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The Distinguishing Characteristics of High Schools with High and Low Enrollments in Physics

Thomas Earl Van Koevering
Western Michigan University

THE DISTINGUISHING CHARACTERISTICS OF HIGH SCHOOLS WITH HIGH AND LOW ENROLLMENTS IN PHYSICS

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Thomas E. Van Koevering

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Thomas E. Van Koevering, Ph. D.

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The purposes of this study were (1) to obtain an accurate assessment of the present (1968-69) high school physics enrollment in Michigan and (2) to determine if measurable differences exist between high schools with high and low percentage enrollments in physics.

Questionnaires were sent to one-half of the high schools in Michigan and from rank-order lists of the percentages of seniors enrolled in physics for Class A, B and C high schools, fifty-two were selected as a sample population. One-half of the high schools were considered to have high percentage enrollments in physics and the other half were considered to have low percentage enrollments in physics.

A visit was made to each of the high schools and questionnaires were administered to physics teachers, physics and chemistry students, and guidance counselors.

Analysis of the data indicate that the following conclusions seem to be warranted.

1. The average high school in Michigan has about 18.1% of the seniors enrolled in physics.

2. The physics teachers from high schools with a high percentage enrollment in physics were more affected by feelings, more unpretentious, and more experimenting than their counter parts in the low enrollment groups. They were also somewhat more enthusiastic about the subject they were teaching.

3. More physics teachers from high schools with high physics enrollment than from the low enrollment group tend to believe geometry or less is sufficient as a mathematics prerequisite for physics. However, the difference was not statistically significant. A significant difference on this same issue was found from the survey of guidance counselors.

4. A higher percentage of students from the high schools with high physics enrollments, expressed vocational choices in a non-science area while lower percentages expressed vocational choices in the physical science and engineering area than did students from the low physics enrollment groups.

5. A larger percentage of physics students from the high physics enrollments group indicated they were taking physics because their friends were taking the course or they thought they would like the teacher, whereas a larger percentage of students from the low physics enrollments groups selected physics because it was required for their future or because they enjoyed the challenge.

6. A larger percentage of the chemistry students from high schools with a high enrollment in physics indicated that they want to take physics because of the influence of their parents or

counselor than chemistry students from high schools with low enrollment in physics. A larger percentage of the chemistry students in the low physics enrollment group believe the physics course will be too difficult. The differences in each case were not statistically significant but they were consistent.

7. Physics students in both of the physics enrollment groups do receive lower grades in physics than in their other academic courses. The physics students in the high physics enrollment groups are on the average poorer students in all areas than students from the low enrollment groups, but their grades in physics do not lower their grade-point averages any more than physics grades lower the grade-point averages of the students from the low enrollment group. The actual achievements of students in physics, from the small segment of schools included in a comparison, indicate that students do equally well from schools with either high or low enrollment percentages in physics.

8. The percentage of high school graduates going on to college has a positive influence on physics enrollments.

9. PSSC materials do not appear to be exerting either positive or negative effects on enrollments as reflected by the number of teachers in each enrollment group using them.

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CHAPTER I

THE RESEARCH PROBLEM

Introduction and Purpose of the Study

The percentage of high school students enrolling in physics has been declining for more than a century. The phenomenon has long been recognized, but, for several reasons it has received substantial publicity only in recent years. Two situations which have accompanied the decline are (1) an acute shortage of qualified high school physics teachers; and (2) recent curriculum innovations in high school physics which have not stemmed that decline. Surprisingly, little research has been undertaken on this problem, and consequently reasons for declining physics enrollments remain in the realm of speculation.

The results of a series of studies of science enrollment conducted over the past seventy-five years are compiled in Table I. If consideration is given to the social and technological changes that have taken place since 1890 and their effects on American education, the seventy-five year span covered in Table I can be categorized into three eras. These eras include (1) 1900-1940, (2) 1940-1960, and (3) 1960-1969.

High School Physics from 1900-1940

This era of 1900-1940 can be characterized as a period of industrialization. A large segment of the population shifted from

TABLE I

HIGH SCHOOL SCIENCE ENROLLMENTS

Percent of the High School Population

Year	Physics	Chemistry	Other Science[1]
1890	22.21	10.10	
1895	22.77	9.15	
1900	19.04	7.72	
1905	15.66	6.76	
1910	14.61	6.89	
1915	14.23	7.38	
1922	8.93	7.40	
1928	6.85	7.07	
1934	6.27	7.56	
1947	5.49	8.62	
1949	5.40	7.60	
1952	4.30	7.60	2.30
1955	4.61	7.35	3.80
1959	4.59	7.96	4.55
1963	3.83	8.28	4.34
1965	3.83	8.57	6.03

Percent of Senior Class

Year	Physics
1955	24.32
1959	24.64
1963	21.28
1965	19.61

Data for 1890 to 1952: Mallinson (1) citing Johnson (2), (3), Office of Education (4), (5), and Rice (6).

Data for 1955 to 1965: Office of Education (7).

Personal communication from Dr. Paul Blackwood, Education Specialist for the Office of Education and the American Institute of Physics indicates that there are no data available concerning physics enrollment later than 1965.

[1]Other science is primarily physical science and second-year biology.

a rural-agricultural to an urban-industrial economy. This shift, coupled with child labor laws resulted in high schools being oriented, at least philosophically, toward general education for all children. Obviously among those who entered school because of the shift from a college-preparatory philosophy to a general education philosophy, many could not possibly be considered as recruits for courses in physics and chemistry. Hence, the decline in the percentage of students taking physics and chemistry is not surprising. This decrease is readily apparent from the data in Table I.

According to Hunter (8), (9), examination of chemistry enrollments from 1890 to 1922 gives a partial explanation for the early decline in physics. After conducting a series of studies dealing with enrollments in high school science courses from 1909 to 1941 he concluded that between 1900 and 1923 physics had moved from the eleventh grade to replace chemistry as the twelth grade science course. Thus, having elected chemistry at the eleventh grade many might not assume that an additional science course was necessary considering the possibility of electives in other areas. The sequence of eleventh grade chemistry and twelth grade physics has remained popular up to the present time. Hunter gives a further explanation for the consistency in the percentage of chemistry enrollments in that numerous descriptive and consumer chemistry courses were added.

Early decreases in enrollment in physics from 22% in 1895 to 6% in 1935 were used as a reason for challenging the content of the course and methods of teaching the course. Brown (10), (11), (12), (13), (14), (15), (16), (17), prior to World War II, published a

series of articles entitled, "The Plight of High School Physics." He suggested that physics enrollments were decreasing because of the way the course was being taught. His suggestions for increasing enrollments were: (1) revise physics textbooks by removing the fundamentals of physics from the traditional compartments of mechanics, heat, and electricity; (2) use lecture materials that will be of greater interest to the students; (3) use the laboratory to solve problems developed by the students; (4) de-emphasize the mathematical approach to teaching physics; (5) teach the social and economic implications of physics; and (6) advertise the course to counselors, parents, and students.

In summary, during this era the high schools changed to accommodate a more general population and physics became the last course in the science sequence. The content and presentation of physics, however, met the needs of a continuously smaller segment of the high school population.

High School Physics from 1940-1960

The second era is characterized by rapid developments in science and technology due to World War II. Yet, Table I indicates that the percentage of high school students enrolling in physics dropped from 5.49% in 1947 to 4.59% in 1959. Meanwhile, chemistry enrollments remained nearly constant, and those in the "other science" category, mainly physical science, doubled. The decline in physics enrollments coupled with the increase of those in physical science resulted in a controversy about the future of physics in the high school.

Hurd (18) pointed out that not only were physics enrollments decreasing but the course was being taught in less than fifty percent of the high schools in many areas. He states that:

> Physics with its traditional objectives, organization, and content has lost its place as a high school subject. It does not fit into either the high school or the college pattern of modern education.

His solution was to replace high school physics with some type of physical science course.

Mallinson (19) took an opposite view and suggested that physics be retained in the high school curriculum, but that it be taught in a more interesting and qualitative manner. Physical science should be used as a prerequisite in grades 9 or 10 to improve the background of prospective chemistry and physics students.

Suffice to say, physics is still a part of the science curriculum in most high schools in the United States.

High School Physics from 1960-1969

As a result of the launching of Sputnik I in October 1957, science education in the United States became the target of much criticism. Since that event science education has been characterized by numerous projects aimed at improving instruction in science programs and courses at all levels.

It is generally accepted that during this period the National Science Foundation has had the most important influence on high school physics. The NSF has provided financial support in two important areas: (1) a total of $5,276,683 (20) was allocated to the Physical Science Study Committee for developing a new physics curriculum at

the high school level, and (2) between 1959 and 1967 one hundred and twenty-eight Summer Institutes funded with about $4,600,000 (21) and 97 In-Service institutes have provided instruction for teachers in the philosophy and use of PSSC materials.

It seems anomalous to note from Table I that from 1960, when PSSC was first available to high schools, until 1965 physics enrollments have continued to decrease. A review of the literature for the past ten years reveals little agreement on either the severity of the problem or a course of action that will, hopefully, provide a solution.

The basic premise that decreasing physics enrollments are a serious problem has been challenged. Pratt (22) and Kleinman (23) point out that even though the percentage of high-school graduates who have taken physics is decreasing, a smaller percentage of students are dropping out of school which has resulted in senior classes of the past few years having more students in a general education curriculum. They contend that the actual percentage of "qualified" students taking physics has probably remained about the same. Increased enrollments then would require lower standards in physics.

An opposing philosophy was expressed by Crane when he was president-elect of the American Association of Physics Teachers (quoted from Sawyer (24)).

> Physics courses are too hard for the largest group of high school students. The grading system for physics courses does not take into consideration the difficulty of the subject compared to other subjects, and there is little later reward in terms of the recognition given in college to high-school physics. The high-school course should be made palatable and its appeal broadened. . . . A physics course does not have to be hard to be good.

In another study Ellis (25) indicates that the percent of college graduates with majors in physics has decreased from 1.31% in 1961 to 1.06% in 1965. The absolute numbers of college graduates with majors in physics has decreased from 5622 in 1962 to 5250 in 1967. The problems with high school physics may be related to this because more than ninety-five percent of the college graduates with physics majors took physics in high school.

The acute shortage of qualified physics teachers has also been considered as a possible reason for decreasing enrollments in high school physics. Sawyer (24) estimates the present number of high school physics teachers to be about seventeen thousand. The number needed annually to accommodate larger senior classes and replace those leaving the field is about 1700. The number of new physics teachers being trained each year is about five hundred with only three hundred actually entering the teaching field.

Watson (26) cites decreasing physics enrollments as an indication that a new course with a "historical and cultural framework" is needed. The development of such a course was referred to originally as "Harvard Project Physics" but is now known as "Project Physics."

The current approach to the solution of the problem of low enrollments in high school physics classes is centered around curriculum innovations. The literature has revealed that this approach is not resulting in increased enrollments and, in fact, has not shifted the trend of decreasing enrollments. Research is needed regarding the basic nature of the problem of decreasing enrollments in high school physics and for this reason this particular study was undertaken.

The purposes of this study were (1) to obtain an accurate assessment of the present enrollments in high school physics in Michigan and (2) to identify the distinguishing characteristics of high schools with high and low enrollments. It is hoped that if distinguishing characteristics can be identified, they can be used as a source for constructive suggestions for modifying science programs to encourage more students to enroll in physics.

The Research Problem

This study was initiated in order to determine if high schools with either high or low enrollments in physics exhibit any distinguishing characteristics that are measurable. The following general areas were considered:

1. The personality of the physics teacher.
2. The training and teaching experiences of the physics teacher.
3. The grading practices of the physics teacher.
4. The students evaluation of the physics teacher.
5. The student's appraisal of the classroom environment.
6. The vocational plans of the physics students.
7. Physics achievement of the students.
8. The reasons chemistry students give for wanting to or not wanting to take physics.
9. The reasons physics students give for taking the course.
10. The science curriculum in the high school.
11. The type of physics course--PSSC or traditional.
12. The mathematics prerequisites for the physics course.

CHAPTER II

RELATED RESEARCH

A search of the literature was made to obtain information from research studies concerning enrollments in physics. None was found dealing directly with comparisons of schools having high enrollments in physics with those having low enrollments. Several studies have been undertaken, however, that are related to some of the areas investigated in this study. These studies have been divided into four major categories.

Research Related to High School Enrollments

The results of several surveys on enrollments in high school physics are discussed in Chapter I. The United States Office of Education has the responsibility for obtaining data about educational enrollments in general, together with collecting specific information about enrollment patterns in subject matter areas. A series of "status studies" conducted on state-wide bases, such as those of Mallinson (1) and Pella (27), have also produced pertinent data concerning distributions of high school physics students.

Deloach (28), using questionnaires in a survey of Tennessee high schools conducted in 1955, found that large urban schools had 7.88% of the high school students enrolled in physics. Small urban schools had 6.18% of the high school population enrolled, whereas in rural high schools only 2.83% of the students enrolled in physics.

Maneval (29) found that in Oklahoma high schools the ratio of boys to girls in physics increased from 2.2 to 1 in 1922 to 4.5 to 1 in 1951. During this same period physics enrollments dropped from 8.3% to 4.5% of the high school population indicating that decreases in enrollments are, in large part, due to fewer girls taking the course. Some of the latest estimates from the U. S. Office of Education place the boy to girl ratio in physics at about 2.65 to 1.

Research Related to Teachers

Numerous studies have been undertaken that have attempted to identify the traits of "successful" or "effective" teachers. The more significant studies are those of Witty (30), Lamke (31), and Michael (32). These studies which involved the collection of data through personality tests, student and administrative assessments, and letters written about influential teachers, seem to suggest that good teachers possess the following qualities:

1. They are unusually proficient at teaching a particular subject which apparently allows them to be flexible. In addition, students have confidence in the teachers' knowledge of the subject matter.

2. They have a good disposition, a sense of humor, and they have strong interests that cover a wide variety of subjects.

3. They are characterized as being patient, fair, and frequently give recognition and praise.

4. They place no special emphasis on discipline which may be due to the other traits listed above or in addition to them.

Poor teachers were characterized as possessing traits opposite to those mentioned above along with being shy, cautious, easily pleased, and attentive to people.

In recent years research has been initiated towards determining characteristics of "good" science teachers. Yager (33), in a study "designed to demonstrate that the teacher is an important factor affecting some of the specific outcomes of instruction" worked with 8 biology teachers of similar backgrounds and professed teaching philosophies. He found, after measuring subject matter achievement, critical thinking, understanding of the nature of science, and attitudes towards science, that the students of any one particular teacher may excel in one or more areas and do poorly in others. He concludes that "apparently individual teachers possess composite traits which must be considered together in terms of student learnings." He suggests "the specific traits of teachers should be studied further in order to establish patterns causing particular outcomes in the students."

In a somewhat similar study Handley and Bledsoe (34), sought to test the hypothesis that "teachers recognized for their nurturing role of young students have enough stable personality traits in common that a characteristic profile of behaviors may be recognized," gave personality tests to 50 influential science teachers, 50 regular teachers, and 50 graduate students in natural science. Influential science teachers were defined as "teachers who had been consistently identified as 'influential' by . . . (students) who had won top state or national awards in science creativity." They found that:

1. Both teacher groups were significantly higher than the research students on scales measuring warm hearted vs reserved and submissive vs aggressive.

2. The influential science teachers were more imaginative, trusting, and confident than the other groups.

3. The regular science teachers differed from the influential teachers and research students by being less conscientious and persevering.

On the basis of the results of this study they concluded that:

1. Influential science teachers were more imaginative and unconventional which allows the teacher "to oppose the structured science curriculum present in most schools in order to support the creative work of the students."

2. The influential science teacher is more calm and serene which gives him "the inner security and confidence needed to innovate and to tolerate working with talented students."

In a study directed specifically towards physics teachers Sadler (35), attempted "to compare physics teachers who have favorable attitudes with those who have unfavorable ones towards the PSSC curriculum." He tested sixty science teachers from 2 NSF Summer Institutes in physics and found that the favorable attitude groups scored significantly higher on three characteristics: (1) GPA in college physics, (2) capacity for status, and (3) intellectual efficiency. The unfavorable attitude group scored significantly higher on the theoretical and economic characteristics. The authors noted a similarity with the results of a study conducted by Blankenship (36) concerning attitudes towards the BSCS Curriculum in that favorable groups for both curricula rated higher on the characteristic of intellectual efficiency.

Two other studies dealing with the characteristics of physics teachers were conducted as part of the evaluation of the Project Physics Curriculum. In this study Walberg and Welch (37) measured the "major factors of personality . . . to be found in a group of physics teachers," by working with a select group of 36 male physics teachers and found that the teachers differed with respect to seven personality factors:

1. Positivism--which reflects exhibitionism, knowledge, and heterosexuality.

2. Altruism

3. Intellectual independence--reflecting theoretical values and a need for achievement.

4. Receptivity--positively oriented towards change and negatively towards dominance.

5. Friendliness--contrasting the protective friendly teacher with the relentless domineering bully.

6. Aestheticism

7. Scholastic Motivation

A comparison of these factors with the general characteristics of good and bad teachers cited earlier indicates numerous parallels. One implication would be that physics teachers do not constitute a group with unique characteristics, but rather conform to a continuum that contains the assessed good and bad characteristics of teachers in general.

One of the important effects of teacher personality is the educational environment created in the classroom. Walberg (38), in an attempt to "predict classroom climate . . . from the teacher's personality," by using the personality characteristics of 36 physics

teachers and comparing these with classroom climate evaluations of 500 of their physics students, identified four teacher-personality-classroom climate relationships:

1. Teacher measured needs for both dependence and power and order and change make for a formal subservient climate with little animosity among class members.

2. Teachers with needs to interact with others, both aggressively and affiliatively tend to have controlled, goal directed classes.

3. A combination of the characteristics of the first two teacher patterns which result in classroom climates that are goal directed, homogeneous socially and respect to interests, lacking in organizational formality, and subservient.

4. The self-centered teacher produces a classroom climate that is characterized by disorganization, constraint, loose supervision of students' work, and lower group status.

From this study, one may conjecture if, as Walberg has pointed out, teacher personality does predict classroom climate, "Does classroom climate predict enrollment?"

Questionnaires have been used on several occasions to obtain direct information from physics teachers concerning their problems in attitudes towards, and suggestions about current physics education. Walberg and Welch (39) used this direct approach in an attempt to determine "if the attitudes of physics teachers were related to declining physics enrollments" by administering questionnaires to 162 physics teachers attending four Summer Institutes related to Project Physics. Some of the teachers expressed attitudes such as:

1. Physics should be studied by nearly all students, not just students who are planning to attend college.

2. Mathematics should be minimized.

3. The difficulty of the course should not be stressed.

4. Grading and homework should be commensurate with other courses.

5. Teachers thought they needed more training in subject matter.

6. Methods courses were the only education courses considered to be of real value to the teachers.

The authors concluded that the "physics teacher seems to be the victim of a trend and not the cause." If consideration is given to the philosophy of Project Physics, given on page 7, the responses of the teachers attending the institutes still leaves in question the effects of teacher attitudes on physics enrollment.

A direct appeal was made to all physics teachers to express their opinions concerning high school physics via a questionnaire published in The Physics Teacher (40). Young (41) in reporting the results of the study indicates that only 1400 responses were obtained from a journal circulation of 17000. The following is a consensus of the opinions that were expressed:

1. Physics is too hard because physics students are expected to work harder than their colleagues and the course takes too much time.

2. Physics students are afraid their physics grades will lower their averages.

3. There is too much mathematics in physics.

4. Ninety percent of the respondents believe that physics is needed by nearly every student.

5. Sixty percent favored an introductory physical science course in grades 9 or 10.

A summary of the research cited in this section points out that each teacher, good or bad, has certain recognizable traits and that physics teachers do not represent a unique segment of the teaching community. Science teachers in general and physics teachers in

particular do influence the learning behaviors and activities of their students. Responses from questionnaires indicate that some physics teachers are at least giving lip-service to the philosophy that physics be taught to a larger segment of the high school population but there is little evidence to indicate that any of the problems identified three decades ago have been resolved.

It should be noted that in most of the research related to physics teachers no attempt has been made to obtain a sample that represents any large segment of the physics teacher population. Consequently implications made from these studies have only limited scope.

Research Related to Physics Students

Research using physics students involves both direct and indirect methods of gathering data. In the direct methods the students are asked to express their opinions about some aspects of the physics course. Shamus (42) carried out a survey "for the purpose of discovering what the students themselves think about physics," and reported the results from four classes in a college preparatory high school. Reasons students gave for taking physics were given in the following order:

1. Interest in the subject matter.
2. A desire to obtain science credits.
3. The course would be helpful in the future.
4. The course was required.

