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The Efficiency of Laboratory Work in Geography

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THE EFFICIENCY OF LABORATORY WORK IN GEOGRAPHY

BY

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CHAPTER I

A SURVEY OF COST, METHOD, AND VALUE OF LABORATORY INSTRUCTION

Great sums of money are expended annually for the upkeep and equipment of laboratories that are used only for teaching, and yet there is little in the way of experimental data to indicate definitely whether the expenditure of time or money is justified.

The laboratory class is smaller, requires per member more floor space and larger outlay for such permanent equipment as desks and lockers, and for materials of various kinds. The first factor alone, that of size of class, justifies the initial statement. Laboratory classes under one instructor are limited to twelve or fifteen students. Recitation classes under one instructor are limited to twenty-five or thirty students. Each student in lecture or recitation requires approximately ten square feet of floor space and one chair. Each student in laboratory requires approximately twenty-six square feet of floor space, a desk equipped with running water, chemicals and adequate drawer and locker facilities, and requires also apparatus varying in value from a few to hundreds of dollars. Each student in a recitation or lecture requires at most a few sheets of examination paper now and then; each student in laboratory work constantly requires chemicals or other materials with which to do his work.

As a result of these factors, it apparently costs more to teach a student one hour in laboratory than to teach him one hour in recitation or lecture.[1]

Not only this, but seemingly it costs more to graduate a student from an institution offering more laboratory work than from an institution of similar academic standing offering less laboratory work, all other factors being equal. Hour for hour the laboratory work is much more expensive, but toward graduation we do not count hour for hour. Paradoxical as it may seem, from a fiscal aspect, the more expensive units counts less. Most institutions of higher learning require a student to furnish from two to four hours of laboratory instruction for the credit equal to one hour of recitation or lecture. Assume for a moment a hypothetical case. An instructor receives $3,600 for thirty-six weeks of teaching. Each week he teaches costs the institution one hundred dollars in salary. Assume that he teaches two hours of lecture, six hours of recitation, and ten hours of laboratory. Each hour of service costs the institution five dollars and fifty-six cents. The lecture classes average thirteen students. The salary cost alone of instruction, then, per student taught one hour are: for the lecture courses five and one half cents, for the recitation work

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[1] E. E. Lindsay, "Laboratory Costs in Institutions of Higher Learning," School and Society, XX (October 25, 1924), 537-542.

twenty-two cents, and for laboratory work forty-three cents. The difference, then, in the cost of the three methods of instruction is quite obvious.[2]

In order to secure the academic equivalent of the five and one half cent hour you must multiply the forty-three cent hour by three, since that is the approximate average number of such hours the student must take in order to secure the same amount of credit as accrued by reason of the five and one half cent or the twenty-two cent hour. Hence the comparison must stand: five and one half cents of lecture equals twenty-two cents of recitation equals $1.29 of laboratory instruction.[3]

To this $1.29 must be added maintenance and depreciation charges on additional floor space and equipment and special maintenance expenditure incurred by the laboratory student and not incurred by the recitation or lecture student. For example, one laboratory student occupies 2.6 times as much floor space as one recitation or lecture student, and three times as long, for the same amount of credit. To one we must charge ten square feet of floor space, heated, lighted, and cleaned, for one hour; to the other twenty-six square feet for three hours, i.e., ten against seventy-eight. Such factors must more than offset the fact that frequently lower salaried

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[2] Loc. cit.

[3] Loc. cit.

men are assigned laboratory work than meet lecture or demonstration classes.

