# THE EFFECT OF THE CLASS PERIOD LENGTH AND FREQUENCY ON STUDENT ACHIEVEMENT IN COLLEGE BIOLOGY LABORATORIES

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# CHAPTER I

## STATEMENT OF THE PROBLEM

### I. INTRODUCTION

During the 1965-1966 school year an increase in enrollment at the University of Minnesota, Duluth, made it necessary to offer additional sections of general biology laboratory. Each laboratory section had been meeting twice a week for a one hour and fifty minute period, or a total of three hours and forty minutes per week. Scheduling difficulties and a lack of space limited the added sections to one two hour and fifty minute meeting per week. Similar arrangements had been used in the Chemistry Department and on other college campuses.

It was hoped that the students would be able to assimilate just as much material in as thorough a manner in these longer, once a week sessions. Some time was ordinarily taken for introduction and review at the beginning of the second of two weekly meetings. Most students took one short break during a laboratory session, whether the session was two or three hours in length, and also needed a few minutes to put away their work. By eliminating these three small time segments, the lengths of time spent by both groups on actual laboratory work were more nearly equal.

*Purpose of the study*. The purpose of this paper is to present an objective statistical comparison of student achievement in these two laboratory situations by using a *t*-test with matched groups. The attempt would be to ascertain whether the introduction of the single longer laboratory session was a justifiable way of coping with the increased enrollment problem. Because this investigation was of necessity done in an ex post facto manner, the following paragraphs will describe the situation being studied.

*Organization of groups*. The general biology laboratories involved are Biology A (general zoology laboratory) and Biology B (general botany laboratory). Each accompanied a lecture course, Biology 1 or 2, in the same subject area. The laboratory sections meeting only once a week were added for each course during both the fall and winter quarters. This resulted in four groups which must be treated individually in this report.

Although they received separate grades and credits for a general biology lecture and the corresponding general biology laboratory, students were required to take these courses concurrently. They were placed together in one large lecture section, and registered for a laboratory section, which could accommodate up to twenty-four people. These laboratories were instructed by several faculty members but were organized by the lecturer, who was also the instructor of one or more laboratories. He devised the schedule of exercises to be covered in each laboratory session and arranged to have the proper materials and demonstrations available. All students purchased copies of the same laboratory manual and every effort was made to offer them uniform laboratory experiences. This arrangement suggests some possibilities for comparing students from different laboratory sections.

## II. REVIEW OF THE LITERATURE

A review of the available literature does not reveal any studies of a similar nature. However, this investigation may be considered as a part of the larger problem of finding optimum time periods for learning, and work that has been done in that field will be pertinent. Although the problem has been explored, current learning theory and experiments in learning do not provide a definitive answer to the question of the optimum length of learning periods.[1] It is evident that current educational practice in class period scheduling has evolved primarily by convention and convenience.

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[1]Clara Kanun, E. E. Ziebarth, and Norman Abrahams, "Comparison of Student Achievement in the Summer Term and Regular Quarter, A Pilot Study", (University of Minnesota, Minneapolis, 1961), p. 4. (Mimeographed and available from Mrs. Clara Kanun, General Extension Division, University of Minnesota.)

*Studies using nonsense materials.* Early experiments in this area were invariably based upon the learning of nonsense materials. Their results showed that spaced practice in memorizing this material was more efficient than massed practice. However, Noble shows that nonsense materials and meaningful materials yield different rates of learning speed and retention.[2] He has found that the ease of learning increases as meaning increases, and implies that we cannot generalize experimental results based on the learning of nonsense material to the classroom situation.

*Studies using meaningful materials.* Unfortunately, conclusions regarding the learning of meaningful materials are not as clear-cut as those concerning nonsense materials. An experiment by Austin tested recall of ideas rather than strict memorization of material, and in this respect is similar to the classroom situation.[3] She arranged to have adult subjects study logical material, including organic chemistry and embryology. Each subject studied the material five times, half doing this in a single long session and half in five

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[2]E. Noble, "The Role of Stimulus Meaning in Serial Verbal Learning," *Journal of Experimental Psychology*, XLIII (June, 1952), pp. 437-446.

[3]Sarah D. M. Austin, "A Study in Logical Memory," *American Journal of Psychology*, XXXII (July, 1921), pp. 370-403.

separated periods. During the testing period, each subject was asked to list ideas recalled and was also asked questions about the studied material. Austin found the results to be as follows: (1) separated study periods were more valuable than single long sessions when testing was done in two weeks or one month, (2) for immediate recall, there was no difference between study groups, and (3) study periods too far apart were as ineffective as those too close together.

William Trow confirmed these findings by having graduate students learn short prose passages under conditions similar to those described above.[4] He concluded that the massed study method was superior to the spaced method for recall in one day, but not for recall in fifteen weeks.

The above findings seem to support a relationship suggested in an earlier descriptive study by Lyon: as meaningfulness of learning material increases, the difference in the effectiveness of the two study methods (massed versus spaced study) decreases.[5] Lyon compared results of groups learning nonsense materials and meaningful materials, both on a continuous study schedule and in once-a-day study

[4]William Clark Trow, "Recall vs. Repetition in the Learning of Rote and Meaningful Material," American Journal of Psychology, XL (January, 1928), pp. 112-116.