This same group of physics students believed that other students did not take physics because they thought the course was too difficult.

In a more extensive study carried out by Ulry and Huttington (43) for the purpose of evaluating the public education system in Maryland and in which they contacted 17,000 high school seniors, it was reported that distribution of IQ scores of students for chemistry and physics were nearly identical, whereas students in biology courses had a lower IQ distribution. The four most important reasons students gave for taking physics were:

1. It was required
2. It was important for their future
3. They had a special interest in the subject
4. It was recommended.

Indirect methods involve using questionnaires which measure factors that may not be immediately obvious to the student. Walberg (44) in an attempt to measure how "the scientific interests of boys and girls differ" worked with 725 boys and 332 girls who were using experimental materials of Project Physics. He found that boys had greater interests in the areas of tinkering and cosmology, while girls were more interested in the academic areas and applications of physics. He concludes that "boys appear to be attracted to areas involving physical manipulations, while girls favor the discussions and the questioning methods of physics."

It is generally agreed that most students enroll in courses anticipating a feeling of satisfaction when the course is completed. Welch (45) in a study designed to determine "what factors are significantly related to satisfaction in high school physics" found that expressed satisfaction is positively related to indications of success in the course (grade), negatively related to the perceived

difficulty of the course, and only slightly related to initial ability. Welch concludes "it is not what they (students) expect to happen that leads to satisfaction, but rather what actually does happen." Another conclusion that should be of interest to physics teachers and guidance counselors is that "it appears to be almost impossible to predict the type of student likely to be satisfied with physics before the course started."

The research cited in this section indicates that physics students can be influenced with respect to their reasons for taking the course. Teachers and counselors should give careful consideration to the fact that they cannot predict in advance the students that will consider physics to be a satisfying experience.

Grading Practices of Physics Teachers

Low grades in physics have been one of the most prominent reasons cited for low enrollments in physics. Yet, there is little relevant data available to substantiate this. Welch (45), in a study previously discussed which related to course satisfaction, also noted "one of the things that happens in physics is that students receive low grades relative to their grades in other courses . . . . (A group having) a median IQ in the eighty-second percentile received average grades in physics in the C+, B- range."

Krieger (46) in a study designed to determine "whether or not high school physics grades were essentially different from high school chemistry grades earned by the same students" found that

students receiving A's and B's in chemistry received physics grades that were 2.4 grade points lower. The difference between any two letter grades (e.g. A and B) represented three points.

In a study directly related to physics enrollment, Bridgham and Welch (47) attempted "to trace out effects on enrollment from severity of standards in grading," and found that among thirty teachers using Project Physics materials a direct relationship exists between the severity of the teachers grading and the number of students dropping the course.

A review of the studies cited in this section illustrates that any study concerned with enrollment in physics should not disregard the grading practices of the teachers.

CHAPTER III

THE DESIGN OF THE STUDY

The purposes of this chapter are: (1) to state the hypotheses of the study and accompanying definitions; and (2) to describe (a) the population and how a sample was obtained from the population, (b) the instruments used in the study, (c) the visits made to the high schools, and (d) the statistical methods employed in the analyses.

Hypotheses

After completing a review of the related research a number of hypotheses were formulated that relate to general areas being investigated which have been described in Chapter I. Each hypothesis is given in the null form and will be rejected at the .05 level of confidence. Definitions of terms follow the list of hypotheses. The hypotheses tested were these:

1. There will be no significant differences between the personality traits of physics teachers from high schools with high percentage enrollments in physics and those of physics teachers from high schools with low percentage enrollments in physics.
2. There will be no significant differences between student evaluations of physics teachers from high schools with high percentage enrollments in physics and those of physics teachers from high schools with low percentage enrollments in physics.

3. There will be no significant differences between the student evaluations of physics learning environments of high schools with high percentage enrollments in physics and those of the physics learning environments of high schools with low percentage enrollments in physics.
4. There will be no significant differences between the teaching loads in science and mathematics of physics teachers from high schools with high percentage enrollments in physics and those of physics teachers from high schools with low percentage enrollments in physics.
5. There will be no significant differences between the college preparations of physics teachers from high schools with high percentage enrollments in physics and those of physics teachers from high schools with low percentage enrollments in physics.
6. There will be no significant differences between (a) the total number of years of teaching experience, (b) the years of teaching physics, and (c) the years taught at that school of physics teachers from high schools with high percentage enrollments in physics and those of physics teachers from high schools with low percentage enrollments in physics.
7. There will be no significant differences between the opinions towards physics of physics teachers from high schools with high percentage enrollments in physics and those from high schools with low percentage enrollments in physics.
8. There will be no significant differences between the number of teachers teaching PSSC physics in high schools with high

percentage enrollments in physics and those teaching PSSC physics in high schools with low percentage enrollments in physics.

9. There will be no significant differences between the numbers of teachers preferring to teach PSSC physics in high schools with high percentage enrollments in physics and those from high schools with low percentage enrollments in physics.

10. There will be no significant difference between the numbers of physics teachers requiring geometry or less as a prerequisite for physics in high schools with high percentage enrollments in physics and those demanding a similar prerequisite from high schools with low percentage enrollments in physics.

11. There will be no significant differences between the percentages of physics students with indicated vocational choices in the areas of physical science and engineering, and other science and mathematics, non-science, and undecided from high schools with high percentage enrollments in physics and that of similar students from high schools with low percentage enrollments in physics.

12. There will be no significant differences between the reason physics students give for taking physics from high schools with high percentage enrollments with those given by students from high schools with low percentage enrollments in physics.

13. There will be no significant differences between the grades received by students in high schools with high percentage enrollments in physics and those of students from high schools with low percentage enrollments in physics.

14. There will be no significant differences between the physics achievement of students from high schools with high percentage enrollments in physics and that of students from high schools with low percentage enrollments in physics.
15. There will be no significant differences between the reasons chemistry students from high schools with high percentage enrollments in physics give for wanting to take physics and those given by chemistry students from high schools with low percentage enrollments in physics.
16. There will be no significant differences between the reasons chemistry students give for not wanting to take physics from high schools with high percentage enrollments in physics and those given by students from high schools with low percentage enrollments in physics.
17. There will be no significant differences between opinions of guidance counselors towards physics from high schools with high percentage enrollments in physics and those of counselors from high schools with low percentage enrollments in physics.
18. There will be no significant differences between the number of high schools with tracked science curricula in high schools with high percentage enrollments in physics and those with tracked curricula in high schools with low percentage enrollments in physics.
19. There will be no significant difference between the numbers of high schools requiring geometry or less as a prerequisite for

physics in high schools with high percentage enrollments in physics and those demanding a similar prerequisite among high schools with low percentage enrollments in physics.

20. There will be no significant differences between the number of high schools offering two levels of first year physics in high schools with high percentage enrollments in physics and those in high schools with low percentage enrollments in physics.
21. There will be no significant differences between the number of high schools offering advanced science courses and that have high percentage enrollments in physics and those that have low percentage enrollments in physics.
22. There will be no significant differences between the percentages of students attending college from high schools with high percentage enrollments in physics and the percentages of those from high schools with low percentage enrollments in physics.
23. There will be no significant differences between the percentages of dropouts from high schools with high percentage enrollments in physics and the percentages of dropouts from high schools with low percentage enrollments in physics.

Definitions

1. A high school with a _high_ or _low_ _percentage_ _enrollment_ _in_ _physics_ must have been in the top or bottom quarter of a rank order of schools returning questionnaires denoting the percentage of seniors enrolled in physics for that particular class of school.

2. Personality traits are the sixteen factors measured by the Sixteen Personality Factor Questionnaire.

3. Student evaluations refer to the twelve categories on the Student Opinion Questionnaire.

4. Learning environment refers to the fourteen factors measured by the Learning Environment Inventory.

5. Teaching load refers to the number of science or mathematics courses the physics teacher teaches.

6. College preparation of physics teachers refers to the number of semester hours of physics, chemistry, biology, earth science, mathematics and education courses the physics teachers have earned at both the undergraduate and graduate levels.

7. The opinions of physics teachers are measured by their responses to questions 10 and 11 on the Physics Teacher Questionnaire.

8. Physical science and engineering includes physicist, chemist, engineer, architect, physics teacher, and chemistry teacher. Vocations in this category would require a concentrated effort in the physical sciences at the college level.

9. Other science and mathematics includes biologist and biology teacher, geologist, medical doctor and medical technologist, mathematician, mathematics teacher, and computer scientist, physical technologist, such as automotive technology; applied biological and physical science work, such as conservation work, television repair.

10. Non-science includes all aspects of social science, military, elementary teaching, and anything else not covered in 8 and 9.

11. Undecided--girls getting married were also included in this category.

12. Physics achievements are scores on the Dunning-Abeles Physics Test.

13. The opinions of guidance counselors are measured by their responses to questions 3 and 4 on the Guidance Counselor Questionnaire.

14. Advanced science courses are second-year courses in either biology or chemistry.

15. Tracked science curricula exist when two or more courses are offered in either first-year biology, chemistry, or physics and students are enrolled in the courses according to their abilities.

16. Percentage of dropouts is percentage of the high school population that leave the high school and do not continue their education during the 1967-68 school year.

17. College refers to either a two or four year institution but does not include such institutions as business schools or beauty academies.

Procedures

Population and Sample

The data were collected in part by sending questionnaires to a random selection of one-half of the Class A, B and C high schools in the State of Michigan for the purpose of obtaining an accurate description of the current physics enrollment percentages. A sample of about seven percent of this population was selected from the schools returning questionnaires. In order to be included in the sample the high school had to be in either the upper or lower quarter of a rank-order list of percentages of seniors enrolled in physics for either class A, B and C schools. Class D schools were contacted with the original questionnaire but were not included in the sample because nearly one-half of the schools offered physics on an alternate year basis; hence physics and chemistry classes could not be visited at the same time. Chapter IV is devoted to a more complete description of the actual procedure used in selecting the sample schools and the arrangements that were made for visiting the schools.

The purpose of visiting each of the schools in the sample was to administer questionnaires to (1) physics teachers, (2) physics students, (3) chemistry students, and (4) guidance counselors. A personal visit to each school rather than sending the questionnaires through the mail appeared to have obvious advantages, namely, (1) uniformity could be established in administering procedures

which would add to the validity of the study, and (2) there was a fair degree of assurance that data would be available from each of the schools.

Instruments Used

Two questionnaires were administered to the physics teachers: (1) the Sixteen Personality Factor Questionnaire and (2) the Physics Teacher Questionnaire.

1. The Sixteen Personality Factor Questionnaire developed by Cattell (48) was used to collect personality data. This questionnaire measures the behavioral characteristics of the individual in terms of sixteen factors that have been isolated by means of factor analysis. Cattell identifies each factor with a letter, bipolar descriptive names, and descriptive adjectives. The factors are described as follows:

Low Score Description	High Score Description
1. Reserved, Detached, critical, aloof	1. Outgoing, warmhearted, easy-going, participating
2. Less intelligent, concrete-thinking	2. More intelligent, abstract-thinking, bright
3. Affected by feelings, emotionally less stable, easily upset	3. Emotionally stable, faces reality, calm, mature
4. Humble, mild, accommodating, conforming	4. Assertive, aggressive, stubborn, competitive
5. Sober, prudent, serious, taciturn	5. Happy-go-lucky, impulsively lively, gay, enthusiastic
6. Expedient, disregards rules, feels few obligations	6. Conscientious, persevering, staid, moralistic

7.	Shy, restrained, timid, threat-sensitive	7.	Venturesome, socially bold, uninhibited, spontaneous
8.	Tough-minded, self-reliant, realistic, no-nonsense	8.	Tender-minded, clinging, over-protected, sensitive
9.	Trusting, adaptable, free of jealousy, easy to get along with	9.	Suspicious, self-opinionated, hard to fool
10.	Practical, careful, conventional, regulated by external realities, proper	10.	Imaginative, wrapped up in inner urgencies, careless of practical matters, bohemian
11.	Forthright, natural, artless, unpretentious	11.	Shrewd, calculating, wordly, penetrating
12.	Self-assured, confident, serene	12.	Apprehensive, self-reproaching, worrying, troubled
13.	Conservative, respecting established ideas, tolerant of traditional difficulties	13.	Experimenting, liberal, analytical, free-thinking
14.	Group-dependent, a "joiner" and sound follower	14.	Self-sufficient, prefers own decisions, resourceful
15.	Undisciplined self-conflict, follows own urges, careless of protocol	15.	Controlled, socially precise, following self-image
16.	Relaxed, tranquil, unfrustrated	16.	Tense, frustrated, driven, overwrought

Cattell and Eber (49) describe the questions as being indirect--asking about interests which the subject would not necessarily perceive to be related to the trait in question--so that some escapes are provided from deliberate or accidental distortions by the subject. The factors are not interpreted from the known correlations between these "mental interiors" elicited by the questionnaire and the factors established in behavior; therefore, the question responses are treated as behavior not as valid self ratings.

The factors are described as being adequate to cover all kinds of individual differences of personality found in common related literature and therefore results in the inclusion of all aspects of the total personality. The factors do not overlap in meaning but are considered to represent clear, functional unities, each having a wide influence on behavior.

The Sixteen Personality Factor Questionnaire has been used in a variety of studies and has numerous references listed in the Sixth Mental Measurement Yearbook (50). Holland (51) (52) (53), as an example, used this instrument for relating personality traits of students to their vocational preferences, college grades, and creativity ratings made by their teachers.

Forms A and B of the questionnaire were used in this study with nearly equal numbers of each being distributed among the six groups of teachers in the sample. Cattell and Eber (49) indicate the split-half reliabilities for the factors range from .71 to .93 (median .85). Validities estimated from the loadings have a range of .73 to .96 (median .84) and validities estimated from correlation of two factor halves range from .84 to .96 (median .92).

2. The second questionnaire that was administered to physics teachers was developed to obtain information concerning the teacher's training, teaching experiences, and opinions regarding high school physics. This questionnaire is referred to simply as the "Physics Teacher Questionnaire" and a copy is included in the Appendix, page 136.

Three questionnaires were administered to the physics students: (1) the Student Opinion Questionnaire in which the students evaluated the physics teacher; (2) the Learning Environment Inventory in which the students evaluated the learning environment of the classroom, and (3) a questionnaire in which the students gave information about their vocational plans, why they took physics, the courses they were taking and the grades they received.

1. The Student Opinion Questionnaire (54), developed by the Educator Feedback Center at Western Michigan University, was selected because it covers most of the areas cited in the literature as being important aspects of teaching. The areas covered in this questionnaire have been associated with other questionnaires that purport to measure teacher "success" or "effectiveness."

The physics students completing the questionnaire were asked to react to the following:

1. Knowledge of subject: (Does he have a thorough knowledge and understanding of his teaching field?)
2. Clarity of explanations: (Are assignments and explanations clear?)
3. Fairness: (Is he fair and impartial in his treatment of all students?)
4. Control: (Does he keep enough order in the classroom? Do students behave well?)
5. Attitude toward students: (Is he patient, understanding, considerate, and courteous?)
6. Ability to stimulate interest: (Is this class interesting and challenging?)
7. Attitude toward subject: (Does he show interest in and enthusiasm for the subject? Does he appear to enjoy teaching this subject?)

8. Attitude toward student opinions: (Are the ideas and opinions of students treated with respect? Are differences of opinion welcomed even when a student disagrees with the teacher?)

9. Variety in teaching procedures: (Is much the same procedure used day after day and month after month, or are different and appropriate teaching methods used at different times (student reports, class discussions, small-group discussions, films and other audio-visual aids demonstrations, debates, field trips, teacher lectures, guest lectures, etc.?)

10. Encouragement of student participation: (Do students feel free to raise questions and express opinions? Are students encouraged to take part?)

11. Sense of humor: (Does he see and share with students amusing happenings and experiences?)

12. Planning and preparation: (Are plans well made? Is class time well spent? Is little time wasted?)

Each question can be answered with one of five choices: poor, fair, average, good, and excellent. The students were told that their teachers would receive a copy of the results and not the questionnaires with responses. The students were directed not to place their names on the questionnaire.

Bryan (55) reported that when averages of student responses from chance halves of fifty randomly selected classes taught by fifty secondary school teachers were correlated the reliabilities obtained for the twelve questions ranged from .77 to .95 (median. 87).

2. The Learning Environment Inventory was developed by Herbert J. Walberg and Gary J. Anderson (56) of Harvard University. They used this instrument to measure the relationships between student perceptions of physics classroom environments and physics achievements. A study conducted by Walberg (38) cited in Chapter II indicates that relationships do exist between the factors included

in the inventory and some aspects of physics teachers' personality.

Physics students evaluated the learning environments of their physics classes by using the Learning Environment Inventory (56). This instrument consists of 105 questions and is designed to measure the following elements of the classroom environment (57): (1) intimacy, (2) cliqueness, (3) favoritism, (4) satisfaction, (5) difficulty, (6) democratic, (7) diversity, (8) friction, (9) apathy, (10) formality, (11) speed, (12) goal direction, (13) disorganization, and (14) environment. Due to the time required for the student to complete the entire questionnaire, two shorter forms were developed. Form A covered the first seven factors and Form B the remaining seven.

Reliabilities for the inventory in terms of the individual student's scale score range from .58 to .86 (median .77). Interclass correlations, which are indices of the reliabilities of the class means range from .43 to .84 (median .77). Correlations of the individual items with a scale range from .41 to .81 (median .63).

3. The third questionnaire given to the physics students was constructed to obtain the following information: (1) vocational plans, (2) three most important reasons for taking the course, (3) the other science courses taken, and (4) the grades received in physics as well as in other courses in which the student was presently enrolled. This questionnaire is referred to as the "Physics Student Questionnaire." A copy is included in the appendix, page 138.

The physics student's achievement in physics was measured using the Dunning-Abeles Physics Test (58). Dunning and Abeles (59) indicate that the appropriateness of each objective and topic measured by the test was determined according to the frequency of its inclusion in current science education materials. Widely used textbooks and representative courses of study were considered in selecting the items. The test attempts to reflect changes in curriculum thus deeming it appropriate for physics classes where traditional or modern approaches are used, whether or not PSSC materials constitute the basic instructional guide.

The test was published in 1967 and is designed to measure knowledge, understanding, and applications of physics. The percentage distribution of the questions with respect to the major areas of physics for Forms E and F are: mechanics, 31%; electricity and magnetism, 25%; atomic and nuclear, 12%; wave motion and light, 21%; and kinetic molecular theory, 11%.

During the Spring of 1966 Dunning and Abeles administered Forms E and F of the test to 4,965 students in 112 public high schools in 41 states. Analysis indicated that the mean values in achievement were 25.5 for Form E and 25.4 for Form F. Using the split-half method and the Spearman-Brown Prophecy Formula the reliabilities are .87 and analysis indicated item difficulties range from .24 to .89 (median .45). The item discriminations range from .26 to .67 (median .46).

One questionnaire was administered to the chemistry students. In it the students were asked to indicate (1) if they intended to go to college, (2) what their vocational plans were, (3) if they planned to take physics the following year, (4) if they planned to take physics, they were asked to give the three most important reasons for wanting to take the course, (5) if they were not going to take physics they were asked for the three most important reasons for avoiding the course, (6) the other science courses they had taken. This questionnaire is included on page 139 of the appendix.

A guidance counselor in each of the schools was asked to complete a questionnaire. The questions concerned: (1) the prerequisites for physics; (2) their attitudes about the course; and (3) their suggestions for increasing physics enrollments. During an interview data were also obtained about the other science courses offered in the high school and their prerequisites.

Data concerning the percentages of high school dropouts and the numbers of student going to college were obtained either from the counselor or the high school principal.

Visitation Procedure

As was expected nearly every visit required a full school day. The questionnaires for the physics students were administered at the beginning of the class period and required from 15 to 30 minutes to complete. The questionnaires for the chemistry students were administered at the beginning of the chemistry class periods unless a chemistry class met at the same time as a physics class. In such cases, these questionnaires were given either at the end

of the class period or by the chemistry teacher. The chemistry questionnaires could be filled out in about five minutes. The physics teachers filled out their questionnaires sometime during the day the visit was made or sometime later and returned them by mail.

Interviews with guidance counselors and principals were conducted at times that were mutually convenient. The interviews lasted from five minutes to, in one case, one and one-half hours.

