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ABSTRACT

This paper presents the procedures, results, and conclusions of a study designed to determine if high schools with either high or low enrollments in physics exhibit any distinguishing characteristics that are measurable. The study involved 48 schools, 51 physics teachers, and 3767 students in the State of Michigan. Questionnaires were administered to (1) physics teachers, (2) physics students, (3) chemistry students, and (4) guidance counselors to collect data pertaining to the personality characteristics of the physics teachers, teaching loads, teaching experience, the learning environment, physics enrollment, the vocational choices of physics students, achievement and grades in physics and the reasons students give for taking physics. The findings show that (1) only a small percentage of students indicated that the physics teacher had either a positive or negative influence on their decision to take physics, (2) guidance counselors were more stringent than physics teachers with regard to the mathematics prerequisite of physics students, and (3) physics grades were in all cases lower than the grades physics students received in their other academic subjects. Some ideas for improving the physics enrollment are presented. Bibliography. (LC)

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

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Introduction

The percentage of high school students enrolling in physics has been declining for more than half 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.

According to Hunter (1) a partial explanation for the early declines in physics enrollment can be attributed to changes in science curriculum structure that resulted in moving physics from the eleventh to the twelfth grade. Consideration must also be given to the fact that high schools during the first quarter of this century were changing to accommodate a more general population. These arguments cannot be used to explain the decline in physics enrollments in the last ten years.

It is generally accepted that during the past decade the National Science Foundation has had the most important influence on high school physics. The NSF has provided support in two important areas; (1) a total of $5,276,683 (2) was allocated to the Physical Science Study Committee for de· ·oping a new phys.cs 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 (3) and 97 Inservice-Service institutes have provided instruction for teachers in the philosophy and use of PSSC materials. It seems anomalous to note that from 1960, when PSSC was first available to high schools, until 1965 physics enrollments have dropped from 24.64 percent to 19.61 percent of the senior class. (4)

The effects of lower enrollments in high school physics could perhaps explain inpart why the number of college graduates with majors in physics has decreased from 5622 in 1962 to 5250 in 1967 (5). This decrease in turn is reflected in the number of qualified physics teachers that are available. Sawyer (6) 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 teachers being trained each year is about five hundred with only three hundred actually entering the teaching field.

The current approach to the solution of the problem of low enrollments in high school physics has centered around curriculum innovation. The literature reveals 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 Problem and Hypotheses

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. After completing a review of the related literature twenty-three hypotheses were formulated that relate to the following areas: the personality characteristics of the physics teachers; the physics students evaluations of their physics teachers; physics students evaluations of the learning environment in the physics class room; the teaching loads and years of teaching experience of the physics teachers; opinions of the physics teachers and guidance counselors concerning physics enrollments at their high school; whether PSSC physics was being taught at the high school and the physics teachers preference for PSSC; mathematics prerequisites for physics as determined by the physics teachers and the guidance counselor; the vocational choices of the physics students; the reasons physics students gave for taking physics and the reasons chemistry students gave for wanting to or not wanting to take physics; the grades, and physics achievements of the physics students; whether the high schools offered two levels of first year biology, chemistry, and physics; and second year courses in biology and chemistry; percent of seniors going on to college; and the percent of the students dropping out of school.

Each hypothesis was given in the null form and was rejected at the .05 level of confidence.

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 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, or 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. The numbers and distributions of students, physics teachers, and high schools included in the sample are given in Table I.

TABLE I

SAMPLE POPULATION STATISTICS

Groups	Chemistry Students	Physics Boys	Students Girls	Physics Teachers	Schools
Class A Schools	(1100 or more -- grades 9-12)				
High	577	436	123	11	8
Low	457	193	42	8	8
Class B Schools	(450 - 1099 -- grades 9-12)				
High	483	257	73	8	8
Low	394	79	15	10	10
Class C Schools	(250 - 499 -- grades 9-12)				
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

Instruments Used

A visit was made to each of the high schools in the sample in order to administer questionnaires to (1) physics teachers, (2) physics students, (3) chemistry students, and (4) guidance counselors.

Two questionnaires were administered to the physics teachers: The *Sixteen Personality Factor Questionnaire* and the Physics Teacher Questionnaire.

1. *The Sixteen Personality Factor Questionnaire* developed by Cattell (7) 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 factor analysis. A complete description of the questionnaire is found in Cattell and Eber (8).

2. The second questionnaire that was administered to Physics teachers was developed to obtain information concerning the teacher's training, teaching experiences, and opinions about high school physics.

Three questionnaires were administered to the physics students: *The Student Opinion Questionnaire*, *The Learning Environment Inventory*, and a Physics Student Questionnaire.