[5]Darwin O. Lyon, "The Relation of Length of Time Taken for Learning and Optimum Distribution of Time," Journal of Educational Psychology, V (January, February, March, 1914), pp. 1-9, 85-91, 155-163.

periods. He found that for those learning nonsense material, continuous study was best. In learning meaningful materials, there was no difference between the two study schedules.

Each of the studies just cited described a brief experiment done in a laboratory situation. Underwood raises the question of whether or not psychological laboratory findings concerning verbal learning can be generalized to apply to the real-life classroom situation.[6] He believes that they are so restricted to a particular set of conditions that they have little significance for the classroom. They may, however, advance the understanding of the learning process. The following paragraphs will describe investigations using the classroom setting. In the first series of studies, the total teaching time during the semester was the variable under consideration.

Studies using the classroom situation. Paul conducted a study using paired groups of college students in each of four lecture courses.[7] Sixty subjects per group were matched using placement tests predicting college performance as

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[6] Benton J. Underwood, "Verbal Learning in the Educative Processes," Harvard Educational Review, XXIX (Spring, 1959), pp. 107-117.

[7] J. B. Paul, "Length of Class Periods," Educational Record, XIII (January, 1932), pp. 68-75.

criteria. All of the subjects attended the same number of lectures, but within each course a control group heard fifty-five minute lectures while an experimental group heard thirty minute lectures. The amount of learning was determined by scores on an objective course test given before and after the semester of lectures. In each course the control group demonstrated the greater gain in amount of learning. Nevertheless, Paul concluded that the shorter lecture was more economical because the control groups' increases in learning were not proportional to the increases in class time. Shorter class periods were advantageous to the better student. Although teachers preferred the longer periods, students preferred the shorter lectures and showed more initiative when enrolled in them. This affected the amount of outside work done by students, a factor that was not controlled in this experiment.

Denman and Kirby conducted two similar studies on the high school level using general science and physics along with other subject areas.[8] Their short classes met from forty to forty-five minute periods, while, in contrast, the longer period classes met from fifty-five to sixty-five minutes.

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[8] George E. Denman and Thomas J. Kirby, "The Length of the Period and Pupil Achievement in High School," <u>School Review</u>, XLI (April, 1933), pp. 284-289.

This investigation involved seventy schools, paired on the basis of several factors. The results, obtained by using standardized objective test scores, all favored the longer period.

Karch was able to confirm these findings on the junior high level.[9] He also noted that in industrial arts the achievement increase was half again greater than the increase in class time. A later study by Paul, again on the college level, revealed that greater gains were made in a class meeting five times a week when compared with a similar class meeting only three times.[10]

A report by Kambly is perhaps more relevant to the present investigation, because he held the total class time constant while varying the length of the class period.[11] He taught high school biology to one group of students for two hours a day during one semester only. The amount of learning

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[9] R. Randolph Karch, "Effect of Doubling Class Periods," Industrial Arts and Vocational Education, XXVI (January, 1937), pp. 9-10.

[10] J. B. Paul, "Class Frequency," Journal of Higher Education, VIII (December, 1937), pp. 480-484.

[11] Paul E. Kambly, "Comparison of a 1-hour Two-semester and a 2-hour One-semester Course in Biology," School Science and Mathematics, XXXIX (March, 1939), pp. 279-381.

by these subjects was compared to that of a conventional group meeting one hour a day for two semesters. The groups were matched on the basis of initial knowledge of biology, and were taught by the same person. Subject matter was not necessarily approached in the same manner nor studied in the same order. Kambly concluded that there was no significant difference in achievement in the two groups.

*Recent studies*. More recent works in this general area include an investigation by Sessions and Carruth comparing student performance in morning and afternoon college classes.[12] Sixty students enrolled in a morning section of beginning English were matched with afternoon section students on the basis of predicted grade point averages. The sections were taught as much alike as possible. Using an analysis of variance design, Sessions and Carruth found no significant difference with respect to the academic performance of students in the two sections.

Kanun, Ziebarth and Abrahams compared achievement in the relatively concentrated lecture time of the summer session with that of the more widely distributed lecture time of the

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[12]Frank Q. Sessions and Max L. Carruth, "Student Performance in Morning and Afternoon Classes," *Personnel and Guidance Journal*, XLI (October, 1962), pp. 144-146.

academic quarter at the University of Minnesota.[13] Their two phase study utilized a projected design as well as an ex post facto design. In both phases they concluded that there was no significant difference between groups when achievement was measured by the usual course examination.

Indiana University offers a concentrated intersession of two and one-half weeks between the spring semester and the regular summer session. Students enrolled in this intersession devote full-time study to one course. Richey, Sinks and Chase investigated academic achievement of students in nine separate courses offered during the intersession.[14] They concluded that these students performed at least as well as students who took the same courses in the preceding semester.

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[13] Clara Kanun, E. W. Ziebarth, and Norman Abrahams, "Comparison of Student Achievement in the Summer Term and Regular Quarter, A Pilot Study," (University of Minnesota, Minneapolis, 1961). (Mimeographed and available from Mrs. Clara Kanun, General Extension Division, University of Minn.)

[14] Robert W. Richey, Ralph W. Sinks, and Clinton I. Chase, "A Comparison of the Academic Achievement of Students Enrolled in Nine Courses in the Intersession of 1963 and that of Students Enrolled in the Same Courses in the Spring Semester of 1962-1963", (Indiana University, Bloomington, 1965). (Mimeographed and available from the Office of the Summer Sessions, Indiana University.)