Analysis

The specific analytical methods employed on the data and the results obtained are discussed in detail in Chapter V. The statistical techniques consisted of two tests; (1) a "t" test to test for significant differences between means and (2) the Fisher Exact Probability Test to test for significant differences in the distributions of schools with respect to particular variables.

Some of the data was obtained in the form of a yes-no or equivalent dichotomous response and so the data for two different groups was represented on a 2 x 2 matrix. Analysis to determine if a significant difference exists between the numbers of yes and no responses or their equivalents attributed to each group was accomplished by using the Fisher Exact Probability Test (61). The test is described by Siegel as being "an extremely useful non-parametric technique for analyzing discrete data . . . when two independent samples are small in size. It is useful when the scores from two independent random samples all fall into one or the other of two mutually exclusive classes." The test can be used to

determine "whether Group I and Group II differ significantly in the proportion of pluses and minuses attributed to them." This test was selected rather than a Chi Square test because the groups are small and there is no way of obtaining the "expected values" required by the Chi Square test.

CHAPTER IV

POPULATION AND SAMPLE

Population

In determining population restrictions for convenience in visiting the individual high schools it was decided to limit the study to schools within the State of Michigan. In order to obtain current enrollment data in physics and chemistry for the population, a random sample was made of one-half of the high schools in Michigan. The schools were selected on an "every-other-one" basis from the list of high schools appearing in the 1967 Directory Issue of the Michigan Athletic Association Bulletin (62). The returned questionnaires were classified as to whether they came from class A, B, C or D Schools. The size of each class as defined by the Michigan Athletic Association is given as follows:

For grades 9-12*

A = 1100 or more

B = 450 - 1099

C = 250 - 449

D = less than 250

*For high schools having only grades 10, 11 and 12, one-third of the number of students in those grades is added to the total for classification purposes. . . . In schools in which the enrollment is made up of seventy-five percent or more boys the enrollment figures are doubled for classification purposes." (p. 230 (62)).

This list is considered to be fairly complete because high schools in Michigan must be classified by the Michigan Athletic Association before they are allowed to compete in any State Association tournaments or meets.

Letters were sent during the third week of October 1968 to the high school principals of 373 of the 749 schools listed in the Bulletin. Two schools were omitted because they served only blind or deaf children. The time for the survey was selected because it closely followed the official "Fourth-Friday Count" required by the state because state funds are allocated to schools on a basis of the number of pupils they have enrolled on the fourth Friday of the new school year.

The principal was asked to indicate the numbers of first-year chemistry and first-year physics students in the high school together with the numbers of students in the eleventh and twelth grades. He was also asked to indicate if his school was interested in participating in the second phase of the study. It was explained that the second phase involved a more detailed investigation of the problem of decreasing physics enrollments. Copies of the letter and questionnaire sent to the high school principal and a cover letter sent by Dr. George G. Mallinson, Dean, School of Graduate Studies of Western Michigan University appear in the appendix.

Eighty-two percent or 308 of the questionnaires were returned which represents 41.1% of the schools in the total population. The initial response was considered to represent adequately the population; so no follow-up techniques were used. There was only a 4%

negative response to the question asking the school if they were interested in participating in the second phase of the study.

The percentages of seniors taking physics and juniors taking chemistry were calculated for each of the schools. The schools in each class were then put in rank orders with respect to their percentages of students electing physics and chemistry. Percentile ranks were then calculated for each school.

Descriptions of the patterns of high school physics and chemistry enrollments in Michigan are found in Tables II to III. Copies of Tables II and III with percentile ranks of the school with respect to physics and chemistry enrollments were sent to each of the high schools returning the questionnaire.

The Sample

The sample consists of the high schools that were visited. All the schools that were selected met these criteria:

1. The school had to be either a class A, B or C school included in the original population of high schools listed in the Directory Issue of the Michigan Athletic Association Bulletin (62).

2. The school had to be one of the schools returning an enrollment questionnaire without a negative response to the question regarding an interest in participating in the second phase of the study.

3. The school had to be either in the upper or lower quarter in its class with respect to the percent of seniors enrolled in physics.

The Class A high schools in the top quarter of a rank-order list of physics enrollment percentages had at least 18.23 percent of the seniors enrolled in physics; while for the bottom quarter it was less than 9.66 percent. The top and bottom quarter percentage limits for Class B and

TABLE II

HIGH SCHOOL PHYSICS ENROLLMENTS IN MICHIGAN

Class A High Schools

		Number of schools from:	
Number of schools in the sample	77		
Percent of seniors enrolled in physics		0 - 5%	2
Mean	15.79	5 - 10%	17
Median	12.87	10 - 15%	32
Standard Deviation	12.65	15 - 20%	9
Range	2.65 - 99.27	20 - 25%	8
		25 - 30%	3
		30 - 100%	6

Class B High Schools

		Number of schools from:	
Number of schools in the sample	97	0 - 5%	6
Percent of seniors enrolled in physics		5 - 10%	22
Mean	15.40	10 - 15%	37
Median	13.27	15 - 20%	16
Standard Deviation	9.39	20 - 25%	6
Range	0 - 58.20	25 - 30%	5
		30 - 100%	5

Class C High Schools

		Number of schools from:	
Number of schools in the sample	81	0 - 5%	2
Percent of seniors enrolled in physics		5 - 10%	12
Mean	20.19	10 - 15%	20
Median	16.50	15 - 20%	17
Standard Deviation	14.44	20 - 25%	12
Range	2.81 - 98.75	25 - 30%	7
		30 - 100%	11

Class D High Schools

		Number of schools from:	
Number of schools in the sample	53	0 - 5%	2
Percent of seniors enrolled in physics		5 - 10%	7
Mean	24.44	10 - 15%	4
Median	22.22	15 - 20%	14
Standard Deviation	13.68	20 - 25%	4
Range	0 - 63.63	25 - 30%	8
		30 - 35%	6
		35 - 40%	2
		40 - 100%	6

TABLE III

HIGH SCHOOL CHEMISTRY ENROLLMENTS IN MICHIGAN

Class A High Schools

		Number of schools from:	
Number of schools in the sample	77	0 - 15%	3
Percent of juniors enrolled in chemistry		15 - 20%	8
Mean	34.78	20 - 25%	11
Median	33.13	25 - 30%	11
Standard Deviation	14.27	30 - 35%	13
Range	13.24 - 95.57	35 - 40%	5
		40 - 45%	7
		45 - 50%	11
		50 - 100%	8

Class B High Schools

		Number of schools from:	
Number of schools in the sample	97	0 - 15%	3
Percent of juniors enrolled in chemistry		15 - 20%	9
Mean	32.56	20 - 25%	17
Median	30.32	25 - 30%	19
Standard Deviation	12.65	30 - 35%	13
Range	8.00 - 78.78	35 - 40%	11
		40 - 45%	12
		45 - 50%	6
		50 - 100%	7

Class C High Schools

		Number of schools from:	
Number of schools in the sample	81	0 - 15%	9
Percent of juniors enrolled in chemistry		15 - 20%	9
Mean	34.12	20 - 25%	13
Median	28.35	25 - 30%	16
Standard Deviation	17.31	30 - 35%	5
Range	8.33 - 98.50	35 - 40%	8
		40 - 45%	5
		45 - 50%	6
		50 - 100%	10

Class D High Schools

		Number of schools from:	
Number of schools in the sample	53	0 - 15%	10
Percent of juniors enrolled in chemistry		15 - 25%	8
Mean	40.81	25 - 35%	13
Median	31.81	35 - 45%	6
Standard Deviation	27.91	45 - 55%	6
Range	13.51 - 91.66	55 - 65%	7
		65 - 100%	5

C schools were 19.81 and 9.90, and 24.48 and 12.12 respectively.

There were thirty-eight Class A, forty-eight Class B, and forty Class C schools that met the three criteria. From these groups sixteen Class A, twenty Class B, and sixteen Class C schools were selected. Of the schools that were selected one-half were in the top quarters and one-half were in the bottom quarters. Due to limited funds and scheduling considerations the final selection of the schools was made using the following general considerations: (1) All the schools had to be in the lower peninsula of Michigan. (2) First priority was given to schools that were within seventy-five miles of Kalamazoo. (3) Second priority was given to schools that were within seventy-five miles of Grand Rapids and Cadillac. (4) Third priority was given to schools that were located within fifty miles of Lansing, Jackson, Saginaw, and Detroit, Some note was also taken as to whether the school had a large or small chemistry enrollment. An effort was made to try to establish 2 x 2 matrices of high and low physics and chemistry enrollments.

When the selection process had been completed letters were sent to the principals of each of the schools indicating that they had been selected for the second phase of the study. A brief description was given of the objectives of the visit to their school along with the time required in the chemistry and physics classes. The principals were asked to return a questionnaire indicating if they wanted their school to participate in the study. A request was also made for the names of their physics and chemistry teacher(s) and the times their classes met. The letter to the principal is included in the appendix

on page 132. A total of fifty-four schools were asked to participate because two of the originally selected schools were not interested. A list of the participating schools can be found in the appendix on page 133.

After the list of participating schools had been finalized a tentative visitation schedule was set up. Each school was contacted to obtain permission to visit the school on the scheduled day. Each high school principal also received either a telephone call or a card two to four days prior to the actual visit reminding him that the visit would be made on the specified date.

CHAPTER V

ANALYSIS

The purposes of this chapter are (1) to describe the methods used in the collection and analysis of data and (2) to show the results of comparisons that were made between high schools with high percentage enrollments in physics and high schools with low percentage enrollments in physics.

The results of this study were obtained by analyzing the responses of students, teachers, and guidance counselors to various questionnaires. A description of each questionnaire is given in Chapter III. As the tables in this chapter indicate, the data from each of the high schools were used in two different sample groupings. The first comparisons were made between groups of high schools that were equivalent in size but which differed with respect to having either high or low percentage enrollments in physics. The high schools were equated according to size by using the Class A, B and C ratings of the Michigan Athletic Association (62). A second comparison was made between groups that had high percentage enrollments in physics and those with low percentage enrollments in physics, but the high schools within each group varied with respect to size.

Visits were made to fifty-three high schools in Michigan, but data from only forty-eight of these are included in the analysis. Five of the high schools were omitted from the study for one of the following reasons:

1. One of the high schools enrolled only boys. Since physics classes usually consist of a large majority of boys, it was believed that this high school would not be representative of a typical high school with a high percentage enrollment in physics.

2. Two of the high schools offered physics only about every three years which would account for a high physics enrollment at the time the course was offered.

3. In one of the high schools the physics teacher was new to the system. A survey of chemistry students indicated that there would probably be a sharp decrease in physics enrollment the following year; therefore, it was believed that this teacher would not be representative of high school teachers from high schools with high percentage enrollments in physics. In five other high schools the physics teachers were teaching physics for the first time in the school but a survey of the chemistry students indicated projected physics enrollment percentages would be similar to their present values. For this reason these schools were not eliminated from the study.

4. In one of the high schools the physics teacher was teaching a class of physics and a class of chemistry in two different rooms during the same class hour. It is believed that this situation is not typical of any group of high schools; therefore data from this high school were not included in the analysis.

Three of the sixteen class A schools that were visited had two physics teachers. Rather than trying to produce one composite set

of responses for the two teachers, each of these teachers and their classes were treated individually in the analysis. The numbers of students, teachers, and schools included in the analysis are given in Table IV.

Statistical Techniques Employed

The data for the comparisons that were made between high schools with high and low percentage enrollments in physics consisted initially of either individual responses from each physics teacher to questionnaires or the mean value of their students' responses to questionnaires. In each case a mean and standard deviation was calculated for each group of teachers. A test was made for a significant difference between the means of two groups by using a "t" test. Since the groups being compared were small, 7 to 26 teachers or schools, the following form of the "t" test was used (60):

$$t = \frac{M_H - M_L}{\sqrt{\frac{N_H (SD_H)^2 + N_L (SD_L)^2}{N_H + N_L - 2}\left(\frac{1}{N_H} + \frac{1}{N_L}\right)}}$$

Where:

M_H = Mean value of the high physics enrollment group.

M_L = Mean value of the low physics enrollment group.

N_H = Number of teachers or schools in the high physics enrollment group.

N_L = Number of teachers or schools in the low physics enrollment groups.

TABLE IV

SAMPLE POPULATION STATISTICS

Groups	Chemistry Students	Physics Students Boys	Physics Students Girls	Physics Teachers	Schools
Class A Schools					
High	577	436	123	11	8
Low	457	193	42	8	8
Class B Schools					
High	483	257	73	8	8
Low	394	79	15	10	10
Class C Schools					
High	257	122	38	7	7
Low	170	40	11	7	7
Class A, B and C Schools					
High	1317	815	234	26	23
Low	1021	312	68	25	25
Totals	2338	1127	302	51	48

SD_H = Standard deviation of the high physics enrollment groups.

SD_L = Standard deviation of the low physics enrollment groups.

$dF = N_H + N_L - 2$

A portion of the data obtained from the physics students, physics teachers, and guidance counselors were recorded on a yes-no basis or some equivalent dichotomous scale. These data were arranged in 2 x 2 matrices with respect to the response and high or low physics enrollment groups. The high and low physics enrollment groups were compared using the Fisher Exact Probability Test (61). The rationale for choosing this test is given in Chapter III. Data from the matrices were analyzed using the following formula:

$$P = \frac{(A + B)!\ (C + D)!\ (A + C)!\ (B + D)!}{N!\ A!\ B!\ C!\ D!}$$

Where:

A and B are the yes and no or equivalent responses of the group with high physics enrollments.

C and D are the yes and no or equivalent responses of the group with low physics enrollments

N equals the total number of responses: A + B + C + D.

P equals the confidence level of the degree of significant difference between the two groups.

The analyses of the data collected in this research study fall into the four categories: (1) the characteristics of the physics teacher; (2) the characteristics of the physics students; (3) the chemistry student questionnaire; (4) the guidance counselor questionnaire and interview.

The Characteristics of the Physics Teacher

The characteristics of the physics teacher were determined by the use of four instruments: (1) the Sixteen Personality Factors Questionnaire, (2) the Student Opinion Questionnaire, (3) the Learning Environment Inventory, and (4) the Physics Teacher Questionnaire. Each of the instruments is described in Chapter III.

The Sixteen Personality Factor Questionnaire

Each teacher was given a copy of either Form A or B of the questionnaire, a separate answer sheet, and a self-addressed envelope for returning the completed questionnaire. Fifty-one copies of the questionnaire were given out and 35, or 69% of the questionnaires were returned. Raw scores were determined by hand scoring the answer sheets using the scoring sheet provided in a specimen set and standard scores were obtained from the appropriate tables in the *Sixteen Personality Factor Questionnaire* norms (62). The raw scores and standard scores were placed on the answer sheet, which was returned to the teacher. Mean values and standard deviations of each factor for each group of teachers were calculated from the values of each of the teachers in the group. The high and low physics enrollment group means for each factor were compared using the previously mentioned "t" test. The results of these comparisons are given in Tables V-XII.

The Student Opinion Questionnaire

Student Opinion Questionnaires, used to evaluate physics teachers,

TABLE V

16 PERSONALITY FACTOR QUESTIONNAIRE--RAW SCORES

Class A Schools	High Physics Enrollment 8 Teachers		Low Physics Enrollment 7 Teachers		dF=13[1]
Factor	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Reserved vs Outgoing	6.750	1.920	7.857	3.440	- .727
2. Less vs More Intelligent	10.500	1.414	9.000	2.203	1.478
3. Affected by Feelings vs Emotionally Stable	16.625	4.998	19.714	1.665	-1.453
4. Humble vs Assertive	12.875	4.594	10.285	3.105	1.173
5. Sober vs Happy-go-lucky	12.250	4.235	10.285	3.806	.874
6. Expedient vs Conscientious	14.000	3.500	16.285	2.249	-1.378
7. Shy vs Venturesome	13.375	3.497	14.428	5.421	- .421
8. Tough-minded vs Tender-minded	6.875	4.539	8.571	2.441	- .822
9. Trusting vs Suspicious	7.500	3.540	6.285	2.118	.722
10. Practical vs Imaginative	10.625	2.232	10.285	4.025	.191
11. Forthright vs Shrewd	10.750	3.418	12.428	3.155	- .915
12. Self-assured vs Apprehensive	9.375	4.820	9.428	3.658	- .022
13. Conservative vs Experimenting	10.375	2.869	10.142	3.136	.139
14. Group-Dependent vs Self-sufficient	11.250	1.561	10.285	1.979	.981
15. Undisciplined Self-conflict vs Controlled	12.375	3.388	13.000	2.329	- .382
16. Relaxed vs Tense	10.750	5.994	9.571	2.871	.422

[1]Significance at .05 = 2.160

TABLE VI

16 PERSONALITY FACTOR QUESTIONNAIRE--RAW SCORES

Class B Schools Factor	High Physics Enrollment 6 Teachers Mean	Std. Dev.	Low Physics Enrollment 6 Teachers Mean	Std. Dev.	dF=10[1] T-Ratio
1. Reserved vs Outgoing	6.500	2.872	6.500	3.354	0.000
2. Less vs More Intelligent	9.833	1.343	8.500	1.500	1.480
3. Affected by Feelings vs Emotionally Stable	16.333	2.560	19.000	2.828	-1.563
4. Humble vs Assertive	12.333	4.606	9.500	2.500	1.208
5. Sober vs Happy-go-lucky	11.166	4.487	11.000	3.415	.065
6. Expedient vs Conscientious	15.166	2.544	15.333	2.357	- .107
7. Shy vs Venturesome	10.000	3.958	11.666	3.726	- .685
8. Tough-minded vs Tender-minded	8.833	4.374	6.000	2.768	.359
9. Trusting vs Suspicious	7.833	1.213	7.166	2.034	.629
10. Practical vs Imaginative	11.333	4.818	10.666	3.091	.260
11. Forthright vs Shrewd	10.666	1.972	12.500	3.095	-1.117
12. Self-assured vs Apprehensive	10.833	1.572	7.000	2.886	2.608*
13. Conservative vs Experimenting	10.000	2.768	10.666	1.598	- .465
14. Group-dependent vs Self-sufficient	11.833	2.671	12.166	4.810	- .135
15. Undisciplined Self-conflict vs Controlled	12.166	2.266	13.666	2.494	- .995
16. Relaxed vs Tense	9.666	3.771	8.666	4.027	.405

[1]Significance at .05 = 2.228

*Significant at $<.05$ but $>.01$

TABLE VII

16 PERSONALITY FACTOR QUESTIONNAIRE--RAW SCORES

Class C Schools	High Physics Enrollment 5 Teachers		Low Physics Enrollment 3 Teachers		dF=6[1]
Factor	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Reserved vs Outgoing	8.600	2.416	10.000	.816	- .840
2. Less vs More Intelligent	8.200	1.720	10.333	1.247	1.247
3. Affected by Feelings vs Emotionally Stable	16.000	5.099	19.399	3.399	- .871
4. Humble vs Assertive	11.400	1.959	14.333	3.091	-1.422
5. Sober vs Happy-go-lucky	9.800	2.993	17.666	2.494	-3.312*
6. Expedient vs Conscientious	13.600	2.244	14.666	1.885	.597
7. Shy vs Venturesome	12.000	3.633	18.000	3.265	-2.033
8. Tough-minded vs Tender-minded	14.600	4.263	12.666	2.624	.201
9. Trusting vs Suspicious	6.000	1.549	6.666	3.399	- .327
10. Practical vs Imaginative	12.200	2.712	10.000	2.449	.997
11. Forthright vs Shrewd	10.600	1.959	10.000	3.265	.281
12. Self-assured vs Apprehensive	8.800	2.925	9.000	4.966	- .062
13. Conservative vs Experimenting	11.200	1.720	10.000	1.414	.882
14. Group-dependent vs Self-sufficient	13.200	1.720	10.666	1.699	1.755
15. Undisciplined Self-conflict vs Controlled	12.200	1.166	13.666	2.054	-1.114
16. Relaxed vs Tense	10.800	4.445	9.000	4.546	.476