1. *The Student Opinion Questionnaire* (9) 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".

2. The Learning Environment Inventory was developed by Herbert J. Walberg and Gary J. Anderson (10) of Harvard University. Walberg used this instrument to measure the students evaluation of physics classroom environments. He found that relationships do exist that are significant between the factors included in the inventory and some aspects of physics teachers' personality.

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) other science courses taken, and (4) the grades received in physics as well as in other courses in which the student was presently enrolled.

The physics students achievement in physics was measured using the Dunning Abeles Physics Test. Dunning and Abeles (11) indicate that 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.

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 for their three most important reasons for taking the course, (5) if they were not going to take physics they were asked for their three most important reasons for avoiding the course, (6) the other science courses they had taken.

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 the 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 drop outs and the numbers of students going to college were obtained from the counselor or the high school principal.

Analysis

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 and guidance counselor to questionnaires or the mean values of 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 two groups by using a "t" test (12).

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 (13).

Results

Comparisons of the mean values obtained for the sixteen personality factors from the Sixteen Personality Factor Questionnaires of 19 physics teachers from high schools with high physics enrollments with those of 16 physics teachers from high schools with low physics enrollments resulted in the following: The factors with "t" ratios of less than 1.0 were: Reserved vs Outgoing, Humble vs Asserting, Sober vs Happy-go-lucky, Tough Minded vs Tender Minded, Trusting vs Suspicious, Practical vs Imaginative, Self-assured vs Apprehensive, Conservative vs Experimenting, Group-dependent vs Self Sufficient, and Relaxed vs Tense. Factors with "t" ratios less than 1.6 were: Less vs More Intelligent, Conscientious vs Expedient, Venturesome vs Shy, Shrewd vs Forthright, and

Controlled vs Undisciplined Self- onflict; with the physics teachers from the high schools with higher physics enrollments exhibiting a g. ater tendency for the latter characteristics in each case. The t ratio had to exceed 2.037 in order to be significant at the .05 level, thus, the only personality factor for which the null hypothesis could be rejected was the factor: Affected by Feelings vs Emotionally Stable in which the physics teachers from high physics enrollment were significantly more affected by feelings ($t = 2.725$) then were their counterparts in the low physics enrollment groups.

The analysis of results from the Student Opinion Questionnaire indicates that the instrument measured very small differences ($t < 1.0$) between the two groups with recpect to: Knowledge of Subject Matter, Clarity of Explanations, Fairness, Control, Attitude Toward Students, Ability to Stimulate Interest, Attitude Toward Subject, Attitude Toward Student Opinions, Variety in Teaching Procedures, Encouragement of Student Participation, Sense of Humor, and Planning and Preparation. The only finding for all three classes that was consistant was 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 they are teaching then did the physics students from high schools with low physics enrollments.

The Learning Environment Inventory purports to measure the following factors: Intimacy, Cliqueness, Favoritism, Satisfaction, Difficulty, Democracy, Diversity, Friction, Apathy, Formality, Speed, Goal Direction, Disorganization and Environment. The only one that was significantly different (2.368 where significance at .05 = 2.007) was the democratic factor. More democracy in physics classes from high schools with low physics enrollments is probably a result of 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 of students than a large one.

Comparisons of the number of other science and mathematics courses taught by the physics teachers indicated that, as was expected, physics teachers from high schools with low percentage enrollments in physics did teach more additional science and mathematics courses. The differences, however, in the number of other courses taught by the teachers from the high and low physics enrollment groups were not significant.

There were no significant differences in the college preparations and number of years of teaching experience of physics teachers from high schools with high or low percentage enrollments in physics. The teachers averaged about 24 semester hours in physics, 22 semester hours in chemistry, 13 semester hours in biology, 4 semester hours in earth science, 24 semester hours in mathematics, and 33 semester hours in education. Physics teachers from both the high and low physics enrollment groups averaged about 12 years of teaching experience, they had taught physics for about nine years and had taught in that particular school for about seven years.

The physics teachers and guidance counselors were asked to express their opinions concerning (1) the percent seniors that they consider qualified but not taking physics, (2) whether physics is a hard course, and (3) whether physics should be taught to one half of the students in the school. The differences between the teachers from high and low physics enrollment groups and the differences between the guidance counselors from the high and low physics enrollment groups were not significant. The teachers and guidance counselors in both enrollment groups indicated that they believe about twenty percent of the seniors in their schools are qualified but are not taking physics. The guidance counselors and physics teachers both indicated they believe that physics does not have to be a hard course; the latter more so than the former. The guidance counselors only slightly disagree while the physics teachers only slightly agree with the statement that physics should be taught to one half of the students in the high school.

