sample
1-100	46	7.1%	5
100-300	68	25.3	5
300-800	21	21.0	4
OVER 800	14	46.6	8

The personal visits served as a method of determining the validity of the "High School Physics Questionnaire". More important, however, is that they allowed the opportunity for a thorough analysis of the physics programs at these schools. The information gained from these visits became the basis for interpreting the results of the questionnaires.

The visits were structured as informal interviews. This insured that information pertaining to the same questions could be obtained from each school. It also allowed for greater freedom of expression by the teachers than was gained from the mailed questionnaire. (A copy of the interview form is in Appendix F, page 260).

Besides the interviews with the teachers, inspection

was made of the library facilities, audio-visual facilities, physics classroom facilities, and physics laboratory equipment at the schools. The form used in this analysis is in Appendix G, page 267.

Analysis of Data

The three methods of collecting data were to study "Fall Report" records, to mail a questionnaire to all physics teachers in Montana, and to visit twenty-two randomly selected high schools. All of these data were compiled statistically, and analyzed and presented in Chapter IV.

The information gathered from the "Fall Reports", the "High School Physics Questionnaire," and the researcher's visits to the high schools were compiled and displayed in tables. Means and medians were computed whenever applicable. Data from the earlier studies in Montana and other parts of the United States which have been discussed previously, were also presented in the tables to allow a direct comparison of the results.

The data from the "Physics Teachers' Objectives Questionnaire" were analyzed by both a Chi-Square Analysis and a "t-test" of significant difference. The variables used in the Chi-Square Analysis were the teachers' responses to the teaching objectives and the classification of the teachers

according to student enrollment, physics class enrollment, and years of teaching experience. When the independence or association of two nominal variables is desired, the Chi-Square test of independence can be used.² The test indicated whether the different classifications of teachers had a significantly different response (at the 0.01 level) for each objective.

The Chi-Square test of significant difference was also used in comparing the results of this study to those of Trowbridge's study. The variables again were the responses to the teaching objectives and the classification of the teachers. The responses of the Montana physics teachers during 1972-73 were compared to those of both the "traditional" and "P.S.S.C." physics teachers in Trowbridge's study. The purpose of this test was to determine whether the responses to the objectives differed significantly, (at the 0.01 level), between these different groups of teachers.

The steps followed in the Chi-Square test of independence were outlined by Ferguson,³ in the Statistical Analysis

²George A. Ferguson, Statistical Analysis In Psychology and Education, McGraw-Hill, New York, 1966, p. 200.

³Ibid., p. 200-204.

In Psychology and Education. The formula used for χ^2 was:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

where O = the observed frequency

E = the theoretical or expected frequency

In order to insure a proper test, 80 percent of the cells in the analysis were required to have an expected frequency of five. If this rule was violated, the cells were collapsed until this criteria was met. A further explanation of this collapsing is found in Chapter IV, page 156.

The Fischer's "t" technique was also applied to the responses from the "Physics Teachers' Objectives Questionnaire". The t-test was used to determine if significant differences at the 0.01 level, occurred between the means of the responses to the objectives by Montana physics teachers in 1972-73 and Trowbridge's "P.S.S.C." and "traditional" physics teachers.

When using the t-test two assumptions are that: 1) the distributions of the variables in the population from which the samples are drawn are normal, and 2) the populations have equal variances.⁴ These conditions were not met

⁴Ferguson, op. cit., p. 168.

completely in this study due to the nature of the "Physics Teachers' Objectives Questionnaire". The responses to each objective were limited to a four choice scale. With such an instrument a normal distribution is not possible. Blommers and Linquist⁵ stated that even if these conditions were not met completely, the approximate model would approach the exact model as the non-normal distribution approaches normality. The randomness and size of the sample in this study insured that the distribution would approach normality. Therefore, although the results of the t-test were not exact, they were good approximations. They indicated the trends in the differences between the variables.

By analyzing the data in this manner, the following questions were answered:

1. What is the percentage of Montana high school students enrolled in physics? How does this figure compare to the 1958-59 data? Does the percentage of students enrolled in physics in the large high schools of Montana (total school enrollment of 300 students or more) differ from

⁵Paul Blommer, and E.F. Lindquist, Elementary Statistical Methods, Houghton Mifflin Company, Boston, 1960, p. 355.

the percentage of students enrolled in physics in the small high schools. (total student enrollment of less than 300 students).

2. What is the present number and the availability of physics courses in the Montana high schools? Does the present situation differ from that for the 1958-59 school year?
3. Is physics in Montana a course taken by a select group of students? What are the prerequisites of a student to take physics?
4. What textbooks and curricula materials were being used in Montana during 1972-73? How do the results compare with the findings in Wisconsin during 1970 and the Northeast States in 1972?
5. To what extent were standardized tests from textbook publishers being used in Montana during 1972-73?
6. What is the quality and quantity of physics laboratory equipment in Montana high schools?
7. To what extent have Federal monies been used in Montana high schools for upgrading the physics facilities and teacher preparation?

8. What audio-visual materials are available to the physics teacher in Montana high schools, and to what extent are they used?
9. What is the extent of physics-related library material in Montana high schools?
10. How did the high school physics teachers of Montana rate the administration as far as being sympathetic to the problems involved in teaching high school physics?
11. What is the number of quarter hours of physics taken by the high school physics teachers in Montana? Does the average number differ from the 1958-59 data? Does the number of quarter hours of physics taken by the physics teachers in the large high schools of Montana differ from those taken by the physics teachers in the smaller high schools?
12. What is the number of quarter hours of mathematics and science taken by the physics teachers of Montana? How does this differ from the 1958-59 data?
13. What were the teaching loads for Montana's physics teachers during 1972-73?

14. What degrees had Montana's physics teachers earned?
15. How many years of teaching experience did Montana's physics teachers have?
16. What professional organizations did Montana's physics teachers belong to?
17. What are the teachers' opinions of what would be the most beneficial programs to be undertaken by the Federal Government, state government, and local school boards, to better the physics teaching done in the state of Montana?
18. What, in the physics teachers' opinions should be done to improve the teacher preparation programs in physics in colleges of Montana?
19. Do the course objectives of the physics teachers in the large high schools differ from the objectives of the teachers in the small high schools?
20. Do the course objectives of the physics teachers who teach physics classes of more than ten students differ from those that teach smaller classes?
21. Do course objectives of the high school physics teachers who graduated from college over fifteen years ago differ from the objectives of the

teachers who graduated since then? A physics teacher who graduated over fifteen years ago would not have been exposed to any of the new curricula material while in undergraduate school.

22. Do the course objectives of Montana's physics teachers in 1972, differ or agree with the course objectives of "traditional" or "P.S.S.C." physics teachers in 1960?
23. What is the high school physics teachers' opinion on the most important purpose of high school physics? (This will only be determined from personal interviews)
24. What, from the researcher's viewpoint, after a thorough study of high school physics teaching in the state of Montana, would be most beneficial programs to be undertaken by the Federal Government, state government and local school boards to better the physics teaching done in the state of Montana?

CHAPTER IV

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Introduction

The data from this study are grouped into three main categories. The first category concerns the "external" factors in teaching. This information came mainly from the "Fall Reports" at the State Department of Public Instruction and from the "High School Physics Questionnaire." The second category concerns the teachers' objectives, and this data was obtained from the "Teachers' Objectives Questionnaire". The third and final category is the subjective opinions of the teachers and this researcher. This information was obtained from the personal interviews of the twenty-two randomly selected high school physics teachers in Montana. (See Appendix A, page 247). The interview data is analyzed in Chapter V.

EXTERNAL FACTORS IN PHYSICS TEACHING

Enrollment

A major concern of many physics educators has been the declining enrollments in physics. In this study, a comparison was made of the 1972-73 enrollment in physics in Montana

high schools with the 1958-59 data.¹ Total student enrollment in the Montana high schools was 33,761 during 1958-59. Of these students, 5.5 percent took physics. This meant there were 1,857 physics students. The enrollment in physics is often represented as the percentage of graduating high school students who had taken physics. Because physics was taken by juniors and seniors, it has to be assumed that these figures remain constant for two years. To determine this percentage, the number of physics students was divided by the total number of seniors. In 1959, 22 percent of the graduating students from all the Montana high schools had taken a physics course.

In 1972-73 these figures had changed. The total number of high school students in Montana had grown to 46,791. Of these students 4.2 percent or 1,967 were taking a physics course. These figures mean that 14.7 percent of the graduating students in 1973 had taken physics. These figures compare similarly with those found in the Northeast States²

¹J. W. Gebhart, "The Teaching of Science In the Secondary Schools of Montana", (unpublished Doctorate thesis, Ohio State University, 1960, p. 56).

²George Ivany et. al., High School Physics Teaching: A Report on Current Practices, American Institute of Physics, New York, 1972, p. 5.

during 1971-72, as shown in Table VIII on this page.

TABLE VIII
PERCENTAGE OF GRADUATING STUDENTS WHO TOOK PHYSICS

Montana (1973)				Northeast States (1972)			
>800*	301-800	101-300	0-100	Urban	Small City	Sub-urban	Rural
15%	14%	13.3%	19%	12%	13.5%	23.4%	18.8%

*This does not include Butte High School because during the 1972-73 year they were undergoing a curriculum change that affected physics enrollments.

To put the enrollment figures in perspective with the other sciences, Table IX on page 94 shows the percentage of the 1973 graduating high school students from Montana, who had taken biology and chemistry. The percentage of graduating students who had taken biology and chemistry had not changed as much as physics since 1958-59. At that time, 84 percent had biology, and 30.4 percent had chemistry.³ The chemistry percentage had risen slightly in Montana since 1959

³Gebhart, op. cit., p. 56.

TABLE IX
 PERCENTAGE OF GRADUATING STUDENTS
 IN 1973 WHO HAD TAKEN THESE SCIENCE COURSES

School Enrollment	>800*	301-800	101-300	0-100	Total
Biology	72%	95%	94%	83%	83.1%
Chemistry	28%	38%	34%	37%	32.3%
Physics	15%	14%	13.3%	19%	14.7%

*This does not include Butte High School.

Availability of Physics Courses

The availability of physics classes to the high school students was studied. Of the original 167 schools who filed "Fall Reports" in 1971, 149 either offered physics during the 1972-73 school year or offered it during the preceding year. Of the remaining eighteen schools, three closed due to consolidation at the end of the 1971-72 school year. The other fifteen schools did not offer physics on a regular basis. However, some of the schools indicated that with the turnover of teachers, if they hired a teacher who could teach physics, this course would be offered.

Table X gives the number of schools that offered physics every year and alternating years with chemistry. It also lists the number of schools that offered more than one type of physics. .

TABLE X
THE AVAILABILITY OF PHYSICS COURSES⁴
IN 1972-73 COMPARED WITH 1958-59

(1958-59) School Enrollment	> 800	301-800	101-300	0-100
Each Year	7	16	19	4
Alternate Years	0	2	34	63
No Physics	0	0	1	27
Total Schools: 173				
(1972-73)				
Each Year	14	20	37	3
Alternate Years	0	0	31	43
No Physics	0	1	5	10
Offers More Than One Type of Physics	5	0	0	0
Total Schools: 164				

⁴Ibid., p. 51.

It can be noted from Table X, page 95, that all schools except one with an enrollment greater than 300 offered physics every year. Only five schools in the entire state indicated they offered more than one type of physics course for students with differing interests and abilities.

Although some schools have closed since the 1958-59 school year, and there has been a general shift upward in school enrollment, there has been no major change in the availability of high school physics in Montana. However, one change that has occurred as the schools grew larger, was an increase in the number of schools that offered physics every year, instead of alternating years.

Prerequisites and Teacher Rating of Physics Students

Since 1958, the total high school enrollment had increased. The student enrollment in physics, however, had remained almost constant. High school physics was just as readily available to the student in 1972 as in 1958. What type of students were taking physics in Montana high schools during 1972-73? To determine this, the teachers were asked to rate the students who took physics at their school.

Table XI, on page 97 shows the results.

As can be seen from this table, the teachers felt that

only "above average" or "superior" students took physics. In fact, the teachers indicated they discouraged many students from taking physics. Among the 117 teachers responding to the question, 45.3 percent indicated they had discouraged some students. The most common type of student discouraged, according to the teachers' responses, were students with:

	No. Responding
poor previous math and/or science performance	25
poor or low ability	13
poor academic record	12
counselor or administrative discouragement	6
lazy or poor attitude	5

TABLE XI
THE TEACHERS' INTELLECTUAL RATING OF THE STUDENTS
WHO TAKE PHYSICS AT THEIR SCHOOL

School Enrollment	>800	301-800	101-300	0-100	Total
Predominantly Superior Students	7	6	12	6	31
Predominantly Above Average Students	7	11	35	26	79
Predominantly Average Students	0	0	3	4	7
Predominantly Below Average Students	0	0	0	0	0
Total Responding	14	17	50	36	117

Even without direct teacher discouragement, certain prerequisites could indirectly discourage students from taking physics in high school. According to Van Koevering,⁵ one of the main characteristics of high schools with low physics enrollments were those with certain math prerequisites. His research concluded that any prerequisite over Algebra I, discouraged students from enrolling in physics. Table XII gives the math prerequisites in Montana high schools during 1972-73. As can be seen from Table XII, only 31.6 percent of the schools had a math prerequisite of Algebra I or below.

TABLE XII
NUMBER OF HIGH SCHOOLS WITH DESIGNATED
MATH PREREQUISITES DURING 1972-73 SCHOOL YEAR

School Enrollment	>800	301-800	101-300	0-100	Total
No Math Prerequisites	3	0	8	4	15
Algebra I	4	1	9	8	22
Geometry	3	2	10	15	30
Algebra II	4	10	21	7	42
Other (trig.) etc.	0	4	2	2	8

⁵Thomas E. Van Koevering, "The Distinguishing Characteristics of High Schools with High and Low Enrollments In Physics", Journal of Research in Science Teaching, 8:37-39, 1971.

To get an indication of other types of prerequisites students must have had to fulfill in 1972-73 in order to take high school physics in Montana, four prerequisites were listed on the questionnaire, and the teachers were instructed to mark the ones that applied to their school. Table XIII presents this information.

TABLE XIII
NUMBER OF HIGH SCHOOLS WITH DESIGNATED
PREREQUISITES DURING 1972-73 SCHOOL YEAR

School Enrollment	>800	301-800	101-300	0-100	Total
Grade Point Average	2	3	3	4	12
Teacher Approval	2	3	13	10	28
Counselor Approval	2	3	9	6	20
Non-Math Course Prerequisite	2	4	7	2	15

Textbooks and Curricula Materials Used

The type of physics course that was offered to the students greatly influences the enrollment. From Table X, on page 95, it was found that only five schools in the state offered more than one type of physics course for students of

varying ability and interests. This means that at most schools, the student could take only one type of physics course.

The textbooks influence the type of physics course offered. Table XIV lists the textbooks that were most commonly used in the Montana high schools during the 1972-73 school year.

TABLE XIV
NUMBER OF HIGH SCHOOLS USING DESIGNATED
TEXTBOOKS DURING THE 1972-73 SCHOOL YEAR

Enrollment	>800	301-800	101-300	0-100	Total
<u>Modern Physics</u>					
Williams, et.al.	5	9	29	21	64
<u>P.S.S.C.</u>					
<u>Physics</u>	2	1	5	3	11
<u>Project</u>					
<u>Physics</u>	4	0	5	0	9
Other	3	7	9	12	31

Other textbooks commonly used were:

<u>Physics:</u>	Stollberg & Hill	(10)
<u>Physics:</u>	<u>Its Methods & Meanings</u> Taffel	(4)
<u>Physics:</u>	Minor & Kelley	(3)
<u>Physics:</u>	Genzer & Younger	(3)

These results are compared to those found in Wisconsin⁶ and the Northeastern States⁷ in Table XV.

TABLE XV
COMPARISON OF TEXTBOOKS USED IN MONTANA
WITH WISCONSIN AND NORTHEAST STATES

	Montana		Wisconsin		Northeast States	
	No.	%	No.	%	No.	%
<u>Modern Physics</u>	64	55.7	119	58.3	8	13.6
<u>P.S.S.C.</u>	11	9.6	43	21.1	19	32.2
<u>Project Physics</u>	9	7.8	8	3.9	10	16.9
Others	31	16.9	34	16.7	22	37.3
Total	115	100.0	204	100.0	59	100.0

It can be seen that Modern Physics was about as popular in Montana as in Wisconsin. Project Physics was used more in Montana than Wisconsin, but these figures were difficult to compare. Project Physics came out for use only one year before Hale and Smith's study. They indicated this was one reason they found so little use of it. It was three years

⁶H. E. Hale IV, and J.R. Smith, "Trends in High School Physics - A Survey In Wisconsin", The Science Teacher, February, 1971, p. 33-34.

⁷Ivany, op. cit., p. 7.

after the introduction of Project Physics when Montana was sampled. This could explain the increased popularity.

P.S.S.C. Physics was less popular in Montana than in Wisconsin.

The textbooks used in the Northeast States during the 1971-72 school year, differed greatly from those in Montana. This could be due to a difference between the two areas or because of Ivany's et. al., sampling technique. They indicated that schools in suburban areas made up over 50 percent of their sample, while the remaining schools were fairly equally divided between urban, rural, and small city. Suburban schools differ from most Montana schools in many different aspects, such as finances available and student population.

In addition to the basic textbook, it was also determined what supplementary texts were used. In order of preference, the following textbooks were listed:

<u>P.S.S.C. Physics</u>	(18)
<u>Modern Physics</u>	(8)
Various University Textbooks	(7)
<u>Project Physics</u>	(5)
<u>Foundations of Physics</u> Lehrman & Swartz	(4)

P.S.S.C. Physics was the most popular supplementary textbook. Most of the more popular textbook authors had prepared tests that could be used along with their textbook. Table XVI gives the number of teachers that used tests in 1972-73.

TABLE XVI
USE OF STANDARDIZED TESTS FROM TEXTBOOK PUBLISHERS

Enrollment	>800	301-800	101-300	0-100	Total
Exclusively	0	0	2	0	2
Extensively	6	3	12	6	27
Occasionally	1	7	12	10	30
Seldom	4	1	12	7	24
Never	3	6	10	11	30

There was little over all difference between use of these tests and the size of the school. Teachers seem to have used these tests, but tried to supplement them with their own.

Project Physics and P.S.S.C. Physics have made available a large amount of curriculum material. The manufacturers of this material encourage all teachers to use some of this material, even if they do not use their textbook.

Table XVII shows the amount of these materials used by Montana teachers during 1972-73. The table shows the number of teachers that indicated they used a particular item in their classes. A teacher could indicate as many items as they used.

TABLE XVII
USE OF P.S.S.C. AND H.P.P. CURRICULA MATERIAL
IN PHYSICS CLASSES

Enrollment	>800	301-800	101-300	0-100	Total
<u>H.P.P.</u>					
Film Loops	8	1	4	1	14
Films	2	0	2	1	5
Transparencies	3	0	4	0	7
Laboratories	9	5	7	1	22
Supplemental Readings	7	1	4	3	15
Readers	7	0	5	0	12
Tests	3	0	3	0	6
Other	1	0	1	0	2
<u>P.S.S.C.</u>					
Film Loops	4	3	0	0	7
Films	7	3	6	1	17
Transparencies	4	2	4	1	11
Laboratories	12	11	16	11	50
Supplemental Readings	1	3	3	3	10
Readers	0	1	2	0	3
Tests	2	2	2	1	7
Teacher's Guide	4	2	12	6	24
Other	0	0	0	0	0

From these data, it was found that, although the P.S.S.C. and Project Physics textbooks were not used to a great extent, the material developed from these programs have had an impact on the physics teaching in Montana. Many teachers who did not use the textbooks in class, did use the teacher's guides as a resource. The most popular supplemental material from Project Physics was the laboratories, supplemental reading, and film loops. P.S.S.C. laboratories were used by 43.5 percent of the teachers. In addition, many "traditional" laboratory workbooks had incorporated P.S.S.C. laboratories in their list of exercises. Therefore, P.S.S.C., and Project Physics had the most affect on the laboratories in Montana high school physics.

Laboratory Equipment

It was important to determine how adequate the schools' physics equipment was during 1972-73 for teaching high school physics. Therefore, each teacher was asked to evaluate the adequacy of the physics equipment at their school for their particular physics program. In addition, the researcher evaluated the physics equipment found during the visits to the high schools. This is reported in Chapter V. The teachers' estimation of how adequate their school's physics equipment was for the teaching of high school phy-

sics in 1972-73 is given in Table XVIII. This is compared with teachers' evaluations made during the 1958-59 school year.

TABLE XVIII

COMPARISON OF THE TEACHERS' RATINGS OF THE ADEQUACY OF THEIR SCHOOL'S PHYSICS EQUIPMENT BETWEEN 1972-73 AND 1958-59

	1972-1973					1958-59
	800	301-800	101-300	0-100	Total	Total ⁸
More than Adequate	3	2	2	0	7	3
Adequate	8	11	24	17	60	42
Inadequate	3	4	24	20	51	55

From Table XVIII, it was determined that in 1958-59, 55 percent of the teachers felt their equipment was inadequate, compared with 43 percent in 1972-73. It does not appear, therefore, that the teachers' laboratory equipment had improved a great deal since 1958-59. Perhaps with the change in the laboratory approach, and the use of different experiments, different equipment was needed than that which was available in 1958-59. New equipment might have been pur-

⁸Donald C. Orlich, An Appraisal of the Methods of Teaching Science In the Senior High Schools of Montana, (unpublished Master's thesis, University of Utah, 1959).

chased, but not enough to meet the demands of the new experiments the physics classes were doing in 1972-73.

Table XIX shows the teachers' ratings in 1972 of the improvement of the laboratory equipment in physics during the preceding ten years.

TABLE XIX
TEACHERS' RATING ON IMPROVEMENT OF PHYSICS
EQUIPMENT IN LAST TEN YEARS

Enrollment	800	301-800	101-300	0-100	Total
Great Improvement	6	7	18	12	43
Slight Improvement	3	8	22	6	39
No Change	0	0	1	4	5
Has Gotten Worse	2	0	2	3	7
Don't Know	3	2	7	12	24

From the 118 responses it can be calculated from Table XVIII, on page 106 and Table XIX that even though 43 percent of the teachers rated their physics equipment inadequate, improvements were being made. In 36.4 percent of the cases there had been a great improvement over the last ten years. This supports the hypothesis that new equipment was being

purchased, but not enough to meet the demands.

Federal Aid

Table XX indicates the number of schools that had participated in Federal Aid. The most common Federal Aid that helped the physics programs was the National Defense Educational Act (NDEA). This data was collected from the teachers, and this was one reason why some schools listed "don't know". The newer teachers in a school district did not know if their school had ever participated in a federal grant to help their physics program.