Summary. To conclude this review of the literature reporting experiments on the effectiveness of massed versus distributed methods of teaching, several inferences may be drawn. Time variation does not seem to make a significant difference when that difference is measured by comparing test performance. No compelling evidence appears relating learning achievement to the number of hours spent in the classroom, or to the concentration or distribution of any given number of hours. Where material to be learned is meaningful, the distribution of learning time does not appear to be a critical variable.[15]

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[15] Clara Kanun, E. W. Ziebarth, and Norman Abrahams, "Comparison of Student Achievement in the Summer Term and Regular Quarter," The Journal of Experimental Education, XXXII (Fall, 1963), p. 123.

## CHAPTER II

## COLLECTION OF DATA

In a very general statement of purpose, this investigation is concerned with the practicality of offering a general biology laboratory course that meets once a week for three hours. This would take the place of the more traditionally scheduled course meeting twice a week for two-hour sessions. The single-session arrangement conserves space for the University, reduces staff member teaching loads, and allows for greater freedom in class scheduling. It saves student time as well, and overcomes some of his scheduling difficulties. On the other hand, there is some doubt that student achievement will compare favorably with that in the traditional course.

Both scheduling arrangements were offered for two courses and during two quarters in the 1965-1966 school year, thus presenting four opportunities for comparing student achievement in the single session with achievement in the two weekly sessions. This comparison is the problem undertaken in the following investigation.

## I. ORIGINAL POPULATION

During the data-collection portion of this study, individual cards were made out for all students who had taken at least one major laboratory examination, either the mid-quarter or the final. The lists of these students were obtained from the grade books of the laboratory instructors. The number of people in each group is shown in Table I, in which the students enrolled in the conventional laboratories meeting twice a week constitute the control groups, while the experimental groups consist of students from the laboratory sections meeting once a week. This designation will be used throughout the remainder of the paper.

TABLE I

ORIGINAL NUMBER OF STUDENTS IN EACH LABORATORY GROUP

| Course | Control Group | Experimental Group |
|---|---|---|
| Biology A, Fall | 182 | 66 |
| Biology A, Winter | 175 | 17 |
| Biology B, Fall | 161 | 21 |
| Biology B, Winter | 164 | 39 |

## II. ITEMS OF DATA

Descriptive information concerning each of these students was obtained from his individual folder in the University Office of Student Personnel Services. This information was added to each data card: sex, age, major field, number of quarters of college completed, type of registration (regular, part-time or adult special), whether or not this course was being repeated, and whether or not the other course (Biology A or B) had already been completed. Several other items were noted but were not found to be useful in this study.

In addition to the student's name, which course he took and during which quarter, the instructors' grade books also revealed his midquarter and final examination grades, his lecture grade, the laboratory section in which he had enrolled, when it met and who taught it. All of this information was recorded on the data cards.

## III. PERTINENCE OF DATA

The following paragraphs will explain how some of these items of data pertain to the courses being investigated. These are basic general biology courses, intended for freshmen and sophomore students. There are no prerequisites, although these courses are required for almost all other biology courses. Biology 1, A and 2, B may be taken in either order. If a student fails only the lecture or laboratory, he may retain his credits for the other whether or not he repeats the portion he failed. Students may take Biology 1 and A, and receive credit, without ever taking 2 and B, and vice versa; but most people do take the entire sequence.

Major fields. General Biology is elected by various groups of students, and for a number of reasons. One of these reasons is the simple fact that the class will fit into a student's schedule. The two lectures with their corresponding laboratories may be taken for general education credit but are required for majors and minors in biology, botany, zoology and general science. Physical education majors must take both courses while speech correction majors are required to have only Biology 1 and A. All students enrolled in a preprofessional program involving the medical field or the forestry field must take both.

Instructors. All of the sections in the A experimental groups, both quarters, were instructed by the same person. A second person did the same in the B experimental groups, but both of these people also instructed sections in the corresponding control groups.

*Lecture examination grades*. Identical written examinations, primarily of the objective type, were given to all students enrolled in a particular lecture course. The external conditions under which the examinations were given were also the same for each student. The tests were graded on the per cent of correct responses. The student's average of these several individual test grades was determined by the lecture instructor as he placed each in the distribution used to assign letter grades for the course. This numerical average of per cents was recorded on the data card of each student used as a subject in this study, and will henceforth be referred to as the lecture grade.

*Laboratory examination grades*. A large proportion of the final laboratory grade was made up of the results on two practical examinations - the midquarter and the final. Both of these examinations consisted of twenty-five pairs of questions, each pair typed on an individual card and referring to an exhibit accompanying the card. The exhibits consisted of microscope slides, models, dissections, preserved specimens, chemical test results, and similar set-ups that the students had been using in their laboratory sessions. The questions were at least partially selected from a permanent file of suitable questions, and were designed to test laboratory learning, rather than on straight lecture facts.

All questions were of the multiple choice type with only one correct answer. The question cards, each with its exhibit, were arranged around the laboratory room in an organized manner. Students moved from one pair of questions to the next, in order, and were timed very precisely with a stop-watch. They were not permitted to go back to a question after the test was over. The subject's grade on each laboratory examination was recorded on his data card as the per cent of correct responses.

