A STUDY OF THE EFFECTIVENESS OF SEVERAL SEQUENCES OF SCIENCE COURSES IN SECONDARY SCHOOLS

A Thesis

Presented to

the Faculty of the Department of Psychology

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

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Jack Franklin Folmar

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ABSTRACT

The problem. The purpose of this study was to determine the effect of training in a given area of science on achievement in other areas of science. Specifically, the purpose was fourfold: namely, in high school sciences, to determine the effect of training in (1) general science on achievement in chemistry; (2) biology on achievement in chemistry; (3) physics on achievement in chemistry; (4) chemistry on achievement in physics.

Procedure. The subjects for this study were 403 students in grades eleven and twelve who were enrolled at three different high schools in the year 1953-1954. Ninety-nine were chemistry and 23 were physics students at the first school; 128 were chemistry and 78 were physics students at the second school; and 75 were the total chemistry and physics students at the third school.

The chemistry students at each school were grouped according to their previous science enrollment. The groups consisted of (1) students who had taken general science or had not taken general science prior to enrollment in chemistry; (2) students who had taken biology or had not taken biology prior to enrollment in chemistry; and (3) students who had taken physics or had not taken physics prior to enrollment in chemistry. Also, students who were taking physics and chemistry concurrently were compared with those students who had taken physics and chemistry consecutively. Only students at the second school were compared in the third group.

Sub-groups for the physics students consisted of students who had taken chemistry or had not taken chemistry prior to enrollment in physics. Students of the first and third schools had to be combined for this grouping.

Groups which were compared were equated for intelligence.

Objective tests were used to measure achievement of the groups at the first school, and the remainder of the groups were measured by teachers' grades. Mean differences for each of the experimental and control groups were checked for significance in the usual manner.

A product-moment correlation coefficient was calculated between chemistry grades and general science grades of chemistry students in all three schools.

Results and conclusions. At the first school, chemistry students who had taken general science showed a higher mean grade than the non-general science students, and the difference was significant at the 1% level of confidence. The mean grades at the second and third schools did not corroborate this result.

At each of the three schools chemistry students having had biology showed no significant difference when compared with non-biology students.

Chemistry students who had taken physics showed a higher mean grade than the non-physics students. The difference was significant at the .05 level. There was no significant difference between the concurrent and consecutive groups, nor the group taking the courses in reverse order.

The correlation of chemistry and general science grades with intelligence partialed out was .52.

It can be concluded that:

1. General science courses have different transfer effects in different schools.

2. It seems that physics taken before chemistry results in superior achievement in the latter course.

3. The biology courses at the high school level seem peculiarly free of transfer toward the physical sciences.

4. Whether physics is studied before or concurrently with chemistry apparently has little effect on achievement.

5. The correlation of grades of general science and chemistry students may be used for prediction with some degree of confidence.

LIST OF TABLES

CHAPTER I

THE PROBLEM AND IMPORTANCE OF THE STUDY

I. THE PROBLEM

The purpose of this study was to determine the effect of training in a given area of science on achievement in other areas of science. Specifically, the purpose was fourfold: namely, in high school sciences, to determine the effect of training in (1) general science on achievement in chemistry; (2) biology on achievement in chemistry; (3) physics on achievement in chemistry; (4) chemistry on achievement in physics.

II. IMPORTANCE OF THE PROBLEM

It is important in secondary school teaching, guidance, and curriculum planning to understand the possibility of transfer between courses. Some courses, like English and mathematics, have prerequisites determining the order of courses, while in many high schools, science courses have no definite sequence or prerequisites.

Odell (7) explains that among the reasons that comparatively few good science tests have been published is the lack of unanimity in the order of science offerings in the high schools.

That there is no agreement in the nation's high schools as to the order of grade levels of the commonly accepted science courses is shown by Johnson (5) in his study for the Office of Education. Although

biology is usually a tenth grade subject, chemistry eleventh grade, and physics twelfth grade in most of the schools offering the subjects, a number of the schools have different orders for the courses. It would seem, therefore, that studies of achievement in courses taken in different orders may help establish the proper order for these courses and may aid in developing new courses or improving the accepted ones.

It seems that it should be possible to predict a student's achievement in one of the science courses on the basis of his prior science work and/or indicated interests and aptitudes. Also, better curriculum planning should follow known effects that training in one science has on achievement in another science.