TABLE XX
TEACHER INDICATION OF FEDERAL AID
TO HELP THE SCHOOL'S PHYSICS PROGRAM

Enrollment	800	300-800	101-300	0-100	Total
<u>Participated Before 1972</u>					
yes	4	6	9	3	22
no	5	8	22	17	52
don't know	5	3	18	16	42
<u>Participated During 1972-73</u>					
yes	1	3	3	0	7
no	9	13	37	33	92
don't know	4	1	9	3	17

Several teachers wrote notes explaining they "don't know" because they were not sure if their school received a block grant for science equipment. This money could have been put into their capital budget for physics equipment without them knowing it. They were not involved in obtaining a grant, but they were not sure if their administration had gotten aid for all the sciences.

Audio-visual Equipment

Table XXI, on page 110 gives the teachers' estimations on the adequacy of their school's audio-visual equipment. The table also indicates how often the teachers used this equipment. It is mainly in the smaller schools that inadequacy of audio-visual equipment became a problem, and then 46.5 percent of the teachers rated the equipment at their school inadequate.

During the interviews conducted by this investigator, the teachers were asked which of the audio-visual equipment they used. It was learned that the types of equipment should have been specified on the questionnaire. Many physics teachers used overhead projectors in lecture, but no other equipment, and therefore, increased the "number of teachers using audio-visual equipment."

TABLE XXI
ADEQUACY AND USE OF AUDIO-VISUAL EQUIPMENT
AS RATED BY PHYSICS TEACHERS

Enrollment	800	301-800	101-300	0-100	Total
<u>Adequacy</u>					
More than Adequate	4	5	3	2	14
Adequate	9	8	26	15	58
Inadequate	1	4	21	19	45
<u>Use of Equipment</u>					
Often	7	4	4	3	18
Occasionally	4	7	23	10	44
Sometimes	3	4	16	9	32
Seldom	0	2	7	11	20
Never	0	0	2	1	3

Library Facilities

While studying high school physics, if a student became interested in any aspect of physics, and wanted to pursue it further, a good library would be necessary as a resource center. Table XXII, on page 111, presents the teachers' estimation of how adequate their school's library was in the area of physics. In 1972, 53.4 percent of the teachers rated their school's library inadequate in physics. This

increased to almost 63 percent when only the smaller schools were considered. Only four teachers rated their school's physics library more than adequate.

TABLE XXII
TEACHERS' ESTIMATES OF ADEQUACY OF
LIBRARY IN AREA OF PHYSICS

Enrollment	800	301-800	101-300	0-100	Total
More than Adequate	1	1	2	0	4
Adequate	9	11	22	8	50
Inadequate	3	5	26	28	62

Administrations' Attitude Toward High School Physics

The attitudes of the administration are extremely important for the success of a high school physics program. There is a danger with the falling enrollments, that physics could lose favor with the administration, and the budget and facilities be cut. Table XXIII, on page 112, gives the teachers' attitudes on the rating of their administration as far as being sympathetic to the problems involved in teaching high school physics during the 1972-73 school year. These data show that the majority of teachers were not hindered by their administration's attitude. Only 10.5 percent rated the administration as being not sympathetic.

TABLE XXIII
TEACHERS' RATING OF THE ADMINISTRATION'S
ATTITUDE TOWARD PHYSICS TEACHING

Enrollment	800	301-800	101-300	0-100	Total
Very Sympathetic	4	3	14	10	31
Sympathetic	8	12	28	24	72
Not Sympathetic	2	2	6	2	12

Teachers' Preparation

During the past fifteen years, one major concern of science educators has been to upgrade the academic preparation of the physics teachers. This effort has been focused at both the preparation of new teachers and the experienced teachers in the field. One of the major determinants of the teachers' preparation has been the number of college or university credits a teacher has in the sciences and mathematics. Gebhart⁹ determined this parameter for Montana physics teachers during the 1958-59 school year. Ivany, et. al. determined the same thing for physics teachers in the Northeast States during the 1971-72 school year.¹⁰ The following

⁹Gebhart, op. cit., pp. 115-127.

¹⁰Ivany, et. al., op. cit., pp. 10-11.

section of this dissertation compares the results of these studies with those found for Montana physics teachers during the 1972-73 school year.

Physics Background of Physics Teachers

Table XXIV, on page 114, gives the distribution of teachers according to the number of undergraduate and graduate quarter hour credits they had in physics. This table represents 147 teachers or 98 percent of the high school physics teachers in Montana. The mean quarter hours taken was 29.4, with a median of 22.1 quarter hours. The smaller schools had some teachers that had very little preparation in physics and this pulled the average down. The mean for schools with enrollments greater than 300 was 42.4 quarter hours with a median of 37.3 quarter hours.

A comparison was made of Montana's physics teachers in 1972-73 with those of Montana's in 1958-59, and those of the Northeast States in 1971-72. In 1958, Gebhart collected data from 44.3 percent of Montana's physics teachers. Ivany et. al. collected data from 32 of the 42 teachers in their sample in the Northeast States.

When comparing the 1972-73 data with the Montana physics teachers in 1958-59, one can see that a great improve-

TABLE XXIV
 DISTRIBUTION OF PHYSICS TEACHERS ACCORDING
 TO THEIR TOTAL CREDITS IN PHYSICS

Quarter Credits	School Size				Total
	>800	301-800	101-300	0-100	
0				6	6
1-5			1		1
6-10			4	1	5
11-15		2	17	21	40
16-20	1	2	8	4	15
21-25	2	6	7	2	17
26-30		1	7	2	10
31-35	1	3	7	1	12
36-40	1	1	5	2	9
41-45	2	2	2		6
46-50	2	1	3	1	7
51-55			3		3
56-60				1	1
61-65	1	1			2
66-70	1	1		1	3
71-75		1	1		2
76-80	1			2	3
80+	3		1	1	5
Median	46-50	31-35	21-25	11-15	21-25
Mean	53.5	34.4	27.0	22.7	29.4

ment has been made. Table XXV shows that there were still 35 percent of the teachers in 1972 with only the equivalent of the first year of college physics. These teachers were mainly in the smaller schools.

TABLE XXV
COMPARISON OF QUARTER HOUR CREDITS IN PHYSICS FOR PHYSICS
TEACHERS IN MONTANA DURING 1972-73, IN MONTANA DURING
1958-59 AND IN THE NORTHEAST STATES DURING 1971-72

Quarter Hours	Montana 1972-73		Montana 1958-59		Northeast States 1971-72	
	No.	%	No.	%	No.	%
0-15	52	35	40	93	5	17.2
16-30	42	29	3	7	1	3.5
31-45	27	18	0	0	3	6.9
46-60	11	7	0	0	11	32.2
61-75	7	5	0	0	4	13.6
75-90	5	3	0	0	4	13.6
90	3	2	0	0	4	13.6
Median	16-30		0-15		46-60	
Mean	29.4		10.1		62.6	

When the 1972-73 Montana data is compared to that found in the Northeast States, one finds that Montana teachers were not as well prepared. The explanation for this is found in the sample of Ivany's study. There were only eight rural schools in the study. The suburban schools outweighed

all of the other categories. If the trend in the Northeast States was the same as in Montana, (i.e. larger schools have teachers with more physics credits) this would explain the difference.

Math Background of Physics Teachers

Table XXVI on page 117, gives the distribution of physics teachers according to the number of undergraduate and graduate quarter hour credits of mathematics they had taken up to 1972. The mean of 42.1 is greater than the mean hours they had in physics. All school categories had roughly the same mean and median. Only 16 percent of the teachers had less than 16 quarter hours of mathematics.

Table XXVII compares the Montana physics teachers mathematical backgrounds in 1972-73, with the physics teachers in the Northeast States during 1971-72. This table can be found on page 118. The 1972-73 data from Montana was collected from 124 physics teachers or 83 percent of those in Montana. The data from Ivany's study was collected from 32 of the 42 teachers in their sample. On the average the Montana physics teachers were better prepared in mathematics than the physics teachers in the Northeast states. There were more Montana physics teachers with 0-15 quarter hours of mathematics, but to balance this out, there were even

TABLE XXVI

DISTRIBUTION OF PHYSICS TEACHERS ACCORDING
TO THEIR TOTAL CREDITS IN MATHEMATICS

Quarter Credits	School Size				Total
	>800	301-800	101-300	0-100	
0				1	1
1-5				3	3
6-10	1	2	2	3	8
11-15			4	4	8
16-20		2	8	4	14
21-25			4	1	5
26-30		2	4	2	8
31-35	2	2	4		8
36-40		1	4	4	9
41-45	4	2	8	4	18
46-50	1		1	3	5
51-55	1		4	5	10
56-60	2	3	1	1	7
61-65		1	2	1	4
66-70				2	2
71-75	1		1		2
76-80	1		3		4
80+		1	5	2	8
Median	41-45	36-40	36-40	36-40	36-40
Mean	48.7	40.9	44.1	37.6	42.1

more Montana physics teachers with greater than 60 quarter hours of mathematics.

TABLE XXVII
COMPARISON OF QUARTER HOUR CREDITS IN MATHEMATICS
FOR PHYSICS TEACHERS IN MONTANA DURING 1972-73
AND IN THE NORTHEAST STATES DURING 1971-72

Quarter Hours	Montana (1972-73)		Northeast States (1971-72)	
	No.	%	No.	%
0-15	20	16	3	7
16-30	27	22	9	28
31-45	35	28	13	45
46-60	22	18	5	13
61-75	8	6	2	7
76-90	7	6	0	0
90	5	4	0	0
Median	31-45		31-45	
Mean	42.1		35.1	

Chemistry Background of Physics Teachers

The distribution of physics teachers according to their quarter hours of undergraduate or graduate chemistry in 1972, is given in Table XXVIII, on page 119. Listed in this distribution are 141 or 95 percent of the Montana physics teachers in 1972-73. The mean of 32.0 quarter hours is larger than the mean number of physics credits, but smaller than the mean number of mathematics credits. There were fewer physics teachers with only 0-15 credits in chemistry than

TABLE XXVIII

DISTRIBUTION OF PHYSICS TEACHERS ACCORDING
TO THEIR TOTAL CREDITS IN CHEMISTRY

Quarter Credits	School Size				Total
	> 800	301-800	101-300	0-100	
0				2	2
1-5					
6-10	2		2	5	9
11-15	3	3	13	5	24
16-20			10	5	15
21-25	1	1	3	6	11
26-30	3	4	10	9	26
31-35	1	2	5	4	12
36-40		1	4		5
41-45	1	3	3	1	8
46-50	1	2	3	4	10
51-55		2	1	2	5
56-60	1	1	2		4
61-65				1	1
66-70			1	1	2
71-75			2		2
76-80		1			1
80+		1	3		4
Median	26-30	36-40	26-30	21-15	26-30
Mean	27.5	40.6	33.4	27.4	32.0

0-15 credits in physics. The mean hours among the various school categories did not differ except for the size range of 301-800 students, where the teachers had an appreciably better preparation in chemistry.

Table XXIX compares the Montana physics teachers of 1972-73 with those in Montana during 1958-59 and the teachers in the Northeast States in 1971-72. The sample in 1958-59 was 44.3 percent of the physics teachers in Montana at that time.

TABLE XXIX
COMPARISON OF QUARTER HOUR CREDITS IN CHEMISTRY FOR
PHYSICS TEACHERS IN MONTANA DURING 1972-73, IN
MONTANA DURING 1958-59, AND IN THE
NORTHEAST STATES DURING 1971-72

Quarter Hours	Montana 1972-73		Montana 1958-59		Northeast States 1971-72	
	No.	%	No.	%	No.	%
0-15	35	25	25	58	14	44.9
16-30	52	37	11	26	8	20.7
31-45	25	18	5	12	5	17.5
46-60	19	13	0		2	6.9
61-75	5	3	2	4	2	6.9
76-90	4	3		0	0	0
90	1	1	0		1	3.5
Median	16-30		0-15		16-30	
Mean	32.0		18.4		18.9	

Ivany's study represents 32 teachers from the 42 in the sample. It can be seen that the Montana teachers have greatly improved their background in chemistry from a mean of 18.4 hours in 1958-59 to 32.0 hours in 1972-73. When comparing Montana physics teachers with those in the Northeast States, one can see that the Montana physics teachers have a stronger background in chemistry. This again could be explained by Ivany's sampling technique. In the Northeast States, many of the teachers came from large schools where they taught only physics. In Montana, many physics teachers also teach chemistry. (see Table XXXIV, page 128)

Biology Background of Physics Teachers

The distribution of physics teachers according to the number of undergraduate and graduate credits in biology is shown in Table XXX on page 122. The mean of 30.9 quarter hours is larger than the mean number of physics credits taken by the physics teachers. When comparing the larger schools with the smaller ones, it was found that the smaller schools had physics teachers with a mean of 32.4 quarter hours of biology compared to 26.6 quarter hours for the larger schools. Again extremes were found. Nineteen teachers had no college biology. Ten teachers had more than 80 quarter hours of biology. A total of 114 teachers were in-

TABLE XXX

DISTRIBUTION OF PHYSICS TEACHERS ACCORDING
TO THEIR TOTAL CREDITS IN BIOLOGY

Quarter Credits	School Size				Total
	> 800	301-800	101-300	0-100	
0	2	2	8	7	19
1-5	4	4	7	3	18
6-10	3	1	7	4	15
11-15		1	5	1	7
16-20	2	1	2	2	7
21-25		2	1	3	6
26-30	2		3		5
31-35			1	2	3
36-40			4	2	6
41-45			3	3	6
46-50		1	3	1	5
51-55					
56-60			1	7	8
61-65				2	2
66-70				2	2
71-75			3	1	4
76-80			1		1
80+		4	5	1	10
Median	6-10	16-20	11-15	21-25	16-20
Mean	11	35.9	32.4	33.3	30.9

cluded or 77 percent of all the physics teachers in Montana during 1972-73.

Table XXXI compares the biology credits of the physics teachers in Montana during 1972-73 with the Montana physics teachers of 1958-59, and the Northeast States' physics teachers during 1971-72. The same large increase from 1958-59 that was found in Montana for chemistry and physics, was not found in biology.

TABLE XXXI

COMPARISON OF QUARTER HOUR CREDITS IN BIOLOGY FOR PHYSICS TEACHERS IN MONTANA DURING 1972-73, IN MONTANA DURING 1958-59, AND IN THE NORTHEAST STATES DURING 1971-72

Quarter Hours	Montana 1972-73		Montana 1958-59		Northeast States 1971-72	
	No.	%	No.	%	No.	%
0-15	49	43	8	19	21	65.5
16-30	18	16	20	46	3	10.3
31-45	15	13	8	18	6	17.2
46-60	13	12	5	12	1	3.5
61-75	8	7	2	5	1	3.5
76-90	5	4	0	0	0	0
Median	16-30		16-30		0-15	
Mean	30.9		27.0		10.2	

As can be seen from the above table, the mean increased only 3.9 quarter hours. There was, however, in 1972-73 a greater number of physics teachers with 15 quarter hours or

less of biology. This indicated that more teachers were employed during 1972-73 to teach only the physical sciences and perhaps mathematics. In 1958-59 more teachers must have been employed to teach biology and then given the responsibility to also teach the physical sciences. The Montana study in 1958, sampled 44.3 percent of the physics teachers. The study of the Northeast States in 1972 included 32 teachers out of the 42 teacher sample.

When the preparation in biology of Montana physics teachers was compared to that of the Northeast States, it was found that Montana teachers were better prepared. Again in the smaller schools of Montana many teachers had to teach more than just physics. (see Table XXXIV, page 128) Many physics teachers were also biology teachers. The Montana schools with enrollments over 800 had physics teachers who taught mainly physics and did not teach biology. They, therefore, had fewer credits in biology and agreed more with the physics teachers of the Northeast States.

Geology and Earth Science Preparation of Physics Teachers

The distribution of physics teachers according to how many quarter hour credits they had in earth science and geology in 1972 is shown in Table XXXII, on page 125. The mean number of credits was 10.9. This was the lowest of all

TABLE XXXII
 DISTRIBUTION OF PHYSICS TEACHERS ACCORDING
 TO THEIR TOTAL CREDITS IN
 GEOLOGY AND EARTH SCIENCE

Quarter Credits	School Size				Total
	>800	301-800	101-300	0-100	
0	2	5	16	12	35
1-5	7	3	6	4	20
6-10	3	3	6	6	18
11-15			6	7	13
16-20			7	2	9
21-25	1	2	2	2	7
26-30		1	1	1	3
31-35			3	1	4
36-40			2	1	3
41-45		1	1		2
46-50					
51-55		1			1
56-60					
61-65					
66-70					
71-75		1			1
76-80					
80+					
Median	1-5	6-10	6-10	6-10	6-10
Mean	6.3	16.8	10.8	9.9	10.9

sciences. Approximately 74 percent of the physics teachers had fifteen or less credits. Eighteen percent had more than twenty credits of earth science and geology. These results represent 116 teachers or 79 percent of the public high school physics teachers in Montana during 1972-73.

Table XXXIII compares the Montana physics teachers of 1972-73 with those of 1958-59. It is apparent that their background in geology and earth science has improved.

TABLE XXXIII
COMPARISON OF QUARTER HOUR CREDITS IN GEOLOGY AND
EARTH SCIENCE FOR PHYSICS TEACHERS IN MONTANA
DURING 1972-73 AND IN MONTANA DURING 1958-59

Quarter Hours	Montana 1972-73		Montana 1958-59	
	No.	%	No.	%
0	35	30	26	60
1-15	51	44	17	40
16-30	19	16	0	0
31-45	9	8	0	0
46-60	1	1	0	0
61-75	1	1	0	0
76-90	0	0	0	0
90	0	0	0	0
Median	1-15		0	
Mean	10.9		4.2	

In 1958-59, there were no physics teachers with more than 15 credits. The sample in 1958 included 44.3 percent of

Montana's high school physics teachers. However, only 26 percent of the teachers had increased their credits in earth science and geology. The remaining teachers still had little preparation in this area.

Teaching Loads

In order to better understand the credit patterns found in the sciences and mathematics for the physics teachers of Montana during 1972-73, it was helpful to look at their teaching loads. Only four high school teachers in the entire state of Montana taught only physics. For this reason, the physics teacher had to be academically prepared in one or two other areas. Table XXXIV, on page 128, presents the number of classes in the sciences and mathematics that the Montana physics teachers taught during the 1972-73 school year. These results were obtained from the "Fall Reports" at the State Department of Public Instruction. Table XXXV, on page 129, lists courses other than science and mathematics that the physics teachers taught during the 1972-73 school year. There are very few of these except for a broad range of courses in the school enrollment category of 0-100. These non-science and mathematics courses could be attributed to certain individual teachers with unusual talents, or individual schools that needed a course taught in which

TABLE XXXIV

CLASSES TAUGHT IN SCIENCE AND MATHEMATICS
BY PHYSICS TEACHERS DURING 1972-73 YEAR

Enrollment	>800 (15) schools	301-800 (20) schools	101-300 (23) schools	0-100 (44) schools	Total
Physics	38	21	52	29	140
Chemistry	3	27	47	21	98
Biology	0	2	45	30	77
Earth Sci.	0	2	22	10	34
Phy. Sci.	8	6	20	9	43
Gen. Sci.	2	6	11	14	33
7th Sci.	0	0	5	19	24
8th Sci.	0	0	12	24	36
Applied Sci.	0	3	0	0	3
Aerospace Education	3	1	1	0	5
Conservation (Ecology)	2	1	1	1	5
Ant. & Phys.	0	0	0	2	2
Alg. I	5	1	19	13	38
Alg. II	6	4	12	9	31
Geometry	3	10	13	16	42
Adv. Math	0	4	15	9	28
Gen. Math	3	5	13	5	26
Jr. High Math	0	0	7	8	15

TABLE XXXV

CLASSES TAUGHT IN NON-SCIENCE AND NON-MATHEMATICS
AREAS BY PHYSICS TEACHERS DURING 1972-73

Enrollment	> 800	301-800	101-300	0-100
Admin.	0	0	3	2
Agriculture	0	0	0	1
Archaeology	0	0	0	1
Chorus	0	0	0	1
Drivers Ed.	0	0	6	5
English	0	0	0	1
German	0	0	0	1
Guidance	0	0	2	3
Health	0	0	0	1
History	0	0	0	1
P.E.	1	1	2	4
Shop	0	0	0	1
Speech	0	2	0	0

there was no regular teacher. No general pattern was found from Table XXV.

Table XXXIV, on page 128, shows that the physics teachers, on the average, fall into two categories. The first category included teachers that taught all the sciences both physical and biological. The second included the teachers that taught both physical science and mathematics. For schools with enrollment greater than 300, the second category prevailed. This explains the credit distributions that were found. The teachers were either prepared to teach all the sciences, or the physical sciences and mathematics. The high mean for mathematics can be explained by the fact that for a teacher to be prepared to teach all the sciences, a certain background in mathematics was necessary. For a teacher to be prepared to teach mathematics, however, no background in the sciences was necessary.

The small mean of 10.9 quarter credits in earth science can be explained by noting the small number of earth science courses taught by the physics teachers. The 34 classes that were offered probably were taught by the 24 percent of the physics teachers that had sixteen or more quarter credits. For the larger schools that offer earth science, a special teacher prepared in earth science was most likely on the

staff. For the small schools that had only one science teacher, it appeared that earth science, physical science, and general science were equally popular as a ninth grade science course.

Financially Supported Academic Work in Physics

In the early 1960's the Federal Government provided money for the purpose of upgrading the academic background of physics teachers. Various kinds of institutes, conferences, and participations were sponsored. Table XXXVI lists the number of financially supported academic programs in physics that the Montana physics teachers of 1972-73 had attended.

TABLE XXXVI

NUMBER OF FINANCIALLY SUPPORTED ACADEMIC PROGRAMS IN PHYSICS THAT THE MONTANA PHYSICS TEACHERS OF 1972-73 HAD ATTENDED

Enrollment	>800	301-800	101-300	0-100	Total
NSF Academic Year Institute	4	5	10	1	20
NSF In-Service Institute	2	1	5	2	10
NSF or AES Summer Institute	15	12	18	4	49
Other	1	1	0	1	3
Total Number of Teachers Attending	12	11	24	6	53

As can be seen from Table XXXVI, on page 131, the most popular program had been the NSF Summer Institute. The next most popular program has been the NSF Academic Year Institute. Altogether 53 physics teachers or 36 percent of Montana's physics teachers had attended at least one financially supported program in physics. In 1972-73, Ivany, et. al. found 62 percent of the teachers in their study of the Northeast States had attended at least one financially supported program.

Degrees

Information on the number of degrees that the Montana physics teachers had been awarded were taken from the "High School Physics Questionnaire". Table XXXVII, on page 133, shows whether 113 or 76 percent of the high school physics teachers in Montana during 1972-73 earned their degrees in or out of state.

It was computed from the data in Table XXXVII, that 74 percent of Montana physics teachers did their undergraduate work at a Montana school. Only 19 percent received their Master's degree from a Montana school. The questionnaire did not try to determine why this difference existed. During the interviews, this subject was discussed with the teachers and their explanation is described in Chapter V. One addi-

tional fact from Table XXXVII is that 43 percent of Montana's physics teachers had a Master's degree. These Master's degrees were not necessarily in physics.