What this emphasis on laboratory instruction means in terms of money may be appreciated by considering that the average cost of a student clock hour in the 50 per cent of higher laboratory department at the state colleges was $00.4413, while the average cost per student clock hour in departments less then 50 per cent laboratories was $00.2369. These are student clock hour costs. To change these student clock hour costs to costs of units equal to academic value they must be multiplied by the number of student clock hours necessary in each case for one credit hour. When this is done we find that one credit hour in the laboratory department costs an average of $00.8176, while one credit hour in the lecture and recitation departments costs $00.2610.[4]

The cost will depend to a great extent upon the method used in the instruction of the laboratory work. During the past few years a number of experiments have been carried on with the purpose of studying the relative merits of certain method of instruction in science. As a result of these studies advocates of the lecture-demonstration method contend that large sums of money are being wasted in the unprofitable purchase of equipment in sufficient quantities for individual laboratory work. The saving of much time

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[4] Loc. cit.

by the lecture-demonstration method is also claimed. The issue, therefore, becomes an important one for administrators, science teachers, and students of education generally. It should, accordingly, be viewed from all angles. The studies of Hunter, Phillip, Wiley, Cunningham, Cooprider, and Woody dealt largely with the acquisition of facts. The differences obtained by the use of the different methods were slight. In most cases the results were slightly in favor of the lecture-demonstration when the tests immediately followed the teaching, while greater retention resulted from the individual laboratory method as evidenced by the delayed recall scores. Whether there are outcomes from the individual laboratory experience in the way of self-confidence, initiative, and gaining of power that justifies the expenditure of additional time, these experiments do not adequately determine. The lecture-demonstration method appears to be the better method for imparting skill in laboratory technique in its initial stage and for developing ability to solve new problems.[5]

The problem of grouping students for laboratory work, especially in sciences which requires expensive apparatus, has been considered for many years. From observations that

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[5] W. C. Croxton, "Shall Laboratory Work in the Public Schools be Curtailed?", School Science and Mathematics, XXIX (January 1929), pp. 79-83.

have been made along this line, the following conclusions are drawn:

1. The average strong students are neither benefitted nor injured by working in pairs.
2. The average weak students are benefitted by working in pairs.
3. The average strong students are not injured by being paired with the weak students, but the weak ones are benefitted by working with the strong ones.
4. Only the mechanical genius is handicapped by being paired with another student and seems to make no difference whether the other student is strong or weak.

As general conclusions we might suggest that in the normal schools and teachers colleges, excepting the occasional student who later expects to get into a school of his type, students may be paired off for laboratory without any concern as to strength or weakness. If the students are paired off for their laboratory work, the instructor could handle twice as many students in the laboratory and he could save half of the expense in apparatus and materials.[6]

Laboratory is intended to develop ingenuity and facili-

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[6] W. G. Bowers, "Grouping Students for Work in the Chemical Laboratory," Education, XLV (March, 1925), 429-37.

tate scientific reasoning. If the laboratory has failed or is failing in this, it might be because we go at labora-- tory in the wrong way. Whether the beginner does the laboratory work himself or sees someone else do it may or may not be material, but it is generally conceded that laboratory work should be done. As to the value of the laboratory work, we have conflicting opinions. It has probably aided us somewhat in the establishment of laws and principles, and in addition it has done a great deal to bring to the students' minds an understanding of these laws and principles.[7]

H. N. Goddard says,

> "The purpose of the laboratory is to give adequate experience and objective illustration for an understanding and appreciation of science, and to give an underatanding of the application of these to common processes and phenomena. The laboratory has accomplished much of this. But the current methods operating in the laboratory, which is supposed to develop a power and habit of scientific thinking, have overlooked to a large degree the necessary conditions of reflective thinking".[8]

This thesis is undertaken with the intention of studying the efficiency of laboratory work in geography. In that much time and money are expended annually on the capital outlay and on the maintenance of laboratories it is highly essential that we determine the effectiveness of our work by objective measurements.

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[7] W. G. Bowers, "Some Educational Values in Laboratory Work," Education, XLIV (May 1924), pp. 446-455.

[8] Loc. cit.

CHAPTER II

LABORATORY VS NON-LABORATORY INSTRUCTION IN GEOGRAPHY 101

The number of hours of laboratory work per week in the many fields of science varies. In the Department of Geography at Western Kentucky Teachers College, Bowling Green, Kentucky, it has been customary to offer only one hour of laboratory work per week in the elements of geography. Whether this is sufficient time to devote to laboratory work, or whether two hours per week would be practically as economical and more efficient is a debatable question.