Teacher differences, school differences, transfer of training, motivation, and objectivity of measures of achievement are problems that arise in such a study, and it is hoped that the results obtained in this study will promote further investigations in the science curriculum.

CHAPTER II

REVIEW OF THE LITERATURE

A survey of the literature revealed no research which was related directly to the present problem, although several studies which relate indirectly were found. Anderson (1), on completion of a study of Minnesota schools, reports:

> The present study did not determine the contributions to achievement in biology and chemistry of such pupil factors as previous courses taken in science and years of high school mathematics taken. ... The data are available and other comparisons can be made at a future date.

In a recent letter (April 25, 1955), answering this writer's inquiry, Anderson says, "... I know of no study related directly with your problem. This does not mean that such a study has not been done or does not exist in the literature. ..."

In a pre-publication statement, Herbert A. Smith of the editorial staff of The Third Annual Review of Research in Science Education says:

> "..., I believe that I may safely say that no studies were reported which related to the effect of prior science courses. However, some studies will be reported which show the effect of high school science on college performance in certain science areas."

A number of studies of the latter type have substantiated Smith's statements. Hadley, Scott, and Van Lente (4) examined the high school records of 696 students who were enrolled in beginning college chemistry. They found that the group that had studied high school chemistry, physics, and mathematics had the lowest percentages of "D" and "E" grades and the

highest percentages of "A", "B", and "C" grades. A comparison of students who had had high school chemistry with those who had had no high school chemistry, with mathematics and physics preparation disregarded in both groups, showed marked superiority for those who had studied chemistry. Students who had had a combination of high school chemistry, physics, and mathematics made the best records in beginning chemistry in college.

Fontenella (3) investigated the use of the American Council on Education's Psychological Examination and General Achievement tests as predictors of achievement in college chemistry and biology. The subjects of this study were 25 freshmen pre-medical students at Fordham College, New York. Using rho (rank-order correlation), he found that achievement test scores and chemistry grades correlated .518; ACE scores and chemistry grades, .694; achievement test scores and biology grades, .808; ACE scores and biology grades, .60.

That interest and retention of early secondary school science is of some lasting benefit has been found by Flather (2). According to his evaluation of the science program in the high schools of British Columbia, the ninth grade general science course has been rather successful in developing students and diffusing ideas into society. He bases his conclusions on former students' opinions.

Not all investigators agree that high school courses favorably affect achievement in subsequent college courses. In a letter, E. L. Miller, professor of biology at Stephen F. Austin State College, reports that first year college students of biology apparently do not benefit

from having high school credit for the course. His investigation of the high school background of failures in introductory college biology revealed that about 51% had high school biology and 49% did not.

Powers (10) is of the opinion that high school science preparation is not of significant importance to later studies in science. He says that, "Many who have become career men in science began ... in college with no apparent disadvantage as compared with ... classmates who had studied science in high school."

Mallinson and Van Dragt (6) reviewed two studies concerned with the interests of high school students. From these studies, they concluded that:

> The possibilities for predicting a person's score or rank in interest in science ... at the twelfth-grade level from the scores or ranks at the ninth grade level are somewhat dubious.

Odell (8) has reported that grades in high school can be predicted by earlier achievement in school. He found that by weighting and combining marks in certain elementary school subjects, the correlation with high school freshman marks averaged .65. Marks during the first two years of high school correlated slightly lower.

Another study by Odell (8) showed about the same degree of correlation between college freshman marks and the best possible combination of intelligence test scores and marks in different high school subjects. The correlation was .63 for the best combination and greater than .50 for less than half of the college subjects.

Travers (13) indicates that aptitude tests are no better for predictive purposes than the methods used by Ross and Odell. He found

that aptitude and achievement can not be correlated properly without better criteria than high school grades.

More and more, general science is coming to be required of all students as the first science course in high school. The reasons listed by Preston (11) are (1) orientation for those who must shortly go to work, and (2) foundation for higher science study. The course is usually given from a different point of view than are physics and chemistry, and, therefore, there should be no great amount of repetition in these courses.