TABLE XXXVII
IN AND OUT OF STATE DEGREES AWARDED
TO MONTANA'S PHYSICS TEACHERS

Enrollment	>800	301-800	101-300	0-100	Total
<u>B.S. or B.A.</u>					
earned in Montana	10	16	30	28	84
earned out-side Montana	5	5	12	7	29
<u>M.S. or M.A.</u>					
earned in Montana	1	3	6	4	14
earned out-side Montana	8	6	16	5	35

Years Experience

Table XXXVIII, on page 134, shows the years teaching experience of Montana's high school physics teachers in 1972. The difference between the mean and median is explained by noting that the mean is sensitive to teachers with a great deal of teaching experience. They would cause the mean to increase faster than the median. The average number of years

teaching experience increased with the student enrollment of the school. The mean for all physics teachers in Montana during 1972-73 was 8.2 years of experience, while the median was 6.4 years of experience.

TABLE XXXVIII
COMPARISON OF SCHOOL ENROLLMENT AND PHYSICS TEACHERS'
TEACHING EXPERIENCE BY YEARS DURING 1972-73

Enrollment	>800	301-800	101-300	0-100	For All Teachers
<u>1972-73</u>					
Median	10.5	12	6	3	6.4
Mean	12.2	12.9	7.6	5.7	8.2

Professional Organizations

It was also determined in the "High School Physics Questionnaire" what professional science organizations the teachers belonged to during 1972. Table XXXIX, on page 135, contains the list of organizations that appeared in the questionnaire and the number of teachers indicating they belonged to each one. One hundred and twenty one teachers or 80 percent of the teachers responded to the question. The National Mathematics Society was not listed, but was written in by the teachers in the "other" blank. Therefore, more

teachers than indicated could have belonged to this organization. The National Science Teacher's Association was the most popular organization, with twenty-five teachers belonging, followed by the American Association of Physics Teachers with eleven teachers belonging. Only 41 teachers or 34 percent of Montana's physics teachers belonged to one or more of the listed organizations.

TABLE XXXIX
NUMBER OF PHYSICS TEACHERS
WHO BELONGED TO FOLLOWING ORGANIZATIONS

Enrollment	>800	301-800	101-300	0-100	Total
NST	4	6	13	2	25
AAAS	0	1	2	0	3
AAPT	4	1	4	2	11
ACS	0	0	6	1	7
Natl. Assn. of Biol. Teachers	0	0	1	0	1
Natl. Assn. of Geol. Teachers	0	1	0	0	1
National Math Society	1	1	1	3	6

Teachers' Recommendations

Six open ended questions were asked in the "High School Physics Questionnaire". These questions sought the teachers'

opinions and recommendations on how different government agencies could better serve to help improve the high school physics programs in the state of Montana. Because the questions were open ended, each answer differed, to some extent, from the others. In the following section, the general ideas of the answers given for each question are reported. For each idea, one representative quote from the teachers' replies is given to help establish the tenor of the composite answers given by the teachers.

1. What course or kinds of courses do you think you should have had in your college preparation that you did not have? Why did you indicate each course?

The most popular answer was additional science methods courses that were laboratory oriented. As one teacher stated, "more science methods courses with an emphasis on a practical laboratory course that teaches the use of equipment." The number of teachers indicating a need for this type of course were:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	7	4	17	13	41

The next answer, in order of frequency, was for more physics courses. Eight teachers in schools with enrollments less than 300 indicated a need for subject matter physics courses, but the majority of the teachers wanted a physics course for teachers. One teacher summed it up by saying, "I needed a physics course for teaching that included use and construction of simple and inexpensive equipment, teaching techniques in physics, the making and use of film loops and transparencies for physics, and ways to relate physics to everyday living." The number of teachers indicating this type of course were:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	2	4	11	8	25

Other courses were listed. The types of courses that were suggested by more than one teacher are listed below:

electronics course	7 teachers
more and earlier student teaching	5 teachers
more mathematics	5 teachers
course relating science & humanities	4 teachers

2. What courses or kinds of courses did you have in your college preparation that you believe you did not need? Why?

There were essentially only two answers to this question. The most frequent reply was the teachers felt they did not need as many "theoretical" education courses, the way they were organized at the time they took them. A representative answer was, "some of the basic orientation to education courses should be revamped and made more strenuous and more practical towards the teaching situation." The specific courses mentioned that needed reorganization were educational psychology, philosophy of education, history of education, and orientation to education. The majority of the teachers also felt that the prospective teacher should practice-teach earlier, and have his education curriculum built around the area of specialty. The number of teachers that indicated "theoretical" education courses were:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	8	7	15	13	43

Seven teachers mentioned their advanced physics training. They felt that they never used the advanced physics in high school classes. Several stated that they would have benefited more by taking more introductory courses, so they would really understand physics at that level.

3. What services do you think the colleges and universities could provide to help improve your physics program?

There were five popular answers to this question. The first was to provide in-service courses in physics. The preference of the teachers was for a discussion or laboratory oriented program. As one teacher put it, "conduct in-service classes in physics and teaching physics that are discussion oriented (i.e. no lectures from "experts"). A great number of teachers wanted this type of program as indicated below:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	4	7	8	8	27

Following in close popularity with in-service programs, were summer courses in physics for physics teachers. The type of courses desired was stated well by one teacher as, "courses in 'how to' in the laboratory in both undergraduate and graduate levels -- also surveys of subject for updating teachers as myself." The number of teachers who indicated a desire for summer courses were as follows:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	3	5	8	7	23

A number of teachers indicated the desire to receive information from the universities concerning physics and physics teaching. They hoped the universities could "issue bulletins and materials on new texts, laboratory material, films, instructional devices, and research going on at the universities." This would help communications among the high schools and between high schools and colleges. Several teachers indicated bulletin board material on physics research being done in Montana would motivate and interest students. The following number of teachers indicated that the above forms of communication should be established between the high schools and colleges:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	5	4	9	14	32

Another idea that was stated was to re-introduce the visiting professor or guest lecturer program. One teacher said, "I would like to have availability to guest lecturers with good demonstrations at the high school level." The number of teachers who indicated this were:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	3	2	4	5	14

The final popular idea was to either have a mobile laboratory exhibit for the State or a strong laboratory sharing program between the high schools and colleges. As one teacher stated, "The colleges should make more expensive and harder to acquire equipment available to the high schools." Many more teachers in the smaller schools than the larger schools would have like this type of program, as the following indicates:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	4	2	6	9	21

Other services were mentioned, such as provide for visits to the physics departments at universities, (4 teachers), provide a good physics audio-visual center, (4 teachers), and provide experts to evaluate and help small school physics teachers, (5 teachers).

4. What do you think the Federal Government could do now to help improve your physics program?

All of the replies fell into two categories. The first was: provide money for laboratory equipment. The teachers expressed concern that the government sponsored the creation of different physics curricula, but provided little money

for the schools to implement them. Without Federal help, many of the smaller schools admitted it was impossible for them to purchase the laboratory equipment necessary for the newer programs. The following number of teachers indicated a need for Federal help toward purchasing laboratory equipment:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	3	7	17	15	42

The second popular answer was to continue summer and academic year institutes. As one teacher expressed it, "right now small schools have to hire a person qualified in one or two branches of science and have them teach all the sciences. Federal institutes are necessary to train us in these other fields." The teachers strongly supported the continuation of summer institutes as the data indicates:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	6	6	15	4	31

5. What could the State Department or your local school board do to help improve your physics program?

The one service the teachers felt the State Department could provide was to establish a program for better communications between the high school physics teachers of Montana. As one teacher expressed it, "provide a program where the textbooks, laboratories, equipment, and technique books, located in various locations could be made more readily available to all teachers." Or as another teacher expressed it, "a need for more correlation and communication on both the horizontal and vertical planes between all science education personnel". The number of teachers who indicated this were:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	5	4	15	4	28

The teachers felt the local school boards could give them more money for equipment. One teacher expressed the problems in this way: "The improvement of our physics program must begin with a desire on the part of the school board to upgrade the program. The school here is so small, that improvement in the physics program is considered of minor importance, since so few students are involved." The

number of teachers indicating the need for increased funds for equipment were:

<u>School Enrollment:</u>	<u>>800</u>	<u>301-800</u>	<u>101-300</u>	<u>0-100</u>	<u>Total</u>
Number of Teachers:	3	4	19	8	34

6. Do you have any other comments about physics teaching or about this questionnaire?

The most frequent concern in this section was the falling enrollments in high school physics. Thirty-two teachers mentioned this problem. Several teachers even questioned whether it was still feasible to teach physics in the high schools with so few students enrolled.

The second most common answer among small schools (less than 300 enrollment) was the teachers heavy teaching loads. They felt physics was a difficult subject to understand and teach. They had so little preparation time for physics, they were unable to do a decent job. None teachers indicated this.

The final type of comments were ones such as this, "I did not enjoy taking physics in high school and college, and dislike teaching it just as much." Five teachers indicated a dislike in having to teach physics. This raises the question of how many teachers were assigned the task of teaching

physics against their desire and interest.

TEACHERS' OBJECTIVES

No matter what laboratory, library, or classroom facilities a school may have, the physics course would still be largely influenced by the teaching objectives of the physics teacher. Therefore, the teaching objectives were determined in order to make a judgement on the quality and quantity of the "external" factors. The "Teachers' Objectives Questionnaire", (Appendix E, page 256) was used in order to obtain an indication of the teaching objectives that the physics teachers in Montana agreed with and worked toward during 1972-73. Thirty-three objectives that Trowbridge found in 1960 which differentiated the "traditional" from the "P.S.S.C." teacher were included in the questionnaire.¹¹ An analysis was made of the teachers' objectives according to the school enrollment, the teachers' years of experience, and the size of the physics class. In addition, the teaching objectives of Montana's physics teachers were compared to the norms Trowbridge established in 1960.

¹¹ L.W. Trowbridge, A Comparison of the Objectives of Traditional High School Physics with the Objectives of the P.S.S.C. Course, (an unpublished Doctorate thesis, University of Michigan, 1961).

An example of a question from the "Teachers' Objectives Questionnaire" follows: (see Appendix E, page 256)

	Agreement				Practice			
6. To teach the proper use of physics apparatus.	Strong	Mild	Non-Committal	Disagree	Accomplish	Occasional	No Effort	Avoid

In order to perform a statistical analysis of the data, the responses were given the following numerical values:

Agreement:	Strong	4 points
	Mild	3 points
	Noncommittal	2 points
	Disagree	1 point
Practice:	Accomplish	4 points
	Occasional	3 points
	No Effort	2 points
	Avoid	1 point

From these values mean scores and standard deviations were calculated for each objective.

A Chi-Square Analysis was used to determine the probability that the categories of teachers (i.e. school enrollment, class enrollment, and teachers' years of experi-

ence) differed in their objectives. The level of significant difference, α , used was 0.01. This level was chosen to reduce the probability of an objective randomly meeting the significant conditions.

Fischer's "t" technique was used to compare the mean scores of Trowbridge's findings in 1960, with those found in Montana in 1972. A Chi-Square Analysis was also made. The results of these two tests indicated what changes in teaching objectives had occurred in Montana since 1960.

Composite Comparison of all Montana Physics Teachers

Table XL, on page 149, lists the composite results of the teaching objectives of all physics teachers in Montana during 1972-73. The "traditional" objectives are listed first and then the "P.S.S.C." objectives. The number of the objective corresponds to the number it was assigned in the questionnaire.

Included, is the mean, \bar{X} , and standard deviation, σ , for both agreement and practice. In the third column of the table is the difference of the means between agreement and practice. Finally, Pearson's product-moment correlation coefficient, r , was calculated between agreement and practice. These data represent the responses of 78 teachers or 85 percent of the sample.

There were five objectives that had a mean greater than 3.80 in Agreement. However, the teachers indicated only one objective that they agreed with and accomplished at greater than the 3.80 level. This objective was "to emphasize the meter-kilogram-second system of units".

When the five objectives that had agreement at greater than a 3.80 mean are studied, they seem to fall in the categories of material covered, laboratory, and system of units. The teachers agreed at this high level that in high school physics:

1. essentially all areas of physics should be studied.
2. the meter-kilogram-second system of units should be emphasized.
3. the scientific method should be taught with an emphasis on laboratory investigation, using simple, inexpensive apparatus.

An agreement on the objectives at below a mean of 2.80 occurred in five cases. In practice, nine objectives were found with a mean of less than 2.80. The teachers had agreement at this lower level that in high school physics:

1. only a few major topics should be studied in depth.
2. the practical (English) units of measurement should be emphasized.
3. the state syllabus should be followed.
4. the students should be prepared for college entrance boards.
5. growth in the use of the democratic processes should be developed.

TABLE XL
 COMPARISON OF AGREEMENT AND PRACTICE FOR SEVENTEEN
 "TRADITIONAL" AND SIXTEEN "PSSC" OBJECTIVES
 AMONG ALL MONTANA HIGH SCHOOL PHYSICS TEACHERS IN 1972-73

Objective	Agreement		Practice		X Difference (A-P)	r between A & P
	\bar{X}	σ	\bar{X}	σ		
<u>Traditional</u>						
1 To use a textbook which helps students retain learned information by use of summaries, tables, lists of conclusions, glossaries, etc.	3.29	.94	3.20	.90	0.09	.791
2 To study the following areas of physics: mechanics, heat, sound, light magnetism, electricity, electronics, atomic structure, and nuclear energy.	3.69	.57	3.45	.64	0.24	.533
3 To provide experience with questions from sample college entrance board and advanced placement tests.	2.35	.92	2.19	.77	0.16	.768
4 To help the students become more intelligent consumers of the products of modern technology.	3.33	.81	3.05	.61	0.28	.644
5 To study magnetism and electricity from the standpoint of electrical circuits, current flow, current generation, and relationships between potential, current and resistance.	3.52	.60	3.31	.57	0.21	.555
6 To teach the proper use of physics apparatus.	3.52	.62	3.56	.55	0.04	.636
7 To study the nature and characteristics of heat phenomena.	3.43	.62	3.25	.70	0.18	.465
11 To cover the requirements of standard state and local syllabi and examinations.	2.32	1.02	2.43	.95	-0.11	.784
12 To teach the elements of the scientific method and skill in its use.	3.61	.57	3.49	.62	0.12	.662
18 To teach the applications of physics principles to modern technology and to devices common in the life of the student.	3.59	.62	3.35	.65	0.24	.736

TABLE XL (continued)

Objective	Agreement		Practice		\bar{x} Difference (A-P)	r between A & P
	\bar{x}	σ	\bar{x}	σ		
<u>Traditional (con't)</u>						
22 To study the nature and characteristics of sound phenomena.	3.45	.66	3.37	.69	0.08	.685
23 To study natural radioactivity and elementary concepts of nuclear reactions.	3.20	.74	2.99	.78	0.21	.665
26 To emphasize the use of the laboratory for the development of instrumental skills.	3.29	.80	3.08	.75	0.21	.726
27 To use laboratories to verify facts and principles of physics.	3.57	.79	3.47	.68	0.10	.597
29 To emphasize practical (English) units of measurement.	1.89	.95	2.07	.91	-0.18	.792
31 To develop growth in skillful use of democratic processes.	2.64	.94	2.59	.87	0.05	.856
33 To study some of the static and dynamic aspects of fluids.	2.81	.78	2.68	.74	0.13	.643
Mean of all Traditional Objectives	3.15		3.03			
<u>P.S.S.C.</u>						
8 To emphasize the understanding and use of physical approximations and models in helping to explain theoretical concepts.	3.59	.66	3.21	.58	.0.38	.591
9 To emphasize the integrated film program for helping to touch the principles of physics.	3.08	.82	2.56	.74	0.52	.439
10 To study electricity predominantly from the standpoint of fundamental charge units, their nature, measurement, and behavior.	3.23	.75	3.19	.61	0.04	.650
13 To show the importance of scaling and its role in physics.	3.11	.71	3.05	.66	0.06	.686
14 To emphasize the continuity and unity of physics.	3.44	.76	3.16	.70	0.28	.708

TABLE XL (continued)

Objective	Agreement		Practice		Difference (A-P)	r between A & P
	\bar{x}	σ	\bar{x}	σ		
<u>P.S.S.C. (cont)</u>						
15 To develop a view of contemporary physics that is consistent with that of the professional physicist.	2.89	.88	2.71	.71	0.18	.791
16 To emphasize that physicists are typical people of academic life with typical human aspirations.	3.03	.82	2.77	.80	0.26	.337
17 To emphasize the meter-kilogram-second system of units.	3.79	.47	3.83	.42	-0.04	.635
19 To emphasize the major concepts and the principles of physics from the standpoint of their contributions to physics as a pure science.	2.93	.78	2.93	.66	0	.750
20 To emphasize development of the ability to organize and display data in useful forms for effective analysis of it.	3.53	.68	3.27	.62	0.26	.677
21 To emphasize use of simple apparatus and inexpensive materials where educationally feasible in the laboratory.	3.71	.59	3.48	.62	0.23	.722
24 To make the laboratory central in the learning process by designing it as a process of inquiry on natural physical problems.	3.52	.70	3.19	.59	0.33	.613
25 To emphasize the use of equipment and instruments whose working parts are clearly visible.	3.40	.79	3.00	.74	0.40	.583
28 To employ tests as a means of determining the ability of students to reason to logical conclusions when working with unfamiliar data.	3.15	.79	2.97	.87	0.18	.664
30 To emphasize the method of laboratory investigation for learning.	3.63	.61	3.39	.59	0.24	.594
32 To emphasize the study of a few major topics at considerable depth.	2.61	1.01	2.67	1.02	-0.06	.643
Mean of All P.S.S.C. Objectives	3.29		3.09			

In practice the teachers scored several other objectives low. These were:

1. to emphasize a film program.
2. to study the static and dynamic aspects of fluids.
3. to develop a view of physics consistent with the professional physicist.
4. to emphasize that physicists are typical people.

There were three objectives that had a correlation coefficient between agreement and practice below 0.50.

These were:

1. to study heat phenomena.
2. to emphasize a film program.
3. to emphasize that physicists are typical people.

When these results were combined, several patterns of the Montana physics teachers' objectives emerged. These patterns were found by comparing the objectives that rated high with those that rated low. In addition, a comparison was made between the teachers' agreement and their actual practices. The following statements can be made about the composite teaching objectives of all the Montana physics teachers in 1972.

1. They agreed and practiced the objective of teaching a survey physics course, covering essentially, all areas of physics. Fluid mechanics and heat were two areas emphasized least.

2. The meter-kilogram-second system of units was emphasized and used rather than the English system.
3. The scientific method was taught with an emphasis on laboratory investigation.
4. The teachers did not concern themselves when planning their physics course, with the state syllabus or any advanced achievement tests.

School Enrollment Size

In addition to the composite analysis of the objectives for all Montana physics teachers, comparisons were made of the objectives for teachers in different size schools, with different size physics classes, and with different number of years experience. Table XLI, on page 154 and 155, compares the means of the agreement and practice for teachers in schools with an enrollment greater than and less than 300 students. The Pearson product-moment correlation coefficient, r , was computed to measure the correlation between agreement and practice. These data represent 29 teachers or 81 percent of the teachers in Montana schools with enrollment greater than 300 students. For schools with enrollment less than 300 students, 49 teachers or 86 percent of the sample responded.

TABLE XLI
COMPARISON OF AGREEMENT AND PRACTICE OF OBJECTIVES FOR
TEACHERS ACCORDING TO SCHOOL ENROLLMENT

Objective	0-300 Students in School					>300 Students in School				
	Agreement		Practice		Cor.	Agreement		Practice		Cor.
	\bar{x}	σ	\bar{x}	σ	r	\bar{x}	σ	\bar{x}	σ	r
<u>Traditional</u>										
1	3.60	.76	3.36	.76	.514	2.92	.96	2.92	1.00	.805
2	3.86	.48	3.44	.52	.313	3.56	.64	3.44	.96	.588
3	2.44	.96	2.24	.76	.748	2.16	.80	2.12	.92	.763
4	3.36	.80	3.04	.68	.694	3.32	.80	3.08	.44	.594
5	3.48	.60	3.20	.56	.614	3.56	.60	3.44	.56	.373
6	3.60	.60	3.60	.56	.687	3.40	.64	3.48	.52	.438
7	3.48	.64	3.32	.48	.467	3.36	.60	3.12	.92	.491
11	2.36	1.04	2.36	.96	.777	2.28	.92	2.52	.92	.763
12	3.68	.56	3.52	.64	.543	3.52	.52	3.44	.56	.619
18	3.68	.56	3.40	.60	.697	3.40	.60	3.24	.60	.680
22	3.48	.64	3.40	.68	.526	3.40	.68	3.32	.68	.855
23	3.32	.72	2.96	.64	.589	3.20	1.00	3.00	.92	.743
26	3.40	.76	3.12	.72	.685	3.12	.80	3.00	.72	.600
27	3.68	.72	3.56	.52	.275	3.40	.92	3.32	.84	.759
29	1.88	1.04	2.00	.92	.801	1.92	.84	2.16	.88	.772
31	2.64	.96	2.68	.92	.887	2.68	.92	2.44	.72	.824
33	2.84	.76	2.72	.64	.499	2.76	.80	2.60	.84	.826

TABLE XLI(continued)

Objective	0-300 Students in School					>300 Students in School				
	Agreement \bar{X}	σ	Practice \bar{X}	σ	Cor. r	Agreement \bar{X}	σ	Practice \bar{X}	σ	Cor. r
<u>P.S.S.C.</u>										
8	3.52	.72	3.04	.48	.562	3.68	.56	3.48	.56	.606
9	3.16	.72	2.64	.60	.313	2.96	.92	2.40	.92	.615
10	3.20	.76	3.08	.68	.698	3.28	.64	3.36	.48	.573
13	3.20	.76	3.12	.64	.706	2.96	.64	2.96	.60	.520
14	3.32	.84	3.04	.72	.729	3.64	.60	3.32	.56	.542
15	2.68	.84	2.56	.72	.777	3.24	.84	3.92	.68	.760
16	2.84	.84	2.64	.88	.829	3.32	.60	3.00	.56	.625
17	3.84	.48	3.76	.48	.796	3.72	.48	3.88	.32	.168
19	2.84	.80	2.84	.64	.763	3.08	.72	3.12	.64	.690
20	3.52	.76	2.96	.68	.749	3.52	.56	3.36	.48	.485
21	3.72	.52	3.56	.60	.680	3.64	.64	3.40	.60	.800
24	3.44	.80	3.20	.60	.720	3.64	.52	3.16	.48	.332
25	3.52	.80	3.08	.72	.544	3.24	.64	2.88	.72	.537
28	3.20	.96	2.96	.88	.740	3.08	.80	2.96	.88	.558
30	3.64	.64	3.40	.64	.514	3.64	.52	3.36	.48	.463
32	2.64	1.08	2.84	1.04	.699	2.60	.88	2.40	.92	.832

To determine the differences in the teachers' objectives for the various categories, a Chi Square Analysis was performed. In order to satisfy the assumption that 75 percent of the cell frequencies were five or more, the cells were collapsed. For all objectives that had a mean greater than 70 percent, the "noncommittal" and "disagree", and the "no effort" and "avoid" cells were combined. If the mean was less than 70 percent the "strong" and "mild", and "accomplish" and "occasional" cells were combined. In this manner, all objectives met the criteria necessary for a Chi Square Analysis.