The guidance counselors and physics teachers were each asked to indicate what they believed to be the minimum mathematics prerequisites for physics. More of the physics teachers from high schools with high percentage enrollments believed that geometry or less is sufficient than do their counter parts from the high schools with low percentage enrollments. The differences, however, were not significant at the .05 level. More of the guidance counselors from the high schools with high percentage enrollments also believe that geometry or less is sufficient than do the guidance counselors from high schools with low percentage enrollments in physics. The differences between the opinions of the two groups of guidance counselors in this instance were significant at less than the .01 level.

A comparison of the number of high schools using PSSC physics and the preference of the physics teachers for PSSC physics indicated that there were no significant differences between the number of teachers in each enrollment group who were either using or who preferred to use PSSC.

The physics students were asked to indicate their vocational plans and then the individual student responses were put into one of the following categories: (1) Physical Science and Engineering, (2) Other Science and Mathematics, (3) Non-Science, (4) Undecided. A comparison of the percentages of physics students in each category from high schools with either high or low enrollments in physics indicates that there are significantly smaller percentages of physics students who plan to enter vocations in the physical sciences or engineering and significantly larger percentages of students in the non-science area in schools that have high percentage enrollments in physics than in schools with low percentage enrollments in physics. Considering that high schools with high physics enrollment schools obviously have more physics students, the actual number of physics students entering the physical sciences and engineering from both groups may be about the same. The larger physics enrollments that characterize the one group of high schools are accounted for by the fact that they have greater numbers of non-science students taking physics.

An examination of the grades the students received in physics and in their other courses indicates that the students from high schools with low enrollments in physics do receive better grades in physics and better grades in other academic areas then do their counterparts from high schools with high enrollments in physics. The physics grades of students in each group, however, were lower than their average grades in other academic subjects.

A comparison of physics achievements using only a small portion of the sample population (15 schools) indicated that there was no significant difference between the physics achievements of students from high schools with either high or low percentage enrollments in physics.

The physics students were asked to select their three most important reasons for taking the course, while the chemistry students were asked to select their three most important reasons for wanting to or not wanting to take physics. High schools with high percentage enrollments in physics had higher percentages of students indicating that they were taking or want to take physics because the course was recommended by their parents or counselors, they thought they would like the teacher, or their friends were taking the course, than did high schools with low percentage enrollments in physics. The high schools with low physics enrollments have higher percentages of chemistry and physics students indicating they are taking physics or want to take physics because they enjoy the challenge or they feel the course is required for their future. A larger percentage of the chemistry students from these schools indicated they do not want to take physics because they feel it will be too hard. Not enough of the differences between the high and low physics enrollment groups were significant, however, to provide evidence for decisive conclusions in regard to the opinions expressed by the students.

There were no significant differences between the high and low physics enrollment groups as to the number of high schools that have two levels of first-year biology and chemistry. A significantly larger number of Class A high schools with high enrollments in physics do offer two levels of first-year physics and advanced science courses then did Class A high schools with low physics enrollments. The differences for Class B and C schools were not significant because most of the high schools were too small to offer more than first-year science courses.

The percent of students going on to college was significantly higher in the high schools with high percentage enrollments in physics than high schools with low percentage enrollments. The percent of students dropping out of school each year was not significantly different between the high and low physics enrollment schools.

Conclusions and Recommendations

The following conclusions and recommendations for improving enrollments are based on the statistical results of this study and the impressions derived while visiting the high schools in the sample.

Although the physics teachers as a group from high schools with high percentage enrollments in physics were considered to be more affected by feelings and somewhat more enthusiastic about the subject they were teaching, only a small percentage of the physics and chemistry students in each enrollment group indicated that the physics teacher had either a positive or negative influence on their decision to take physics. More extensive direct and indirect evaluations of physics teachers by their students may give a clearer picture of the physics teacher's effect, if any, on physics enrollments.

There were several differences between the opinions of the physics teachers and guidance counselors. More physics teachers than guidance counselors indicated that they thought physics should be taught to one half of the students in high school; yet, the physics teachers identified smaller percentages of students who are qualified but are not taking physics. Two-thirds of the physics teachers from the high schools with low percentage enrollments in physics indicated that geometry or less was a sufficient mathematics prerequisite for physics, while three-fourths of the guidance counselors in this same group indicated that more than geometry was required for physics.

One question that can be raised is what qualifications must a student possess in order to be successful in physics. The mathematics prerequisite; as presented by guidance counselors, of three years of high school mathematics is directly linked to low enrollments. The measure of success in physics is still an open question because physics grades were in all cases lower than the grades physics students receive in their other academic subjects. It seems quite likely that physics enrollments could be improved if physics teachers graded their students on a scale similar to the scales used by teachers in the other academic

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