At the time of Preston's (12) study in 1936, most science curricula were composed of the four courses now generally accepted: general science, biology, chemistry, and physics. He suggested an improved arrangement of work to follow a four year plan. The courses would be of graduated difficulty so that a student may progress as far as he wishes or is capable. He foresaw, however, the possibilities that elementary and junior high school science courses might provide preparation for successive courses, making it possible to leave senior high school sciences as elective.

CHAPTER III

GROUPS STUDIED AND TESTS AND MEASURES USED

I. GROUPS STUDIED

The subjects for this study were 403 students in grades eleven and twelve who were enrolled at three different high schools in the year 1953-1954. These schools are designated as School Number One, School Number Two, and School Number Three in this study. Of the 403 students, 93 were chemistry and 23 were physics students at School Number One; 128 were chemistry and 78 were physics students at School Number Two; and 73 were the total chemistry and physics students at School Number Three.

For the sake of clarity in presentation of the data, the three schools are indicated by a subscript in the different groups studied. For example, Group A_1 was made up of chemistry students in School Number One. Groups A_2 and A_3 were chemistry students in School Number Two and School Number Three respectively. This system of identifying groups is followed throughout the study.

Groups A_1, A_2, A_3, were each divided into two sub-groups, one of which was made up of students who had studied general science before enrollment in chemistry, and the other group was made up of students who had not studied general science.

Group B consisted of chemistry students who either had taken biology, or had not taken biology prior to enrollment in chemistry. Students from School Number One and School Number Two participated in this section of the study; therefore results are reported for Groups B_1 and B_2.

Group C consisted of chemistry students who had taken physics or who had not taken physics prior to enrollment in chemistry. School Number Two was the only school in which this group could be studied. It is designated as C_2.

Group D consisted of physics students who had taken chemistry or who had taken no chemistry before enrollment in physics. Students of two schools had to be combined for this group, as only two physics students at School Number One had not had chemistry, and only six physics students at School Number Three had had chemistry. The group, therefore, is identified as Group D_{13}.

Other groups are reported briefly to help interpret the study.

II. TESTS USED

The California Test of Mental Maturity, Form 1950, was administered to all students reported in the study, except for rare cases where the Otis Quick Scoring Test was used. Groups which were compared were equated for intelligence by use of these tests.

The Kuder Preference Record proved to be of some value as an aid in interpretation of results. This test was used only at School Number Three.

For Groups A_1 and B_1, objective tests were used to measure achievement. Standardised tests, Series C, and accompanying workbook units in "Discovery Problems in Chemistry," by Eckert, Lyons, and Strevell, were used. Five units of work were covered for the period of the study, but two units, III and IV were excluded to insure validity.

The remainder of the groups were measured by teachers' grades. Letter grades were assigned the following numerical values for purposes of tabulation: A/—97, A—93, B/—88, B—83, C/—78, C—74, D—70, F—65. Where grades were recorded in numbers, the actual grades were tabulated. At School Number Two, the grades were recorded in letters; at School Number Three, most of the grades were recorded in numbers.

III. TREATMENT OF DATA

Mean scores were obtained for the raw scores of Group A_1 for each unit of work completed. The final tabulation contains the average scores for three units of work, which made it necessary to reduce the group in size because of absences on the dates of the regular tests. Make-up tests were not included. Mean scores were also obtained for the raw scores of Group B_1 and teachers' grades were used for all the other groups. Mean differences for each of the experimental and control groups were then checked for significance in the usual manner.

A product-moment correlation coefficient was calculated between chemistry grades of Group A_{123} and general science grades of the same students.

CHAPTER IV

RESULTS AND DISCUSSION

Achievement in chemistry for Group A_1 was checked at the end of three separate units of the course, and achievements of the general science and non-general science groups were compared. Average grades for the three units combined were then compared.

At the end of the first unit of work in chemistry, the general science group, A_1, showed a slight superiority over the non-general science group, the difference between the means being significant slightly below the 1% level of confidence. The differences between means of the same groups were significant at the .01 level at the end of both of the remaining units of the course. Table I shows data for an average of the three units of chemistry. This shows that the difference between means is significant at the .01 level.

To verify the results obtained for Group A_1, chemistry students at the same school in 1952 were grouped in the same manner. The students were taught by a different teacher, but the same workbook and standardized tests were used. It was found that the results for this group confirmed those obtained for Group A_1. This check was made for unit I only. A statistical analysis of raw scores yielded a critical ratio of 3.43, which indicates a significant difference at the .01 level.