Table XLII lists the objectives that had significant difference at the 0.01 level.

TABLE XLII
THE TEACHING OBJECTIVES WITH A SIGNIFICANT DIFFERENCE WITH A CHI SQUARE ANALYSIS BETWEEN TEACHERS AT SCHOOLS WITH ENROLLMENTS OF LESS THAN AND GREATER THAN 300 STUDENTS

Objective	Agreement χ^2	Practice χ^2
7		10.06
8		11.34
13	9.60	
15	9.28	11.20
16	10.45	17.02
31		10.69

critical value of χ^2 , $\alpha = 0.01$, $df = 2$, is 9.21.¹²

¹²George A. Ferguson, Statistical Analysis In Psychology and Education, McGraw-Hill, New York, 1966, p. 407.

There was significant difference in "agreement" for the following objectives:

- 13. to show the importance of scaling and its role in physics.
- 15. to develop a view of physics that is consistent with that of the professional physicist.
- 16. to emphasize that physicists are typical people.

In "practice" the teachers differed in the following objectives:

- 7. to study the nature and characteristics of heat.
- 8. to emphasize the understanding and use of the physical approximations and models in helping to explain theoretical concepts.
- 15. to develop a view of physics that is consistent with that of the professional physicist.
- 16. to emphasize that physicists are typical people.
- 31. to develop growth in skillful use of democratic processes.

The Chi Square Analysis can only detect a difference, and does not indicate the cause of the difference. An indication of which group scored higher on these objectives can be found from Table XLII, on page 156. It was found that teachers from schools with enrollment greater than 300 students scored noticeably higher on the "P.S.S.C." objectives. Teachers from schools with less than 300 students scored higher on the traditional objectives.

Physics Class Size

The size of the physics classes depended on different factors. These included the size of the school, how often physics was offered, and the type of physics being offered. Only six Montana schools with total enrollment of over 300 students, had less than ten students in the physics class during 1972-73. In addition, 14 schools in the sample, with enrollment below 300 students, had ten or more students in class. A comparison was made between the teachers' objectives in classes with more than and less than ten students. Table XLIII, on pages 159 and 160 list the mean of the agreement and practice of the objectives for these categories. In the category 0-10 students, 38 teachers from the sample are included. Thirty-seven teachers responded in the "greater than 10 student" category.

The Pearson product-moment correlation coefficient, r , was computed to measure the correlation between agreement and practice. To determine differences between categories, a Chi Square Analysis was performed on each objective. To meet the criteria of a Chi Square Analysis, the cells were collapsed in the same manner as in the school size analysis. (see page 156).

TABLE XLIII

COMPARISON OF AGREEMENT AND PRACTICE OF OBJECTIVES FOR TEACHERS
WHO HAD PHYSICS CLASSES OF LESS THAN TEN AND MORE THAN TEN STUDENTS

Objective	0-10 Students In Class					>10 Students in Class				
	Agreement		Practice		Cor. r	Agreement		Practice		Cor. r
	\bar{X}	σ	\bar{X}	σ		\bar{X}	σ	\bar{X}	σ	
<u>Traditional</u>										
1	3.48	.80	3.40	.76	.715	3.12	1.04	3.00	1.00	.821
2	3.80	.48	3.40	.56	.329	3.60	.64	3.52	.72	.691
3	2.40	.96	2.20	.84	.785	2.32	.88	2.16	.68	.746
4	3.36	.88	3.00	.68	.750	3.32	.76	3.12	.52	.483
5	3.56	.56	3.28	.56	.569	3.48	.64	3.32	.60	.558
6	3.60	.64	3.60	.60	.756	3.48	.60	3.52	.52	.477
7	3.52	.52	3.36	.48	.462	3.32	.72	3.16	.88	.454
11	2.36	1.16	2.48	1.00	.850	2.28	.88	2.40	.92	.698
12	3.76	.44	3.60	.56	.416	3.48	.64	3.40	.68	.791
18	3.76	.56	3.44	.60	.665	3.40	.64	3.24	.68	.780
22	3.56	.60	3.48	.68	.526	3.32	.72	3.28	.68	.811
23	3.20	.76	3.00	.68	.582	3.20	.72	2.96	.88	.760
26	3.44	.72	3.12	.72	.624	3.16	.84	3.04	.80	.808
27	3.72	.60	3.56	.56	.485	3.44	.92	3.40	.80	.638
29	1.92	1.04	1.96	1.00	.874	1.88	.84	2.16	.80	.683
31	2.64	1.00	2.64	.96	.889	2.64	.88	2.56	.76	.816
33	2.88	.80	2.72	.68	.459	2.72	.76	2.64	.80	.826

TABLE XLIII (continued)

Objective	0-10 Students in Class					>10 Students in Class				
	Agreement		Practice		Cor. r	Agreement		Practice		Cor. r
	\bar{X}	σ	\bar{X}	σ		\bar{X}	σ	\bar{X}	σ	
<u>P.S.S.C.</u>										
8	3.56	.68	3.04	.52	.602	3.64	.64	3.40	.60	.607
9	3.24	.76	2.76	.64	.284	2.92	.88	2.40	.88	.491
10	3.28	.72	3.16	.60	.700	3.16	.76	3.20	.64	.618
13	3.24	.72	3.12	.68	.730	2.96	.68	2.96	.64	.626
14	3.48	.76	3.12	.64	.674	3.40	.76	3.20	.76	.747
15	2.68	.88	2.56	.72	.797	3.12	.84	2.88	.68	.761
16	2.84	.84	2.60	.92	.815	3.24	.76	2.96	.64	.800
17	3.80	.52	3.76	.48	.847	3.80	.40	3.88	.32	.240
19	2.96	.68	2.84	.68	.841	2.92	.88	3.04	.64	.704
20	3.60	.72	3.28	.68	.736	3.48	.64	3.24	.56	.594
21	3.84	.44	3.60	.56	.675	3.60	.68	3.36	.68	.736
24	3.52	.80	3.20	.56	.693	3.52	.60	3.16	.60	.527
25	3.60	.72	3.08	.64	.488	3.20	.80	2.92	.80	.643
28	3.28	.96	3.04	.88	.730	3.00	.80	2.88	.88	.583
30	3.72	.64	3.44	.60	.596	3.56	.56	3.36	.60	.591
32	2.68	1.08	2.84	1.04	.749	2.56	.92	2.48	1.00	.702

At the 0.01 level there were no objectives that had a significant difference in "agreement". There was one objective that differed in "practice". This objective had a χ^2 of 11.45, while the critical value of χ^2 , $\alpha = 0.01$, $df = 2$, is 9.21.¹³ This objective was:

16. to emphasize that physicists are typical people.

Years of Experience

A third variable that was used to compare the teachers' objectives was the number of years experience the physics teacher had. The teachers were divided into three categories. These were those that had 0-5 years, 6-15 years, and greater than 15 years of experience teaching physics. The teachers with more than fifteen years experience graduated from undergraduate school before the start of the new physics curricula. The teachers with 0-5 years experience graduated from undergraduate school after the new curricula were developed.

Table XLIV, on pages 162 and 163 lists the means of agreement and practice for the objectives according to these three categories. The Pearson product-moment correlation coefficient, r , was computed to measure the

¹³Ibid., p. 407.

TABLE XLIV
COMPARISON OF AGREEMENT AND PRACTICE OF OBJECTIVES FOR TEACHERS
WITH DIFFERENT NUMBER OF YEARS TEACHING EXPERIENCE

Obj.	0-5 Years					6-15 Years					15 Years				
	Agree \bar{X}	σ	Practice \bar{X}	σ	r	Agree \bar{X}	σ	Practice \bar{X}	σ	r	Agree \bar{X}	σ	Practice \bar{X}	σ	r
Trad.															
1	3.40	.88	3.36	.92	.73	3.20	1.00	3.00	.92	.87	3.28	1.04	3.28	.84	.78
2	3.72	.52	3.48	.52	.51	3.56	.68	3.36	.84	.60	3.88	.36	3.60	.52	.08
3	2.24	.88	2.08	.80	.77	2.32	.84	2.08	.72	.75	2.72	1.08	2.68	.64	.81
4	3.36	.84	3.04	.64	.70	3.32	.88	3.08	.68	.67	3.32	.72	3.08	.44	.36
5	3.52	.56	3.28	.60	.51	3.36	.68	3.24	.60	.70	3.80	.40	3.48	.52	.13
6	3.56	.64	3.68	.56	.74	3.36	.68	3.44	.56	.64	3.72	.44	3.52	.52	.34
7	3.40	.68	3.24	.48	.31	3.40	.52	3.24	.84	.46	3.52	.76	3.32	.80	.75
11	2.36	1.08	3.24	.96	.76	2.40	1.04	2.48	.96	.82	2.12	.92	2.52	.92	.85
12	3.76	.44	3.64	.60	.72	3.44	.68	3.36	.68	.69	3.68	.48	3.48	.52	.38
18	3.60	.68	3.32	.64	.68	3.52	.64	3.24	.72	.79	3.72	.44	3.60	.52	.74
22	3.32	.68	3.28	.76	.62	3.56	.68	3.48	.60	.75	3.60	.52	3.40	.72	.84
23	3.08	.72	2.96	.64	.65	3.12	.72	2.84	.92	.70	3.60	.64	3.40	.72	.52
26	3.24	.72	3.04	.76	.65	3.28	.96	3.12	.84	.82	3.40	.72	3.12	.64	.64
27	3.52	.84	3.56	.56	.34	3.56	.84	3.28	.80	.84	3.72	.60	3.60	.64	.65
29	1.72	.92	1.80	.88	.87	1.80	.92	2.04	.80	.62	2.48	.92	2.68	.96	.83
31	2.60	1.00	2.64	1.00	.88	2.60	1.00	2.48	.84	.81	2.80	.76	2.72	.72	.94
33	2.72	.76	2.56	.76	.39	2.60	.80	2.64	.72	.83	3.08	.80	3.00	.64	.82

TABLE XLIV (continued)

Obj.	0-5 Years						6-15 Years						15 Years					
	Agree		Practice		r	Agree		Practice		r	Agree		Practice		r			
	\bar{X}	σ	\bar{X}	σ		\bar{X}	σ	\bar{X}	σ		\bar{X}	σ	\bar{X}	σ				
PSSC																		
8	3.44	.72	3.08	.48	.55	3.68	.60	3.28	.64	.60	3.72	.60	3.32	.60	.65			
9	3.16	.72	2.48	.72	.17	2.84	.92	2.48	.76	.51	3.40	.72	2.92	.72	.74			
10	3.12	.88	3.08	.68	.63	3.20	.64	3.20	.48	.67	3.48	.64	3.32	.60	.66			
13	3.04	.80	3.00	.64	.66	3.12	.68	3.00	.72	.68	3.28	.60	3.28	.60	.80			
14	3.40	.80	3.16	.68	.60	3.36	.80	3.16	.76	.85	3.68	.60	3.20	.68	.34			
15	2.76	.96	2.60	.72	.80	3.04	.80	2.88	.64	.73	2.92	.88	2.68	.80	.07			
16	2.96	.88	2.68	.88	.81	3.16	.84	2.88	.80	.84	3.08	.72	2.80	.68	.78			
17	3.72	.60	3.80	.48	.80	3.84	.40	3.88	.36	.34	3.88	.36	3.88	.36	.42			
19	2.72	.72	2.84	.72	.71	3.08	.76	3.04	.56	.75	3.12	.84	2.92	.72	.87			
20	3.44	.76	3.20	.76	.77	3.60	.68	3.36	.56	.57	3.60	.52	3.28	.44	.49			
21	3.76	.52	3.56	.56	.73	3.64	.68	3.52	.68	.79	3.72	.60	3.28	.60	.62			
24	3.44	.76	3.24	.64	.72	3.56	.72	3.20	.68	.61	3.60	.52	3.08	.28	.22			
25	3.48	.72	3.36	.68	.55	3.20	.96	2.88	.84	.63	3.60	.52	3.32	.48	.29			
28	3.00	1.00	3.04	.92	.62	3.24	.76	2.88	.84	.76	3.28	.96	3.08	.88	.73			
30	3.64	.56	3.40	.56	.51	3.60	.72	3.36	.68	.74	3.68	.48	3.40	.52	.29			
32	2.44	1.00	2.60	1.12	.54	2.56	1.08	2.52	.96	.88	3.08	.80	3.08	.88	.90			

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correlation between agreement and practice for each objective. There were 32 teachers that responded in the 0-5 year category, 28 teachers in the 6-15 year category, and 15 teachers in the greater than 15 year category.

To determine if there were any differences in objectives between the three categories, a Chi-Square Analysis was performed. To insure that all the criteria for a Chi Square Analysis were met, the cells were collapsed in the same manner as with school size (see page 156). In both "agreement" and "practice" there were no significant differences measured at the 0.01 level.

Summary of Areas Where Objectives of the Teachers Differed the Greatest

Three different groupings of teachers were made to determine any differences in teaching objectives. These groups were made according to school size, physics class size, and teachers' years of experience. For each grouping a certain number of objectives have been found to differ by a Chi Square Analysis at the 0.01 level of significance. In this section, the objectives that differed for each grouping are combined into three broad areas. These included the teaching objectives where the Montana physics teacher differed the greatest in their teaching objectives. These areas are not listed in any particular order.

1. What information should be covered in a high school physics course? Should all areas of physics be covered? This would include mechanics, heat, sound, light, magnetism, electricity, electronics, atomic structure, and nuclear energy. Some teachers agreed with this and some thought that only a few major topics should be covered in depth.
2. Should high school physics be taught to develop in the student the viewpoint of physics that the professional physicist has or not? Should time be spent on the physicist to emphasize to the student that they are typical people with human aspirations?
3. Should physical approximations and models be emphasized to teach theoretical concepts? Should scaling be used, and its role in physics be shown?

Montana Teachers' Objectives in 1972, Compared with the "Traditional" and "PSSC" Teaching Objectives in 1959

In 1959, Trowbridge determined the teaching objectives of physics teachers who had attended P.S.S.C. Institutes and were teaching P.S.S.C. Physics. He also determined the objectives of physics teachers who had not attended any

institutes and were teaching in the traditional manner. Thirty-three of these objectives (17 "traditional" and 16 "P.S.S.C.") were used in the "Teachers' Objectives Questionnaire." The composite objectives that were found for the Montana physics teachers in 1972 were compared with the results Trowbridge found in his study.¹⁴ His sample consisted of randomly selected, "traditional" and "P.S.S.C." physics teachers from throughout the United States.

An assumption can be made that in 1959, the Montana physics teachers were, on the average, "traditional" teachers. This was at the very early stages in the development and implementation of P.S.S.C. Physics. Therefore, very few physics teachers in Montana would have been familiar with this new curriculum. To determine if any changes in the teachers' objectives had occurred, a comparison was made between the Montana teachers' objectives in 1972, and the objectives of the "traditional" and "P.S.S.C." teachers in 1959.

Table XLV, on pages 167 and 168 compares the means of agreement and practice for these two groups.

¹⁴L.W. Trowbridge, Private communications; Dr. Trowbridge made available the raw data from his study. The standard deviations in Table XLV were computed from this data.

TABLE XLV
 COMPARISON OF THE AGREEMENT AND PRACTICE OF OBJECTIVES FOR MONTANA
 PHYSICS TEACHERS IN 1972 WITH "TRADITIONAL" AND "PSSC" TEACHERS IN 1959

Objective	Montana Teachers 1972		"Traditional" Teachers 1959				"PSSC" Teachers 1959				
	Agreement	Practice	Agreement		Practice		Agreement		Practice		
	\bar{x}	\bar{x}	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	
<u>Traditional</u>											
1	3.29	3.20	3.28	.76	3.24	.76	1.04	1.04	1.28	1.08	
2	3.69	3.45	3.64	.52	3.60	.48	1.44	1.12	1.80	1.16	
3	2.35	2.19	1.12	1.08	1.84	.92	1.48	1.00	1.40	.96	
4	3.33	3.05	2.88	1.00	2.64	.72	2.04	1.04	1.84	.76	
5	3.52	3.31	3.80	.32	3.64	.52	2.36	.96	2.16	.88	
6	3.52	3.56	3.80	.32	3.56	.52	3.28	.60	3.04	.64	
7	3.43	3.25	3.64	.48	3.60	.52	2.08	.88	2.08	.80	
11	2.32	2.43	2.44	1.04	2.36	1.00	1.40	1.00	1.56	.96	
12	3.61	3.49	3.64	.52	3.28	.56	3.16	1.00	2.68	.88	
18	3.59	3.35	3.08	.84	2.88	.80	1.76	1.08	1.72	1.04	
22	3.45	3.37	3.60	.84	3.36	.60	2.24	.84	2.08	.84	
23	3.20	2.99	3.36	.72	2.96	.76	3.08	.80	2.78	.68	
26	3.29	3.08	2.44	.80	2.36	.76	1.40	.92	1.56	.84	
27	3.57	3.47	3.44	.76	3.32	.52	2.48	1.08	2.48	1.04	
29	1.89	2.07	2.52	1.00	2.60	.92	0.96	.88	1.20	.96	
31	2.64	2.59	2.96	.84	2.72	.76	2.72	.92	2.24	.76	
33	2.81	2.68	3.56	.44	3.48	.48	2.00	.92	1.88	.92	

TABLE XLV (continued)

Objective	Montana Teachers 1972		"Traditional" Teachers 1959				"PSSC" Teachers 1959			
	Agreement \bar{X}	Practice \bar{X}	Agreement \bar{X}	σ	Practice \bar{X}	σ	Agreement \bar{X}	σ	Practice \bar{X}	σ
<u>P.S.S.C.</u>										
8	3.59	3.21	3.08	.64	2.60	.68	3.88	.28	3.44	.52
9	3.08	2.56	2.92	.96	2.52	.88	3.28	.72	3.12	.80
10	3.23	3.19	3.04	.68	2.84	.76	3.56	.64	3.28	.64
13	3.11	3.05	3.48	.64	3.24	.60	3.32	.60	3.08	.60
14	3.44	3.16	3.32	.60	2.96	.64	3.68	.48	3.24	.56
15	2.89	2.71	2.88	.72	2.44	.72	3.28	.72	2.68	.72
16	3.03	2.77	2.68	.88	2.40	.88	3.40	.72	2.64	.80
17	3.79	3.83	3.48	.68	3.44	.60	3.68	.56	3.68	.48
19	2.93	2.93	2.36	1.08	2.32	.92	3.52	.76	3.24	.80
20	3.53	3.27	3.24	.68	2.80	.64	3.76	.48	3.20	.52
21	3.71	3.48	3.60	.60	3.44	.64	3.72	.60	3.60	.56
24	3.52	3.19	3.00	.84	2.48	.76	3.68	.52	3.04	.64
25	3.40	3.00	3.04	.80	2.76	.72	2.48	.92	2.28	.84
28	3.15	2.97	3.36	.76	3.04	.80	3.44	.68	3.04	.72
30	3.63	3.39	2.80	.96	2.44	.88	3.92	.20	3.52	.52
32	2.61	2.67	2.20	1.08	2.24	1.00	3.60	.72	3.44	.68

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To better determine if any differences in the objectives had occurred, a Chi Square Analysis was made for each objective. The composite objectives of the 67 "traditional" teachers and the objectives of the 72 "P.S.S.C." teachers in Trowbridge's study were separately compared to the objectives of all Montana physics teachers in 1972. Due to the large N, the cells of the questionnaire did not have to be collapsed. The criteria of the Chi Square Analysis were met. Table XLVI, on page 170 lists the objectives that differed at the 0.01 level of significance.

The Chi Square Analysis only determines if differences in the responses exist. It does not calculate what causes the differences. A two tailed, independent "t test" was performed for each objective to determine if the means were significantly different. If there was a significant difference, Table XLV, on pages 167 and 168, established which group favored the objective more. This established the trend for the differences found in the Chi Square Analysis. Table XLVII, on page 171 lists the objectives that had a difference at the 0.01 level of significance when using the "t test".

TABLE XLVI

THE TEACHING OBJECTIVES OF THE MONTANA
PHYSICS TEACHERS IN 1972 AND "TRADITIONAL"
AND "PSSC" PHYSICS TEACHERS IN 1959
THAT HAD A SIGNIFICANT DIFFERENCE
WITH A CHI SQUARE ANALYSIS

Objective	Montana vs. "Traditional" 1972		Montana vs. "P.S.S.C." 1972	
	Agreement χ^2	Practice χ^2	Agreement χ^2	Practice χ^2
<u>Traditional</u>				
1			54.5	53.4
2		14.0	68.5	38.6
4			36.5	28.8
5	19.2	23.7	25.5	19.9
6	15.9			
7		23.5	42.2	33.6
12			13.4	12.6
18			55.0	38.0
22	34.2		34.2	29.8
23	12.5			
27			18.9	13.0
29	32.5	32.2		
31	13.8			
33	55.2	61.7		
<u>P.S.S.C.</u>				
8			14.3	21.8
9		11.9	14.7	33.1
10			26.2	13.9
13	19.9			
14			13.1	13.4
15			18.5	
16			14.5	
19			45.4	31.4
21				12.5
25			15.4	
28			14.9	
30	11.8	15.2	20.9	
32			73.8	56.7

critical value of χ^2 , $\alpha = 0.01$, $df = 3$, is 11.34¹⁵

¹⁵Ferguson, *op. cit.*, p. 407.

TABLE XLVII

THE TEACHING OBJECTIVES OF THE MONTANA PHYSICS TEACHERS IN 1972 AND "TRADITIONAL" AND "PSSC" PHYSICS TEACHERS IN 1959 WHO HAD A SIGNIFICANT DIFFERENCE WITH THE "T-TEST"

Objective	Montana vs. "Traditional" 1972		Montana vs. "P.S.S.C." 1972	
	Agreement t	Practice t	Agreement t	Practice t
<u>Traditional</u>				
1			9.24	8.03
2		3.40	10.73	6.87
4			6.07	5.90
5	4.31	4.67	5.72	4.36
6	4.19			
7	3.36	4.54	6.89	5.02
11	3.53	2.72		
12				3.33
18			8.85	7.26
22		6.29	6.29	5.76
23	2.71			
26		2.73		
27			4.52	3.77
29	6.16	6.20		
31	3.90	3.42	2.72	
33	8.72	9.43		
<u>P.S.S.C.</u>				
8			4.09	5.00
9		2.64	2.47	5.73
10			4.27	2.85
13	4.54		3.66	2.75
14			3.41	3.28
15			4.15	
16			2.96	
19			5.81	4.44
20			2.93	3.33
25			3.64	
28	2.85		3.35	3.06
30	3.53	4.09	4.35	3.29
32			8.06	7.22

critical value of t for two tailed test, $\alpha=0.01$, $df=120$, is 2.62^{16}

¹⁶Ferguson, *op. cit.*, p. 406.