[1]Significance at .05 = 2.447

*Significant at $<.05$ but $>.01$

TABLE VIII

16 PERSONALITY FACTOR QUESTIONNAIRE--RAW SCORES

Class A, B and C Schools Factor	High Physics Enrollment 19 Teachers Mean	Std. Dev.	Low Physics Enrollment 16 Teachers Mean	Std. Dev.	dF=33[1] T-Ratio
1. Reserved vs Outgoing	7.157	2.539	7.750	3.326	- .580
2. Less vs More Intelligent	9.684	1.748	9.062	1.919	.973
3. Affected by Feelings vs Emotionally Stable	16.368	4.415	19.375	2.546	-2.338*
4. Humble vs Assertive	12.315	4.117	10.750	3.381	1.179
5. Sober vs Happy-go-lucky	11.263	4.152	11.937	4.422	- .450
6. Expedient vs Conscientious	14.263	2.988	15.625	2.315	-1.442
7. Shy vs Venturesome	11.947	3.953	14.062	5.018	-1.353
8. Tough-minded vs Tender-minded	9.526	4.839	9.125	3.119	.167
9. Trusting vs Suspicious	7.210	2.686	6.687	2.416	.583
10. Practical vs Imaginative	11.263	3.341	10.375	3.443	.739
11. Forthright vs Shrewd	10.684	2.676	12.000	3.297	-1.265
12. Self-assured vs Apprehensive	9.684	3.671	8.437	3.856	.949
13. Conservative vs Experimenting	10.473	2.623	10.312	2.390	.182
14. Group-dependent vs Self-sufficient	11.947	2.163	11.062	3.418	.902
15. Undisciplined Self-conflict vs Controlled	12.263	2.612	13.375	2.368	-1.271
16. Relaxed vs Tense	10.421	5.008	9.125	3.705	.831

[1]Significance at .05 = 2.037

*Significant at $<$ .05 but $>$ .01

TABLE IX

16 PERSONALITY FACTOR QUESTIONNAIRE--STANDARD SCORES

Class A Schools	High Physics Enrollment 8 Teachers		Low Physics Enrollment 7 Teachers		dF=13[2]
Factor	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Reserved vs Outgoing	4.000[1]	.866	5.142	1.726	-1.535
2. Less vs More Intelligent	9.125	.927	7.857	1.647	1.641
3. Affected by Feelings vs Emotionally Stable	5.875	2.260	7.428	.728	-1.620
4. Humble vs Assertive	6.000	2.236	4.571	2.060	2.060
5. Sober vs Happy-go-lucky	5.250	2.165	4.285	1.484	.924
6. Expedient vs Conscientious	5.500	2.449	6.714	1.577	-1.045
7. Shy vs Venturesome	5.125	1.165	5.428	1.916	- .349
8. Tough-minded vs Tender-minded	3.875	2.204	5.857	1.807	-1.757
9. Trusting vs Suspicious	5.000	2.549	4.000	1.414	.857
10. Practical vs Imaginative	5.000	1.414	5.142	2.641	- .122
11. Forthright vs Shrewd	5.250	2.222	6.428	2.060	- .986
12. Self-assured vs Apprehensive	4.875	1.832	5.428	1.590	- .577
13. Conservative vs Experimenting	5.750	1.984	5.714	2.432	.029
14. Group-dependent vs Self-sufficient	6.000	1.000	5.571	1.178	.710
15. Undisciplined Self-conflict vs Controlled	6.000	2.236	6.571	1.840	- .498
16. Relaxed vs Tense	5.375	2.341	5.142	.989	.227

[1]Range for Standard Scores is 1 to 10

[2]Significance at .05 = 2.160

TABLE X

16 PERSONALITY FACTOR QUESTIONNAIRE--STANDARD SCORES

Class B Schools Factor	High Physics Enrollment 6 Teachers Mean	High Physics Enrollment 6 Teachers Std. Dev.	Low Physics Enrollment 6 Teachers Mean	Low Physics Enrollment 6 Teachers Std. Dev.	dF=10[2] T-Ratio
1. Reserved vs Outgoing	4.333[1]	1.247	3.666	1.598	.735
2. Less vs More Intelligent	8.833	.897	7.833	1.067	1.604
3. Affected by Feelings vs Emotionally Stable	5.500	1.258	7.333	1.490	-2.101
4. Humble vs Assertive	5.666	2.624	4.166	1.572	1.096
5. Sober vs Happy-go-lucky	4.833	2.034	4.666	1.490	.148
6. Expedient vs Conscientious	6.000	1.527	6.500	1.384	- .542
7. Shy vs Venturesome	4.166	1.572	4.666	1.247	.557
8. Tough-minded vs Tender-minded	5.166	2.266	4.333	1.598	.671
9. Trusting vs Suspicious	5.333	1.105	4.833	1.067	.727
10. Practical vs Imaginative	5.666	2.357	5.166	1.572	.394
11. Forthright vs Shrewd	5.166	1.572	6.666	1.972	-1.329
12. Self-assured vs Apprehensive	5.833	.897	3.833	1.771	2.252*
13. Conservative vs Experimenting	5.333	2.134	6.166	1.343	- .738
14. Group-dependent vs Self-sufficient	6.500	1.500	6.833	2.910	- .227
15. Undisciplined Self-conflict vs Controlled	5.833	1.674	6.833	1.462	-1.115
16. Relaxed vs Tense	5.000	1.527	5.000	1.914	0.000

[1] Range for Standard Scores is 1 to 10

[2] Significance at .05 = 2.228

*Significant at $< .05$ but $> .01$

TABLE XI

16 PERSONALITY FACTOR QUESTIONNAIRE--STANDARD SCORES

Class C Schools Factor	High Physics Enrollment 5 Teachers		Low Physics Enrollment 3 Teachers		dF=6[2]
	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Reserved vs Outgoing	5.200[1]	1.166	5.333	.942	- .145
2. Less vs More Intelligent	7.600	1.624	9.000	.816	- .320
3. Affected by Feelings vs Emotionally Stable	5.200	2.561	7.000	2.160	- .882
4. Humble vs Assertive	5.200	1.326	7.666	1.699	-1.979
5. Sober vs Happy-go-lucky	4.200	1.166	7.666	1.699	-2.956*
6. Expedient vs Conscientious	5.000	1.264	6.000	1.414	.896
7. Shy vs Venturesome	5.200	1.660	7.000	1.632	-1.569
8. Tough-minded vs Tender-minded	5.241	2.162	6.666	1.699	-1.215
9. Trusting vs Suspicious	4.000	1.095	4.333	2.357	- .234
10. Practical vs Imaginative	6.000	1.264	4.333	1.247	1.571
11. Forthright vs Shrewd	5.000	1.673	5.000	2.160	0.000
12. Self-assured vs Apprehensive	5.200	1.720	4.666	2.867	.285
13. Conservative vs Experimenting	6.200	1.166	5.666	1.247	.529
14. Group-dependent vs Self-sufficient	7.400	1.356	5.666	.942	1.689
15. Undisciplined Self-conflict vs Controlled	6.000	.894	6.666	1.247	- .759
16. Relaxed vs Tense	5.600	2.154	4.333	2.054	.709

[1]Range for standard scores is 1 to 10

[2]Significance at .05 = 2.447

*Significant at $< .05$ but $> .01$

TABLE XII

16 PERSONALITY FACTOR QUESTIONNAIRE--STANDARD SCORES

Class A, B and C Schools	High Physics Enrollment 19 Teachers		Low Physics Enrollment 16 Teachers		dF=33[2]
Factor	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Reserved vs Outgoing	4.421[1]	1.183	4.625	1.727	- .400
2. Less vs More Intelligent	8.631	1.306	8.062	1.390	1.210
3. Affected by Feelings vs Emotionally Stable	5.578	2.110	7.312	1.401	-2.725*
4. Humble vs Assertive	5.684	2.201	5.000	2.236	.882
5. Sober vs Happy-go-lucky	4.842	1.953	5.062	1.983	- .320
6. Expedient vs Conscientious	5.526	1.956	6.500	1.500	-1.581
7. Shy vs Venturesome	4.842	1.386	5.437	1.836	-1.059
8. Tough-minded vs Tender-minded	4.657	2.321	5.437	1.935	.371
9. Trusting vs Suspicious	4.842	1.926	4.375	1.576	.753
10. Practical vs Imaginative	5.473	1.787	5.000	2.091	.700
11. Forthright vs Shrewd	5.157	1.899	6.250	2.136	-1.555
12. Self-assured vs Apprehensive	5.263	1.617	4.687	2.083	.893
13. Conservative vs Experimenting	5.736	1.887	5.875	1.899	- .210
14. Group-dependent vs Self-sufficient	6.526	1.390	6.062	2.075	.764
15. Undisciplined Self-conflict vs Controlled	5.947	1.791	6.687	1.609	-1.238
16. Relaxed vs Tense	5.315	2.078	4.937	1.638	.572

[1] Range for Standard Scores is 1 to 10

[2] Significance at .05 = 2.037

*Significant at < .05 but > .01

were administered to each of the physics students contacted in the study. Average values for each of the questions were obtained for each of the teachers. Mean values and standard deviations of each question for each group of teachers were calculated from the average values of each of the teachers in the group. The high and low physics enrollment groups were compared using the previously described "t" test. The results are given in Tables XIII-XVI. The teachers were sent copies of their average scores on this instrument along with the over-all averages of all the teachers in the study.

The Learning Environment Inventory

The original Learning Environment Inventory Questionnaire obtained from Herbert J. Walberg was divided into two parts, Forms A and B, to allow the physics students to answer the questions in about fifteen minutes. The questionnaire is discussed in Chapter III. Equal numbers of each form were randomly distributed to students in each of the physics classes. Therefore, there were only one-half as many scores for each question as there were students in the physics class.

The process of obtaining mean values for each of the factors was complicated by the fact that seven questions were associated with each factor and some of the questions were given in a negative form. The responses to the negative questions were given opposite scores and then these were added to the scores of the positive questions; then an average score was obtained for the factor. Each teacher received a copy of the mean values for each of the factors

TABLE XIII

STUDENT OPINION QUESTIONNAIRE

Class A Schools Question	High Physics Enrollment 11 Teachers Mean	Std. Dev.	Low Physics Enrollment 8 Teachers Mean	Std. Dev.	dF=17[2] T-Ratio
1. Knowledge of Subject	4.489[1]	.300	4.343	.602	.656
2. Clarity of Explanations	3.148	.619	3.339	.682	- .601
3. Fairness	3.970	.370	4.022	.716	- .194
4. Control	3.628	.637	3.735	.612	- .347
5. Attitude toward Students	3.903	.610	3.950	.839	- .133
6. Ability to Stimulate Interest	3.384	.533	3.295	.837	.267
7. Attitude toward Subject	4.273	.533	4.149	.622	.441
8. Attitude toward Student Opinions	3.978	.485	4.010	.780	- .103
9. Variety in Teaching Procedures	3.028	.466	3.140	.815	- .358
10. Encouragement of Student Participation	3.966	.556	3.929	.774	.114
11. Sense of Humor	4.403	.793	4.225	.581	.509
12. Planning and Preparation	3.451	.578	3.631	.629	- .610

[1] 1=Poor, 2=Fair, 3=Average, 4=Good, 5=Excellent

[2] Significance at .05 = 2.110

TABLE XIV

STUDENT OPINION QUESTIONNAIRE

Class B Schools Question	High Physics Enrollment 8 Teachers Mean	High Physics Enrollment 8 Teachers Std. Dev.	Low Physics Enrollment 10 Teachers Mean	Low Physics Enrollment 10 Teachers Std. Dev.	dF=16[2] T-Ratio
1. Knowledge of Subject	4.272[1]	.344	4.324	.598	- .206
2. Clarity of Explanations	3.777	.543	3.342	.593	1.513
3. Fairness	4.103	.311	3.949	.588	.631
4. Control	3.730	.835	3.382	.908	.789
5. Attitude Toward Students	4.232	.271	3.997	.623	.937
6. Ability to Stimulate Interest	3.665	.476	2.991	.885	1.830
7. Attitude Toward Subject	4.256	.447	4.197	.602	.217
8. Attitude Toward Student Opinions	4.244	.356	4.115	.710	.442
9. Variety in Teaching Procedures	3.506	.386	2.931	.571	2.297*
10. Encouragement of Student Participation	4.280	.168	4.210	.441	.400
11. Sense of Humor	4.333	.449	4.118	.667	.736
12. Planning and Preparation	3.714	.560	3.399	.820	.874

[1] 1=Poor, 2=Fair, 3=Average, 4=Good, 5=Excellent

[2] Significance at .05 = 2.120

*Significant $< .05$ but $> .01$

TABLE XV

STUDENT OPINION QUESTIONNAIRE

Class C Schools Question	High Physics Enrollment 7 Teachers Mean	Std. Dev.	Low Physics Enrollment 7 Teachers Mean	Std. Dev.	dF=12[2] T-Ratio
1. Knowledge of Subject	4.300[1]	.590	4.336	.390	- .124
2. Clarity of Explanations	3.569	.831	3.703	.479	- .342
3. Fairness	4.103	.513	4.114	.473	- .038
4. Control	3.674	.799	4.002	.374	- .910
5. Attitude Toward Students	4.191	.506	4.436	.344	- .980
6. Ability to Stimulate Interest	3.410	.738	3.581	.628	- .432
7. Attitude Toward Subject	4.359	.299	4.237	.481	.527
8. Attitude Toward Student Opinions	4.132	.446	4.134	.494	- .007
9. Variety in Teaching Procedures	3.088	.574	3.568	.661	-1.343
10. Encouragement of Student Participation	4.221	.274	4.326	.457	- .482
11. Sense of Humor	4.316	.376	4.645	.378	-1.511
12. Planning and Preparation	3.622	.742	3.622	.484	0.000

[1] 1=Poor, 2=Fair, 3=Average, 4=Good, 5=Excellent

[2] Significance at .05 = 2.179

TABLE XVI

STUDENT OPINION QUESTIONNAIRE

Class A, B and C Schools	High Physics Enrollment 26 Teachers		Low Physics Enrollment 25 Teachers		dF=49[2]
Question	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Knowledge of Subject	4.371[1]	.422	4.333	.549	.272
2. Clarity of Explanations	3.455	.717	3.442	.617	.067
3. Fairness	4.047	.403	4.019	.608	.190
4. Control	3.672	.748	3.668	.744	.018
5. Attitude Toward Students	4.082	.523	4.105	.675	- .133
6. Ability to Stimulate Interest	3.478	.594	3.254	.840	1.082
7. Attitude Toward Subject	4.291	.455	4.193	.578	.660
8. Attitude Toward Student Opinions	4.101	.453	4.086	.684	.090
9. Variety in Teaching Procedures	3.191	.521	3.176	.730	.083
10. Encouragement of Student Participation	4.132	.424	4.152	.595	- .135
11. Sense of Humor	4.358	.607	4.300	.612	.334
12. Planning and Preparation	3.578	.632	3.536	.688	.222

[1] 1=Poor, 2=Fair, 3=Average, 4=Good, 5=Excellent

[2] Significance at .05 = 2.007

obtained from the responses of his students along with the over-all average values for each factor for all of the teachers in the study.

A mean value and standard deviation for each factor was obtained for each group of teachers and group means were compared using the "t" test. The results of these comparisons are given in Tables XVII-XX.

The Physics Teacher Questionnaire

Comparisons using the "t" test were made between groups of physics teachers from high schools with high percentage enrollments in physics and those with low percentage enrollments in physics. The areas considered were: (1) the number of other science or mathematics courses taught by the physics teachers; (2) the number of undergraduate and graduate hours the teachers had in various areas of science, mathematics, and education; (3) the number of years of teaching experience; and (4) their opinions concerning physics as represented by their responses to three questions on the questionnaire. Data concerning the textbooks used by the physics teachers, the type of physics course they would prefer to teach, and the minimum mathematics prerequisites for physics were grouped according to the size of the high school and whether they had a high or low percentage enrollment in physics. These data were represented in a series of 2 x 2 matricies and comparisons were made with respect to percentage enrollments in physics by using the Fisher Exact Probability Test. The results of all the comparisons are included in Tables XXI-XXVIII.

TABLE XVII

LEARNING ENVIRONMENT INVENTORY

Class A Schools Factors	High Physics Enrollment 11 Teachers Mean	Std. Dev.	Low Physics Enrollment 8 Teachers Mean	Std. Dev.	dF=17[2] T-Ratio
1. Intimacy	1.982[1]	.155	2.016	.293	- .309
2. Cliqueness	2.422	.250	2.277	.315	1.057
3. Favoritism	3.116	.191	3.245	.319	-1.038
4. Satisfaction	2.463	.243	2.479	.348	- .111
5. Difficulty	2.055	.148	2.000	.326	.467
6. Democratic	2.437	.139	2.450	.255	- .134
7. Diversity	2.217	.115	2.191	.215	.321
8. Friction	2.838	.366	2.895	.378	- .312
9. Apathy	2.667	.175	2.674	.253	- .067
10. Formality	2.629	.234	2.544	.212	.769
11. Speed	2.718	.266	2.693	.545	.124
12. Goal Direction	2.499	.179	2.410	.274	.808
13. Disorganization	2.549	.278	2.795	.323	-1.681
14. Environment	2.255	.150	2.060	.299	1.763

[1] 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree

[2] Significance at .05 = 2.110

TABLE XVIII

LEARNING ENVIRONMENT INVENTORY

Class B Schools Factors	High Physics Enrollment 8 Teachers Mean	Std. Dev.	Low Physics Enrollment 10 Teachers Mean	Std. Dev.	dF=16[2] T Ratio
1. Intimacy	1.842[1]	.135	1.718	.139	1.795
2. Cliqueness	2.407	.156	2.637	.219	-2.361*
3. Favoritism	3.175	.170	3.152	.274	.195
4. Satisfaction	2.243	.212	2.391	.370	- .949
5. Difficulty	2.030	.206	2.130	.169	-1.066
6. Democratic	2.401	.197	2.225	.220	1.665
7. Diversity	2.101	.149	2.246	.246	-1.382
8. Friction	2.839	.274	3.086	.417	-1.361
9. Apathy	2.792	.241	2.903	.272	- .852
10. Formality	2.507	.208	2.671	.120	-1.975
11. Speed	2.806	.170	2.830	.203	- .252
12. Goal Direction	2.198	.287	2.322	.250	- .922
13. Disorganization	2.851	.345	2.692	.433	.797
14. Environment	2.093	.274	2.119	.241	- .201

[1] 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree

[2] Significance at .05 = 2.179

*Significant < .05 but > .01

TABLE XIX

LEARNING ENVIRONMENT INVENTORY

Class C Schools Factor	High Physics Enrollment 7 Teachers Mean	Std. Dev.	Low Physics Enrollments 7 Teachers Mean	Std. Dev.	dF=12[2] T Ratio
1. Intimacy	1.687[1]	.129	1.458	.124	3.134**
2. Cliqueness	2.397	.232	2.714	.236	-2.346*
3. Favoritism	3.044	.239	3.295	.275	-1.687
4. Satisfaction	2.452	.328	2.211	.309	1.310
5. Difficulty	2.076	.135	1.984	.387	.549
6. Democratic	2.409	.196	2.110	.223	2.466*
7. Diversity	2.190	.121	2.289	.085	-1.639
8. Friction	2.929	.319	3.132	.275	-1.180
9. Apathy	2.850	.253	3.197	.284	-2.234*
10. Formality	2.586	.222	2.524	.093	.630
11. Speed	2.737	.288	2.923	.394	- .933
12. Goal Direction	2.232	.270	2.103	.255	.850
13. Disorganization	2.949	.405	2.925	.161	.134
14. Environment	2.229	.268	2.010	.292	1.353

[1] 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree

[2] Significance at .05 = 2.179

*Significant < .05 but > .01

**Significant < .01

TABLE XX

LEARNING ENVIRONMENT INVENTORY

Class A, B and C Schools Factor	High Physics Enrollment 26 Teachers Mean	Std. Dev.	Low Physics Enrollment 25 Teachers Mean	Std. Dev.	dF=49[2] T=Ratio
1. Intimacy	1.859[1]	.186	1.741	.294	1.685
2. Cliqueness	2.411	.220	2.543	.317	-1.698
3. Favoritism	3.115	.205	3.222	.296	-1.475
4. Satisfaction	2.392	.279	2.369	.362	.249
5. Difficulty	2.053	.166	2.047	.303	.086
6. Democratic	2.418	.175	2.265	.269	2.368*
7. Diversity	2.174	.137	2.241	.206	-1.345
8. Friction	2.863	.330	3.038	.382	-1.718
9. Apathy	2.755	.233	2.912	.337	-1.902
10. Formality	2.580	.229	2.589	.164	- .157
11. Speed	2.750	.250	2.812	.404	- .648
12. Goal Direction	2.334	.280	2.289	.286	.556
13. Disorganization	2.750	.380	2.790	.353	- .381
14. Environment	2.198	.239	2.070	.279	1.726