TABLE I

AVERAGE OF THREE UNIT TESTS OF GROUP A_1 SHOWING THE DIFFERENCE IN SCORES OF GENERAL SCIENCE AND NON-GENERAL SCIENCE STUDENTS

	General Science N = 44	No General Science N = 14
Mean score	64.0	53.1
SD	12.5	13.6
Difference of means	10.9	
SE of difference	4.2	
Critical ratio	2.59	

For Group A_2, Table II, neither yearly averages nor first semester grades corroborated the results obtained for Group A_1. At the end of the first semester, a higher proportion of "A" grades was obtained by the group which had studied general science, but a Chi square of 1.74 calculated for the proportion indicated no significant difference.

Likewise for Group A_3, no significant difference was found between general science and non-general science students. These data are shown in Table III.

The Kuder Preference Record was used with Group A_3. Investigation failed to reveal any significant difference in science interest raw scores between students having had general science and those that had not.

Group B_1 showed no significant difference in means, but the difference was in favor of those students that had had no biology. The data for this group are shown in Table IV.

TABLE II

FIRST SEMESTER SCORES FOR GROUP A_2 SHOWING THE DIFFERENCE BETWEEN GENERAL SCIENCE AND NON-GENERAL SCIENCE STUDENTS

	General Science N = 62	No General Science N = 66
Mean grade	82.26	81.14
Difference of means	1.12	

Note: The difference of means is obviously too slight to merit further statistics.

TABLE III

SCORES FOR GROUP A_3 SHOWING THE DIFFERENCE BETWEEN GENERAL SCIENCE AND NON-GENERAL SCIENCE STUDENTS

	General Science N = 23		No General Science N = 15
Mean grade	78.42		81.17
SD	8.16		7.89
Difference of means		2.75	
SE of difference		2.77	
Critical ratio		.994	

TABLE IV

UNIT TEST SCORES OF GROUP B_1 SHOWING THE DIFFERENCE BETWEEN BIOLOGY AND NON-BIOLOGY STUDENTS

	Biology N = 45		No Biology N = 15
Mean score	56.9		60.5
SD	18.1		21.2
Difference of means		3.6	
SE of difference		6.1	
Critical ratio		.59	

Group B_2 showed the same slight negative trend as B_1 for the first semester grades. However, the slightly higher mean grades for the students with no biology does not indicate superiority, since the difference can be explained in terms of chance factors. These data are shown in Table V.

Group C_2 was first tabulated without correction for intelligence, as the difference of intelligence quotients between the groups was not significant at the .05 level. Chemistry students having had physics numbered 35 and those with no physics, 72. A critical ratio of 3.82 indicated that there was a significant difference between means, and the difference was significant beyond the 1% level of confidence in favor of those having had physics. A slight correction to better equate the group for intelligence resulted in a reduction of non-physics students to 48, the difference of means from 6.1 to 3.5, and the consequent critical ratio to 2.08. Table VI shows the proper statistics.

Since student load might have an effect on the results, the tabulation of grades of those having had physics in Group C_2 was compared with grades of 18 students who were taking the courses concurrently. There was no significant difference in the grades of the group. There was a difference in intelligence which tended to favor the concurrent group, which would indicate the possibility of a slight negative trend for achievement, though the difference was not significant.

TABLE V

FIRST SEMESTER SCORES OF GROUP B, SHOWING THE DIFFERENCE BETWEEN BIOLOGY AND NON-BIOLOGY STUDENTS

	Biology N = 92		No Biology N = 35
Mean grade	80.1		84.8
SD	15.6		9.13
Difference of means		4.7	
SE of difference		5.03	
Critical ratio		.936	

TABLE VI

SCORES OF GROUP C_2 SHOWING THE DIFFERENCE BETWEEN PHYSICS AND NON-PHYSICS STUDENTS

	Physics N = 35		No Physics N = 48
Mean grade	84.3		80.8
SD	6.5		5.3
Difference of means		3.5	
SE of difference		1.68	
Critical ratio		2.08	

Group D_{13} made a well balanced study group not possible in either school studied independently. The relationship of chemistry and physics was not as pronounced in this order of enrollment as in Group C_2. The critical ratio calculated from the difference of the means, being only 1.61, does not indicate a significant difference. The trend, however, is the same as the other significant relationships between the physical sciences. These data are shown in Table VII.