When Tables XLVI and XLVII are studied, it can be observed that the objectives of Montana's physics teachers in 1972 differed from the "P.S.S.C." teachers more than from the "traditional" teachers. Using the initial assumption that in 1959, Montana's physics teachers were "traditional", it can be determined which objectives have changed since then.

Differences In Agreement

When the agreement of the "traditional" teachers were contrasted to the 1972 Montana physics teachers by Chi Square Analysis, there were significant differences at the 0.01 level for nine objectives. Seven of these objectives were "traditional", and two were "P.S.S.C.". Using the "t test", all of these objectives, except one, had significant differences at the 0.01 level.

Three of the objectives of the Montana physics teachers also had a significant difference at the 0.01 level when compared to the "P.S.S.C." teachers using the Chi Square Analysis. From Table XLV, it was found, however, that the mean of Montana's physics teachers had moved in the direction of the "P.S.S.C." teachers.

These objectives were:

5. To study magnetism and electricity from the standpoint of electrical circuits, current flow, current generation, and relationships between potential, current, and resistance.

22. To study the nature and characteristics of sound phenomena.

30. To emphasize the method of laboratory investigation for learning.

Seven of the objectives of the Montana physics teachers did not differ from the "P.S.S.C." teachers at the 0.01 level of significance using Chi Square Analysis. These were:

6. To teach the proper use of physics apparatus.

13. To show the importance of scaling and its role in physics.

23. To study natural radioactivity and elementary concepts of nuclear reactions.

29. To emphasize practical (English) units of measurement.

31. To develop growth in skillful use of democratic processes.

33. To study some of the static and dynamic aspects of fluids.

Differences in Practices

When the practices of the "traditional" teachers were contrasted to the 1972 Montana physics teachers by using the Chi Square Analysis, there were significant differences at the 0.01 level for eight objectives. Six of these objectives were "traditional" and two were "P.S.S.C." Using the "t test", all of these objectives, except one, had significant differences at the 0.01 level.

Five of the objectives of the Montana physics teachers also had significant differences at the 0.01 level when compared to the "P.S.S.C." teachers using Chi Square Analysis. From Table XLV, on pages 167 and 168, it was found that the means of four of these had moved away from the "traditional" value and closer to the "P.S.S.C." value. These objectives were:

2. To study the following areas of physics: mechanics, heat, sound, light magnetism, electricity, electronics, atomic structure, nuclear energy.

5. To study magnetism and electricity from the standpoint of electrical circuits, current flow, current generation, and relationships between potential, current and resistance.

7. To study the nature and characteristics of heat phenomena.

9. To emphasize the integrated film program for helping to teach the principles of physics.

Objective twelve, a traditional objective, was accomplished in practice more in Montana during 1972 than among "traditional" teachers in 1959. This objective was "to teach the elements of the scientific method and develop skill in its use."

Three of the objectives of the Montana teachers did not differ in practice at the 0.01 level with Chi Square Analysis when compared to the "P.S.S.C." teachers. These were:

29. To emphasize practical (English) units of measurement.

30. To emphasize the method of laboratory investigation for learning.

33. To study some of the static and dynamic aspects of fluids.

Summary of Areas Where Montana Physics Teachers' Objectives Differ from "Traditional" Teachers

By incorporating the objectives, in which a difference was measured between the "traditional" teacher and the Montana teacher in 1972, three general areas of differences were found. These areas can be interpreted as the places in Montana high school physics which have experienced change since 1959.

The first area concerned the laboratory. The use of the laboratory investigation as a method of learning was emphasized more in 1972 than in 1959. In conjunction with this, the proper use of physics apparatus was taught more.

The second area concerned the syllabus of the high school physics course. Several units of physics were losing popularity and were not being taught to the extent they were in 1959. These units were sound, heat, nuclear physics, statics, and dynamics.

The last area of change has been the system of units used in the classroom. In 1959, the English system of units was popular. In 1972, this system had lost popularity, and the meter-kilogram-second system had replaced it.

Comparison of Changes to Trends Found by Orlich

In Orlich's study of Montana science teaching, seven "current" trends were listed.¹⁷ These were the "current" trends in 1959. Three of the trends involved the "better" students. Either these students would be allowed to accelerate their classwork, or special classes would be designed for for them in the sciences. From the data collected in 1972, it was found that dual track science courses did not materialize. Many schools, in 1972, allowed the better student to take biology in the ninth grade.

Three of Orlich's trends involved an increased use and availability of the laboratory. It was found that this trend has continued, and in 1972, the laboratory was a more significant part of the high school physics program than it was in 1959.

The last of Orlich's trends indicated that teachers were covering fewer topics, but more thoroughly, rather than to cover several topics less thoroughly. This trend has continued. Indications were that in 1972, several topics were not emphasized as much as in 1959. However, a broad spectrum of physics was still being taught. The areas of mechanics, electricity, magnetism, light, and atomic theory

¹⁷Orlich, op. cit., p. 65.

were still covered in the typical one year Montana high school physics class.

CHAPTER V

ANALYSIS OF THE INTERVIEWS WITH THE MONTANA PHYSICS TEACHERS AND VISITS TO THE HIGH SCHOOLS

During the fall of 1972, the researcher personally visited twenty-two stratified, randomly selected high schools in Montana. The stratification of the selection was made according to the total student enrollment in the high school. At each school a set procedure was followed. This was done to insure that the same information would be obtained at each school.

A minimum of one hour and maximum of three hours were spent interviewing each physics teacher. The interview was conducted in an informal manner, whenever possible. The teachers were encouraged to talk freely about the physics program at their high schools. At the end of the interview if all of the topics on the "Teacher Interview" form (see Appendix F, page 260) had not been covered, these questions were specifically asked. After the teacher interview, the researcher examined the physics laboratory, high school library, and audio-visual center. Notes were kept on the "Researcher's Investigation" form, (see Appendix G, page 267).

The findings from these visits were analyzed according to the enrollment category of the high school. The interviews were made after the questionnaires had been received

from the teachers. When the teachers filled out the questionnaires, they were unaware that they would be interviewed. In the sample of schools visited, four teachers were interviewed that did not complete the questionnaire. This allowed a test to be made of the validity of the questionnaire. The results of this test will be discussed.

Schools Visited with Enrollment Less Than 100 Students

Five schools with enrollments less than 100 students were visited by the researcher. All were offering physics and chemistry on alternate years. Enrollment in the physics class varied from 4 to 11 students. Total enrollment in the high schools varied from 36 to 82 students.

All the teachers felt that only the high ability students took physics. The other students went into business or shop courses. There was a general feeling among the teachers that students in small high schools were not very interested in going on to college. The teachers felt that only three or four students from each graduating class really had a strong desire to continue their education beyond high school.

All of the teachers mentioned that one of their main goals was to provide the students with a basic foundation in physics so that they could take college physics. Three of

the teachers admitted that they had a difficult time with college physics, and they wanted to prepare their students so they would not have the same problems. One teacher was trying to develop a practically oriented physics class which would be meaningful to more high school students. However, this teacher felt that chemistry was the science course for all students, and in order to take physics, a student should have had advanced algebra.

Three of the teachers were using a straight "traditional" approach. In these classes, laboratory and exercise workbooks were being used. The class would meet four days per week in lecture or discussion (including problem solving) and one day per week in the laboratory. The laboratories were "cookbook". No P.S.S.C. or Project Physics was being used, although one school did have one ripple tank, and several carts and timers from P.S.S.C. The laboratory equipment was interpreted by the researcher as being the minimal "traditional" equipment necessary for the number of students enrolled. No "extra" equipment was available for special demonstrations or student projects in physics.

One teacher used a straight P.S.S.C. approach. This teacher had not taken a P.S.S.C. institute, but when he came to the school he found that the only equipment available

was P.S.S.C. Therefore, he followed the teacher's handbook closely and became knowledgeable about the curriculum. He covered most of the P.S.S.C. material in a one year course.

The fifth teacher had designed his own syllabus. He used P.S.S.C. laboratories and Physics: An Exact Science by White, as the student textbook. He covered electricity and electronics the first semester, and light and astronomy the second semester. Mechanics was only taught when it was needed for these areas. He believed strongly in a practically oriented, "hands on" science. The students were allowed to pick the problems in these areas they wanted to study. The teacher found that no matter what problems were picked by the class, essentially all of a typical high school physics course had to be studied to solve the problems.

All of the teachers relied heavily on testing for grading the students. One teacher used the standardized tests that accompany Taffel's text,¹ but the other teachers made up their own tests. About three-fourths of the teacher-made tests were mathematical or formula type word problems. The rest of the tests were multiple choice, essays, or definition problems.

¹Alexander Taffel, Physics: Its Methods and Meanings, Allyn and Bacon, Inc., New Jersey, 1969.

The use of field trips or guest speakers in the physics classes was minimal. All of the teachers indicated, however, that if guest speakers were available who could speak at the level of high school students, they would use them. Three of the schools had science clubs. It was mentioned by the teachers that physics did not play a very large role in these science clubs.

None of the schools had a regular equipment and supply budget. The teachers had to make out a list of needed material and take it to the superintendent. The superintendent and school board then decided exactly what was purchased. Three of the teachers noted that this did not lead to wise, long range planning. The amount of money spent on physics equipment during the preceding year varied among the schools from nothing to 300 dollars. The mean among the five schools was 170 dollars. Two teachers said that their school had purchased physics equipment with federal aid in the past, but this equipment was wearing out now and not being replaced. Three teachers claimed it was hard to justify the expenses of a physics program with so few pupils.

When the researcher looked over the laboratory equipment, he found the two schools that were using P.S.S.C. laboratories were well equipped. These schools had physics

teachers who had remained at the school for over five years and built up a "good" laboratory. Both of these schools had used federal money to purchase the equipment. These two schools still had the older "traditional" equipment which blended together with the P.S.S.C. equipment, to provide many different opportunities for the students.

The other three schools were not as well equipped. One of the schools did have extra "tinkering" equipment for the students, but on the whole, they had the minimal equipment necessary to do one laboratory workbook exercise each week for one group.

The teachers' personal information obtained during the interviews agreed very well with that reported in Chapter IV. One of the teachers had no college physics, two had one year of introductory college physics, one had 30 quarter hours of physics, and one had 60 quarter hours of physics. The teachers with one year or less of physics admitted that this hurt their teaching style. They expressed an interest in taking physics courses from the colleges that would help them be better physics teachers. Two of the teachers admitted that they would not take a regular physics course, for it would be too difficult and therefore, not benefit their teaching. It would have to be a physics course for teachers.

None of the school libraries were sufficient. Three of the schools had very poor libraries. Two of the libraries had several general interest books dealing with physics or physicists. These two libraries also had one or two general interest science magazines, such as Scientific American. One of the teachers maintained his own science library in his classroom. He was the only teacher among the five that required the students to write reports or do any outside reading.

The schools were equipped with sufficient audio-visual materials. All of the teachers said they had no problem due to insufficient materials. The equipment that was used most were overhead and movie projectors. Four of the teachers showed some movies to their physics classes. The main source of the films were the Federal Government, Oil Companies, and Modern Learning Aids. Three teachers complained about the difficulty in obtaining films from the State Film Library in Helena. They stated further that when they did get the films, they were usually old and out of date. Three of the teachers used the overhead projector frequently in their classes. Only one teacher claimed that he never used any audio-visual materials besides the blackboard and chalk.

Recommendations by Teachers of Schools with Enrollment Less Than 100

At the conclusion of each interview, the teachers were asked to make suggestions on how various government agencies could help the physics program at their school.

1. What do you think the State Department could do to help improve your physics program?

Four teachers had suggestions. They all felt that the film library could be improved. Two major problems were mentioned. The first concerned the availability of the films when they were needed. Several teachers said that when they ordered them, they often did not arrive until late. This meant that the films often could not be shown when they would have the greatest learning impact on the students. The second problem was on the quality of films. The teachers said there were too many old films in the library and not enough new films that were produced for the new curricula.

It was also suggested that the State Department mail a pamphlet once a month to all physics teachers. This pamphlet could contain "practical" information such as: job opportunities, applications of physics, new teaching methods and evaluations of equipment.

2. What do you think the Federal Government could do to improve your physics program?

Only one answer was given by three of the teachers, and that was to provide money to purchase equipment. These teachers said that their small school districts could not afford to buy the equipment necessary for a strong physics program.

3. What do you think the colleges and universities could do to improve your physics program?

This question received the greatest number of replies. All of the teachers mentioned the lack of communications among physics teachers in the state. They all felt that somehow the teachers should be brought together. Four teachers suggested seminars at the colleges. Two teachers said that they would need to receive some travel expenses in order to attend, but it would not have to be as much as was usually paid. They felt the teachers could form car pools and get to know each other while traveling to the seminar.

Three teachers mentioned the need for summer courses in physics for the physics teacher. They expressed a desire to learn how to make physics more practical and how to use the laboratory more effectively.

Three teachers mentioned the science teaching assistance center at Montana State University, (see definition page 17). In principle, they thought it was an excellent idea. They felt that the equipment should be loaned to the schools for use by the students. Two said that it was impractical for them to travel all the way to Bozeman to look at science equipment. Two teachers felt a science coordinator should be assigned to the center. This person should be on call for any problems the teachers may have. He could also serve as a catalyst to start communications among the teachers. One teacher suggested that every school in the state could contribute 25 or 50 dollars that could be used to help pay the expenses of travel and mailing involved with the center.

Several other suggestions were made by one teacher. These included making available visiting professors, writing programmed courses in P.S.S.C. and Project Physics, and having the University library start a high school student loan service by mail.

Summary of Findings For Schools with Enrollment Less Than 100 Students

The physics programs in the high schools with less than 100 students are beset by some major problems. However, these could be solved with outside help and guidance. One

of the historical problems that has hurt the small schools has been the large turn-over of teachers. In the visits, four of the five teachers indicated they enjoyed teaching at a small school, and planned to stay at the school where they were teaching. Perhaps the current job market will help stabilize the teachers at the small schools. This must be accompanied by the school boards' willingness to pay the teachers a living wage.

The teachers at the small schools were young and energetic. On the whole, they were not well prepared to teach physics, but were anxious for the opportunity to learn. If these teachers were given the knowledge of how to teach physics in a more meaningful fashion for the typical high school student, they would most likely change their methods.

This would mean an increased enrollment, which would make the school boards more willing to fund the physics program at a higher level. The problems of physics at the small schools were interrelated in a circular fashion. In order to break this circle someone has to be committed to improving the physics program. From the visits, it appeared that the local schools and physics teachers could not do this alone. They were not knowledgeable enough on how to actually accomplish it. Help must come from an outside

source. This help must be in a cooperative, sharing manner; one which would benefit all teachers.

Schools with Enrollment Between 100 and 300 Students

Five schools were visited in this size range. The total enrollment of the schools varied from 126 to 275 students. Four of the schools offered physics every year and had between six and nine students in the class. One school offered physics on alternate years with chemistry and had eleven physics students.

Only the high ability students were taking physics. In two of the schools, the enrollment in physics during the preceding five years had decreased by 50 percent. College preparatory was one of the main concerns of the teachers. They wanted to make sure their students were prepared for college physics.

Four of the schools were using a "traditional" approach to teaching physics. One teacher was using P.S.S.C. The "traditional" teachers varied in their outlook on physics. Two felt that the students needed to be pushed and to work problems, to fully understand physics. The other two questioned the value of high school physics to the typical student the way it was presently being taught, and wanted to

change their approach. They indicated they would need help in order to do this.

The teacher who was using P.S.S.C. followed the teacher's handbook closely. He emphasized the creative laboratories and believed in the inquiry approach. He felt this type of physics could only be successful with the better students. He had, therefore, prepared a special one semester electronics course for the other students. This course had not reached the popularity he had hoped for, but he was still optimistic. He did not want all high school students in electronics, for he felt some would only ruin the equipment.

Even though only one teacher was using P.S.S.C. exclusively, two other teachers did use some of the laboratory exercises from P.S.S.C. The laboratory facilities for three of the schools were excellent. They had new laboratories and equipment. Most of this was funded with federal money. These schools had enough P.S.S.C. and "traditional" equipment for classes twice the size that they had. Many of the larger schools that were visited did not have the excellent facilities that these three schools had.

Two of the schools visited in this size category did not have well equipped laboratories. One of these schools

had burned down the previous year, and all the equipment was lost. The other school had a new laboratory classroom, but very little equipment. The teacher said there was not enough equipment at this school for the students to do one laboratory exercise per week.

None of the teachers had a yearly budget for equipment and supplies. Each year a list had to be made of the needed equipment, and taken to the superintendent. The superintendent and school board members then decided what to purchase. The amount of money the teachers received during the 1971-72 school year to purchase physics equipment varied from nothing to 500 dollars. The mean was 250 dollars. Three of the schools had received federal money in past years to buy equipment and remodel the laboratory. For the most part, this equipment was still in excellent condition.

The emphasis during 1972 for four of the teachers was on problem solving. The class followed a routine schedule each week. Problems would be assigned each week, one laboratory would be done each week when possible, time would be spent in class answering questions on the problems and theory, and in most cases a quiz would be given on Friday. The next week a new chapter would be started.

Four teachers made up their own tests. They were over

50 percent problems. The rest of the test would consist of matching, essay, short answer, and fill in type questions. One teacher did use the textbook tests, even though he did not like them.

There were no science clubs in the five schools. Very few field trips were taken by the physics classes. Two schools did have science fairs, but one teacher said that most of the projects were in biology. Three teachers expressed an interest in taking field trips and having outside speakers to their classes, but did not know where to go or who to invite.

The high schools' library facilities varied again from excellent to poor. Two of the schools had new libraries with a good selection of scientific books and magazines for high school students. One school did not have good facilities, but the teacher had built up an excellent personal library for student use. Two schools had poor libraries. One school had burned down, so the lack of a library was understandable. The library in the other school contained several older textbooks, and no scientific magazines. None of the teachers required outside library work, and three teachers commented on how little the students used the library.

The movie and overhead projectors were the only audio-visual equipment used by the teachers the researcher visited. One teacher mentioned she did not show movies because the projectors were too hard to obtain. Three teachers showed movies. The most popular source for films was the Federal Government or industry. Films from the State Library were used, but comments were made as to the poor selection, and bad delivery. Two teachers said that all movies put the students asleep, and had lost their effect because of over-use by some other teachers.

The preparation in physics for the teachers varied. Three teachers had 15 quarter hours or less of college physics. One teacher had 40 hours and the other 60 hours of physics coursework. The comment was often made that they had to teach too many courses, to be well prepared in any one. Three of the teachers had attended NSF summer institutes and felt they were very valuable to their teaching.

Recommendations of Physics Teachers

1. What do you think the State Department could do to help improve your physics program?

Two suggestions were given. Three teachers felt the film library should have a larger and more up to date

selection of films. One teacher felt that in conjunction with the annual MEA Convention, a meeting of all science teachers should be held.

2. What do you think the Federal Government could do to improve your physics program?

Three teachers felt the need for continued support for physics institutes in order that they could learn more physics and how to teach it. Two teachers felt the need for money to purchase laboratory equipment for their schools.

3. What do you think the colleges and universities could do to improve your physics program?

The need for summer and in-service courses was mentioned by four of the teachers. Three mentioned they were interested in both junior and senior level physics courses as well as methods courses. The methods courses should emphasize how to teach laboratory and "practical" physics.

Communications among the high school physics teachers in the state was mentioned by three teachers. They hoped the curriculum center would increase this. Two teachers also hoped the center would lend equipment to the schools and publish bulletin board material. These two schools were

a long way from Bozeman, and these teachers doubted whether they could use the center if it could not be by mail.

Summary of Findings For This School Size

The overall quality of the laboratory and physics equipment at these schools was very good. It was surprising to note the amount of equipment available for so few students. The small number of students still posed a problem. With a small enrollment, physics did not demand a major position in the overall high school curricula. Outside help was needed and would be welcomed to increase the interest and enrollment in physics.

The teachers varied from young to the more experienced. The young were energetic and eager to learn new ways. The more experienced were cooperative and would be eager to share their experiences with the younger teachers, if the opportunity was available.

When contrasted with teachers of schools with enrollments less than 100 students, the teachers seemed a little more certain of their teaching approach. The traditional teachers seemed to express a feeling that the universities expected and wanted them to teach in this manner. They felt that problem solving in high school was necessary to succeed in college physics. They, therefore, had to provide this

for the students who wanted to continue their education in science and engineering. These teachers would not change their approach quickly, but would have to be confident that any new approach was better and more successful than their present methods.

Schools with an Enrollment Between 301 and 800

Four out of the twenty-two Montana high schools visited were in this size range. Over 20 percent of the high school students in Montana attended one of these twenty-two schools during 1972-73. The schools that were visited had total enrollments varying from 413 to 570 students. Two of the schools were three year high schools and only the enrollment in those three years were counted.

Physics was offered every year in all four schools. The enrollment in physics in 1972 was between 11 and 27 students. This was compared to the enrollment in chemistry which ranged between 29 and 72 students. The enrollment in all the schools came from only the top 25 percent of the students. In three of the schools only the excellent or very high ability students took physics. Two of the teachers were very concerned about the rapidly falling enrollments in physics, and were modifying their courses to try and attract more students. One teacher had an enrollment

drop from 65 to 16 students in three years. At this school, in 1972-73, many of the better students were not taking physics. Three of the teachers indicated that one of their main goals was to prepare students for college.

None of the teachers used a totally "traditional" approach. P.S.S.C. laboratories were used in all four schools. One school used P.S.S.C. totally, while another teacher had just changed from the P.S.S.C. text to Taffel's book to try to attract more students. All of the teachers emphasized problem solving. The classroom routines were similar. One half of the period was spent on lecture, and the rest of the time was spent in working problems and answering questions. One laboratory exercise was done each week.

All four teachers constructed their own tests. At least three quarters of the questions were word problems. The rest were fill in, essay, and some multiple choice questions. The scores on the tests were weighted heavily on the students' grades.

Three of the schools that were visited had new science facilities. All of the schools had good equipment for the number of students enrolled in physics. Federal money helped in purchasing the equipment and building the new

facilities. Most of the new equipment was for P.S.S.C. laboratories. This new equipment blended together with the older "traditional" equipment to provide a diverse opportunity for the students.

Three of the schools had no annual budget for purchasing equipment or supplies. A list had to be made out by the teacher and given to the principal or superintendent. The administration and school board then decided what equipment to buy. One teacher was given a budget for science equipment each year by the principal. The principal did, however, want to look over the order list to make sure nothing inappropriate was being purchased. The amount spent on physics equipment during the 1971-72 school year varied from 300 to 700 dollars. The mean for the four schools was 515 dollars. All the teachers indicated that in the past large blocks of money had been spent on science equipment. Often this was associated with Federal funds.

The college preparation in physics for the teachers varied. The number of quarter hours of physics for the four teachers were 15, 20, 34, and 45. Two teachers were teaching all science classes while two were teaching physical science and mathematics classes. On the average, these teachers had fewer class preparations than the teachers from

the smaller schools, and thus, could devote more time to their physics classes. Three of the teachers had attended Federally sponsored institutes.