[1] 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree

[2] Significance at .05 = 2.007

*Significant < .05 but > .01

TABLE XXI

TEACHING LOADS OF PHYSICS TEACHERS

Number of Other Science Course Taught

	High Physics Enrollment			Low Physics Enrollment			
	Mean	Std. Dev.	N[1]	Mean	Std. Dev.	N	T-Ratio
Class A Schools	1.444	1.342	9	1.833	1.863	6	.437
Class B Schools	1.500	1.118	8	2.444	1.498	9	-1.369
Class C Schools	2.333	1.795	6	3.500	.866	4	-1.082
Class A, B and C Schools	1.695	1.457	23	2.473	1.634	19	-1.590

Number of Math Courses Taught by Physics Teachers

	Mean	Std. Dev.	N	Mean	Std. Dev.	N	T-Ratio
Class A Schools	.111	.314	9	.666	1.490	6	-1.007
Class B Schools	1.000	1.000	8	1.111	1.662	9	- .154
Class C Schools	1.500	2.140	6	.500	.866	4	.793
Class A, B and C Schools	.782	1.381	23	.842	1.496	19	- .131

[1]Number of teachers in the group

TABLE XXII

COLLEGE PREPARATION OF PHYSICS TEACHERS

Class A Schools Undergraduate and Graduate Semester Hours in:	High Physics Enrollment 9 Teachers		Low Physics Enrollment 6 Teachers		dF=13[1]
	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
Physics	26.888	8.451	38.166	21.271	-1.331
Chemistry	27.444	17.417	20.166	11.466	.839
Biology	16.666	16.573	14.833	11.524	.219
Earth Science	6.333	9.910	1.500	3.354	1.071
Mathematics	22.666	7.659	25.166	11.378	- .473
Education	31.888	6.773	34.333	21.944	- .291
Class B Schools	8 Teachers		9 Teachers		dF=15[2]
Physics	21.750	12.774	23.555	15.478	- .244
Chemistry	22.875	16.721	21.111	12.395	.233
Biology	.750	1.299	14.888	21.686	-1.729
Earth Science	2.875	3.059	5.555	8.368	- .804
Mathematics	30.125	13.392	26.777	15.497	.444
Education	30.500	9.473	29.666	15.755	.122

[1]Significance at .05 = 2.160

[2]Significance at .05 = 2.131

TABLE XXIII

COLLEGE PREPARATION OF PHYSICS TEACHERS

Class C Schools Undergraduate and Graduate Semester Hours in:	High Physics Enrollment 6 Teachers		Low Physics Enrollment 4 Teachers		dF=8[1]
	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
Physics	15.833	12.680	17.250	8.525	- .175
Chemistry	19.166	11.141	19.750	7.562	- .082
Biology	5.833	13.043	32.000	28.142	-1.771
Earth Science	6.666	11.055	3.750	3.766	.454
Mathematics	20.833	19.047	10.750	8.757	.866
Education	39.500	14.986	38.250	17.151	.109
Class A, B and C Schools	23 Teachers		19 Teachers		dF=40[2]
Physics	22.217	12.079	26.842	18.348	- .955
Chemistry	23.695	16.106	20.526	11.254	.706
Biology	8.308	14.186	18.473	21.914	-1.769
Earth Science	5.217	8.747	3.894	6.544	.532
Mathematics	24.782	13.990	22.894	14.512	.417
Education	33.391	11.012	32.947	18.525	.093

[1]Significance at .05 = 2.306

[2]Significance at .05 = 2.021

TABLE XXIV

TEACHING EXPERIENCE OF PHYSICS TEACHERS

	High Physics Enrollment			Low Physics Enrollment			
	Mean	Std. Dev.	N[1]	Mean	Std. Dev.	N	T-Ratio
Total Years of Teaching Experience							
Class A Schools	12.555	7.212	9	15.000	13.178	6	- .430
Class B Schools	10.500	10.024	8	10.222	6.612	9	.064
Class C Schools	18.833	13.655	6	11.250	11.188	4	.064
Class A, B and C Schools	13.478	10.717	23	11.947	10.313	19	.457
Number of Years Teacher has Taught Physics							
Class A Schools	8.666	7.688	9	12.500	10.874	6	- .744
Class B Schools	8.250	6.378	8	7.444	4.645	9	.281
Class C Schools	10.666	9.758	6	3.250	3.344	4	1.309
Class A, B and C Schools	9.043	7.942	23	8.157	7.822	19	.353
Total Number of Years Teacher has Taught in that School							
Class A Schools	6.222	6.069	9	5.000	4.725	6	.387
Class B Schools	7.875	9.006	8	7.666	5.577	9	.054
Class C Schools	11.166	7.945	6	7.750	9.522	4	.549
Class A, B and C Schools	8.808	7.934	23	6.842	6.515	19	.534

[1]Number of teachers in the group

TABLE XXV

OPINIONS OF PHYSICS TEACHERS

Percent of Seniors Qualified but Not Taking Physics

	High Physics Enrollment Mean	Std. Dev.	N[1]	Low Physics Enrollment Mean	Std. Dev.	N	T-Ratio
Class A Schools	2.666[2]	.666	9	3.166	.687	6	-1.309
Class B Schools	2.125	.330	8	2.555	.684	9	-1.520
Class C Schools	2.500	1.258	6	2.250	.928	4	.313
Class A, B and C Schools	2.434	.824	23	2.684	.798	19	- .968

Physics Has to be a Hard Course

	High Physics Enrollment Mean	Std. Dev.	N[1]	Low Physics Enrollment Mean	Std. Dev.	N	T-Ratio
Class A Schools	3.111[3]	.566	9	3.333	.471	6	.739
Class B Schools	3.000	.000	8	2.888	.566	9	.525
Class C Schools	3.333	.471	6	3.250	.471	4	.252
Class A, B and C Schools	3.130	.447	23	3.105	.552	19	.158

Physics should be Taught to One-half of the Students

	High Physics Enrollment Mean	Std. Dev.	N[1]	Low Physics Enrollment Mean	Std. Dev.	N	T-Ratio
Class A Schools	2.444[3]	.684	9	2.333	.942	6	.245
Class B Schools	2.250	.829	8	2.444	.684	9	- .496
Class C Schools	1.833	.687	6	3.000	.000	4	-3.038
Class A, B and C Schools	2.217	.777	23	2.526	.751	19	-1.270

[1] Number of Physics teachers in the group
[2] 1=0%, 2=5%, 3=15%, 4=25%, 5=40%
[3] 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly disagree

TABLE XXVI

COMPARISONS OF THE PHYSICS TEXTBOOKS USED BY PHYSICS TEACHERS

	Traditional	PSSC	Level of Significance[1]
Class A Schools			
High Physics Enrollment	7	2	$> .05$
Low Physics Enrollment	5	1	
Class B Schools			
High Physics Enrollment	6	2	$> .05$
Low Physics Enrollment	8	1	
Class C Schools			
High Physics Enrollment	5	1	$> .05$
Low Physics Enrollment	3	1	
Class A, B and C Schools			
High Physics Enrollment	18	5	$> .05$
Low Physics Enrollment	16	3	

TABLE XXVII

COMPARISONS OF THE TYPES OF PHYSICS COURSES TEACHERS WOULD PREFER TO TEACH IN THEIR HIGH SCHOOLS

	Traditional	PSSC	Level of Significance[1]
Class A Schools			
High Physics Enrollment	4	4	$> .05$
Low Physics Enrollment	3	2	
Class B Schools			
High Physics Enrollment	6	1	$> .05$
Low Physics Enrollment	6	2	
Class C Schools			
High Physics Enrollment	5	1	$> .05$
Low Physics Enrollment	3	1	
Class A, B and C Schools			
High Physics Enrollment	15	6	$> .05$
Low Physics Enrollment	12	5	

[1]Level of significance taken either from Table I or calculated using the formula for degree of significance, Siegel (61), p. 99.

TABLE XXVIII

COMPARISONS OF PHYSICS TEACHERS' OPINIONS
CONCERNING THE MINIMUM PREREQUISITES
IN MATHEMATICS FOR PHYSICS STUDENTS

	Geometry or less	More than Geometry	Level of Significance[1]
Class A Schools			
High Physics Enrollment	9	0	> .05
Low Physics Enrollment	5	1	
Class B Schools			
High Physics Enrollment	6	2	> .05
Low Physics Enrollment	6	3	
Class C Schools			
High Physics Enrollment	6	0	> .05
Low Physics Enrollment	2	2	
Class A, B and C Schools			
High Physics Enrollment	21	2	> .05
Low Physics Enrollment	13	6	

[1] Level of Significance taken either from Table I or calculated using the formula for degree of significance of Siegel (61), p. 99.

The Characteristics of Physics Students

The physics students filled out three questionnaires and were administered a physics achievement test. Data from two of the questionnaires, the Student Opinion Questionnaire and the Learning Environment Inventory, however, were considered to be more related to the physics teacher so the results from these instruments are included in the previous section of this chapter.

The Physics Student Questionnaire

The questionnaire is described in Chapter III and a copy is included in the appendix. The vocational plans of the physics students as listed on the questionnaire were coded and later categorized into one of the following classifications:

1. Physical science and engineering--includes physicist, chemist, engineer, architect, physics teacher, and chemistry teacher. Vocations in this category would require a concentrated effort in the physical sciences at the college level.

2. Other science and mathematics--includes biologist and biology teacher, geologist, medical doctor and medical technologist, mathematician, mathematics teacher, and computer scientist, physical technologist, such as automotive technology; applied biological and physical science work, such as conservation work, television repair.

3. Non-science--includes all aspects of social science, military, elementary teaching, and anything else not covered in 1 and 2.

4. Undecided--girls getting married were also included in this category.

The percentage of physics students in each category was calculated for each group of students taught by a particular teacher

and mean values were obtained for each group of teachers. The results of comparisons made between the mean values of high and low physics enrollment groups are shown in Tables XXIX-XXX.

Each physics student was asked to indicate by number his three most important reasons for taking physics. The popularity of each reason was calculated three times on a percentage basis as to how many times it was listed as (1) the most important (2) the second most important and (3) the third most important reason for taking physics.

Three analyses were run using "t" tests to compare the mean values of high and low physics enrollment groups. In the first analysis only the percentages for the most important reasons were used. In the second analysis the percent popularity of a reason as a first choice was added to the percent popularity as a second choice and then the sums for each of the percentages were averaged for the students of one group of physics teachers and compared with the averaged sums for the students of another group of physics teachers. The third analysis was similar to the second except all three popularity percentages were added for each reason. The results of these analysis are included in Tables XXXI-XXXVI.

The physics students were asked to list all of the courses they were presently taking and the first semester grades they received. As the study progressed, previous six weeks grades were used in many instances. The courses were categorized as to whether they were physics, other science, English, social studies, mathematics, vocational or business (e.g. shop, home economics, typing, etc.), foreign

TABLE XXIX

VOCATIONAL CHOICES OF PHYSICS STUDENTS

Class A Schools Vocations	High Physics Enrollment 11 Teachers Mean	 Std. Dev.	Low Physics Enrollment 8 Teachers Mean	 Std. Dev.	dF=17[2] T-Ratio
1. Physical Science and Engineering	23.421[1]	7.471	33.181	7.734	-2.620*
2. Other Science and Math	30.734	8.969	31.425	11.373	.139
3. Non-Science	27.101	8.005	18.630	7.969	2.158*
4. Undecided	18.726	5.656	16.748	6.314	.677
Class B Schools	8 Teachers		10 Teachers		dF=16[3]
1. Physical Science and Engineering	20.562	7.326	38.875	17.525	-2.610*
2. Other Science and Math	31.143	8.209	34.074	13.687	- .503
3. Non-Science	33.767	8.815	10.369	5.692	6.416**
4. Undecided	14.510	8.772	16.669	11.988	.401

[1]Percent of physics students with vocational choices in this area

[2]Significance at .05 = 2.110

[3]Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

**Significant at $< .01$

TABLE XXX

VOCATIONAL CHOICES OF PHYSICS STUDENTS

Class C Schools Vocations	High Physics Enrollment 7 Teachers Mean	Std. Dev.	Low Physics Enrollment 7 Teachers Mean	Std. Dev.	dF=12[2] T-Ratio
1. Physical Science and Engineering	14.484[1]	6.326	16.070	19.396	- .190
2. Other Science and Math	29.040	9.597	28.710	23.067	.032
3. Non-Science	36.718	8.524	33.982	30.902	.209
4. Undecided	19.747	5.359	21.228	19.494	- .179
Class A, B and C Schools	26 Teachers		25 Teachers		dF=49[3]
1. Physical Science and Engineering	20.135	8.008	30.667	18.329	-2.623*
2. Other Science and Math	30.404	8.960	31.724	16.435	- .350
3. Non-Science	31.741	9.360	19.624	19.823	2.752*
4. Undecided	17.703	7.046	17.971	13.445	- .087

[1]Percent of physics students with vocational choices in this area

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.009

*Significant at < .05 but > .01

TABLE XXXI

THE ONE MOST IMPORTANT REASON STUDENTS GAVE FOR TAKING PHYSICS

Class A Schools Reason	High Physics Enrollment 11 Teachers Mean	 Std. Dev.	Low Physics Enrollment 8 Teachers Mean	 Std. Dev.	dF=17[2] T-Ratio
1. Challenge	5.176[1]	5.259	2.292	2.614	1.350
2. Friends	.681	1.282	0.000	0.000	1.421
3. Enjoy Science	25.876	10.630	31.361	12.957	- .958
4. Recommended	12.331	7.634	11.880	6.873	.125
5. Good Teacher	2.505	2.531	2.148	4.527	.206
6. Required for Future	41.246	8.715	38.930	10.120	.505
7. Other	12.154	5.600	13.361	9.131	- .420
Class B Schools	8 Teachers		10 Teachers		dF=16[3]
1. Challenge	6.455	4.060	2.594	4.077	1.884
2. Friends	0.000	0.000	0.000	0.000	
3. Enjoy Science	31.631	10.061	34.660	13.295	- .503
4. Recommended	10.438	6.657	15.585	10.535	-1.134
5. Good Teacher	3.353	3.627	0.000	0.000	2.756*
6. Required for Future	36.961	10.508	42.072	17.225	.694
7. Other	11.136	6.131	5.078	6.299	1.934

[1] Average percent of students giving this as the most important reason

[2] Significance at .05 = 2.110

[3] Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

TABLE XXXII

THE ONE MOST IMPORTANT REASON STUDENTS GAVE FOR TAKING PHYSICS

Class C Schools Reason	High Physics Enrollment 7 Teachers Mean	Std. Dev.	Low Physics Enrollment 7 Teachers Mean	Std. Dev.	dF=12[2] T-Ratio
1. Challenge	5.755[1]	3.459	19.837	16.444	-2.052
2. Friends	1.322	2.118	0.000	0.000	1.528
3. Enjoy Science	26.712	12.986	23.211	16.669	.405
4. Recommended	14.640	10.723	11.618	8.357	.544
5. Good Teacher	1.464	2.392	1.785	4.374	.157
6. Required for Future	40.500	10.547	37.864	16.684	.327
7. Other	9.592	8.082	5.667	6.616	.920
Class A, B and C Schools	26 Teachers		25 Teachers		dF=49[3]
1. Challenge	5.725	4.505	7.325	12.060	- .619
2. Friends	.644	1.468	0.000	0.000	2.150*
3. Enjoy Science	27.872	11.434	30.401	14.975	.665
4. Recommended	12.370	8.473	13.288	9.088	- .365
5. Good Teacher	2.486	2.968	1.187	3.588	1.383
6. Required for Future	39.726	9.977	39.888	15.256	- .044
7. Other	11.155	6.545	7.893	8.235	1.314

[1]Average percent of students giving this as the most important reason

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.009

*Significant at < .05 but > .01

TABLE XXXIII

THE TWO MOST IMPORTANT REASONS STUDENTS GAVE FOR TAKING PHYSICS

Class A Schools	High Physics Enrollment 11 Teachers		Low Physics Enrollment 8 Teachers		dF=17[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	11.673[1]	7.384	15.228	8.035	- .944
2. Friends	5.218	3.165	4.045	3.928	.680
3. Enjoy Science	55.854	9.303	58.547	14.062	- .474
4. Recommended	37.062	9.671	33.180	12.157	.732
5. Good Teacher	8.674	8.274	9.583	11.004	- .194
6. Required for Future	62.133	5.669	61.072	11.304	.253
7. Other	17.779	6.048	15.916	7.746	.251
Class B Schools	8 Teachers		10 Teachers		dF=16[3]
1. Challenge	22.151	12.172	16.258	7.485	1.189
2. Friends	6.377	4.136	1.428	4.284	2.331*
3. Enjoy Science	53.182	12.353	57.671	12.809	- .707
4. Recommended	33.403	10.021	47.443	7.845	-3.143**
5. Good Teacher	14.243	12.364	.833	2.499	3.154**
6. Required for Future	53.515	5.849	64.909	17.795	-1.639
7. Other	16.043	8.270	11.434	11.383	.905

[1]Sum of average percents of students giving this as first or second important reasons

[2]Significance at .05 = 2.110

[3]Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

**Significant at $< .01$

TABLE XXXIV

THE TWO MOST IMPORTANT REASONS STUDENTS GAVE FOR TAKING PHYSICS

Class C Schools	High Physics Enrollment 7 Teachers		Low Physics Enrollment 7 Teachers		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	20.280[1]	6.118	28.082	15.799	-1.128
2. Friends	3.857	5.171	2.380	5.829	.464
3. Enjoy Science	51.062	17.465	51.127	20.538	- .005
4. Recommended	6.761	8.475	6.205	7.252	.122
5. Good Teacher	6.761	8.475	6.205	7.252	.122
6. Required for Future	59.210	6.650	58.115	21.214	.166
7. Other	16.881	11.069	11.788	16.046	.639
Class A, B and C Schools	26 Teachers		25 Teachers		dF=49[3]
1. Challenge	17.214	10.087	19.239	11.982	- .640
2. Friends	5.208	4.197	2.532	4.798	2.080*
3. Enjoy Science	53.742	13.023	56.119	16.026	- .570
4. Recommended	37.102	14.144	40.752	16.512	- .832
5. Good Teacher	9.873	10.219	5.137	8.368	1.771
6. Required for Future	58.694	7.026	61.790	17.358	- .824
7. Other	17.003	10.341	12.967	12.109	1.251

[1]Sum of the average percents of students giving this as the first or second most important reason

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.009

*Significant at < .05 but > .01

TABLE XXXV

THE THREE MOST IMPORTANT REASONS STUDENTS GAVE FOR TAKING PHYSICS

Class A Schools	High Physics Enrollment 11 Teachers		Low Physics Enrollment 8 Teachers		dF=17[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	24.457[1]	9.447	32.605	11.330	-1.613
2. Friends	13.731	6.547	10.243	8.308	.967
3. Enjoy Science	76.368	5.599	77.377	14.192	- .202
4. Recommended	54.952	12.448	50.553	12.736	.712
5. Good Teacher	21.864	18.682	18.190	19.396	.393
6. Required for Future	72.981	7.372	75.401	9.458	- .592
7. Other	26.444	9.779	22.251	9.360	.367
Class B Schools					dF=16[3]
1. Challenge	38.623	14.646	43.848	10.911	- .817
2. Friends	19.096	10.332	5.998	7.790	2.889*
3. Enjoy Science	69.388	14.089	76.398	15.441	- .937
4. Recommended	51.087	13.819	59.590	15.591	-1.139
5. Good Teacher	24.247	19.010	8.537	11.385	2.047
6. Required for Future	66.147	4.627	78.947	17.501	-1.898
7. Other	24.693	8.999	17.599	18.447	.939

[1] Sum of the average percents of students giving this as the first, second, or third most important reasons

[2] Significance at .05 = 2.110

[3] Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

TABLE XXXVI

THE THREE MOST IMPORTANT REASONS STUDENTS GAVE FOR TAKING PHYSICS

Class C Schools Reason	High Physics Enrollment 7 Teachers Mean	Std. Dev.	Low Physics Enrollment 7 Teachers Mean	Std. Dev.	dF=12[2] T-Ratio
1. Challenge	34.820[1]	8.783	47.665	17.095	-1.637
2. Friends	17.000	9.105	16.435	15.645	.076
3. Enjoy Science	69.051	14.448	69.320	19.347	- .027
4. Recommended	60.168	20.360	60.138	20.232	.002
5. Good Teacher	21.022	17.220	12.071	8.403	1.444
6. Required for Future	70.161	7.909	69.321	17.628	.106
7. Other	23.358	9.021	18.987	19.547	.497
Class A, B and C Schools	26 Teachers		25 Teachers		dF=49[3]
1. Challenge	31.606	12.809	41.319	14.445	-2.492*
2. Friends	16.262	8.867	10.279	11.526	2.041*
3. Enjoy Science	72.250	11.957	74.729	16.619	- .601
4. Recommended	55.167	15.741	56.852	16.807	.362
5. Good Teacher	22.371	18.449	12.615	14.446	2.055*
6. Required for Future	70.119	7.399	75.117	15.920	-1.417
7. Other	25.074	9.359	19.476	16.569	1.182

[1]Sum of the average percents of students giving this as the first, second, or third most important reasons

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.009

*Significant at $< .05$ but $> .01$

languages, music or art, and physical education. The grades for each course were rostered according to the following scale:

A+, A = 9
A- = 8
B+ = 7
B, B- = 6
C+ = 5
C, C- = 4
D+ = 3
D, D- = 2
E = 1

In an instance where the student was taking two or more courses in the same category, one average grade was used. Analysis of physics students' grades consisted of first obtaining an average grade for each student in an area called "other academic grades." This included an average of all grades the student listed except physics, music and art, and physical education. Mean values for the physics grades, other academic grades, and the differences between the other academic grades and physics grades were calculated for the students of each of the physics teachers. These averages were used to obtain mean values and standard deviations of student grades for groups of physics teachers from high schools with high percentage and low percentage enrollments in physics. The mean values of the high and low physics enrollment groups were compared using the "t" test. The results are given in Table XXXVII.