The examinations were originally set up by the lecturer, but were modified somewhat by laboratory instructors after each two laboratory sections had taken them, one section directly after the other. This was done to discourage students from passing along information about the test. Care was taken to replace a question with one that was equivalent in difficulty and in the subject matter to which it pertained. The total number of test items did not vary from one form of the test to the other.

The Biology Department faculty members who administered these examinations assumed that the forms of each test were equivalent. This assumption appears to be confirmed when test results on different forms were compared. It can be demonstrated that forms on which the results were noticeably higher or lower had been taken by groups of students with markedly differing ability. When assigning course grades, it was customary to enter the results from all forms of the test on a single distribution. It had been particularily noted that in the Biology B examinations, the numerical range to which each letter grade corresponded did not vary more than two points from one quarter to the next. Because of the nature of this study, it was impossible to test the equivalence of the forms of each examination; but, in view of the above discussion, it will be assumed that they are equivalent. The mean and standard deviation for each form of each examination are tabulated in Appendix A.

The fact that Biology B examination score distributions could be predicted so accurately each quarter points to the comparability of the tests - a basic assumption that must be made. It must also be assumed that the examinations were valid. Before they were constructed, a plan was devised so that each area of subject matter would be covered by an appropriate number of test items. Suitable items were then chosen in accordance with the course objectives. These procedures helped to assure that the examination was a true measure of the students' laboratory learnings.

After complete information was compiled for each student, it was coded and punched on IBM computer cards, to be used in the campus 1620 computer. From this point on, the student was identified on his card by a number only, not by his name.

## IV. DEFINING THE POPULATION OF THE STUDY

In order to more exactly define the population on which this study was made, an automatic sorting machine was used to eliminate the cards of certain groups of students. By successive sortings in this order, people were not considered as a part of the statistical population if they belonged to one or more of the following groups: course repeaters, part-time and adult special students, juniors and seniors, those who had not taken both laboratory examinations, those who had missed one or more lecture tests, and students over twenty-two years old. After doing this, it was possible to limit the investigation to people who matched the qualifications of those for whom the courses were originally intended. All students not enrolled in lecture had been excluded during the sorting, and also those who dropped out of either lecture or laboratory.

Table II shows the number of cards removed from each group at each successive sorting.

TABLE II

NUMBER OF STUDENTS EXCLUDED FROM THE STATISTICAL POPULATION OF THE STUDY

| Group | Original Number | Number of Students Eliminated: Re-peaters | Part-time & Adult Specials | Juniors & Seniors | Missed Laboratory Exams. | Missed Lecture Exams. | Over 22 Yrs.Old | Number Of Students Remaining |
|---|---|---|---|---|---|---|---|---|
| Biology A (Fall, 1965) | | | | | | | | |
| Control | 182 | 8 | 4 | 16 | 5 | 2 | 2 | 145 |
| Experimental | 66 | 3 | 2 | 0 | 1 | 1 | 0 | 59 |
| Biology A (Winter, 1965) | | | | | | | | |
| Control | 175 | 8 | 1 | 13 | 3 | 2 | 1 | 147 |
| Experimental | 17 | 1 | 0 | 6 | 0 | 0 | 0 | 10 |
| Biology B (Fall, 1965) | | | | | | | | |
| Control | 161 | 5 | 2 | 18 | 5 | 1 | 1 | 129 |
| Experimental | 21 | 1 | 1 | 2 | 2 | 0 | 0 | 15 |
| Biology B (Winter, 1965) | | | | | | | | |
| Control | 164 | 5 | 1 | 5 | 2 | 2 | 3 | 146 |
| Experimental | 39 | 1 | 2 | 10 | 0 | 2 | 1 | 23 |

It should be noted, in reading Table II, that in many cases individuals who were eliminated during an early sorting would have been part of another elimination group as well. For instance, all Adult Special students are over twenty-two years old, but their number is not included in the figures in that column. For this reason, the numbers appearing in Table II should not be read as the total number of students in that category, but only as the number eliminated on that basis. This table also makes obvious the small enrollment in the experimental groups as compared to the control groups, both before and after sorting.

# CHAPTER III

## MATCHING OF EXPERIMENTAL SUBJECTS WITH CONTROL SUBJECTS

### I. BASIS FOR MATCHING

Because all of the experimental groups involved in this study contained very few subjects when compared with the control groups, each person in an experimental group was matched with one from the corresponding control group. This matching was done on the basis of lecture grades, and demanded that both members of the pair be taking the general biology courses in the same sequence. For instance, if a subject in the winter Biology B experimental group had already taken Biology A, he was matched with an individual in the winter Biology B control group who had also completed Biology A.

*Previous course experience*. Whether or not an individual had already completed the other course of the general biology sequence was considered as a significant factor in determining his initial success in the laboratory under consideration. If he had already completed one laboratory course, he would find that some of the introductory concepts are repeated in the other course. He would already be quite familiar with the microscope and its use. In addition, he could anticipate the type of midquarter exam and the conditions under which it would be given. These things could give him an advantage over students who lacked this background and should therefore be taken into consideration during pairing.