Two of the teachers were anxious to try a dual track physics program at their schools. They wanted to start a Project Physics class for the non-science students. They were trying to figure out how they could obtain some of the necessary equipment, and the extra free period to teach the class. They felt it would take several years to build up a good enrollment in the class. At the time of the visit, none of the schools had any Project Physics material.

The quality of the school libraries varied. Two of the libraries were good in the area of science. They had a very good selection of science magazines and periodicals. These libraries also contained a number of physics or physics related books. One of the teachers at these schools was the only teacher visited in this size category that required outside reading or library work. A spring research report had to be done by each student.

Two schools had better overall libraries than their science section would indicate. These schools had only one or two popular science magazines and several old high school textbooks in physics. To compensate for this, one of the

teachers had started his own physical science library in the classroom. These teachers did not require any outside library work and did not seem very concerned about the condition of the science library.

All of the schools had sufficient audio-visual equipment. All of the basic equipment was available for teacher use. The teachers used overheads, film loops, and movie projectors exclusively. The overhead projector was most popular with two teachers who used it instead of the blackboard. One other teacher indicated he used the overhead once in a while.

Three teachers showed films in their physics classes. The only source for the films mentioned was the State Library. Two teachers mentioned the difficulty in obtaining these films and the poor condition and quality of many. One other teacher thought the students were super-saturated with movies, and thus, did not show any.

Three teachers used film loops in their classes. Two of these teachers were not happy with the student response to the film loops. They now used them only as a review technique. They had them available for students to use in the back of the classroom. According to the teachers very few students used them.

Recommendations by Teachers of Schools with Enrollments
Between 301 and 800 Students

1. What do you think the State Department could do to help improve your physics program?

Two teachers felt the biggest problem in the physics program of Montana high schools was the lack of communications among the high school teachers, and between the high school and college teachers. They hoped the State Department could do something to increase this communication.

Two teachers mentioned the film library. They hoped this library could be updated and enlarged to meet the demands of all the teachers in Montana.

2. What do you think the Federal Government could do to improve your physics program?

All four teachers thought the most important program the Federal Government could continue for high school science teachers was the institutes. Three of the teachers had attended institutes in science and felt they were very valuable in improving their teaching methods. Two teachers indicated that as much support as was previously given to the teachers to attend institutes was not necessary, but they needed some help in order to be able to attend.

3. What do you think the colleges and universities could do to improve your physics program?

Three teachers indicated the need for summer classes in physics and physics education. They all felt the courses should be a combination of theory and laboratory work that could be used in the high schools. One teacher suggested short one or two week workshops on specific areas of physics.

Three teachers also indicated the need for better communication among high school teachers and between the high school teachers and the colleges. They hoped the curriculum center at Montana State University, would serve as a catalyst in bringing the teachers together. All the teachers indicated a need for the center in principle. Two teachers hoped the high schools would be involved in helping to operate the center. They felt the need for high school teacher input in critiquing and evaluating the materials. They also thought this would be a way to bring the teachers together.

Summary of Findings for This School Size

The teachers visited were very concerned about the falling enrollment in physics. They were very interested in making physics more practical and relevant to the average high school student.

These goals were combined with the common belief that mathematics is very necessary to understand physical principles. The students going on for more education in the sciences and engineering need the vigorous physics to succeed.

The laboratories were relatively well stocked for the enrollment in physics. However, they did not have enough of the equipment needed for a physics course for non-science students. In addition, the teachers would need to be freed of teaching another course in order to be able to teach a dual-tracked physics program. The total student enrollment at the schools were large enough to justify such a program, but the student interest was not there. In order to initiate such a program, the students would have to be "sold" on taking physics. With the large working load of most of the physics teachers, due to the large number of preparations, they would need outside help in order to do this.

The teachers in this size school, when compared to the teachers visited in schools with enrollment below 300 students had fewer classroom preparations. They, therefore, had more time to devote to their physics teaching. This was shown in their knowledge about the various types of teaching approaches in physics. However, they did not have

enough time to thoroughly analyze and test out these different methods. They were very anxious to work with other teachers in improving their approach. This would have to occur in a cooperative, sharing manner in order to succeed. These teachers were well aware that no method of teaching is without its drawbacks.

Schools With An Enrollment of Over 800

Eight of the fourteen Montana high schools in this size range were visited. Over 46 percent of the high school students in Montana attended one of these fourteen schools during 1972-73. The schools that were visited had total enrollments varying from 933 to 2,300 students. Seven of the schools were three year high schools, and only the enrollment in those three years were counted.

The enrollment in physics varied from 18 to 140 students. The trend in enrollment depended upon the high school. Several teachers were introducing new approaches to teaching physics to try and attract more students. For the most part they were succeeding. In the new courses some students who were non-science, non-college preparatory were enrolling. In general, however, only the better, science oriented, college-bound students were taking physics. The percent of total high school students enrolled in physics

was the lowest in the high schools with over 800 students enrolled. This can partly be due to the greater diversity of courses offered to the students.

Three of the teachers mentioned difficulty in getting counselors to recommend physics to the average or non-science student. These teachers indicated that the counselors felt other courses would be of more benefit to these students rather than physics.

Because of the great difference in techniques used by these teachers, the teaching methods will be discussed in depth at the end of this section. The "external" factors found at these schools were more uniform, and thus, can be reported collectively.

The equipment and laboratory facilities were, in general, very good for the number of students being taught. The equipment was a blend of "traditional", P.S.S.C., and in some cases, Project Physics. This provided a wide range of options for the students in the laboratory. Three teachers indicated that they were having difficulty ordering enough equipment to keep up with their increased enrollments. However, these schools still had excellent equipment for the students.

Two schools had the minimum amount of equipment

necessary for a physics program of their size. These schools had a great deal of old equipment, and it took the ingenuity of the teacher to provide the students with educational demonstrations and laboratories. One school had below average equipment. The equipment that was available was good, but there was not enough for a complete high school physics laboratory. Recently, this school had to divide its physics equipment with another school, and money was not provided for replacement.

Three of the teachers had a physics equipment budget. This budget was given in February, and the teacher could order equipment and supplies up to this amount. The order had to be given to the science department head for approval. The other five teachers had to submit a list of needed equipment and supplies to the principal. The principal then decided what equipment would be purchased. The amount of money spent on physics equipment during the 1971-72 school year varied from 100 to 1,500 dollars. The mean for the eight schools was 600 dollars. The school that spent 1,500 dollars was buying Project Physics equipment over a several year span of time. Four other teachers indicated that in the past, their schools had spent large amounts of money on equipment. Federal money had been used at many schools to

improve their physics equipment.

On the average, the library facilities, including the science and physics sections, were very good. Only two schools did not have a good selection of books and magazines in physics and science for the students' reference work. Most of the schools, however, had few general or relaxation books in physics for the students to read. One reason for this could be because only three teachers indicated they worked with the librarians in choosing books for the library.

Four teachers said they required outside library work of their students. Two of these teachers assigned research projects for the students to do each year. Two other teachers required one or two books to be read and reported on in science fiction or biographies of physicists.

The audio-visual equipment available at all the schools was adequate. The teachers had no problems in obtaining any common piece of audio-visual equipment they wanted to use. The equipment that was used the most were the overhead, movie, film loop, and filmstrip projectors.

Four teachers had overhead projectors permanently located in their classrooms. Two other teachers used the overhead projector, but not to the extent of these four

teachers who used them instead of the blackboard.

Four teachers showed films to their physics classes on a regular basis. The most common sources for films were the State Library, Modern Learning Aids, and the Federal Government. Three of these teachers indicated they showed one film per week. It was mentioned by five teachers that the State Film Library had an insufficient selection of films, and were often late in delivering them to the teachers. Because of this, two teachers said they only showed one or two films per year.

The college preparation in physics for the teachers visited varied between 25 and over 60 credits. On the average, these teachers were the best prepared, and most knowledgeable about current teaching methods in physics, than any other school size category. One reason for this was that many of these larger schools had multiple sections of physics, and could employ a teacher who could specialize in physics teaching. Seven of the teachers had attended NSF Institutes on teaching physics. The teachers who attended all indicated this had helped their teaching very much.

One result of the teachers' knowledge about different teaching methods was the wide range of approaches used by the teachers. Physics classes in these schools were being

taught in the "traditional", P.S.S.C., and Project Physics manner.

Three teachers were using the "traditional" approach. Modern Physics was used as the textbook in these three classes. Problem solving and demonstrations were emphasized. The laboratory was not an integral part of the course. All of these schools had very low physics enrollment, with 43 students being the maximum.

Two of these schools had alternative courses in physical science for the non-science student. In one of the schools a comprehensive physical science course was offered during the sophomore year. The other school offered an environmental physics course using Project Physics, but this course had not attracted many students.

One teacher used straight P.S.S.C. This teacher followed the teachers manual closely. The enrollment in physics had dropped drastically during the preceding three years, and for this reason, the teacher had decided to change textbooks for the next year. What new approach he would take had not been decided yet.

One teacher used Project Physics as much as possible. This school was still buying the necessary equipment, and thus, in certain areas the teacher used P.S.S.C. exercises

when the needed equipment was unavailable. Two years previous, this teacher had changed from P.S.S.C. physics to Project Physics because of dropping enrollment. The switch had increased enrollment to 30 students per class. The teacher was presently teaching two classes in another subject, and felt that starting next year he should become a fulltime physics teacher.

Two teachers had their physics classes arranged on an independent study system a great deal of the time. This was done to attract more students. One of these teachers emphasized "practical" physics and only several of the "major laws of physics". The other teacher had three differently paced individualized programs. The students could choose which program they wanted to enter. If a student spent one year in the "practical" program, an option could be made to spend another year in the "college preparatory" program if desired. The physics enrollment had doubled at this school since the inception of this approach. The teacher hoped to double the enrollment again over the next few years.

One teacher had regular and honors physics classes. The honors class consisted of 25 to 30 students who planned on continuing their education in the physical sciences. These students could also take a second year of physics,

which actually started them on college physics. Usually about 20 students took this course.

The rest of the students, which numbered over 100, took a physics course geared toward general education. This teacher did not believe in teaching technology or "practical" physics, but wanted the students to appreciate physics and its applications to nature. Laboratories were an integral part of all these courses.

Recommendations by Teachers in Schools of This Size Category

1. What do you think the State Department could do to help improve your physics program?

Four teachers suggested expanding the State Film Library, so it could better serve all the teachers in Montana. The problems of delivering the films on time, and the poor quality of many films were mentioned.

One teacher would like a library book list sent to the teachers. Another teacher wanted a state competition started for the best physics student and teacher. A scholarship could be given to each winner for further college study.

Two teachers suggested subsidies for summer work. They wanted the opportunity to work with engineers or scientists during the summer. They felt this would improve their

teaching. The State Department would arrange a program such as this.

2. What do you think the Federal Government could do to improve your physics program?

Four teachers mentioned the need for the continuation of institutes. They all indicated they did not need as much support as they had received in the past, but some help would be necessary.

In addition, five teachers mentioned Federal funds had built up their laboratories in past years, and was not needed as much at this time.

3. What do you think the colleges and universities could do to improve your physics program?

All eight teachers mentioned the need for better communications among Montana physics teachers at all levels. They felt this could be accomplished by summer courses and extension work or seminars. Four teachers felt that in the summer, junior and senior level physics courses for teachers should be offered. In addition, courses are needed in physics teaching methods. These should not be high school courses, but a combination of theory and application for

the classroom. All the teachers felt that they would benefit by sharing their ideas with other teachers. Any courses or seminars should draw upon the experiences of the high school teachers.

The science center at Montana State University was mentioned by five teachers. They felt the services the center could perform for them would be to evaluate the laboratory equipment, lend them the more expensive equipment to use, and provide guest speakers. They felt it was essential for the center to get out into the schools if it was to succeed.

Summary of Findings For Teachers in This Size School

On the average, the teachers in these schools were found to be better prepared to teach physics. They were teaching more classes of physics, and thus, had the time to try out different teaching methods. It was disturbing that even though several schools had over 100 students enrolled in physics, percentage-wise this was not large. Several teachers were trying to correct this problem and increase their enrollment. Their experiences and knowledge should be shared with other teachers in the state.

In the large schools the students who did not take physics, had few other alternatives to learn basic physical

science. Several schools offered lower track physics, but the enrollment was small when compared to total school enrollment. Four schools that were visited offered Earth Science in ninth grade. Therefore, the only physical science many students had above elementary school, was that learned in seventh and eighth grade general science.

The laboratories and equipment at these schools were very adequate on the average. Most of the teachers kept up to date on trends in laboratory exercises, and the school districts and Federal Government had provided funds to purchase the latest equipment. If some of the teachers succeed in increasing their enrollments, the laboratory space at several of the schools may become overcrowded. Physics is an expensive program, and it will be interesting to determine if the schools will fund this program for a larger number of students.

Summary of Visits to Twenty-Two High Schools of All Sizes

The conditions found at the schools that were visited corresponded very well with the results of the "high school physics questionnaire". One important discovery was the diversity of the public high schools in Montana. They ranged from the small rural high school of 40 students to the large urban three year school of over 2,000 students.

Each school seemed to have its own set of unique advantages and disadvantages. However, in most of the schools visited, there were several common trends and needs that affected the physics program.

The first and probably the most important was the attitude of the teachers. All of the teachers were open and sincerely interested in improving their physics teaching. So much could be learned if the Montana high school physics teachers could get together and share their experiences. Each of the teachers could share the successful programs at their school.

Another common trend was the falling enrollment. Only a few schools had increasing physics enrollments. The teachers were concerned about this and many were beginning to question the way they were teaching physics. The most common approach was to emphasize problem solving, and prepare students for college physics. The interest in science among high school students was declining and some teachers thought this accounted for their enrollment decrease.

On the average, the schools had adequate laboratory space and equipment for the number of students enrolled in physics. There was a definite contrast, however, between schools that remodeled and bought equipment with Federal

money, and those that had not. It appeared that somehow the students in the schools that had not updated their physics program during the past ten years were being penalized. The center could perhaps help these schools by lending them some equipment to use during the year.

The formal college education in physics for the teachers varied. Teachers with all levels of training still wanted more courses or seminars in teaching high school physics. These courses should emphasize both theory and teaching methods. On the average, the teachers at the larger schools were better prepared in physics. They had fewer preparations, and could devote more time to physics teaching. At the smaller schools, the teacher taught four or five other courses and, because of the low enrollment in physics, they could not devote a great deal of extra time to it. In the small schools, physics was also usually taught on alternate years, which increased its neglect.

The physics section of most of the high school libraries was inadequate. Most teachers did not have students do any outside reading. The schools provided little opportunity for the students to do leisure reading in physics.

The audio-visual equipment was adequate at most high schools. The physics teachers used mainly the overhead and

movie projectors. Filmstrip and film loop projectors were used at some of the larger schools. The overhead projector was used in most cases, as a substitute for the blackboard. It therefore, provided little change in the teaching approach. The films were obtained from the State Library, Federal Government, industry, and Modern Learning Aids. The State Library was often criticized for its poor service and selection of films.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary problem of this study was to investigate the status of Montana public high school physics teaching during the 1972-73 school year. Both the physics teachers' objectives and "external" factors were explored. The "external" factors included the teachers' academic preparation, availability of laboratory equipment, availability of supplementary teaching materials, and availability of physics courses to high school students.

The Montana public high schools were categorized into various groupings according to total student enrollment in the high school, student enrollment in physics, and the physics teachers' years of experience. These groups were compared to determine if any differences existed.

The review of literature revealed several studies on high school physics practices. These studies formed a basis of comparison for the 1972 results. Two studies were done in Montana. These were done by Orlich in 1958¹ and Gebhart

¹ Donald C. Orlich, An Appraisal of the Methods of Teaching Science In the Senior High Schools of Montana, (unpublished Master's thesis, University of Utah, 1959).

in 1959.² In comparing the 1972 results with these, an indication was obtained on what changes had occurred in Montana's high school physics program since Sputnik.

Two studies had been made on the physics teaching practices in other states. In 1970, Hale, et. al.³ conducted a survey in Wisconsin. In 1971, Ivany, et. al.⁴ investigated high school physics teaching in the Northeast States. A comparison of the results found in Montana during 1972 with these two states provided an indication of the quality of Montana high school physics education.

The questionnaire used to determine the physics teaching objectives in Montana was developed by Trowbridge in 1960.⁵ Trowbridge determined certain teaching objectives

²J.W. Gebhart, "The Teaching of Science In the Secondary Schools of Montana", (unpublished Doctorate thesis Ohio State University, 1960).

³H.E. Hale IV, and J.R. Smith, "Trends in High School Physics - A Survey In Wisconsin", The Science Teacher, February, 1971, p. 33-34.

⁴George Ivany, et. al., High School Physics Teaching: A Report on Current Practices, American Institute of Physics New York, 1972.

⁵L.W. Trowbridge, A Comparison of the Objectives of Traditional High School Physics with the Objectives of the P.S.S.C. Course, (unpublished Doctorate thesis, University of Michigan, 1961).

that were unique to "P.S.S.C." and "traditional" physics. He then developed a questionnaire using these objectives, that was administered nationwide to teachers who were known as "traditional" or "P.S.S.C." physics teachers. Norms were then established. The results of administering this questionnaire in Montana during 1972, were compared to Trowbridge's norms. Significant differences were tested at the 0.01 level using both a Chi-Square test and a t-test.

The population for this study was composed of all the public high schools in Montana that offered physics at least once during the previous two years. The "High School Physics Questionnaire" was mailed to all the high school physics teachers in the population. Usable responses were obtained from 81 percent of the population. The "Teachers' Objectives Questionnaire" was mailed to all teachers in schools with enrollment over 300 students, and to a randomly selected one-half of the teachers at the other schools. The usable response was 84 percent to this questionnaire.

The school categories were based on total school enrollment, physics enrollment, and the teachers' years of experience. The school enrollment divisions were 0-100, 101-300, 301-800 and greater than 800 students. The two physics enrollment divisions were less than and greater

than 10 students. The years of teaching experience were divided into the three categories of 0-5 years, 6-15 years, and greater than 15 years. The Chi Square test of significance was utilized to test if these school categories differed significantly, (at the 0.01 level), regarding physics education curriculum standards and practices.

In addition to the questionnaires, personal visits were made to 22 high schools. These schools were selected on a stratified random sample according to total student enrollment. During each visit, an interview was conducted with the physics teacher. An inspection was also made of the library, audio-visual center, and physics laboratory facilities.

The data were compiled and reported in narrative and table form in Chapters IV and V. The questions answered relative to high school physics standards and practices are as follows. Their answers follow each question.

1. What is the percentage of Montana high school students enrolled in physics? How does this figure compare to the 1958-59 data? Does the percentage of students enrolled in physics in the large high schools of Montana (total school enrollment of 300 students or more) differ from

the percentage of students enrolled in physics in the small high schools. (total student enrollment of less than 300 students)

Question number one was answered by the following statements:

1. In 1973, 14.7 percent of Montana's graduating high school students had taken physics.
2. In 1959, 22 percent of Montana's graduating high school students had taken physics.
3. In Montana high schools with an enrollment of less than 300 students, 14.6 percent of the graduating students in 1973, had taken physics.
4. Montana high schools with an enrollment of more than 300 students, 14.7 percent of the graduating students in 1973, had taken physics.
5. The two extreme Montana high school enrollment categories were 0-100 students where 19.0 percent, and 101-300 where 13.3 percent of the graduating students had taken physics.

2. What is the present number and the availability of physics courses in the Montana high schools? Does the present situation differ from that of the 1958-59 school year?

Question number two was answered by the following statements:

1. Sixteen Montana high schools indicated they did not offer a physics course on a regular basis.
2. Seventy four Montana high schools offered physics every year.
3. Seventy four Montana high schools offered physics alternate years.
4. Since 1958, there has been a trend in Montana for more high schools to offer physics every year.

3. Is physics in Montana a course taken by a select group of students? What were the prerequisites of a student to take physics?

Question number three was answered by the following statements:

1. The Montana physics teachers felt that predominantly only "above average" or "superior" students took physics.

2. Forty-five percent of the teachers indicated they had discouraged some students from taking physics.

3. The students most commonly discouraged were those with a poor previous mathematics and/or science performance.

4. Thirty-one percent of the schools had a math prerequisite of Algebra I or below.

5. Algebra II was the most common math prerequisite.

4. What textbooks and curricula materials were used in Montana during 1972-73? How do the results compare with the findings in Wisconsin during 1970 and the Northeast States in 1972?

Question number four was answered by the following statements:

1. Modern Physics was the most popular textbook, with 56 percent of the teachers using it.

2. P.S.S.C. and Project Physics were used very little as the class textbook in Montana, but P.S.S.C. was the most popular supplementary textbook.

3. These results compared well with those found in Wisconsin in 1970.

4. Compared to Montana, the schools in the Northeast States used Modern Physics less often and P.S.S.C. and Project Physics more often.

5. The P.S.S.C. curricula materials that were used the most was the laboratories. Fifty teachers used some of these during 1972-73.

6. The P.S.S.C. Teacher's Guide was used by 24 teachers in Montana during 1972-73.

7. Some of the Project Physics laboratories were used by 22 teachers in Montana during 1972-73.

5. To what extent were standardized tests from textbook publishers being used in Montana during 1972-73?

Question number five was answered by the following statements:

1. Two Montana physics teachers used standardized tests exclusively.

2. Thirty Montana physics teachers never used standardized tests.

3. Most of Montana's physics teachers used standardized tests, but tried to supplement them with their own tests.

6. What is the quality and quantity of physics laboratory equipment in Montana high schools?

Question number six was answered by the following statements:

1. Fifty-five percent of the Montana physics teachers in 1972; rated their physics equipment inadequate for teaching high school physics.

2. Forty-three percent of Montana's physics teachers in 1972, indicated the physics equipment at their school had greatly improved in the past ten years.

3. The researcher found during his visits that there was a large disparity in the quantity and quality of physics equipment in the high schools of Montana. Some schools were equipped with excellent apparatus, while others were totally inadequate.

7. To what extent have Federal monies been used in Montana high schools for upgrading the physics facilities and teacher preparation?

Question number seven was answered by the following statements:

1. The most common Federal Aid that helped the Montana high school physics programs was the National Defense Educational Act (NDEA).

2. Twenty-two schools indicated they participated in Federal Aid for their physics program before 1972. Forty-two schools were not sure.

3. Seven schools indicated they were participating in Federal Aid for the physics program during 1972-73. Seventeen schools did not know.

4. From the researcher's visits, there seemed to be a strong correlation between Federal Aid and the quality of the physics laboratory.

8. What audio-visual materials are available to the physics teachers in Montana high schools, and to what extent are they used?

Question number eight was answered by the following statements:

1. Forty-eight percent of the teachers rated their schools' audio-visual equipment inadequate. Most of these teachers came from schools with an enrollment of 300 or less students.