TABLE XXXVII

COMPARATIVE GRADES OF PHYSICS STUDENTS

	High Physics Enrollment			Low Physics Enrollment			
	Mean	Std. Dev.	N[1]	Mean	Std. Dev.	N	T-Ratio
Physics Grades							
Class A Schools	5.474[2]	.626	11	5.900	.729	8	-1.319
Class B Schools	5.601	.786	8	5.807	.729	10	- .542
Class C Schools	5.328	.601	7	6.409	.501	7	-3.384**
Class A, B and C Schools	5.474	.681	26	6.008	.719	25	-2.669*
Average of Other Academic Grades							
Class A Schools	6.075	.508	11	6.471	.336	8	-1.816
Class B Schools	6.342	.270	8	6.653	.526	10	-1.432
Class C Schools	6.299	.385	7	6.758	.486	7	-1.813
Class A, B and C Schools	6.217	.432	26	6.624	.475	25	-3.139**
Other Academic Grades Minus Physics Grades							
Class A Schools	.601	.374	11	.561	.776	8	.140
Class B Schools	.740	.819	8	.846	.526	10	- .313
Class C Schools	.917	.401	7	.349	.513	7	2.339*
Class A, B and C Schools	.743	.575	26	.616	.648	25	.726

[1]Number of teachers in the group

[2]Refer to page 86

*Significant at $< .05$ but $> .01$

**Significant at $< .01$

The Dunning-Abeles Physics Test

The Dunning-Abeles Physics Test, described in Chapter III, is designed to measure achievement in physics. During the visits to the high schools physics teachers were shown a copy of Form E of the test and asked if they would be interested in giving the test to their students sometime near the end of the school year. Forty-four teachers were interested and did receive by mail the tests (Forms E or F), answer sheets, a page of directions, an answer key, and an envelope for returning the tests and the answer sheets.

Forty-four sets of tests were sent to teachers but the results from only fifteen teachers are included in the analysis. Seventeen teachers did not return the materials and in nine instances the teachers received the tests after the seniors had finished the school year. In three instances teachers indicated that they let the students use their physics books during the test.

Although each teacher had corrected the answer sheets of his students before returning them, the answer sheets were machine scored and a mean value was obtained for the students of each of the teachers. The small amount of data available dictated that a comparison be made only between the mean values of all the students from high schools with high percentage enrollments in physics and low percentage enrollments in physics. No comparisons of achievement were made between high schools equal in size but differing with respect to physics enrollments. The "t" test was used to compare the physics achievements of the high and low physics enrollment groups and the results are included in Table XXXVIII.

TABLE XXXVIII

COMPARISON OF THE ACHIEVEMENTS OF PHYSICS STUDENTS

Class A, B and C Schools

High Physics Enrollment 5 Teachers		Low Physics Enrollment 10 Teachers		dF=13[2]
Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
24.712[1]	5.200	24.397[1]	5.697	.097

[1]Average score for that group of students on the Dunning-Abeles Physics Test

[2]Significance at .05 = 2.160

Chemistry Student Questionnaire

Chemistry students were asked if they were planning to take physics the following year, and according to their response, indicated the three most important reasons for their choice. The comparative analyses of reasons chemistry students gave for wanting to or not wanting to take physics were done in an identical manner to the method described in the section dealing with reasons physics students gave for taking physics. Even though in many schools students from more than one chemistry teacher were contacted, all of the questionnaires were analyzed as a group. An effort was made to obtain responses from chemistry students that would be representative of all the chemistry students in the high school. The results of the analyses are given in Tables XXXIX-L.

Guidance Counselor Questionnaire and Interview

A guidance counselor was contacted in each of the high schools that was visited. The counselors were asked to complete a questionnaire, a copy of which is included in the Appendix, as well as supply data concerning the science curriculum at the high school, the number of students going on to college each year, and the number of students that drop out of school each year. In some instances the last two pieces of data were obtained from the high school principal. The opinions of the counselors concerning physics were ascertained by their responses to three questions. The questions and comparative

TABLE XXXIX

THE MOST IMPORTANT REASON CHEMISTRY STUDENTS GAVE FOR WANTING TO TAKE PHYSICS

Class A Schools	High Physics Enrollment 8 Schools		Low Physics Enrollment 8 Schools		dF=14[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	4.406[1]	3.167[1]	7.367	7.955	- .914
2. Friends	.283	.750	1.200	2.277	-1.012
3. Interest in Science	25.203	7.856	25.432	8.806	- .051
4. Recommended	12.007	6.163	14.416	9.954	- .544
5. Good Teacher	.283	.750	2.080	3.311	-1.400
6. Required for Future	49.681	10.463	46.725	20.010	.346
7. Other	8.112	6.024	2.762	3.173	1.637
Class B Schools	8 Schools		10 Schools		dF=16[3]
1. Challenge	4.556	3.860	6.438	5.544	- .768
2. Friends	0.000	0.000	2.048	2.630	-2.076
3. Interest in Science	27.936	13.077	34.282	16.198	- .847
4. Recommended	19.148	14.569	11.565	6.686	1.380
5. Good Teacher	2.145	4.041	1.458	2.952	.392
6. Required for Future	37.815	14.606	37.016	17.106	.098
7. Other	8.378	6.842	7.184	8.044	.446

[1]Percent of chemistry students giving this as the most important reason for wanting to take physics

[2]Significance at .05 = 2.145

[3]Significance at .05 = 2.120

TABLE XL

THE MOST IMPORTANT REASON CHEMISTRY STUDENTS GAVE FOR WANTING TO TAKE PHYSICS

Class C Schools	High Physics Enrollment 7 Schools		Low Physics Enrollment 7 Schools		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	8.131	7.244	8.498	9.141	- .077
2. Friends	0.000	0.000	1.298	3.180	- .999
3. Interest in Science	26.688	14.769	23.502	5.048	.500
4. Recommended	15.532	11.662	9.347	10.769	.954
5. Good Teacher	1.385	2.509	1.587	3.887	- .106
6. Required for Future	43.505	11.534	44.142	10.930	- .098
7. Other	4.744	4.427	11.615	10.702	-1.178
Class A, B and C Schools	23 Schools		25 Schools		dF=46[3]
1. Challenge	5.592	5.241	7.312	7.526	- .892
2. Friends	.098	.462	1.566	2.723	-2.498*
3. Interest in Science	26.606	12.191	28.432	12.660	- .497
4. Recommended	15.564	11.718	11.856	9.271	1.194
5. Good Teacher	1.266	2.898	1.693	3.361	- .459
6. Required for Future	43.674	13.314	42.118	17.233	.340
7. Other	7.179	6.086	7.009	8.351	.155

[1]Percent of chemistry students giving this as the most important reason for wanting to take physics

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.016

*Significant at $< .05$ but $> .01$

TABLE XLI

THE TWO MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR WANTING TO TAKE PHYSICS

Class A Schools	High Physics Enrollment 8 Schools		Low Physics Enrollment 8 Schools		dF=14[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	12.375[1]	4.464	36.313	24.024	-2.591*
2. Friends	3.997	2.577	7.420	6.448	-1.304
3. Interest in Science	53.536	15.222	55.406	12.455	- .251
4. Recommended	42.691	13.803	38.116	10.622	.694
5. Good Teacher	5.483	5.540	12.366	11.557	-1.420
6. Required for Future	68.682	8.725	60.086	18.597	1.107
7. Other	13.191	6.665	13.871	5.026	- .337
Class B Schools	8 Schools		10 Schools		dF=16[3]
1. Challenge	17.095	9.964	25.534	18.166	-1.112
2. Friends	5.422	6.359	4.672	6.029	.241
3. Interest in Science	50.148	12.783	56.600	12.600	-1,011
4. Recommended	44.042	13.813	37.536	10.430	1.073
5. Good Teacher	8.101	8.032	5.499	6.783	.702
6. Required for Future	60.288	11.816	58.470	20.686	.214
7. Other	14.866	4.540	11.725	9.635	.928

[1]Sum of the percents of students giving this as the first or second most important reason for wanting to take physics

[2]Significance at .05 = 2.145

[3]Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

TABLE XLII

THE TWO MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR WANTING TO TAKE PHYSICS

Class C Schools	High Physics Enrollment 7 Schools		Low Physics Enrollment 7 Schools		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	18.012	10.055	25.712	18.133	- .909
2. Friends	.792	1.942	4.925	8.449	-1.167
3. Interest in Science	57.278	11.423	50.264	17.398	.825
4. Recommended	43.777	15.941	36.622	19.958	.686
5. Good Teacher	9.308	15.276	10.474	13.436	- .140
6. Required for Future	63.771	10.422	58.778	4.712	1.069
7. Other	7.032	6.309	13.202	9.843	-1.020
Class A, B and C Schools	23 Schools		25 Schools		dF=46[3]
1. Challenge	15.732	8.854	29.033	20.825	-2.776**
2. Friends	3.517	4.596	5.622	7.026	-1.191
3. Interest in Science	53.496	13.616	54.444	14.316	- .229
4. Recommended	43.491	14.503	37.466	13.838	1.441
5. Good Teacher	7.558	10.328	9.089	10.992	- .485
6. Required for Future	64.268	10.975	59.052	16.987	1.225
7. Other	11.899	6.698	12.825	8.543	- .227

[1] Sum of the percents of students giving this as the first or second most important reason for wanting to take physics

[2] Significance at .05 = 2.179

[3] Significance at .05 = 2.016

**Significant at < .01

TABLE XLIII

THE THREE MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR WANTING TO TAKE PHYSICS

Class A Schools	High Physics Enrollment 8 Schools		Low Physics Enrollment 8 Schools		dF=14[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	26.723[1]	6.744	40.960	9.192	-3.303**
2. Friends	16.300	7.305	20.360	15.586	- .624
3. Interest in Science	74.726	12.608	55.846	32.994	1.414
4. Recommended	66.738	10.355	47.513	19.550	2.299*
5. Good Teacher	12.396	10.230	22.900	16.238	-1.448
6. Required for Future	80.105	6.023	65.182	26.200	1.468
7. Other	21.944	5.164	22.186	6.765	- .105
Class B Schools	8 Schools		10 Schools		dF=16[3]
1. Challenge	33.993[1]	10.477	47.311	21.494	-1.514
2. Friends	18.885	9.678	12.642	9.145	1.322
3. Interest in Science	71.610	10.235	79.300	11.552	-1.391
4. Recommended	65.482	10.124	54.063	15.742	1.676
5. Good Teacher	15.888	12.053	16.248	12.593	- .057
6. Required for Future	71.670	10.124	70.203	16.271	.210
7. Other	22.407	6.386	20.202	13.597	.462

[1]Sum of the percents of students giving this as the first, second and third most important reason for wanting to take physics
[2]Significance at .05 = 2.145
[3]Significance at .05 = 2.120
*Significant at $< .05$ but $> .01$
**Significant at $< .01$

TABLE XLIV

THE THREE MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR WANTING TO TAKE PHYSICS

Class C Schools	High Physics Enrollment 7 Schools		Low Physics Enrollment 7 Schools		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Challenge	37.810[1]	17.800	49.627	24.306	- .960
2. Friends	16.474	9.534	8.157	12.131	1.320
3. Interest in Science	78.650	13.683	74.218	14.015	.554
4. Recommended	60.912	15.322	54.928	10.277	.794
5. Good Teacher	15.778	22.214	17.398	14.630	- .149
6. Required for Future	76.962	11.385	72.188	7.614	.853
7. Other	13.370	9.639	23.455	14.155	-1.456
Class A, B and C Schools	23 Schools		25 Schools		dF=46[3]
1. Challenge	32.626	13.091	45.927	19.742	-2.669*
2. Friends	17.252	8.957	13.856	13.252	1.009
3. Interest in Science	74.836	12.520	70.372	23.670	.789
4. Recommended	64.528	12.264	52.209	16.171	2.892**
5. Good Teacher	14.640	15.485	18.698	14.706	- .911
6. Required for Future	76.214	10.017	69.152	18.704	1.576
7. Other	19.843	8.244	21.747	12.072	- .612

[1] Sum of the percents of students giving this as the first, second, and third most important reason for wanting to take physics

[2] Significance at .05 = 2.179

[3] Significance at .05 = 2.016

*Significant at $< .05$ but $> .01$

**Significant at $< .01$

TABLE XLV

THE MOST IMPORTANT REASON CHEMISTRY STUDENTS GAVE FOR NOT WANTING TO TAKE PHYSICS

Class A Schools	High Physics Enrollment 8 Schools		Low Physics Enrollment 8 Schools		dF=14[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Too Difficult	32.881[1]	8.296	31.383	7.711	.349
2. Possible Low Grade	5.450	5.494	9.647	9.120	-1.042
3. Would Not Like Teacher	.896	1.230	.265	.701	1.179
4. Recommended Not To	2.911	1.804	5.553	4.550	-1.433
5. Little Interest in Subject	28.098	6.831	18.016	8.079	2.521*
6. No Need	17.820	9.653	13.690	10.352	.771
7. Conflicts With Another Course	7.236	4.153	10.275	7.398	- .947
8. No Friends Taking Physics	0.000	0.000	0.000	0.000	
9. Other	4.681	4.387	11.143	8.266	-1.826
Class B Schools	8 Schools		10 Schools		dF=16[3]
1. Too Difficult	25.721	9.687	31.866	7.346	-1.442
2. Possible Low Grade	6.297	4.536	4.742	4.580	.677
3. Would Not Like Teacher	.542	.939	0.000	0.000	1.720
4. Recommended Not To	2.442	2.308	2.794	4.516	- .189
5. Little Interest in Subject	29.246	8.370	32.480	8.287	- .772
6. No Need	20.116	7.598	13.999	7.161	1.652
7. Conflicts With Another Course	7.868	4.969	8.477	5.706	- .224
8. No Friends Taking Physics	0.000	0.000	0.000	0.000	
9. Other	7.738	4.988	5.619	4.236	.918

[1]Percent of chemistry students giving this as the most important reason for not wanting to take physics

[2]Significance at .05 = 2.145

[3]Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

TABLE XLVI

THE MOST IMPORTANT REASON CHEMISTRY STUDENTS GAVE FOR NOT WANTING TO TAKE PHYSICS

	High Physics Enrollment		Low Physics Enrollment		
Class C Schools	7 Schools		7 Schools		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Too Difficult	28.572	21.643	43.547	8.828	-1.569
2. Possible Low Grade	11.255	16.751	4.761	8.747	.841
3. Would Not Like Teacher	.865	1.369	1.360	3.331	- .336
4. Recommended Not To	6.557	9.479	1.190	2.914	1.325
5. Little Interest in Subject	26.988	10.783	24.650	8.626	.414
6. No Need	14.145	14.650	9.584	7.830	.672
7. Conflicts With Another Course	6.285	6.504	9.214	6.848	- .759
8. No Friends Taking Physics	0.000	0.000	0.000	0.000	
9. Other	5.312	6.792	5.678	5.902	- .099
Class A, B and C Schools	23 Schools		25 Schools		dF=46[3]
1. Too Difficult	29.079	14.428	34.982	9.539	-1.648
2. Possible Low Grade	7.511	10.455	6.317	7.852	.440
3. Would Not Like Teacher	.763	1.196	.465	1.894	.631
4. Recommended Not To	3.857	5.793	3.228	4.480	.413
5. Little Interest in Subject	28.160	8.765	25.659	10.333	.881
6. No Need	17.500	11.120	12.664	8.699	1.649
7. Conflicts With Another Course	7.166	5.279	9.258	6.651	-1.174
8. No Friends Taking Physics	0.000	0.000	0.000	0.000	
9. Other	5.936	5.584	7.403	6.737	- .800

[1]Percent of chemistry students giving this as the most important reason for not wanting to take physics

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.016

TABLE XLVII

THE TWO MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR NOT WANTING TO TAKE PHYSICS

Class A Schools	High Physics Enrollment 8 Schools		Low Physics Enrollment 8 Schools		dF=14[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Too Difficult	52.138[1]	11.900	51.811	14.778	.045
2. Possible Low Grade	22.238	7.909	29.975	15.892	-1.153
3. Would Not Like Teacher	1.837	1.653	3.061	5.335	- .579
4. Recommended Not To	9.951	4.559	12.702	6.291	- .936
5. Little Interest in Subject	51.462	4.864	49.457	14.488	.347
6. No Need	37.866	11.269	29.327	13.191	1.302
7. Conflicts With Another Course	17.746	5.927	21.196	9.273	- .829
8. No Friends Taking Physics	0.000	0.000	0.000	0.000	
9. Other	6.705	5.817	14.915	8.023	-2.191
Class B Schools	8 Schools		10 Schools		dF=16[3]
1. Too Difficult	51.768	12.076	54.884	12.343	- .506
2. Possible Low Grade	17.775	10.182	24.333	11.857	-1.169
3. Would Not Like Teacher	.542	.939	3.287	5.208	-1.387
4. Recommended Not To	13.522	6.654	6.159	3.925	2.669*
5. Little Interest in Subject	52.571	8.025	52.877	7.280	- .079
6. No Need	36.065	10.735	29.917	10.309	1.163
7. Conflicts With Another Course	16.542	6.908	16.489	10.233	.011
8. No Friends Taking Physics	.283	.750	1.451	2.480	-1.212
9. Other	10.873	6.252	10.548	4.229	.123

[1]Sum of the percents of chemistry students giving this as a first and second reason for not wanting to take physics

[2]Significance at .05 = 2.145

[3]Significance at .05 = 2.120

*Significant at $< .05$ but $> .01$

TABLE XLVIII

THE TWO MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR NOT WANTING TO TAKE PHYSICS

Class C Schools	High Physics Enrollment 7 Schools		Low Physics Enrollment 7 Schools		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Too Difficult	40.378[1]	21.804	61.290	10.072	-2.132
2. Possible Low Grade	31.488	21.292	21.514	12.728	.984
3. Would Not Like Teacher	8.140	6.658	5.288	8.957	.625
4. Recommended Not To	6.290	6.618	5.475	10.416	.161
5. Little Interest in Subject	57.207	12.062	49.227	12.043	1.146
6. No Need	37.935	20.509	28.350	9.614	1.036
7. Conflicts With Another Course	14.150	16.113	18.548	13.847	- .507
8. No Friends Taking Physics	4.761	11.663	.714	1.749	.840
9. Other	6.574	7.112	9.574	8.815	- .648
Class A, B and C Schools	23 Schools		25 Schools		dF=46[3]
1. Too Difficult	48.430	16.525	55.694	13.156	-1.655
2. Possible Low Grade	23.501	15.072	25.340	13.921	- .432
3. Would Not Like Teacher	3.305	5.026	3.775	6.582	- .270
4. Recommended Not To	10.079	6.773	8.061	7.708	.939
5. Little Interest in Subject	53.596	8.990	50.760	11.488	.926
6. No Need	37.260	14.595	29.289	11.157	2.090*
7. Conflicts With Another Course	16.233	10.487	18.572	11.271	- .726
8. No Friends Taking Physics	1.547	6.791	.780	1.921	.530
9. Other	8.115	6.695	11.672	7.390	-1.705

[1]The sum of the percents of chemistry students giving this as the first and second reasons for not wanting to take physics