Lecture grades. In determining suitable matches, the control subject must have had a lecture grade that did not vary more than two points from the experimental subject's lecture grade. If several control subjects met these requirements, the person with the closest grade was selected. If a choice remained, persons of the same sex were paired. In cases where a final selection still had to be made, a control group card was selected at random from possible matches to overcome any tendencies to consistently choose those with higher (or lower) lecture grades.

There are several reasons for selecting the students' numerical lecture grades as the basis for pairing subjects. They are the combined results of teacher-made tests given under carefully controlled conditions, and represent student performance over an entire quarter. The tests are specifically designed for each course. For these reasons they may be considered more valid than certain standardized tests administered to college-bound high school students. Another disadvantage to using the standardized test grade is the fact that not all students had taken them. The elimination of these subjects from the study would have further reduced the size of groups that were already too small.

High school grades were not used as the pairing criterion because there was such a variation in the size and location of high schools attended by these students. There was no way of ascertaining exactly what the letter grades represented.

The grade point average earned in college work was another possible basis for pairing, but because a large number of subjects were first or second quarter freshmen, it became impractical to use this. The grade point average based on one quarter's grades is not an adequate measure.[1] To wait until the grades from three quarters had been earned and recorded, and then to calculate each individual grade point average was an impossibility as far as time was concerned.

Although practically all persons enrolled in General Biology had taken biology in high school, the college course was taught assuming that the students had no background in this subject field. This fact, together with the method of

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[1]Clara Kanun, E. W. Ziebarth, and Norman Abrahams, "Comparison of Student Achievement in the Summer Term and Regular Quarter, A Pilot Study, Second Phase" (University of Minnesota, Minneapolis, 1962), p. 4. (Mimeographed and available from Mrs. Clara Kanun, General Extension Division, University of Minnesota.)

matching, tended to minimize any differences between the subjects in their original proficiency in biology.

## II. Elimination of Subjects

A small number of subjects from the experimental groups had to be eliminated from the study at this point because suitable matches were not available. These figures are shown in Table III, which also reports the final number of subjects in each experimental group. In each case, this is identical to the number of matched subject pairs used in the study.

TABLE III

NUMBER OF EXPERIMENTAL SUBJECTS ELIMINATED DURING MATCHING WITH CONTROL SUBJECTS IN GENERAL BIOLOGY LABORATORY COURSES

| Experimental Group | Number of Subjects Eliminated | Final Number Of Subjects |
|---|---|---|
| Biology A, Fall | 3 | 56 |
| Biology A, Winter | 0 | 10 |
| Biology B, Fall | 2 | 13 |
| Biology B, Winter | 1 | 22 |

## III. Comparison of Groups Before and After Matching

A comparison was made of the composition of the control and experimental groups before and after matching, in respect to these factors: the sex of the subjects, their major fields, number of quarters of college completed, and whether or not they had completed the other course of the sequence. This information is reported in Tables IV-VII.

Previous course experience. Table IV presents information on the per cent of Biology A students who had already taken Biology B, and the per cent of Biology B students who had already taken Biology A. It was not a requirement to take these courses in sequence.

TABLE IV

COMPARISON WITH RESPECT TO PER CENT OF SUBJECTS HAVING ALREADY COMPLETED THE OTHER COURSE OF THE GENERAL BIOLOGY LABORATORY SEQUENCE

| Course | Control Group | | Experimental Group | |
|---|---|---|---|---|
| | Before Matching | After Matching | Before Matching | After Matching |
| Biology A, Fall | 14% | 4% | 3% | 4% |
| Biology A, Winter | 23% | 10% | 10% | 10% |
| Biology B, Fall | 30% | 15% | 13% | 15% |
| Biology B, Winter | 54% | 36% | 39% | 36% |

It should be noted that in Table IV, identical figures appear for both the control group and its experimental counterpart after matching had taken place. This occurs because the factor considered in this comparison formed a part of the basis for the matching of subjects. The tabulated information tends to confirm the fact that students register first for Biology A in the fall; therefore this group contains the lowest per cent of people with previous course experience. These same students enroll in Biology B during the following winter, resulting in this group having the highest per cent of subjects who had completed the previous course. In all cases, the selection of matches from the control group resulted in a lower per cent of students who had already taken the opposite course.

Sex. Table V indicates that, in three out of the four courses, students were matched on the basis of sex. This was possible because in most cases there were several equally suitable control subjects who could be matched with any one experimental subject. When a choice was made, it was of a control subject of the same sex as the experimental person.

TABLE V

COMPARISON WITH RESPECT TO PER CENT OF MALES AMONG STUDENTS ENROLLED IN GENERAL BIOLOGY LABORATORY COURSES

| Course | Per Cent of Males in Control Group | | Per Cent of Males in Experimental Group | |
|---|---|---|---|---|
| | Before Matching | After Matching | Before Matching | After Matching |
| Biology A, Fall | 62% | 64% | 61% | 64% |
| Biology A, Winter | 51% | 50% | 50% | 50% |
| Biology B, Fall | 57% | 77% | 87% | 92% |
| Biology B, Winter | 62% | 55% | 52% | 55% |

Table V also demonstrates that Biology B in the fall quarter is the only course in which it was not possible to match on the basis of sex. This is also the course in which matching had the greatest effect on the sex ratio, particularily in the control group. Both of these observations can be related to the fact that this course was one of the smaller groups involved in the study. It was considered undesirable to eliminate experimental subjects in order to match on the basis of sex. In all of the other courses, matching had very little effect on the sex ratio.