2. The most popular audio-visual equipment was the overhead projector. Many teachers used this instead of the blackboard.

3. Films were shown by many teachers. The most common complaint about the audio-visual equipment, however, was the poor quality and selection of films in physics at the State Library.

9. What is the extent of physics-related library material in Montana high schools?

Question number nine was answered by the following statements:

1. Fifty-three percent of Montana's physics teachers rated their school's library inadequate in physics.

2. During the researcher's visits it was found that very few physics teachers require the students to use the school's library facilities. The teachers had little interest in the library.

10. How did the high school physics teachers of Montana rate the administration as far as being sympathetic to the problems involved in teaching high school physics?

Question number ten was answered by the following statements:

1. Only ten percent of the teachers rated the administration as being not sympathetic to the problems involved in teaching high school physics.

2. Physics teachers were only mildly concerned that the falling enrollments in physics would make physics lose favor with the administration.

11. What is the number of quarter hours of physics taken by the high school physics teachers in Montana? Does the average number differ from the 1958-59 data? Does the number of quarter hours of physics taken by the physics teachers in the large high schools of Montana differ from those taken by the physics teachers in the small high schools?

Question number eleven was answered by the following statements:

1. In 1973, Montana physics teachers had a mean of 29.4 quarter hour credits in physics.

2. The physics teachers in schools with enrollments of over 300 students, on the average, had more physics credits than the teachers at schools of under 300 students enrolled.

3. In 1958, Montana physics teachers had a mean of 10.1 quarter hours of physics.

4. In 1972, the physics teachers in the Northeast States had a mean of 62.6 quarter hours of physics.

12. What is the number of quarter hours of mathematics and science taken by the physics teachers of Montana? How does this differ from the 1958-59 data?

Question number twelve was answered by the following statements:

1. In 1973, Montana physics teachers had a mean of 42.1 quarter hour credits in mathematics. There was very little difference among teachers at different size schools. This was more than the 35.1 quarter hours the physics teachers had in the Northeast States during 1972.

2. In 1973, Montana physics teachers had a mean of 32.0 quarter hour credits in chemistry. There was very little difference among teachers at different size schools. This mean was more than the 18.4 quarter hours Montana physics teachers in the Northeast States had in 1972.

3. In 1973, Montana physics teachers had a mean of 30.9 quarter hour credits in biology. The teachers at the smaller schools had more hours on the average than the teachers at the larger schools. This mean was more than the 27.0 quarter hours for the Montana physics teachers in 1958, and the 10.2 quarter hours that physics teachers in the Northeast States had in 1972.

4. In 1973, Montana physics teachers had a mean of 10.9 quarter hour credits in geology and earth science. There was very little difference among teachers at different size schools. Many of the teachers, however, had zero credits in these areas. This mean was more than 4.2 quarter hours that Montana physics teachers had in 1958.

13. What were the teaching loads for Montana's physics teachers during 1972-73?

Question number thirteen was answered by the following statements:

1. The teaching loads for Montana's physics teachers were of two main types. One was to teach only in the sciences and the other was to teach the physical science and mathematics.

2. Montana's physics teachers taught very few classes in non-science and non-mathematics areas.

3. Four high school teachers in Montana taught only physics during the 1972-73 school year.

14. What degrees had Montana's physics teachers earned?

Question number fourteen was answered by the following statements:

1. Forty-three percent of Montana's physics teachers had a Master's degree.

2. Seventy percent of the Master's degrees were earned at schools outside Montana.

3. Seventy-five percent of the Bachelor degrees were earned at schools in Montana.

4. Fifty-three Montana physics teachers had attended financially supported academic programs in physics. The most popular programs had been NSF Summer Institutes.

15. How many years of teaching experience did Montana's physics teachers have?

Question number fifteen was answered by the following statements:

1. The mean number of years experience for Montana physics teachers in 1972 was 8.2 years.

2. The teachers at schools with an enrollment of more than 300 students had more experience (a mean of 12.5 years), than those at schools of less than 300 students (a mean of 6.6 years).

16. What professional organizations did Montana's physics teachers belong to?

Question number sixteen was answered by the following statements:

1. Thirty-four percent of Montana's physics teachers belonged to one or more professional science organizations.

2. Twenty-five teachers belonged to "National Science Teachers Association" and eleven teachers belonged to the "American Association of Physics Teachers".

17. What are the teachers' opinions of what would be the most beneficial programs to be undertaken by the Federal Government, state government, and local school boards to better the physics teaching done in the state of Montana?

Question number seventeen was answered by the following statements:

1. The physics teachers felt the colleges and universities should provide in-service and summer courses for physics teachers. These courses should be both "theory" and "methods" courses.

2. The physics teachers felt the colleges and universities should help to increase communications among high schools and between high schools and colleges.

3. The physics teachers thought the colleges and universities should share their more expensive equipment with the high schools.

4. The physics teachers felt the Federal Government should provide money for purchasing laboratory equipment.

5. The physics teachers felt the Federal Government should continue or increase support for physics institutes for high school teachers.

6. The physics teachers felt the State Department should establish a program for better communications among Montana's high school physics teachers.

7. The physics teachers indicated the local school boards should provide more money for equipment.

18. What, in the physics teachers' opinions, should be done to improve the teacher preparation programs in physics in colleges of Montana?

Question number eighteen was answered by the following statements:

1. The physics teachers felt that additional science methods courses that were laboratory oriented should be offered.

2. The physics teachers felt that additional physics courses should be required. These courses should be geared for the high school teacher.

3. The teachers felt fewer "theoretical" education courses should be required.

19. Do the course objectives of the physics teachers in the large high schools differ from the objectives of the teachers in the small high schools?

Question number nineteen was answered by the following statements. In "agreement" the teachers differed in the following areas:

1. to use a textbook which helps students.
2. to show the importance of scaling and its role in physics.
3. to develop a view of physics that is consistent with that of the professional physicist.
4. to emphasize that physicists are typical people.

In "practice" the teachers differed in the following objectives:

1. to study the nature and characteristics of heat.
2. to emphasize the understanding and use of the physical approximations and models in helping to explain theoretical concepts.
3. to develop a view of physics that is consistent with that of the professional physicist.
4. to emphasize that physicists are typical people.
5. to develop growth in skillful use of the democratic processes.

In general, the teachers at the smaller schools were in better agreement with the "traditional" objectives. The teachers at the larger schools were in better agreement with the "P.S.S.C." objectives.

20. Do the course objectives of the physics teachers who teach physics classes of more than ten students differ from those that teach smaller classes?

Question number twenty was answered by the following statements. In "agreement" the teachers had no significant differences in objectives.

In "practice" the teachers differed in the following objective:

1. to emphasize that physicists are typical people.

In general, when the means for each objective were studied, the teachers with less than ten students were in better agreement with the "traditional" objectives. The teachers with more than ten students, were in better agreement with the "P.S.S.C." objectives.

21. Do the course objectives of the high school physics teachers who had fifteen years teaching experience differ from the objectives of the teachers with less than fifteen years experience?

Question number twenty-one was answered by the following statements. In "agreement" and "practice" the teachers had no significant differences in objectives.

When the means for each objective were studied, the teachers with more than fifteen years experience favored the "traditional" objectives more than the other teachers.

22. Do the course objectives of Montana's physics teachers in 1972, differ or agree with the course objectives of "traditional" or "P.S.S.C." physics teachers in 1960.

Question number twenty-two was answered by the following statements:

1. The Montana physics teachers in 1972, differed less with the objectives of the "traditional" physics than the "P.S.S.C." physics. The Montana teachers differed with three "traditional" objectives and nine "P.S.S.C." objectives.

2. Since 1960, the objectives of Montana's physics teachers have moved in the direction of the "P.S.S.C." teachers. They still, however, favor the "traditional" objectives.

3. The greatest area of change since 1960, has been in the laboratory and the change in objectives showed this.

4. The syllabus of the high school physics course has changed since 1960, and the change in objectives showed this. Units such as sound, heat, nuclear physics, statics, and dynamics had lost popularity.

5. The meter-kilogram-second system of units had replaced the English system in popularity. The objectives showed this.

23. What is the high school physics teachers' opinion on the most important purpose of high school physics? (this will only be determined from personal interviews)

Question number twenty-three was answered by the following statements:

1. The most important purpose of high school physics according to the majority of teachers was to prepare students for further study in science.

2. Mathematics and "problems" were emphasized in most physics classes.

3. Very few teachers felt high school physics should have as its main objective to provide an appreciation of the physical world to all high school students. Physics was geared for science and engineering.

24. What, from the researcher's viewpoint, after a thorough study of high school physics teaching in the state of Montana, would be most beneficial programs to be undertaken by the Federal Government, state government, and the local school boards to better the physics teaching done in the state of Montana?

Question number twenty-four was answered by the following statements:

1. The Federal Government should continue and increase support for summer institutes for high school physics teachers.

2. The Federal Government should provide funds for the schools that have not yet participated in programs for the purpose of improving the physics laboratory.

3. The State Department of Public Instruction should provide support for an annual high school physics convention.

4. The State Department should improve and update their physics film library.

5. The state should provide funds for a State Coordinator of Physics.

6. Each local district should re-examine their physics program and determine whether the present objectives are meeting the needs of their community.

Conclusions

The following conclusions have been made from the analysis of the data received in this study.

1. The percentage of Montana high school students enrolled in physics has decreased since 1958. The percentage of students enrolled in physics did not seem to be influenced by school size. In all categories of school size approximately 15 percent of Montana's 1973 graduating high school students had taken physics.
2. Physics was available to most Montana high school students. The physics classes were mainly for the better students who were planning on going on to college in science or engineering. Mathematics and problem solving were emphasized in most classes.

3. "Traditional" textbooks were used most often in the Montana physics classes. Modern Physics was the most popular. P.S.S.C. Physics and Project Physics were used by many teachers as a supplementary textbook. These two curricula had changed the physics laboratories greatly since 1958. Many of the laboratory exercises from these curricula were being used. Often they were being used in a "verification" type exercise, and not in a "discovery" process. Standardized tests available from curricula publishers were used as a source of questions, but were often supplemented with additional word problems.
4. The quality and quantity of physics laboratory equipment had changed since 1958 at many Montana high schools. The equipment necessary for P.S.S.C. Physics and Project Physics laboratories had been added. In many cases laboratories had been built or remodeled. Most of the high schools with improved physics facilities had used some Federal money. There were still, however, many Montana high schools with inadequate laboratory facilities. These schools usually had enrollments of less than

300 students. Money was not available and physics was not a high enough priority for funding.

5. Montana high schools had adequate audio-visual equipment except for a "good" physics film source. In most schools, the audio-visual equipment was more than adequate when the extent to which Montana physics teachers used them was considered.
6. The physics-related library material at most Montana high schools was inadequate. Very few physics teachers encouraged or required their students to use the library. The physics teachers did not seem concerned about the quality of the library.
7. The academic preparation in physics of the Montana high school physics teachers had improved greatly since 1958. However, there were still many teachers with 15 or less quarter hour credits of physics. These teachers were mainly at schools with enrollments of less than 300 students. The academic preparation of the teachers in mathematics and the other sciences had also improved since 1958. In comparing the physics teachers' academic preparation, and their teaching loads, two trends became

evident. The teachers were prepared for and taught either totally science, or physical science and mathematics.

8. Montana physics teachers felt the most beneficial programs for their physics classes that the Federal Government could sponsor would be funding for laboratory equipment and teacher institutes. Many teachers were disturbed that these programs were being curtailed.
9. Montana physics teachers felt the most beneficial programs for their physics classes that the State Department could sponsor would be an updating and expanding of the film library and the introduction of a program that would increase communications among the high school physics teachers of Montana.
10. Montana physics teachers felt the college and universities should introduce a program that would increase communications between the high school teachers and the college professors. Types of programs suggested were courses for high school physics teachers, the visiting lecturer program, a mobile laboratory for high schools, the lending

of college laboratory equipment to the high schools, and a cooperative program of improving high school physics.

11. The objectives of Montana physics teachers could be generalized to have been "traditional" in 1972. The curricula developed since 1958, had an effect on the laboratory and syllabus. The laboratory became more central to the teaching process of the physics class. Some units of physics, such as sound, heat, nuclear physics, statics, and dynamics had become less important. The trend had been to teach fewer topics, but teach them in a more thorough manner.
12. The objectives of teachers in schools with an enrollment of less than 300 students, with a physics class of less than ten students, and with more than fifteen years of experience were generally more "traditional" than the other teachers.

Recommendations

The findings and conclusions of this study appear to justify the following recommendations by the researcher:

1. The Montana colleges and universities should offer in-service and summer courses for high school physics teachers.
2. The degree of Master of Applied Science should be re-instated or a similar degree should be introduced to allow a high school teacher to take a variety of courses in the sciences and minor in secondary education.
3. The physics education personnel of Montana's colleges and universities should get together and cooperate in formulating a program to work with the high school physics teachers. When communications are established between these people, the high school teachers should be included as equals in the planning stages.
4. A program designed to increase communications between all physics teachers in Montana should be implemented.

5. More science methods courses should be included in the physics teachers' undergraduate preparation. These courses should be laboratory-oriented. Perhaps the "theoretical" education courses could be combined with these methods courses. This would result in a coherent program with the specific goal of training science teachers.
6. The undergraduate programs leading to overspecialization in one subject area should be re-evaluated. Most physics teachers teach either many different sciences or the physical sciences and mathematics. Teachers should be prepared to teach a variety of subjects. The few teachers who teach only one or two subjects at the larger schools could specialize when obtaining their Master's degree.
7. A one hour seminar for future teachers should be implemented in each scientific discipline. This seminar could specifically deal with the problems of teaching that particular subject.
8. The science curriculum laboratory at Montana State University should work toward a program that would allow more Montana teachers to use its facilities and resources. This may require increased mobility.

9. The State Department should upgrade and expand its physics film library.
10. The State Department should provide information to the physics teachers about good high school library books in physics.
11. The State Department or universities should establish at the minimum, a part-time coordinator in high school physics. This person should have time to visit with physics teachers and determine what services they need. The present State Department science and mathematics curriculum director has too large a job to be able to work specifically in the area of physics. Considering the cost of high school physics in Montana, the cost of a person to serve as a high school physics liason would be nominal.
12. The Federal Government should provide money to high schools who had not participated in the funding for upgrading science equipment. The students at these schools were being deprived of an adequate science experience.

13. The Federal Government should continue its institute program. This program is necessary for the small high school teacher. This teacher is typically paid less, and has to teach a greater variety of courses. Summer institutes are necessary to bring this type of teacher up to standards in all their teaching areas.
14. The entire Montana high school physics program should be re-evaluated. Does the emphasis on mathematics, problem solving, and preparation for college physics really meet the desired objectives of high school physics?
15. A study should be done to determine what degrees high school science teachers have earned, where they earned their degrees, and why they attended the particular school they did. This would help the universities plan their future graduate programs.
16. Comprehensive studies should be made of all the public school science programs. These studies could then serve as a basis for developing a coherent K-12 science program in Montana.

17. A study should be made into the feasibility of having regular high school science teacher meetings in Montana.
18. A study should be made concerning the attitudes of high school administrators toward the physics program. Do the administrators support the physics program, or is physics becoming the "Latin" of the sciences?
19. A study should be made in Montana to determine the influence high school physics has on the student success in college physics. Is it necessary to have a rigorous high school program for the future scientist and engineer?

APPENDICES

APPENDIX A

TWENTY-TWO RANDOMLY SELECTED HIGH SCHOOLS VISITEDEnrollment Greater
than 800

Billings West
 Bozeman
 Butte
 Glendive
 Great Falls Senior
 Helena
 Kalispell
 C.M. Russell

100 to 300

Belt
 Darby
 Fairfield
 Ronan
 Shepard

300 to 800

Dillon
 Hamilton
 Livingston
 Whitefish

Less than 100

Antelope
 Geysler
 Joliet
 Roberts
 Winnett

APPENDIX B

— *Montana State University* —

Bozeman, Montana 59715

Tel. 406-587-3121

Department of Educational Services

September 1972

Dear Physics Teacher,

This year I am conducting a study on the teaching of physics in the high schools in Montana. Very little research has been done in this area since 1959. It would now seem appropriate to examine our current status in order to determine if we are making progress toward "better physics teaching" we all hope for. The American Institute of Physics has been very enthusiastic and feels this project will be extremely useful to educational planners in the northwestern states.

One part of this study involves the enclosed confidential questionnaire. There are two sections to this questionnaire. The first involves statistical information on your school, your physics classes, and your college preparation. The second section solicits your opinions on what services various agencies could provide in order to help you in your physics teaching. Your thoughts will be very important to these agencies in helping them plan for the future. Your responses to this questionnaire will remain anonymous and completely confidential.

Your assistance in filling out this questionnaire and returning it in the enclosed envelope is essential to a successful study. Therefore, I do hope you will take the time in your already busy schedule to complete it. Next spring, when the study is completed, I will send you a resume of the results.

Thank you very much for your time and interest.

Sincerely,

Alexander K. Dickison

APPENDIX C

— *Montana State University* —

Bozeman, Montana 59715

Tel. 406-387-3121

Department of Educational Services

October 16, 1972

Dear Physics Teacher,

On September 22, 1972, I sent you a questionnaire concerning the teaching of physics in the high schools of Montana. Your school was selected for this study by a random-sampling technique. For this reason a high percentage of usable returns is essential to assure the proper statistical treatment of the data and reliability of conclusions. With the thought that the first questionnaire I sent may have been mislaid, I am enclosing another copy. If you have not already done so your assistance in filling out this questionnaire and returning it in the enclosed envelope will be greatly appreciated. Your responses to this questionnaire will remain anonymous and completely confidential.

This study will determine the present status of physics education in Montana. This can be compared to a study done fifteen years ago to determine how things have changed and what, if any, services can be provided for the physics teachers to improve their physics programs. A stratified approach according to school enrollment has been taken so the results can be useful to all schools in the state. Next spring, when the study is completed, I will send you a resume of the results.

Your response is greatly needed and that is why I ask you to take the time from your busy schedule to complete this questionnaire. Thank you very much for your time and interest.

Sincerely,

Alexander K. Dickison

APPENDIX D

HIGH SCHOOL PHYSICS QUESTIONNAIRE

1. How often is physics offered at your school?
 - a. every year
 - b. every other year
 - c. not offered
 - d. other (specify) _____

2. Does your school offer a physical science class to provide a "general education" background for those students who do not want to take a regular physics or chemistry course?
 - a. yes
 - b. no
 - c. offer a physical science class but it is the regular ninth grade science course.

3. At your school, are there different physics classes available for students of varying interests and ability?
 - a. yes
 - b. no

4. How much math is required as a prerequisite to enroll in a physics class at your school?
 - a. none
 - b. Algebra I
 - c. Geometry
 - d. Algebra II
 - e. other (specify) _____

5. What other prerequisites must a student fulfill to enroll in a physics course at your school?
 - a. none
 - b. grade point average
 - c. teacher approval
 - d. class prerequisite (soph., junior, senior)
 - e. counselor approval
 - f. course prerequisite (specify) _____
 - g. other (specify) _____

6. Are any students at your school discouraged from taking physics?
 - a. yes
 - b. no

If yes, what students are discouraged and why? _____

APPENDIX D (continued)

7. Intellectually, how would you rate the students who take physics at your school?
- predominantly superior students
 - predominantly above average students
 - predominantly average students
 - predominantly below average students
8. What book do you use as your basic physics text?
- Modern Physics (Dull)
 - PSSC Physics
 - Project Physics (Harvard)
 - Foundations of Physics (Lehrman and Swartz)
 - Physics: An Experimental Science (White)
 - other (specify) _____
9. If you use a supplementary text, please list it below: _____

10. To what extent do you make use of the tests available from the publisher of your textbook?
- exclusively
 - extensively
 - occasionally
 - seldom
 - never
11. Circle any of the Harvard Project Physics curriculum material that you use in your classes.
- none
 - film loops
 - films
 - transparencies
 - laboratories
 - supplemental readings
 - readers
 - tests
 - teacher's guide
 - other (specify) _____
12. Circle any of the P.S.S.C. curriculum material that you use in your classes.
- none
 - film loops
 - films
 - transparencies
 - laboratories
 - supplemental readings
 - readers
 - tests
 - teacher's guide
 - other (specify) _____

252 APPENDIX D (continued)

13. How would you rate your administration as far as being sympathetic to the problems involved in teaching high school physics?
 - a. very sympathetic
 - b. sympathetic
 - c. not sympathetic

14. In your estimation, how adequate is your school's physics equipment for the teaching of high school physics?
 - a. more than adequate
 - b. adequate
 - c. inadequate

15. Compared to ten years ago, how would you rate the physics laboratory equipment at your school?
 - a. great improvement
 - b. slight improvement
 - c. no change
 - d. has gotten worse
 - e. don't know

16. Has your school taken part in any Federal Aid to high school physics programs?
 - a. yes
 - b. no
 - c. don't know

17. Is your school currently taking part in any Federal Aid to high school physics programs?
 - a. yes
 - b. no
 - c. don't know

If you answered "yes" to either 16 or 17, please specify the type of aid:

18. In your estimation how adequate is your school's library facilities in the area of physics?
 - a. more than adequate
 - b. adequate
 - c. inadequate

19. In your estimation how adequate is your school's audiovisual equipment as far as that which can be used in a physics class?
 - a. more than adequate
 - b. adequate
 - c. inadequate

20. How often do you use audio-visual equipment in your physics classes?
 - a. often
 - b. occasionally
 - c. sometimes
 - d. seldom
 - e. never

NECESSARY TEACHER PERSONAL INFORMATION

Institution graduated from:

BA or BS _____
 Degree Major _____
 Degree Minor _____
 Year Received Degree _____

MA or MS _____
 Degree Major _____
 Degree Minor _____
 Year Received Degree _____

How many years of teaching experience do you have? _____

Approximately how many college hours of physics have you had?
(Quarter Hours)

BA or BS _____
 MA or MS _____
 Other _____

Approximately how many total college hours in the following fields
have you had?

(Quarter Hours)

Biology _____
 Chemistry _____
 Earth Science or Geology _____
 Mathematics _____
 General Science _____

Please circle any of the following financially supported academic
work in physics which you have participated in:

- a. NSF Academic Year Institute
- b. NSF In-Service Institute
- c. NSF or AEC Summer Institute
- d. NSF or AEC Summer Participation
- e. NSF or AEC Summer Conference
- f. Government Fellowship
- g. Other (specify) _____

Please circle any of the following organizations to which you belong:

- a. National Science Teachers Association
- b. American Association for the Advancement of Science
- c. American Association of Physics Teachers
- d. American Chemical Society
- e. National Association of Biology Teachers
- f. National Association of Geology Teachers
- g. Others (specify) _____

APPENDIX E

TEACHERS' OBJECTIVES QUESTIONNAIRE

Instructions

Please think in terms of the kind of high school physics course which you feel should be taught in the secondary schools of this country.

In the column marked "Agreement," please indicate the extent of your agreement or disagreement by placing a check mark (✓) in one of the four sub-columns.