[2]Significance at .05 = 2.179

[3]Significance at .05 = 2.016

*Significant at $< .05$ but $> .01$

TABLE XLIX

THE THREE MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR NOT WANTING TO TAKE PHYSICS

Class A Schools	High Physics Enrollment 8 Schools		Low Physics Enrollment 8 Schools		dF=14[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Too Difficult	72.385[1]	11.112	55.961	22.024	1.761
2. Possible Low Grade	38.813	9.861	37.962	18.219	.108
3. Would Not Like Teacher	9.288	9.870	4.952	6.962	.949
4. Recommended Not To	19.686	6.528	24.318	11.630	- .918
5. Little Interest in Subject	68.386	7.931	59.037	24.174	.972
6. No Need	54.820	10.106	38.177	17.548	2.174
7. Conflicts With Another Course	24.600	7.726	25.681	16.548	- .156
8. No Friends Taking Physics	1.108	1.955	1.190	3.148	.058
9. Other	10.835	5.339	18.895	11.449	1.688
Class B Schools	8 Schools		10 Schools		dF=16[2]
1. Too Difficult	67.147	9.655	68.190	10.119	- .209
2. Possible Low Grade	35.047	12.129	43.314	17.447	-1.073
3. Would Not Like Teacher	4.183	3.361	7.383	8.502	- .946
4. Recommended Not To	22.142	11.328	12.439	4.422	2.340*
5. Little Interest in Subject	68.481	8.060	72.327	6.962	-1.023
6. No Need	54.533	7.780	52.248	12.964	.414
7. Conflicts With Another Course	27.802	11.326	21.754	12.656	.994
8. No Friends Taking Physics	.998	1.722	1.773	2.856	- .632
9. Other	19.577	5.049	20.495	7.809	- .271

[1]Sum of the percents of chemistry students giving this as a first, second, and third reasons for not wanting to take physics
[2]Significance at .05 = 2.145
[3]Significance at .05 = 2.120
*Significant at $< .05$ but $> .01$

TABLE L

THE THREE MOST IMPORTANT REASONS CHEMISTRY STUDENTS GAVE FOR NOT WANTING TO TAKE PHYSICS

Class C Schools	High Physics Enrollment 7 Schools		Low Physics Enrollment 7 Schools		dF=12[2]
Reason	Mean	Std. Dev.	Mean	Std. Dev.	T-Ratio
1. Too Difficult	67.348	24.324	76.414	11.599	- .824
2. Possible Low Grade	37.814	21.598	44.745	10.341	- .708
3. Would Not Like Teacher	9.301	13.568	11.765	18.052	- .267
4. Recommended Not To	14.841	11.570	8.202	10.905	1.022
5. Little Interest in Subject	69.434	26.742	73.604	11.805	- .349
6. No Need	44.721	30.260	42.760	8.521	.152
7. Conflicts With Another Course	16.757	16.366	22.655	15.159	- .647
8. No Friends Taking Physics	0.000	0.000	2.142	3.642	-1.440
9. Other	11.170	8.436	17.685	11.013	-1.150
Class A, B and C Schools	23 Schools		25 Schools		dF=46[3]
1. Too Difficult	69.030	16.169	66.579	17.264	.495
2. Possible Low Grade	37.199	15.152	42.002	16.308	-1.032
3. Would Not Like Teacher	7.516	9.988	7.832	11.947	- .096
4. Recommended Not To	19.066	10.443	15.054	11.302	1.247
5. Little Interest in Subject	68.738	16.197	68.432	16.947	.062
6. No Need	51.646	18.875	45.088	14.947	1.311
7. Conflicts With Another Course	23.326	12.945	23.263	14.716	.015
8. No Friends Taking Physics	.733	1.630	1.690	3.207	-1.259
9. Other	13.977	7.562	19.196	10.082	-1.972

[1] Sum of the percents of chemistry giving this as the first, second, and third reasons for not wanting to take physics

[2] Significance at .05 = 2.179

[3] Significance at .05 = 2.016

analyses of the averaged responses of the counselors from different size high schools that have either high or low percentage enrollments in physics are given in Table LI.

Data concerning the science curriculum and the mathematics prerequisites for physics were recorded in the 2 x 2 matrices in Tables LII-LV. The hypotheses tested concerning these data were rejected or not rejected on the basis of the degrees of significant differences obtained by analyses using the Fisher Exact Probability Test.

The percentages of students going on to college and dropping out of high school for each of the schools included in the study were averaged with similar data from other high schools in the same high or low physics enrollment groups. The mean values of the groups were compared using the "t" Test and the results are given in Table LVI-LVII.

TABLE LI

OPINIONS OF GUIDANCE COUNSELORS CONCERNING HIGH SCHOOL PHYSICS

Percent of Seniors Qualified but not Taking Physics

	High Physics Enrollment Mean	Std. Dev.	N[1]	Low Physics Enrollment Mean	Std. Dev.	N	T-Ratio
Class A Schools	3.500[2]	1.118	8	2.750	.661	8	1.527
Class B Schools	2.500	.707	8	2.500	.670	10	0.000
Class C Schools	2.142	.832	7	2.857	.638	7	-1.670
Class A, B and C Schools	2.739	1.072	23	2.680	.676	25	.225

Physics has to be a Hard Course

	High Physics Enrollment Mean	Std. Dev.	N	Low Physics Enrollment Mean	Std. Dev.	N	T-Ratio
Class A Schools	3.000[3]	.500	8	2.750	.433	8	1.000
Class B Schools	2.875	.330	8	2.500	.780	10	- .780
Class C Schools	2.857	.349	7	2.571	.494	7	1.158
Class A, B and C Schools	2.869	1.072	23	2.600	.489	25	1.654

Physics Should Be Taught To One-half of the Students

	High Physics Enrollment Mean	Std. Dev.	N	Low Physics Enrollment Mean	Std. Dev.	N	T-Ratio
Class A Schools	2.875[3]	.300	8	3.125	.780	8	- .780
Class B Schools	2.750	.829	8	2.900	.300	10	- .603
Class C Schools	2.571	.728	7	2.857	.349	7	- .867
Class A, B and C Schools	2.739	.605	23	2.960	.525	25	-1.323

[1] Number of schools in the group

[2] 1=0%, 2=5%, 3=15%, 4=25%, 5=40%

[3] 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree

TABLE LII

COMPARISONS OF THE NUMBERS OF HIGH SCHOOLS THAT HAVE TRACKED COURSES IN BIOLOGY AND CHEMISTRY

	Yes	No	Level of Significance[1]
Class A Schools			
High Physics Enrollment	5	2	.3142
Low Physics Enrollment	3	6	
Class B Schools			
High Physics Enrollment	2	2	.8692
Low Physics Enrollment	6	8	
Class C Schools			
High Physics Enrollment	0	7	1.0000
Low Physics Enrollment	0	7	
Class A, B and C Schools			
High Physics Enrollment	7	16	.3982
Low Physics Enrollment	4	21	

TABLE LIII

COMPARISONS OF GUIDANCE COUNSELORS' OPINIONS CONCERNING THE MINIMUM PREREQUISITES IN MATHEMATICS FOR PHYSICS STUDENTS

	Geometry or less	More Than Geometry	Level of Significance[1]
Class A Schools			
High Physics Enrollment	4	4	.9994
Low Physics Enrollment	3	5	
Class B Schools			
High Physics Enrollment	6	2	.0610
Low Physics Enrollment	2	8	
Class C Schools			
High Physics Enrollment	5	2	.0208
Low Physics Enrollment	0	7	
Class A, B and C Schools			
High Physics Enrollment	15	8	.0032
Low Physics Enrollment	5	20	

[1] Level of significance calculated using the formula for significance in Siegel (61) p. 99.

TABLE LIV

COMPARISONS OF THE NUMBERS OF HIGH SCHOOLS OFFERING TWO LEVELS OF FIRST-YEAR PHYSICS

	Yes	No	Level of Significance[1]
Class A Schools			
High Physics Enrollment	6	2	.0410
Low Physics Enrollment	1	7	
Class B Schools			
High Physics Enrollment	1	7	.8888
Low Physics Enrollment	0	10	
Class C Schools			
High Physics Enrollment	0	7	1.0000
Low Physics Enrollment	0	7	
Class A, B and C Schools			
High Physics Enrollment	7	16	.0348
Low Physics Enrollment	1	24	

TABLE LV

COMPARISONS OF THE NUMBERS OF HIGH SCHOOLS OFFERING ADVANCED SCIENCE COURSES

	Yes	No	Level of Significance[1]
Class A Schools			
High Physics Enrollment	8	0	.0256
Low Physics Enrollment	5	3	
Class B Schools			
High Physics Enrollment	8	0	.9999
Low Physics Enrollment	9	1	
Class C Schools			
High Physics Enrollment	3	4	.1922
Low Physics Enrollment	0	7	
Class A, B and C Schools			
High Physics Enrollment	19	4	.0914
Low Physics Enrollment	14	11	

[1]Level of significance calculated using the formula for significance in Siegel (61) p. 99.

TABLE LVI

PERCENT OF STUDENTS GOING ON TO COLLEGE

	High Physics Enrollment			Low Physics Enrollment			
	Mean	Std. Dev.	N[1]	Mean	Std. Dev.	N	T-Ratio
Class A Schools	58.875	17.186	8	37.250	5.517	8	3.169
Class B Schools	56.875	15.527	8	41.900	6.410	10	2.610
Class C Schools	50.714	19.710	7	39.285	6.226	7	1.354
Class A, B and C Schools	55.695	17.787	23	39.680	6.398	25	4.126

[1]Number of schools in the group

TABLE LVII

PERCENT OF STUDENTS DROPPING OUT OF SCHOOL PER YEAR

	High Physics Enrollment			Low Physics Enrollment			
	Mean	Std. Dev.	N[1]	Mean	Std. Dev.	N	T-Ratio
Class A Schools	4.875	4.013	8	7.625	2.057	8	-1.613
Class B Schools	3.000	1.224	8	4.600	.663	10	-3.333
Class C Schools	4.428	2.555	7	4.142	2.099	7	.211
Class A, B and C Schools	4.086	2.962	23	5.440	2.246	25	-1.755

[1]Number of schools in the group

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The purposes of this study were (1) to obtain accurate assessment of the present high school physics enrollment in Michigan and (2) to determine if measurable differences exist between high schools with high and low percentage enrollments in physics.

Conclusions Regarding the Population

The first purpose was accomplished by sending three hundred and seventy-three questionnaires to high schools in Michigan in October, 1968. The results of the analyses, described in Chapter IV, indicate that if physics enrollment percentages of the individual high schools are averaged the physics enrollment in the average high school in Michigan is about 18.1% of the senior class. If consideration is given to the fact that larger high schools have, on the average, lower enrollments in physics, the actual number of students enrolled in physics is probably closer to 16.5% or 17% of the total number of seniors enrolled in high school. This value would nearly coincide with projections for 1968 that could be made based on the 1955-1965 data available.

Conclusions Regarding the Hypotheses

In order to determine if measurable differences exist between high schools with high percentage enrollments in physics and high

schools with low percentage enrollments in physics the hypotheses given in Chapter III were tested using the data described in Chapter V. Each of the hypotheses was given in the null form. The evaluation of the results of the analyses and subsequent conclusions follow.

Hypothesis number one tested a comparison of the personality characteristics of physics teachers, as ascertained from the Sixteen Personality Factor Questionnaire, from schools with high and low percentage enrollment in physics. Data from Tables V-XII indicate that factor three, affected by feelings vs emotionally stable, was the only one that was significant for the combined results of Class A, B and C schools for both raw scores and standard scores. Teachers from high schools with high enrollments in physics appear to be more affected by feelings while teachers from high schools with low enrollments in physics appear to be more emotionally stable. Consistent, but not statistically significant, differences indicate that physics teachers from high physics enrollment groups were more pretentious, experimenting, undisciplined, and tense while physics teachers from low physics enrollment groups were more shrewd, conservative, self-controlled, relaxed.

Factor 4, humble vs assertive, and Factor 5, sober vs happy-go-lucky, shifted from positive to negative differences between high physics enrollment and low physics enrollment schools as the schools decreased in size. This indicates that physics teachers from Class A schools with high physics enrollments and teachers from Class C schools with low enrollments are more aggressive and competitive

than their counter-parts. An explanation for this is not really apparent. The other statistically significant difference, factor 12, self-assured vs experimenting, for Class B schools seems to be a characteristic of only that group of schools and thus is probably significant due to chance. Hypothesis one was rejected due to the significant differences found for factor three.

Hypothesis two tested a comparison of the student evaluations of physics teachers from high and low physics enrollment groups using the Student Opinion Questionnaire. Data from Tables XIII-XVI indicate that the instrument measured very small differences between the two groups. The only consistent finding for all three classes of schools was question 7 which indicates that physics students from high schools with a high percentage enrollment in physics believe that their physics teachers have a slightly more enthusiastic attitude toward the subject. The significant difference between Class B schools with respect to variety in teaching procedures does not appear to be a part of any trend and thus is probably due to chance. Hypothesis two was not rejected.

Hypothesis three tested a comparison of the student evaluations of the classroom learning environments, using the Learning Environment Inventory, between high schools of high and low percentage enrollment. The data from Tables XVII-XX indicates that physics students from schools with high percentage enrollments in physics consider their physics classes to be less democratic than physics classes from high schools with low percentage enrollments.

The democratic factor is evaluated by noting the students responses to statements similar to the following:

> Class decisions tend to be made by all the students.
> Certain students have more influence on the class than others.

Hypothesis three was rejected because of the significant differences found with the factor measuring democracy in the classroom. More democracy in the physics classes from high schools with low physics enrollments is probably a result of the low enrollment rather than a cause. Low physics enrollments in many schools would mean only a few students in one section of physics. Obviously physics teachers could be more accommodating to a small group than a large one.

Hypothesis four compared the science and mathematics teaching loads of physics teachers from high schools with high percentage enrollments in physics to those of physics teachers from high schools with low percentage enrollments in physics. Table XXI indicates that there are no significant differences between the teaching loads of the two groups of teachers in any of the three classes of schools. As was expected the teachers from low physics enrollment schools did teach more mathematics and other science courses because they taught fewer sections of physics. All of the physics teachers did teach more science courses than mathematics courses. Hypothesis four was not rejected.

Hypothesis five compared the college preparation of physics teachers from high schools with high percentage enrollments in physics with those from high schools with low percentage enrollments

in physics. Tables XXII and XXIII indicate that the physics teachers from the high physics enrollment groups have more hours in chemistry, earth science, mathematics, and education and a fewer hours in physics and biology in their preparation than those from the low physics enrollment groups. None of the differences are significant at the .05 levels and so hypothesis five was not rejected.

Hypothesis six compared the physics teachers from high schools with high percentage enrollments in physics to physics teachers from high schools with low percentage enrollments with respect to the total number of years he has taught, the number of years the teacher has taught physics, and the number of years the teacher has taught at that school. Table XXIV indicates that there are no significant differences with respect to these variables; therefore, hypothesis six was not rejected.

Hypothesis seven compared the opinions, regarding some aspects of physics, of physics teachers from high schools with high percentage enrollments in physics to those of physics teachers from high schools with low percentage enrollments in physics. Table XXV indicates that teachers from Class A and B high schools with low physics enrollments believe that there are higher percentages of qualified seniors who are not taking physics than do teachers in the high physics enrollment groups. The differences, however, are not significant. All of the groups compared agree that physics does not have to be a hard course, but high physics enrollment groups expressed this belief to a slightly greater extent. These

differences were not significant either even though all of the groups of Class A and B schools slightly agreed that physics should be taught to one-half of the students; no significant differences resulted. A significant difference did occur between the two groups of Class C schools with the high physics enrollment groups agreeing that physics should be taught to one-half of the students and the low physics enrollment group disagreeing. However, this single significant difference from the smallest groups in the sample does not justify rejecting the hypothesis.

Hypotheses eight and nine compared the numbers of physics teachers from high schools with high percentage enrollments in physics to those from high schools with low percentage enrollment that were using and/or preferred to use PSSC materials. Tables XXVI and XXVII indicate that no significant differences were found; therefore these hypotheses were not rejected.

Hypothesis ten compared the numbers of physics teachers from high schools with high percentage enrollments in physics to those from high schools with low percentage enrollments in physics that consider geometry or less as a minimum mathematics prerequisite for physics. Table XXVIII indicates that although none of the differences are significant at the .05 level the comparison involving all three classes of schools was significant at the .133 level. This hypothesis cannot be rejected.

Hypothesis eleven compared the vocational choices of physics students from high schools with high percentage enrollments in

physics to those of physics students from high schools with low percentage enrollments in physics. Tables XXIX and XXX indicate that physics classes from Class A and B schools and also the combined groups of schools with high physics enrollments have greater percentages of students with expressed vocational plans in the non-science category and smaller percentages of students in the physical science and engineering category. These differences are significant and so hypothesis eleven was rejected.

Hypothesis twelve compared the reasons physics students from high schools with high percentage enrollments in physics and those from high schools with low percentage enrollments gave for taking physics. Tables XXXI-XXXVI reveal that greater percentages of students in the high physics enrollment groups indicated that they took physics because their friends were taking the course and because they thought they would like the teacher. It should be noted that these percentages were small in all cases. Students in the low physics enrollment groups indicated they were taking the course because they considered it a challenge or it was required for their future. The eight of the eighty-four comparisons significant at the .05 level and two at the .01 level were more than could be expected by chance and thus the hypothesis has been rejected.

Hypothesis thirteen compared the grades of physics students from high schools with high percentage enrollments in physics with those of students from high schools with low percentage enrollments

in physics. Table XXXVII indicates that the students from low physics enrollment groups do receive better physics grades and better grades in other academic areas then do their counter parts in the other group. Yet, the differences between the other academic grades and the physics grades of the students from Class A and B high schools with high physics enrollment and those for students from Class A and B high schools with low physics enrollments were not significant. The hypothesis was rejected because four comparisons were significant at the .05 level or greater.

Hypothesis fourteen compared the physics achievement of students from high schools with high percentage enrollments in physics with those of students from high schools with low percentage enrollments in physics. Table XXXVIII indicates that there is no significant difference between the physics achievements of the two groups compared, thus the hypothesis was not rejected.

Hypothesis fifteen compared the reasons chemistry students from high schools with high percentage enrollments in physics gave for wanting to take physics with those of chemistry students from high schools with low percentage enrollments in physics. A survey of Tables XXXIX-XLIV indicates that larger percentages of chemistry students from high physics enrollment groups want to take physics because the course is recommended by either their parents or a counselor while a larger percent of chemistry students in the low physics enrollment groups want to take physics because they consider the course to be a challenge. Four of the comparisons were

significant at the .05 level and three at the .01 level which are more than those that would be expected by chance; thus the hypothesis was rejected.

Hypothesis sixteen compared the reasons chemistry students from high schools with high percentage enrollments in physics with those of chemistry students from high schools with low percentage enrollments in physics gave for not wanting to take physics. A survey of Tables XLV-L indicates that a larger percentage of chemistry students from the high physics enrollments groups did not want to take physics because they saw no need for the course; while a larger percentage of the chemistry students in the low physics enrollment groups did not want to take physics because they believed the course will be too difficult. Only four comparisons were significant at the .05 level out of a possible eighty-four. This could have happened on the basis of chance and thus the hypothesis is not rejected.

Hypothesis seventeen compared the opinions regarding some aspects of physics of guidance counselors from high schools with high percentage enrollments in physics and those of guidance counselors from high schools with low percentage enrollments in physics. Table LI indicates that there is little agreement about the percentages of seniors who are qualified but are not taking physics. All groups of guidance counselors seem to believe that physics does not have to be a hard course and that physics should not be taught to one-half of the students in the schools. The

hypothesis was not rejected because none of the comparisons was significant at the .05 level.

Hypothesis eighteen compared the number of high schools with a high percentage enrollment in physics with those with low percentage enrollment in physics as to whether the high schools have a tracked science curricula. Table LII indicates that tracked science curricula are not significantly related to physics enrollments. The comparisons are not significant and so the hypothesis was not rejected.

Hypothesis nineteen compared the numbers of high schools with high percentage enrollments in physics to those with low percentage enrollments in physics as to whether geometry or less was a mathematics prerequisite for physics. Table LIII indicates that more of the Class B and C schools and also the combined group of Class A, B and C schools which have high physics enrollments have geometry or less as a prerequisite for physics. Considering that three of the four comparisons ranged from .003 to .06 as levels of significance, the hypothesis was rejected.