<u>Class levels</u>. Table VI, on page 31, reporting the college class to which the subjects belong, indicates a wide variety in the make-up of experimental versus control groups. Two factors that have already been mentioned have an influence on this situation. One is the fact that students tend to take Biology A before Biology B. The second is the small size of the groups after matching. For instance, in Biology A, winter, one person represents ten per cent of the group. A third influencing factor is the time at which students are able to register for courses. These biology courses are usually filled and closed before all students have completed registration. Therefore, those who register early are those who get into the biology courses. Sophomores traditionally register before freshmen. Because they had taken so many of the available places in the fall courses, the experimental sections were added in time for freshman registration. This resulted in a much higher per cent of freshmen in the experimental group. For example, only fifty-two per cent of the control subjects in Biology A (fall quarter) were first quarter freshmen, while eighty-six per cent of the experimental subjects were in this category.

In Table VI, first quarter freshmen have been separated from second and third quarter freshmen. Many students have difficulty adjusting to college life during their first quarter, and it was assumed that this might have an effect upon their performance in biology courses, especially laboratories.

Major fields. In compiling Table VII, on page 32, it was discovered that there were no general science majors enrolled during either quarter. Ordinarily, this column would be included, but there was no need for it. It should not be assumed that general science people are included in the column labeled "Other Majors." This table differs from the previous ones in that it does not compare groups before and after matching, but it does show comparisons between experimental and control people as far as their major fields are concerned.

TABLE VI

COMPARISON WITH RESPECT TO PER CENT OF

SUBJECTS AT VARIOUS CLASS LEVELS

| Group | Level in College | | | | | |
|---|---|---|---|---|---|---|
| | Before Matching | | | After Matching | | |
| | 1st Quarter Freshmen | 2nd & 3rd Quarter Freshmen | Sophomores | 1st Quarter Freshmen | 2nd & 3rd Quarter Freshmen | Sophomores |
| Biology A, Fall | | | | | | |
| Control | 46% | 9% | 45% | 52% | 7% | 41% |
| Experimental | 86% | 2% | 12% | 86% | 2% | 12% |
| Biology A, Winter | | | | | | |
| Control | 0% | 72% | 28% | 0% | 90% | 10% |
| Experimental | 0% | 40% | 60% | 0% | 40% | 60% |
| Biology B, Fall | | | | | | |
| Control | 28% | 8% | 64% | 31% | 0% | 69% |
| Experimental | 53% | 14% | 33% | 46% | 15% | 39% |
| Biology B, Winter | | | | | | |
| Control | 0% | 62% | 38% | 0% | 73% | 27% |
| Experimental | 13% | 70% | 17% | 14% | 68% | 18% |

TABLE VII

COMPARISON WITH RESPECT TO PER CENT OF SUBJECTS

MAJORING IN VARIOUS FIELDS

| Group After Matching | Total No. of Students | Biology Botany Zoology | Pre-Prof. | Phy. Ed. | Speech Corr. | AA Degree (Two Yr. Students) | Undecided | Other Majors |
|---|---|---|---|---|---|---|---|---|
| Biology A, Fall Control | 56 | 4% | 18% | 2% | 0% | 8% | 43% | 25% |
| Biology A, Fall Experimental | 56 | 4% | 37% | 0% | 4% | 12% | 27% | 16% |
| Biology A, Winter Control | 10 | 0% | 0% | 0% | 0% | 20% | 50% | 30% |
| Biology A, Winter Experimental | 10 | 10% | 0% | 0% | 0% | 10% | 30% | 50% |
| Biology B, Fall Control | 13 | 0% | 15% | 0% | 0% | 31% | 15% | 39% |
| Biology B, Fall Experimental | 13 | 0% | 15% | 8% | 0% | 8% | 46% | 23% |
| Biology B, Winter Control | 22 | 0% | 18% | 0% | 0% | 4% | 28% | 50% |
| Biology B, Winter Experimental | 22 | 4% | 28% | 0% | 0% | 14% | 54% | 0% |

# CHAPTER IV

## STATISTICAL ANALYSIS OF DATA

The statistical analysis of the data collected for this study was designed by Mr. Rodney Rosse, who was at that time a faculty member of the University of Minnesota, Duluth, Psychology Department. The author is indebted to Mr. Rosse for this help, and also for his facilitating the use of the computer.

### I. The Dependent Variable

Before analyzing the data, the raw score that each subject earned on the laboratory midquarter examination was added to his laboratory final examination raw score. These combined scores were treated as the dependent variable. Their distributions were used for the statistical comparison of experimental and control groups.

The combining of scores has the advantage of increasing the validity of the measure. The midquarter and final examinations test on two different sets of topics studied during the quarter. By combining the results, a longer test is, in effect, being used to measure student achievement over the entire quarter. Its use lessens the influence of several factors that would tend to decrease the reliability and validity of a test. The possibility that some students are not performing at their maximum capacity because of temporary distractions is decreased by testing on two widely separated days. Having missed one or more sessions during either half of the quarter is less detrimental to the student and his score when the entire quarter is the basis for scoring. Finally, the lack of student orientation at the beginning of the course will be less important than it might have been if the midquarter were used alone. Controlling the above factors by combining test scores helps to strengthen the assumption that any differences between student achievement in experimental and control groups is due to scheduling differences only.