At the same time, in the column marked "Practice," please check (✓) in one of the four sub-columns the degree to which you are able to teach for the objective with your present materials and classes.

Kindly check all the items to the best of your ability.

Key - (For column marked "Agreement")

- Strong -----I strongly agree with the objective.
- Mild -----I mildly agree with the objective.
- Non-committal-I have no definite feelings either way regarding the objective.
- Disagree -----I disagree with the objective.

Key - (For column marked "Practice")

- Accomplish ---I feel I definitely accomplish this objective for most of the students in my physics teaching.
- Occasionally -I occasionally achieve this objective in my physics teaching.
- No Effort ----I make no special effort to achieve this objective.
- Avoid -----I intentionally avoid teaching this objective.

APPENDIX E (continued)

	Agreement				Practice			
	Strong	Mild	Non-Committal	Disagree	Accomplish	Occasional	No Effort	Avoid
23. To study natural radioactivity and elementary concepts of nuclear reactions.								
24. To make the laboratory central in the learning process by designing it as a process of inquiry on natural physical problems.								
25. To emphasize the use of equipment and instruments whose working parts are clearly visible.								
26. To emphasize the use of the laboratory for the development of instrumental skills.								
27. To use laboratories to verify facts and principles of physics.								
28. To employ tests as a means of determining the ability of students to reason to logical conclusions when working with unfamiliar data.								
29. To emphasize practical (English) units of measurement.								
30. To emphasize the method of laboratory investigation for learning.								
31. To develop growth in skillful use of democratic processes.								
32. To emphasize the study of a few major topics at considerable depth.								
33. To study some of the static and dynamic aspects of fluids.								

Thank you very much for your cooperation.

APPENDIX F

TEACHER INTERVIEW

DATE _____

BACKGROUND INFORMATION

Name of school _____

City _____

Teacher's Name _____

Type of school _____

Enrollment in High School _____

Teacher's Class Load:

- | | |
|----|----|
| 1. | 5. |
| 2. | 6. |
| 3. | 7. |
| 4. | 8. |

Number of physics classes _____ Enrollment in physics _____

Number of class periods and laboratories per week:

Length of class periods and laboratories:

INFORMATION DIRECTLY FROM THE TEACHER

Types of classes taught (introductory overview):

Extent of using P.S.S.C.

Extent of using H.P.P.

Use of any other new teaching curricula (either the teacher's own or someone else's):

Types of students taking physics (teacher's opinion)
Do only high ability students take physics?

Are any courses offered for non-science students?

Are any courses offered for gifted students? (special classes, special assignments, special seminars or labs, use as lab assistants, special classroom privileges, summer science institutes)

Type of teacher delivery that is used:

Amount of lecture (do students take notes):

Incorporation of demonstrations:

How are laboratories related to classwork?

Amount of independent study:

How are tests constructed? (teacher-made or standardized)

If standardized, by whom?

Problems _____ Multiple Choice _____ Essay _____ T-F _____

Other:

What kind of outside activities do your students participate in?

Field Trips _____

Physics Club _____

Science Fair _____

Guest Speakers _____

Astronomy, Radio, Electronics Club _____

Other _____

Use of motivational tactics to get students into physics:
(does teacher sell physics?)

Use of current events: (check bulletin boards)

Laboratory Equipment:

Is there an annual budget for purchasing new equipment?

Is there an annual budget for purchasing consumable materials?

Are you permitted to purchase equipment and supplies directly?

Have your expenditures for laboratory and demonstration equipment increased in the past two years? What are the trends?

Estimate amount spent this past year for physics equipment.

Have you remodeled with Federal money?

Have you purchased equipment with Federal money?

What would you say generally about the quantity and quality of laboratory equipment? (change over the years)

LIBRARY FACILITIES

How would you rate your library's facilities in physics?

LIBRARY FACILITIES (con't)

Is the physics section of your library kept up to date?

Do you require your students to use the library?

AUDIO-VISUAL EQUIPMENT

How often do you use audio-visual equipment in your classes?
Which ones?

How often do you show movies?

Where do you obtain your movies?

Other information:

TEACHER PERSONAL INFORMATION

Sex:

Age:

Degrees Earned:

Major:

Minor:

Quarter hours earned in physics:

Undergraduate:

Graduate:

Other:

How many years since last taking a physics course?

How many years of teaching experience?

How much supported work have you done?

Summer Workshops _____ Academic Year Institutes _____

In-Service Institutes _____ Fellowships _____

Other:

Any other comments about physics preparation?

Any professional societies you belong to?

Any physical science publications you have access to?

RECOMMENDATIONS BY THE TEACHER

What do you think the State Department could do to help improve the physics program?

Do you use the state curriculum recommendations?

What do you think the colleges and universities could do to improve the physics program?

What do you think the Federal government could do to improve the physics program?

What do you think your local district could do to improve the physics program?

Do you think physics should be taken before, or after biology and chemistry?

Do you think certain math prerequisites are necessary for physics?

Do you think physics should be more "practical"?

Should fewer topics be covered in more depth?

Have students changed (amount learned) in the last fourteen years?

APPENDIX G

RESEARCHER'S INVESTIGATION

ROOM FACILITIES

_____ Combination Classroom and Laboratory

_____ Separate Classroom and Laboratory

_____ Room for primarily non-science

Special facilities or other comments:

EQUIPMENT THAT IS AVAILABLE: (spell out in detail).

LIBRARY FACILITIES:

General reference:

General reference in physics:

Science periodicals: (containing some physics)

Popular science magazines available:

Physics Books: (comment on age of books)

Physics related books: (astronomy, radio, science fiction,
etc.)

AUDIO-VISUAL MATERIALS:

What types of audio-visual equipment is available in your school? (movie projectors, slide projectors, film-strip projectors, television, overhead projectors, charts, etc.)

APPENDIX H

CONDITIONS FOR GOOD SCIENCE TEACHING
IN SECONDARY SCHOOLSRESOURCES FOR LEARNINGScience Rooms

1. There should be at least one separate laboratory for each kind of science course offered.
2. There must be enough laboratory rooms provided for each science course to accommodate all students who can profit from the course and wish to take it.
3. Each laboratory must be large enough to accommodate real experimentation.
4. Each laboratory should have ceilings that are at least 10 feet (3 meters) high.
5. Each laboratory should be appropriately furnished for each science.
6. Every laboratory should have conveniently located electric, gas, and water outlets.
7. Waste disposal facilities must be provided in all laboratories.

Commission on Professional Standards and Practices,
Conditions for Good Science Teaching in Secondary Schools,
National Science Teacher's Association, Washington, D.C.,
1970.

8. For reasons of work efficiency and safety, laboratories should have lighting which takes into account the variances in working conditions common to science laboratories.
9. Reasonable considerations of comfort and health require that each laboratory have the capability of renewing the room air at a rate compatible with normal student occupancy and the potential uses of science laboratories, such as maintenance of etc. animals, release of noxious gases.
10. Fire blankets and fully operable fire extinguishers must be located in each laboratory where they are quickly accessible. Every laboratory should be protected by automatic overhead sprinklers.
11. Chemistry laboratories must contain an emergency shower, an eye-wash fountain, and safety goggles for all students
12. Every science laboratory must have two unobstructed exits.
13. There should be an annual, verified safety check of each laboratory.
14. No more than 24 students should be assigned to a space intended for group discussion and activity (as distinct from large-group lecture).

15. A science classroom should have full audio-visual capability and facilities for conducting scientific demonstrations.
16. Specialized facilities are needed.
17. Individual project areas are needed for students working on special experiments.
18. Ample science library space must be available.
19. Conference rooms are needed.

Science Learning Materials

20. When needed for learning, individual textbooks and laboratory manuals should be available without cost to every student.
21. The science textbooks used by students at any time should be no more than four years past the date of the last major revision.
22. For each science course there should be an ample supply of diverse printed materials to supplement the textbook and laboratory manual.
23. The school science library should contain an adequate selection of books, periodicals, and pamphlets on the sciences, the applications of science, and the history, philosophy, and sociology of science.

24. An adequate supply of modern science equipment should be available for individual and small group activities and experiments, in quantities sufficient to execute the locally adopted curriculum.
25. A diverse supply of audio-visual learning materials needs to be readily available for each science course.
26. Certain items of audio-visual equipment should be provided as permanent equipment of individual courses.

Science Programs

27. The program must provide at least two years of science for every student.
28. The science program must provide the opportunity for science-oriented students to study science every year.
29. There should be at least 315 minutes per week of instruction available to every student enrolled in a science course.
30. All science courses must include student laboratory work.
31. The science program should be under constant review.

Science Teachers

32. Every teacher in the science department should meet the standards of preparation and performance outlined in the NSTA Annual Self-Inventory for Science Teachers (ASIST).

33. The number of teachers in a science department should be large enough and the distribution of their science fields should be wide enough to support a full science program.

CONDITIONS OF INSTRUCTION

Teaching Assignments

34. Science teachers should not be asked to be responsible for the education of students in content areas in which they are not competent in subject matter.
35. A science teacher should not have more than two preparations or class-management situations.
36. If a science teacher is given assignments of unusual responsibility, his total load should be adjusted to a reasonable level.
37. Each science teacher's week should be programmed so that he has some time available to meet with individual students.
38. All laboratory sections should be strictly limited to a maximum of 24 students per instructor.
39. Group discussion classes should be limited to a maximum of 24 students.
40. A science teacher's involvement in extracurricular activities should be limited.

Working Space

41. Ample space is needed for the storage of supplies and equipment.
42. Every science teacher requires access to a preparation area free from students.
43. Every science teacher should have private office space.
44. The science teacher needs access to a professional library.

Services

45. Schools employing four or more science teachers should have a science department headed by a chairman.
46. Laboratory assistants should be available on a professional basis.
47. Professional secretarial and clerical help should be available to science teachers on a systematic basis.
48. Consultants and specialists should be called in to help the science department and science teachers as needed.

Budget

49. The science department budget should appear as a separate account within the whole school budget, and it should be subdivided functionally.

50. Supplies should be budgeted on a per capita basis with the amount varying according to the nature of the course and the consumable materials involved.
51. Budgetary provision needs to be made so that items may be ordered during the school year for new projects, for perishable materials, and for unforeseen contingencies.
52. If a science department does not possess all of the major equipment that the science teachers and department head agree is essential to the department program, then there should be explicit budgetary provision for obtaining all such equipment in no less than three years.

PROFESSIONAL GROWTH

Professional Library

53. The school professional library should contain a large selection of books on science education, science, and the history and philosophy of science as recommended by the science teachers.
54. Subscriptions to at least eight science education journals should be maintained by the school professional library. These ought to include, among others, The Science Teacher, School Science and Mathematics, and Journal of Research in Science Teaching, and journals in various science teaching fields, such as The American Biology

Teacher, Chemistry, The Geology Teacher, and The Physics Teacher.

55. An up-to-date file of science curriculum information and science education research reports should be maintained.
56. The professional library should contain one or more microfilm/microfiche readers and draw heavily on the output of the Educational Resources Information Center (ERIC).

Learning Opportunities

57. Schools should provide opportunities for the inservice education of science teachers throughout their teaching career.
58. Paid sabbatical leaves should be provided for the periodic updating of science teachers.
59. A permanent teacher should be permitted to take leaves-of-absence of up to two years for purposes of further education without jeopardy to his position or salary advances.
60. Science teachers should be allowed a reasonable number of days each year away from school for professional purposes
61. Support should be given so that all science teachers can attend and participate in local, state, and national science teacher conventions.

62. Science teachers should be urged to attend National Science Foundation teacher institutes dealing with the new science curricula.
63. First and second year teachers should be given special consideration.

Recognition and Incentive

64. Teachers who have pursued a program of professional improvement until reaching a superior standard of teaching competence should be rewarded with special recognition.
65. Teachers who have attained a special status through advanced study should occasionally be given the opportunity to work on projects of their own choosing.

LITERATURE CITED

BIBLIOGRAPHY

- Abegg, Gerald, and Glenn H. Crumb. "Why Not High School Physics?", School Science and Mathematics, 66:211-15, February, 1966.
- Aldridge, Bill G., and David Underwood. "A New Direction For Television In Education", Science Education, 51:483-8, December, 1967.
- Andrews, Rebecca E. "Some Methods of Instruction in High School Physics and Some Goals and Psychological Factors Relating to Them", Science Education, 48:146-56,
- Backstrom, Charles H., and Gerald D. Hursh. Survey Research. Northwestern University Press, 1963.
- Barry, David G. Barry. "Early American Science and the Roots of Modern Biology", American Biology Teacher, 27:600-06, 1965.
- Boilyn, Bernard. Education In the Forming of American Society. New York: Vintage Books, 1960.
- Brandwein, Paul F., Paul E. Blackwood, and Fletcher G. Watson. Teaching High School Science - A Book of Methods. New York: Harcourt, Brace and Company, 1958.
- Brauer, Oscar L. "Something Dangerously New In Physics Teaching:", Science Education, 47:365-72, October, 1963.
- Bromley, D. Allan. "Physics in Perspective," Physics Today, 25:7:23-35, July, 1972.
- Buchta, J.W. "Physics Education: An Account of the Paris Conference", Physics Today, 14:28-9, January 1961.
- Buethel, L. Chris. "Dimensional Analysis in High School Physics", School Science and Mathematics, 68:699-700, November, 1968.

Campbell, William Giles. A Form Book For Thesis Writing.
New York: Houghton Mifflin Company, 1939.

Commission on Professional Standards and Practices.
Conditions for Good Science Teaching in Secondary
Schools. Washington: National Science Teachers'
Association, 1970.

Conant, James B. On Understanding Science. New Haven:
Yale University Press, 1947.

Cowan, Paul J. "An Audio-instructional Program in P.S.S.C.
Physics for Small High Schools", Science Education,
52:371-6, October, 1968.

Detenbeck, R.W., and P. Di Lavore. "Harvard Project
Physics", The Physics Teacher, 5:223, May, 1967.

Downing, Elliot Rowland. Teaching Science In the Schools.
Chicago: The University of Chicago Press, 1925.

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

Editorial: "Need for Multiplicity of Physics Courses",
The Physics Teacher, 3:371-72, November, 1965.

Elliott, Walter E. "Perceptions of High School Physics
Teaching", The Physics Teacher, 9:33-38, January, 1971.

European Economic Cooperation. Physics Today, 14:31-38,
January, 1961.

Fenis, Frederick L. Jr. "Testing for Physics Achievement",
American Journal of Physics, 28:269-78, March, 1960.

Finlay, D. "Summary of Judgements Made By Teachers About
P.S.S.C. Physics", Science Teacher, 26:579-81,
December, 1959.

Finley, Gilbert C. "Secondary School Physics: P.S.S.C.",
American Journal of Physics, 28:286-93, March, 1960.

- Fowler, H. Seymour. Secondary Science Teaching Practices. New York: The Center for Applied Research In Education, Inc., 1964.
- Gebhart, James W. "The Teaching of Science In the Secondary Schools of Montana", (unpublished Doctorate thesis, The Ohio State University, 1960).
- Green, Ben A., et. al. "Preparing High School Physics Teachers", The Physics Teacher, January, 1968, p. 25.
- Haber-Schaim, Uri. "The P.S.S.C. Course", Physics Today, 20:3, March, 1967, p. 26.
- Hale, Henry E. IV, and John R. Smith. "Trends in High School Physics - A Survey in Wisconsin", The Science Teacher, February, 1971, pp. 33-34.
- Heath, Robert W. Heath. "Comparison of Achievement In Two Physics Courses," Journal of Experimental Education, 32:347-54, Summer, 1964.
- Holton, Gerald. "Project Physics: A Report on Its Aims and Current Status," The Physics Teacher, 5:198-211, May, 1967.
- _____, and F. James Rutherford, and Fletcher G. Watson. About the Project Physics Course, New York: Holt, Rinehart, and Winston, Inc., 1971.
- Hudek, Albert D. "The Relative Effects of P.S.S.C. Physics and Traditional Physics on Achievement In College Physics", (unpublished thesis, University of South Dakota, 1969).
- Hurd, Paul de H. "The Case Against High School Physics", School Science and Mathematics, III:439-449, June, 1953.
- Iona, Maria. "Physics Teaching and the National Assessment of Educational Progress", The Physics Teacher, November, 1970, pp. 445-448.

- Ivany, George, Richard Mullaney, Douglas Huegal, Russell Faust, and A.A. Strassenburg. High School Physics Teaching: A Report on Current Practices, New York: American Institute of Physics, 1972.
- Johnson, Philip O. "The Teaching of Science in Public High Schools", Washington D.C.: Bulletin 1950, Number 9, Federal Security Agency, p. 6.
- Kranzberg, Melvin. "On Understanding Our Time: The History of Science", Teachers College Record, 64: 545-555, April, 1963.
- Krieger, Albert G. "A Comparative Study of Grades Received by Students in Chemistry and Physics", School Science and Mathematics, 68:828-33, December, 1968.
- Kruglak, Haym. "Pre- and Post-Sputnik Physics Background of College Freshmen", Journal of Research in Science Teaching, 6:42-43, 1969.
- _____. "Pre- and Post-Sputnik Physics Background of College Freshmen - II", Journal of Research in Science Teaching, 7:41-42, 1970.
- _____. "Testing for Achievement in Physics", The Physics Teacher, May, 1966, pp. 199-205.
- Kutzman, Nathaniel. "Science Teaching Assistance Center", Handout available at Montana State University, Bozeman, Montana, 1973.
- Lark-Horavitz, K. "Physics in the Secondary School," Review of Scientific Instruments, XIII, April, 1942, pp. 137-39.
- Lefler, R.W. "Trends in High School Physics", National Association of Secondary-School Principals, January, 1953, pp. 74-83.
- Little, R.N. "Trends in Physics Education", Paper presented at AAPT Meeting, New York, February, 1971.

- Mann, C.R. The Teaching of Physics, New York: The MacMillan Co., 1912, p. 29.
- Marsh, Paul E., and R.A. Gartner, Federal Aid To Science Education: Two Programs. New York: Syracuse University Press, 1963, p. 15.
- Marshall, J. Stanley, and Ernest Burkman. Current Trends in Science Education, New York: The Center for Applied Research In Education, inc., 1966.
- Matthews, Jack G. "A Study of the Teaching Process In the Classroom of Selected Physics Teachers", (thesis, Ohio State University), 1970.
- Miller, Perry. The New England Mind. New York: The MacMillan Company. 1939.
- Montana Science Curriculum Committee. The Study Guide in Science Grades 10-12. State Superintendent of Public Instruction, 1961.
- National Science Teachers' Association. "The National Science Teachers' Association Annual Self-Inventory for Science Teachers", The Science Teacher, September, 1970.
- Oppenheimer, Robert J. "Some Reflections on Science and Culture", Journal of Secondary Education, 41:99-104 and 41:147-153, March-April, 1966.
- Orlich, Donald C. "An Appraisal of the Methods of Teaching Science In the Senior High Schools of Montana", (unpublished Master's thesis, University of Utah, Salt Lake City, 1959).
- Paris Conference. "Physics Education", Physics Today, 14:28-30, January, 1961.
- Piaget, Jean. "Physical World of the Child", Physics Today, 25:6:23-27, June, 1972.
- _____. The Child's Conception of Physical Curiosity, New York: Littlefield, Adams, and Patterson, 1969.

- Piaget, Jean, and Barbel Inhelder. The Psychology of the Child. New York: Basic Books, 1969, p. 99.
- Poorman, Lawrence G. "Indiana Physics Teachers React to P.S.S.C.", Science Education, 49:171-2, March, 1965.
- Pratt, Harold. "On the Declining Enrollment in Physics", The Physics Teacher, October, 1968, pp. 365-66.
- Renner, J.W., and A.E. Lawson. "Piagetian Theory and Instruction in Physics", The Physics Teacher, 11:165-169, March, 1973.
- _____, and D.G. Stafford. Teaching Science In the Secondary School. New York: Harper and Row, 1972, pp. 291-300.
- Robinson, James T. "Philosophical and Historical Bases of Science Teaching", Review of Educational Research, October, 1969.
- Rogers, Lola E. Science Teaching In the Public Junior High Schools. (Washington, D.C.: U.S. Office of Education, 1967), Catalog Number 5.229:29067.
- Rothman, Arthur I., Wayne W. Welch, and Herbert J. Walberg. "Physics Teacher Characteristics and Student Learning", Journal of Research in Science Teaching, 6:59-63, 1969.
- Rutherford, F. James. "Flexibility and Variety in Physics", The Physics Teacher, 5:215-221, May, 1967.
- "Second Round for Science Assessment", N.A.E.P. Newsletter, 6:4, October, 1972.
- "Science and Writing Assessment - Facts and Figures", National Assessment of Educational Progress, 3:1-4, May-June, 1971.
- Science Educators. "Consultants Revise Science Objectives", N.A.E.P. Newsletter, 3:5-6, May, 1972.

- Smith, T.C. Jr. "The Utility of An Evaluative Model In Judging the Relationship Between Classroom Verbal Behavior and Student Achievement in Three Selected Physics Curricula", (unpublished Doctorate thesis, Houston University, August, 1971).
- Street, Stewart A. "Trends in the Physics Curriculum", The Physics Teacher, 5:319-321, October, 1967.
- Thompson, Raymond E. A Survey of the Teaching of Physics in Secondary Schools. Princeton, New Jersey: Educational Testing Service, 1969.
- Tisher, R.P. "A Piagetian Questionnaire Applied to Pupils in a Secondary School", Child Development, 42:1633-6, November, 1971.
- Trowbridge, Leslie W. "A Comparison of the Objectives and Instructional Materials in Two Types of High School Physics Courses", Science Education, 49:117-119, March, 1965.
- Tweenten, Paul W., and Robert E. Yoger. "Science Curriculum Trends in Iowa", School Science and Mathematics, 67:32-36, January, 1967.
- U.S. Office of Education. "Suggested Checklist for Assessing a Science Program", Government Printing Office, Document OE-29034A, 1964.
- Van Koevering, Thomas E. "High School Physics and Chemistry Enrollments in Michigan", School Science and Mathematics, 72:379-83, May, 1972, pp. 379.
- Verduin, John R. Jr. "Pupil-Teacher Planning in H.S. Science", Science Education, 49:254-9, April, 1965.
- Watson, Fletcher G. "Why Do We Need More Physics Courses?", The Physics Teacher, 5:213, May, 1967.
- Welch, Wayne W. "The Impact of National Curriculum Projects The Need for Accurate Assessment", School Science and Mathematics, 68:225-234, 1968.

_____, and Robert G. Bridgham. "Physics Achievement Gains as a Function of Teaching Duration", School Science and Mathematics, 68:449-54, May, 1968.

Wosik, John L. "A Comparison of Cognitive Performance of P.S.S.C. and Non-P.S.S.C. Physics Students", Journal of Research In Science Teaching, 8:85-90, 1971.

Yale, F.G. "Why Are High School Students Avoiding Physical Science?", Science Education, 50:325-8, October, 1966.

Young, Victor J. "A Report on Pre-College Physics", The Physics Teacher, January 1966, pp. 20-22.



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