A correlation coefficient for chemistry and general science grades was computed for the 117 students in Group A_{123} having had both courses. A partial correlation was made to correct intelligence as a factor. The product-moment correlation for intelligence and chemistry grades was .32; for intelligence and general science grades, .29; for chemistry and general science grades, .566. The correlation of chemistry and general science grades with intelligence partialed out was .52. All of the correlations were significant beyond the .01 level.

The inconsistent results of the study regarding the effect of general science upon chemistry achievement in different schools may be explained in part by the nature of the course itself. According to Odell (9) there is less agreement on the content of the general science course than is true of the other high school science courses.

TABLE VII

GRADES FOR GROUP D_{13} SHOWING THE DIFFERENCE BETWEEN CHEMISTRY AND NON-CHEMISTRY STUDENTS

	Chemistry N = 26		No Chemistry N = 30
Mean grade	78.08		74.5
SD	8.15		9.95
Difference of means		3.58	
SE of difference		2.22	
Critical ratio		1.61	

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

The objective of this study was to determine the relationship between general science and chemistry, biology and chemistry, and physics and chemistry.

A review of the literature indicated that no studies have been made directly relating to the problem.

Four hundred and three students at three high schools were studied. They consisted of 99 chemistry and 23 physics students at one school, 128 chemistry and 78 physics students at the second school, and 75 total chemistry and physics students at the third school. All of the groups studied were equated for intelligence.

The chemistry students at each school were measured by the difference of mean grades (or scores) of those having had general science and no general science, biology and no biology, physics and no physics. At the first and third schools, the difference of mean grades of physics students having had chemistry and no chemistry was used for comparison.

Kuder Preference Records were used at the third school in an attempt to gain some insight as to the cause of the relationships.

A correlation coefficient was computed between the chemistry and general science grades of 117 students at the three schools that offered both courses.

The results of the studies to determine the effect of general science on later achievement in chemistry were inconsistent. There was a significant difference between chemistry students having had general science and no general science at School Number One, but the difference between like groups was not significant at Schools Two and Three.

Biology grades showed no significant relationship with chemistry grades.

Physics showed a decisive effect on chemistry achievement; but the study was limited to the second school, because insufficient data were available at the other two schools.

The possibility of some transfer of training from chemistry to physics was indicated in a combined study of the first and third schools. The results, however, are not considered to be significant, as were those found for the reverse order of the courses in the second school.

Students studying chemistry and physics concurrently showed no difference in achievement compared to students having physics and chemistry consecutively.

Chemistry grades for the students at all three schools correlated .52 with general science grades. Intelligence was partialed out. This (.52) is a significant relationship.

The Kuder Preference Record science interest raw scores showed no relationship for the dichotomy of chemistry students (general science and no general science) at the third school.

II. CONCLUSIONS

From this study it can be concluded that:

1. General science courses have different transfer effect in different schools. Interest, as a factor, is not a reliable indicator of achievement in the small groups studied.

2. With only one school from which to judge, it seems that physics taken before chemistry results in superior achievement in the latter course. The same statement can not be made for the courses in reverse order.

3. The biology courses at the high school level seem peculiarly free of transfer toward the physical sciences.

4. Whether physics is studied before or concurrently with chemistry apparently has little effect on achievement.

5. The correlation of grades of general science and chemistry students may be used for prediction with some degree of confidence. The relationship compares favorably with other measures reported.

III. RECOMMENDATIONS

It is suggested that more guidance based upon a recognition of certain facts may be advantageous for certain students, such as the influence of general science on achievement in chemistry in one school, and the effect of physics on chemistry achievement in another school.

Some high schools, such as School Number Three, offer chemistry and physics in the eleventh and twelfth grades with the choice of order depending on the student. A continued study of the ranks of students taking the courses in different orders might prove helpful in removing unfair competition by having members of a class equally prepared. Such careful planning is especially important to those concerned with academic success.

The proper order of science courses in the high school seems important enough to merit more attention. More educational and psychological research is needed involving many more schools. Such research does not need to be elaborate, but more objective measures of achievement should be used than those used in this study.

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