## II. The Null Hypothesis

In each of the four courses, a _t_-test was performed between the combined score distributions for the experimental (E) and control (C) groups. This was done to test the null hypothesis that there is no difference between the means of the laboratory examinations for each group. It was determined prior to calculating the value of _t_ that a "two-tailed" test would be appropriate and that the .05 significance level would be adequate for rejecting the null hypothesis. Tables VIII-XI give the necessary values for these _t_-tests, as well as their results. The symbols used are indicated in Appendix B.

TABLE VIII

COMPARISON OF LABORATORY EXAMINATION SCORES
IN BIOLOGY A - FALL QUARTER

(n=56)

| | M | s | t | P |
|---|---|---|---|---|
| E | 111.179 | 25.947 | -0.047 | P>.05 n.s. |
| C | 111.393 | 24.785 | | |

TABLE IX

COMPARISON OF LABORATORY EXAMINATION SCORES
IN BIOLOGY A - WINTER QUARTER

(n=10)

| | M | s | t | P |
|---|---|---|---|---|
| E | 110.400 | 24.346 | -0.802 | P>.05 n.s. |
| C | 119.600 | 19.179 | | |

TABLE X

COMPARISON OF LABORATORY EXAMINATION SCORES
IN BIOLOGY B - FALL QUARTER

(n=13)

| | M | s | t | P |
|---|---|---|---|---|
| E | 136.000 | 19.166 | -0.506 | P>.05 n.s. |
| C | 139.538 | 23.793 | | |

TABLE XI

COMPARISON OF LABORATORY EXAMINATION SCORES
IN BIOLOGY B - WINTER QUARTER

| | M | s | t | P |
|---|---|---|---|---|
| E | 147.273 | 17.937 | 1.053 | P>.05 n.s. |
| C | 140.500 | 24.342 | | |

(n=22)

Tables VIII-XI all indicate that there is no significant difference between the means for the experimental and control groups; therefore the null hypothesis cannot be rejected. The differences that were noted must be due to sampling error and are likely to occur by chance alone, even though there is no significant difference between means. It cannot be assumed that changing the schedule of general biology laboratories from two meetings a week to a single longer meeting has an effect upon the achievement of the students as measured by practical laboratory examinations.

It may be of interest to note that in three of the four courses the control mean exceeded the experimental mean. In the one remaining course, which favored the experimental group, the largest value of $t$ resulted. No conclusions should be drawn from these observations because the values of $t$ are not significant.

## III. Basic Assumptions

The statistical analysis used in this study demands that several basic assumptions be made. The factor under consideration (student achievement in the general biology laboratory situations described earlier), must be normally distributed in the defined population. The groups of experimental subjects must be representative of this population. The matching of control subjects with experimental subjects must result in two comparable groups. This was done by matching on the basis of lecture grades and allowing a maximum difference of only two points. It was assumed that the matched groups would then be nearly equal in their ability to achieve in biology laboratories. Each of these assumptions must be made if the foregoing results are to be accepted.

# CHAPTER V

## CONCLUSIONS

In this study, an attempt has been made to determine whether or not a change in the scheduling of general biology laboratory sessions affects student achievement of laboratory learnings. The investigation was conducted in an ex post facto manner and involved four college courses. The control group in each met twice a week for laboratory sessions, while the experimental group met only once a week for a longer period. Experimental subjects were matched with control subjects, and were compared with them on the basis of laboratory examination scores. Statistical *t*-tests demonstrated in each course that there was no significant difference between the examination score means for experimental and control groups. This supports the conclusion that the difference in scheduling did not affect student achievement (as here measured) in the situation under consideration.

### I. Limitations of the Study

Care must be taken in generalizing from this conclusion. Although it is based on findings from four separate groups, these groups were small. They ranged from ten pairs of subjects to fifty-six pairs. Another disadvantage is the fact that the conclusion is not based upon a designed experiment. If an experiment had been possible, greater care could have been taken in the selection of a true random sample of subjects from the population. It would also have been possible to test the equivalence of alternate forms of the examinations.

## II. Disadvantages of Single Weekly Sessions

In spite of the conclusion that the scheduling change did not significantly affect student achievement, some disadvantages were apparent in the single weekly meeting schedule. A ten-week quarter afforded just barely enough time to present all of the laboratory work considered essential to the course. Holidays that fell on school days eliminated an entire week's laboratory for sections meeting on that day. To include this with the following week's work was very difficult in terms of time, space and materials. A crowded schedule of full laboratory sections made it difficult for students to make up this work on their own time. This is also true for students who are absent from a session because of illness. Even if they attemnted to do this work on their own, they missed the explanations and demonstrations, and found that perishable materials were no longer available. These disadvantages were reflected in the reactions of both students and faculty members involved in the experimental sections.

## III. Student Reactions

No systematic collection of student opinion was attempted; however, the Biology B experimental group was asked for written comments at the end of the fall quarter. Negative reactions included those mentioned above as well as several additional disadvantages. Students who attended afternoon sections found it difficult to concentrate over a three-hour period. Many felt that there was too much work to cover in the given time. If this work included several different topics, some people found it confusing to go from one area to another during one laboratory period. On the other hand, a few people mentioned the advantage of being able to follow through with an experiment in the longer period. These same people found it possible to better integrate topics when several are included in one laboratory session.