Hypothesis twenty compared the numbers of high schools with high percentage enrollments in physics and those with low enrollments in physics as to whether the school had two levels of first-year physics. Table LIV indicates that there is significant difference only for Class A schools. This is not surprising, considering that many Class B and all Class C schools are too small to offer more than one section of physics. Due to the significance of the comparison of Class A schools, the hypothesis was rejected.

Hypothesis twenty-one compared the number of high schools with a high percentage enrollment in physics to those with a low percentage enrollment in physics as to whether advanced science courses were offered. Table LV indicates that for Class A and C schools, if advanced science course are not available physics enrollments are lower. Since only one of the four comparisons was not significant at the .05 level, the hypothesis was rejected.

Hypothesis twenty-two compared percentages of students going on to college from high schools that have high percentage enrollments in physics with those from high schools that have low percentage enrollments in physics. Tables LVI indicates that all of the groups of high schools with high physics enrollments have a larger percentage of their students going on to college. Three of the four comparisons were significant at the .05 level thus the hypothesis was rejected.

Hypothesis twenty-three compared the percentage of students dropping out of high schools from high schools that have high percentage enrollments in physics with those from high schools that have low percentage enrollments in physics. Table LVII indicates that Class A and B schools with high physics enrollments have smaller percentages of high school drop-outs. The hypothesis was rejected because one of the four comparisons was significant at the .01 level and two were significant at about .10.

Major Findings

1. The physics teachers from high schools with a high

percentage enrollments in physics when compared with those from high schools with low percentage enrollments in physics were more affected by feelings, more unpretentious, and more experimenting. They were also somewhat more enthusiastic about the subject they were teaching. The fact that their classrooms were considered to be less democratic is attributed to be the result of larger numbers of students and not a factor contributing to increased enrollments. These characteristics are for the most part similar to some of the general characteristics of "good" teachers as identified from the literature in Chapter II.

2. The physics teachers from high and low enrollment groups have nearly identical training in all aspects of science as well as in mathematics and education. They do not differ significantly with respect to their preferences for PSSC physics.

The physics teachers from both of the enrollment groups believe: (1) that between five and fifteen percent of the seniors are qualified but are not taking physics; and (2) physics does not have to be a hard course. Both groups only slightly agree that physics should be taught to one-half of the students.

The guidance counselors from high and low physics enrollment groups believe: (1) that between fifteen and twenty-five percent of the seniors are qualified but are not taking physics; (2) physics does not have to be a hard course; and (3) physics should <u>not</u> be taught to one-half of the students.

3. More physics teachers from high schools with high physics enrollment than from the low enrollment group tend to believe geometry or less is sufficient as a mathematics prerequisite for physics. However, the difference was not statistically significant. A significant difference on this same issue was found from the survey of guidance counselors.

4. A higher percentage of students from the high schools with high physics enrollments expressed vocational choices in a non-science area while lower percentages expressed vocational choices in the physical science and engineering area than did students from the low physics enrollment groups. It should be remembered, however, that the high physics enrollment schools do have more physics students so even though this group has a lower percentage of students interested in a vocation in the physical sciences or engineering, the actual number of students in this category may be the same or greater than the number of those in the low enrollment schools. Real differences occur in the actual number of students in the other three areas: other science and mathematics, undecided, and particularily the non-science areas.

5. A larger percentage of physics students from the high schools with high physics enrollments than those from high schools with low physics indicated they were taking physics because their friends were taking the course or they thought they would like the teacher. Whereas a larger percentage of students from high schools with low physics enrollments selected physics because it was required for their future or because they enjoyed the challenge.

A larger percentage of the chemistry students from high schools with a high enrollment in physics indicated that they want to take physics because of the influence of their parents or counselor than chemistry students from high schools with low enrollment in physics. A larger percentage of the chemistry students in the low physics enrollment group believe the physics course will be too difficult. The differences in each case were not statistically significant but they were consistent.

7. The results from this study indicate that the students in all of the physics enrollment groups do receive lower grades in physics than in their other academic courses. This does correlate with their responses on the <u>Learning Environment Inventory</u> where they also agree that the course is difficult. The physics students in the high physics enrollment groups are on the average poorer students in all areas than students from the low enrollment groups, but their grades in physics do not lower their grade-point averages any more than physics grades lower the grade-point averages of the students from the low enrollment group. The actual achievements of students in physics, from the small segment of schools included in the comparison, indicates that students do equally well in classes from schools with either high or low enrollment percentages in physics.

8. Physics enrollments are greater in schools that offer two levels of physics. The availability of advanced or second-year science courses in biology and chemistry tends to increase physics

enrollments. This is probably due to greater interests that have been developed in the school in all aspects of science.

9. The social and economic characteristics of the area being served by the high school as reflected in the percentage of high school graduates going on to college has a positive influence on physics enrollments. However, the percentage of students dropping out of school did not seem to influence percentage enrollments in physics.

10. PSSC materials do not appear to be exerting either positive or negative effects on enrollments as reflected by the number of teachers in each enrollment group using them.

Recommendations For Improving Physics Enrollments

Recommendations for improving enrollments in physics are based upon the statistical results of the study and the impressions derived from the visits to the schools.

1. In some instances physics teachers might improve enrollments in their physics classes by being more sociable, less aloof, and exhibiting more enthusiasm for the subject matter.

2. Physics enrollments might be improved by reducing the mathematics prerequisites for physics to geometry or less, with a corresponding de-emphasis on the mathematical approach to physics in the classroom.

3. Physics enrollment might be improved if physics grades were more comparable with the grades physics students receive in other academic subjects. Physics teachers should be more willing

to admit students who are achieving at the average level in other academic courses.

4. Many students are not aware of what the study of physics entails and consequently do not enroll in the course. An effective advertising campaign for physics could be launched by the physics teachers and the guidance counselors if: (1) the guidance counselor became more aware of the nature of the physics curriculum; and (2) if the physics teacher became more aware of the needs and abilities of the entire student body the physics curriculum could be adjusted to meet the interests and needs of a larger percentage of the high school population.

5. Physics enrollments might be improved if more attention were given to providing students with a well-rounded background in all aspects of science rather than allowing them to specialize in one particular area.

6. Guidance counselors should encourage more students with vocational plans in the non-science areas to enroll in physics.

Recommendations For Future Research

Data that could be obtained by replicating this study would be useful in an attempt to add validity to the results of his study. Some areas where special emphasis should be placed are the following:

1. Due to the small number of schools providing usable data on student achievement in physics much more data are needed to test the conclusion reached in this study that increasing the quantity of

students in physics classes does not diminish the quality of student achievements.

2. A more through investigation into the reasons chemistry students give for avoiding physics has merit in that the image of physics these students have will have to be changed if larger physics enrollments are forthcoming.

3. More extensive direct and indirect evaluations of physics teachers by their students may give a clearer picture of the physics teacher's effect on physics enrollment.

EPILOGUE

There is little comfort derived in noting that the recommendations that have been made for improving physics enrollments as a result of this study are very similar to some of the recommendations H. Emmett Brown made three decades ago for improving physics instruction. It may be that the lack of research on physics enrollment problems stems from the realization that the results of such endeavors will become a part of the literature and never implemented.

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APPENDIX

The study being undertaken by Mr. Thomas Van Koevering, in my opinion, is one of the most significant now underway in science education anywhere in the United States. At Western Michigan University we have been greatly concerned about the small number of students electing physics either with intentions to teach or to enter industry. Obviously, the situation is self-defeating, since a shortage of teachers of physics only reduces the number of students in high school who are likely to be motivated to enter physics in college.

Somehow the cycle must be broken. But, without having better information than we have at the present time, it is highly unlikely that any tangible gains may be made. Mr. Van Koevering's study is one move to obtain on-the-spot information which may be helpful in solving the problem.

Obviously, the information needed for a solution must, in part, come from the high schools. Therefore, I hope that it will be possible for you to participate in this study in the hopes of improving the situation in the years ahead.

Sincerely,

George G. Mallinson, Dean

Dear (Principal's Name):

I am certain that you are familiar with the various programs concerning high school physics that have been sponsored by the National Science Foundation and other agencies for the past decade. The purposes of these programs have been to increase the competence of high school physics teachers and to introduce a new approach to teaching physics through the PSSC physics project. In spite of all these efforts which have cost millions of dollars, high school physics enrollments are decreasing at an alarming rate. The number of physics majors in college is also declining steadily which gives a partial explanation for the acute shortage of high school physics teachers.

The Science Education Committee of Western Michigan University is making an effort to determine the reasons why students are not enrolling in physics at both the high school and college level. In order to begin this investigation enrollment data are required to determine the present pattern of physics enrollment in Michigan. Obviously individual high schools are the only sources for this information.

Approximately four hundred schools, or about one-half the high schools in Michigan, are being asked to provide the information requested in the enclosed questionnaire. A sample of about sixty schools will be selected from this population for a more intensive study. You are one of these being asked to serve as a source of data.

Since you may be interested in the result of the initial phase of the study, you will receive a copy of the various data tabulations, including specific information about your school. You can be assured that the science enrollment statistics of your school will be held in the strictest confidence.

We would appreciate hearing from you as soon as possible since without your assistance, data needed for analyzing this problem will not be available.

Thank you very much for your assistance in this study.

Sincerely yours,

Dear (Principal's Name):

A short time ago you received a questionnaire concerning problems with enrollments in physics. Already more than 80% of the 373 Michigan high schools that were contacted have responded, your school being one of them. We are more than pleased with your cooperation. The data are now being compiled and a copy of the results will be sent to you in the near future.

It has been particularly gratifying to note that your high school, as well as nearly every other high school responding to the questionnaire, has indicated an interest in participating in the second phase of this study. Your high school is one of sixty that has been selected to be given an opportunity to participate in this second phase, if you so choose.

The purpose of the second phase of the study is to reveal some of the reasons why some students elect physics in high school and others do not. This is critical considering that physics enrollment has increased only one third as fast as the number of high school graduates during the last decade despite the increased emphasis on the importance of physics. Contacts will have to be made with students presently taking physics and potential physics students for next year. I would like to contact some of the students in your school by making a single visit sometime between February 1 and April 15, 1969.

During the visit, I would like to administer questionnaires to students in the chemistry and physics classes. This should require about ten minutes in each chemistry class and twenty minutes in each physics class. I would also like to have brief individual discussions with you, the principal, as well as with the physics teachers, the chemistry teachers, and the guidance counselors. You can be assured that all data obtained will be held in the strictest confidence. An appointment for the visit will be made in advance so that the data can be obtained with a minimum of interference.

Thank you very much for your assistance in this study.

Yours truly,

PARTICIPATING SCHOOLS

Athens High School
Holcomb Street
Athens, Michigan

Springfield High School
765 Upton Avenue
Battle Creek, Michigan

Blissfield High School
630 Lane
Blissfield, Michigan

Byron Center High School
8542 Byron Center
Byron Center, Michigan

Center Line High School
26300 Arsenal
Center Line, Michigan

Centreville High School
Centreville
Michigan

Coloma High School
West Street
Coloma, Michigan

Constantine High School
750 Canaris
Constantine, Michigan

Dansville High School
1264 Adams Street
Dansville, Michigan

Delton-Kellogg High School
Delton
Michigan

Cody High School
18445 Cathedral
Detroit, Michigan

Ecorse High School
4165 7th Street
Ecorse, Michigan

Lake Fenton High School
11425 Torrey Road
Fenton, Michigan

Central High School
431 Fountain Street, N.E.
Grand Rapids, Michigan

East Grand Rapids High School
1121 Lake Drive
Grand Rapids, Michigan

Grayling High School
500 Spruce
Grayling, Michigan

Greenville High School
111 Hillcrest
Greenville, Michigan

Hemlock High School
733 N. Midland
Hemlock, Michigan

West Ottawa High School
1024 N. 136th Avenue
Holland, Michigan

Jackson High School
544 Wildwood
Jackson, Michigan

Lakewood High School
Velte Road, Route 3
Lake Odessa, Michigan

Leslie High School
400 Kimball Street
Leslie, Michigan

Ludington High School
N. Washington Avenue
Ludington, Michigan

Merrill High School
555 W. Alice
Merrill, Michigan

Midland High School
1301 Eastlawn Street
Midland, Michigan

Catholic Central High School
Barclay at Laketon
Muskegon, Michigan

North Muskegon High School
1500 Mills Avenue
North Muskegon, Michigan

Okemos High School
Okemos Road
Okemos, Michigan

Parchment High School
1916 East "G" Avenue
Parchment, Michigan

Perry High School
Britten Road
Perry, Michigan

Quincy High School
41 East Jefferson
Quincy, Michigan

Avondale High School
1435 West Auburn Road
Rochester, Michigan

Rochester High School
180 S. Livernois
Rochester, Michigan

Brablec High School
16250 Martin Road
Roseville, Michigan

Arthur Hill High School
3115 Mackinaw Street
Saginaw, Michigan

Wilson High School
Cass Street
St. Johns, Michigan

Saline High School
7265 N. Ann Arbor Street
Saline, Michigan

Saranac High School
150 Pleasant
Saranac, Michigan

Southgate High School
15475 Leroy Avenue
Southgate, Michigan

Lakeshore High School
John Beers Road & Cleveland Avenue
Stevensville, Michigan

Sturgis High School
216 Vinewood
Sturgis, Michigan

River Valley High School
Route 2, Box 330
Three Oaks, Michigan

Traverse City High School
Eastern at Milliken
Traverse City, Michigan

Union City High School
430 St. Joseph
Union City, Michigan

Maple Valley High School
Nashville Highway
Vermontville, Michigan

Cousino High School
30333 Hoover Road
Warren, Michigan

Warren High School
5460 Arden
Warren, Michigan

Ogemaw Heights High School
West Branch
Michigan

PARTICIPATING SCHOOLS CONTINUED

White Pigeon High School
Lincoln at Hotchin Street
White Pigeon, Michigan

Williamston High School
3845 Vannetter Road
Williamston, Michigan

Godwin Heights High School
15 36th Street, S.W.
Wyoming, Michigan

Zeeland High School
320 E. Main Street
Zeeland, Michigan

HIGH SCHOOL PHYSICS TEACHER

1. Present teaching load:

2. How many semester hours (or their equivalent) have you in:

	Undergraduate	Graduate
(a) Physics		
(b) Chemistry		
(c) Biology		
(d) Earth Science		
(e) Mathematics		
(f) Education		

3. Do you have a masters degree? Yes____ No____ If yes, in what area? ______________________________

4. Have you attended any summer institutes in physics? Yes___ No___

5. If you have attended summer institutes, which of the following best characterizes the course work?
   (a) ___Regular graduate work in physics.
   (b) ___Comparable to undergraduate course work in physics.
   (c) ___Methods courses in teaching physics.

6. When did you take your last course for college credit? ________

7. How many years have you taught? ____________________
   How many years have you taught physics? ______________
   How many years have you taught in this school? __________

8. What physics textbook are you using?
   Name ______________________________
   Author ______________________________
   Publisher ______________________________
   Year ______________________________

9. If given a choice which course would you prefer to teach in this school? ___Traditional, ___PSSC, ___Harvard Project Physics.

10. Do you believe there are any students in the present senior class who are qualified to take physics but are not taking the course?

    (a) ____None
    (b) ____Perhaps 5%
    (c) ____Perhaps 15%
    (d) ____Perhaps 25%
    (e) ____Perhaps 40%

11. Please indicate your reaction to the following statements:

"No matter how you look at it, physics has to be a hard course."

(a) ____Strongly agree
(b) ____Agree
(c) ____Disagree
(d) ____Strongly disagree

"Physics has many aesthetic values and so it should be taught to at least one half of the students in high school."

(a) ____Strongly agree
(b) ____Agree
(c) ____Disagree
(d) ____Strongly disagree

12. If you feel that more students should be taking physics, what suggestions would you offer to increase enrollment?

13. What suggestions would you offer to increase the number of people going into physics teaching?

14. What do you feel are the minimum pre-requisites for students who wish to take physics?

(PHYSICS STUDENTS)

NAME____ GRADE_______________

1. Do you plan to attend college?

    1. ______ Definitely will
    2. ______ Probably will
    3. ______ Completely undecided
    4. ______ Probably not
    5. ______ Definitely not

2. Vocational plans ____

3. Please reply to three responses in this question. Place a 1 by the most important reason for you taking physics, a 2 by the second most important reason, and a 3 by the third most important reason.

    1. ______ It has a reputation as a difficult subject and I like the challenge.
    2. ______ Many of my close friends are taking the course.
    3. ______ I think the subject matter is interesting and I enjoy science courses.
    4. ______ The counselor and/or my parents recommended that I take the course.
    5. ______ I heard that the course was taught by a good teacher and that many students enjoyed the course.
    6. ______ The subject is required for my future college and/or career plans.
    7. ______ Other (Please Specify) ______________________________

4. Please indicate which science courses you have taken during your ninth, tenth, and eleventh grades. If the course has a particular letter or number to distinguish it from another similar course at your school, please indicate which course you took.

    1. ______ General Science
    2. ______ Earth Science
    3. ______ Physical Geography
    4. ______ Biology
    5. ______ Physics
    6. ______ Physical Science
    7. ______ Second-Year Biology
    8. ______ Chemistry
    9. ______ Second-Year Chemistry
    10. ______ Other (Please Specify) ______________________________

5. Will you please list the courses that you took last semester and your first semester grades.

    COURSE____ GRADE_______________

(CHEMISTRY STUDENTS)

GRADE______________ MALE______________ FEMALE______________

1. Do you plan to attend college?

   1. ______ Definitely will
   2. ______ Probably will
   3. ______ Completely undecided
   4. ______ Probably not
   5. ______ Definitely not

2. Vocational plans ______________________________

3. Do you plan to take physics next year?

   1. ______ Definitely will
   2. ______ Probably will
   3. ______ Completely undecided
   4. ______ Probably not
   5. ______ Definitely not

4. If you think you will take physics next year (response 1 or 2 in question 3) please reply to three of the responses in this question. Place a 1 by the most important reason, a 2 by the second most important reason, and a 3 by the third most important reason.

   1. ______ It has the reputation of being a difficult subject and I like the challenge.
   2. ______ Many of my friends are taking the course.
   3. ______ I think the subject matter will be interesting because I enjoy science courses.
   4. ______ The counselor and/or my parents recommend that I take the course.
   5. ______ I have heard that the course is taught by a good teacher and that many students enjoy the course.
   6. ______ The subject is required for my future college and/or career plans.
   7. ______ Other (Please Specify) ______________________

5. If you are undecided or do not plan to take physics next year (response 3, 4, or 5 in question 3) please reply to three of the responses in this question. Place a 1 by the most important reason, a 2 by the second most important reason, and a 3 by the third most important reason.

   1. ______ I think the subject will be too difficult for me.
   2. ______ I am afraid that a possible low grade will hurt my average.
   3. ______ I do not think that I would like the teacher.

4. ______ The counselor and/or my parents advised me not to take the course.
5. ______ I have very little interest in the subject matter.
6. ______ I will not need any additional science for my college and/or career plans.
7. ______ It conflicts with another course. (Please Specify) ______________________________
8. ______ None of my close friends are taking the course.
9. ______ Other (Please Specify) ______________________________

6. Please indicate which science courses you have taken during your ninth, tenth, and eleventh grades. If the course has a particular letter or number to distinguish it from another similar course at your school please indicate which course you took.

1. ______ General Science
2. ______ Earth Science
3. ______ Physical Geography
4. ______ Biology
5. ______ Physics
6. ______ Physical Science
7. ______ Second-Year Biology
8. ______ Other (Please Specify) ______________________________

HIGH SCHOOL COUNSELORS

1. Have you held your present position for more than one year?
   Yes______ No______

2. What prerequisites do you use as guidelines for advising students about taking high school physics?

3. Do you believe there are any students in the senior class who are qualified to take physics but are not taking the course?

   (a) _____ None
   (b) _____ Perhaps 5%
   (c) _____ Perhaps 15%
   (d) _____ Perhaps 25%
   (e) _____ Perhaps 40%

4. Please indicate your reactions to the following statements:
   "No matter how you look at it, physics has to be a hard course".

   (a) _____ Strongly Agree
   (b) _____ Agree
   (c) _____ Disagree
   (d) _____ Strongly Disagree

   "Physics has many aesthetic values and so it should be taught to at least one-half of the students in high school."

   (a) _____ Strongly Agree
   (b) _____ Agree
   (c) _____ Disagree
   (d) _____ Strongly Disagree

5. If you feel that more students should be taking physics, what suggestions would you offer to increase enrollments?