## IV. Advantages of Single Weekly Sessions

The major advantage in having a single longer laboratory session per week appears to be the ease with which it will fit into both student and University schedules. The students who favor it are those who have an unusual assortment of classes, a number of especially time-consuming classes, or an outside work schedule. The offering of single longer laboratory session per week might very well present a suitable solution to their problems, and at the same time facilitate scheduling for the University.

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# APPENDIXES

# APPENDIX A

A COMPARISON OF MEAN AND STANDARD DEVIATION VALUES FOR ALTERNATE

FORMS OF LABORATORY MIDQUARTER AND FINAL EXAMINATIONS

| Course | Sections | Test Form | Number of Students | Midquarter Examination Mean | Midquarter Examination Standard Deviation | Final Examination Mean | Final Examination Standard Deviation |
|---|---|---|---|---|---|---|---|
| Biology A, Fall | 1 and 2 | $A_1$ | 33 | 48.12 | 20.89 | 57.03 | 11.02 |
| | 3 and 4 | $B_1$ | 39 | 50.77 | 17.28 | 61.23 | 13.48 |
| | 5 and 6 | $C_1$ | 32 | 52.09 | 15.78 | 62.88 | 12.81 |
| | 7 and 8 | $D_1$ | 41 | 52.10 | 15.53 | 59.27 | 10.75 |
| | 9, 10 and 11 | $E_1$ | 59 | 53.27 | 16.72 | 56.64 | 11.75 |
| Biology A, Winter | 1 and 2 | $A_2$ | 29 | 60.97 | 10.90 | 58.35 | 11.33 |
| | 3 and 4 | $B_2$ | 37 | 65.30 | 14.29 | 65.30 | 13.64 |
| | 5 and 6 | $C_2$ | 37 | 59.24 | 10.25 | 61.51 | 10.83 |
| | 7 and 8 | $D_2$ | 44 | 61.55 | 10.57 | 67.23 | 10.06 |
| | 9 and 10 | $E_2$ | 10 | 55.60 | 12.43 | 54.80 | 15.98 |
| Biology B, Fall (No Section 8) | 1 | $A_3$ | 18 | 72.33 | 11.53 | 75.00 | 11.89 |
| | 2 and 3 | $B_3$ | 37 | 73.08 | 8.57 | 66.32 | 15.10 |
| | 4 and 5 | $C_3$ | 36 | 72.00 | 9.39 | 69.61 | 11.25 |
| | 6 and 7 | $D_3$ | 38 | 69.79 | 11.35 | 67.05 | 13.74 |
| | 9 and 10 | $E_3$ | 15 | 72.13 | 11.12 | 64.67 | 12.89 |
| Biology B, Winter | 1 | $A_4$ | 21 | 67.71 | 8.21 | 62.76 | 13.12 |
| | 2 and 3 | $B_4$ | 41 | 80.32 | 9.60 | 71.42 | 13.77 |
| | 4 and 5 | $C_4$ | 39 | 74.92 | 10.21 | 62.77 | 11.86 |
| | 6 and 7 | $D_4$ | 45 | 76.80 | 9.09 | 73.87 | 11.70 |
| | 8 and 9 | $E_4$ | 23 | 71.22 | 9.83 | 75.13 | 9.94 |

# APPENDIX B

# STATISTICAL FORMULAS*

Arithmetic mean (M) of a distribution of scores:

$$M = \frac{\Sigma X}{N}$$

Standard deviation (s):

$$s = \sqrt{\frac{\Sigma (X-M)^2}{N}}$$

t-test by the direct difference method:

Mean difference or mean of the distribution of differences ($M_D$):

$$M_D = \frac{\Sigma D}{N}$$

Standard deviation of the distribution of differences ($\sigma_D$):

$$\sigma_D = \sqrt{\frac{\Sigma D^2}{N} - (M_D)^2}$$

Standard error of the mean difference ($\sigma_{M_D}$):

$$\sigma_{M_D} = \frac{\sigma_D}{\sqrt{N-1}}$$

$$t = \frac{M_D}{\sigma_{M_D}}$$

The value of t is compared with values in Student's Distribution Table to determine its significance.

*Taken from "Elementary Statistics" by Underwood, Duncan, Taylor and Cotton. Published by Appleton-Century-Crofts, Inc. of New York, 1954.

The $\underline{t}$-test formulas given on the previous page may be combined into one, resulting in the following:

$$t = \frac{\frac{\Sigma D}{N}}{\sqrt{\frac{N\Sigma D^2 - (\Sigma D)^2}{N^2(N-1)}}}$$

Although the direct-difference method is ordinarily used for hand computation of the $\underline{t}$-test, the following formulas for determining the value of $\underline{t}$ for matched samples was used in the IBM 1620 computer:

Standard error of the mean ($\sigma_M$):

$$\sigma_M = \frac{\sigma}{\sqrt{N-1}}$$

Standard error of the difference between means ($\sigma_{diff}$) for matched samples:

$$\sigma_{diff} = \sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2 - 2 r_{12}\, \sigma_{M_1} \sigma_{M_2}}$$

$$t = \frac{M_1 - M_2}{\sigma_{diff}}$$