In order to gain some knowledge upon the problem, an experiment was carried on with the students who were enrolled in geography 101. From a group of 120 students, sixty were selected with which to make this experiment. As far as the chronological ages were concerned, the students were chosen indiscriminately. The psychological ranking and the grades made on its first comprehensive test in geography formed the chief basis of the selection. The psychological ranking was taken from the Kentucky classification. The comprehensive test, which was a true and false type, was worked out by the teachers in the Geography Department at Western State Teachers College, Kalamazoo, Michigan.

The sixty students who were chosen for this study were

divided into three groups of twenty students each for their instruction in laboratory work. According to the average scores made on both of the tests mentioned above, the three groups of students were approximately of the same rank. The individual grades as a whole were rather low. This was probably due to the fact that many of these students had but little training in their pre-college geography.

In the regular classroom work the sixty students were under the same instructor throughout the period of the experiment. They were, however, retained in the three classes with the sixty non-experimental students. The hours for the meeting of the lecture work was seven-thirty o'clock, ten o'clock, and three o'clock on Monday, Wednesday, and Friday. In so far as the classroom teaching was concerned, the lecture method of instruction was generally used.

The classes in the laboratory, as has been stated, were divided into groups of twenty students each. An equal number of high, median, and low grade students were placed in each group. For convenience, we shall call these groups A, B, C. Group A enrolled for two hours of laboratory per week; Group B enrolled for one hour of laboratory per week; and Group C was left without the laboratory work. The time of meeting for the two groups which had the laboratory might have some significance. Group B met class at three o'clock on Tuesday afternoon. This hour, according to the opinion of some, might be considered an undesirable one. Group A met their

class on Saturday morning from nine to eleven o'clock. In that a person usually feels less fatigued in the morning, the students in Group A might have had a very slight advantage over Group B in so far as the time element is concerned. The two classes in the laboratory work were taught by the same instructor throughout the fifteen weeks of the experiment. The lecture-demonstration method as well as the individual method of instruction was used in the laboratory work. At the beginning of each class period, twenty-five minutes was devoted to testing the pupils on the previous exercises. The remainder of the class period was used in lecture and demonstration on the material to be studied for the next week. After having the demonstration, the students were free to study the material for one week, the time elapsing between class periods.

The Group which was without laboratory work had some opportunity to make individual study of the laboratory exercises which were given to the other two groups. They were requested, however, not to make any study of this material, and apparently a fine spirit of cooperation prevailed.

At the close of the fifteen weeks of experimentation, the same comprehensive test that was given at first was again given and the results tabulated.

CHAPTER III

INTERPRETATION OF DATA

The data collected in this experiment are probably insufficient to enable one to draw any very definite conclusions; however, from the information obtained it is possible to see trends which seem to favor laboratory instruction. These trends are brought out in the interpretation of the various tables listed below.

TABLE I

NUMBER OF POINTS GAINED BY EACH INDIVIDUAL STUDENT IN GROUP A.

Number of Pupil	Comprehensive Test I	Comprehensive Test II	Gains
1	70	81	11
2	55	61	6
3	60	70	10
4	60	66	6
5	58	62	4
6	70	73	3
7	80	84	4
8	60	62	2
9	59	75	16
10	63	74	11
11	77	87	10
12	39	64	25
13	48	62	14
14	48	53	5
15	71	80	9
16	51	61	10
17	54	56	2
18	62	67	5
19	58	55	-3
20	76	75	-1

TABLE II

NUMBER OF POINTS GAINED BY EACH INDIVIDUAL STUDENT IN GROUP B

Number of Pupil	Comprehensive Test I	Comprehensive Test II	Gains
1	75	80	5
2	60	65	5
3	73	77	4
4	62	84	22
5	80	84	4
6	59	74	15
7	54	61	7
8	57	43	-14
9	57	62	5
10	72	77	5
11	75	80	5
12	59	62	3
13	61	65	4
14	56	62	6
15	61	61	0
16	60	65	5
17	55	72	17
18	48	68	20
19	61	63	2
20	62	69	7

TABLE III

NUMBER OF POINTS GAINED BY EACH INDIVIDUAL STUDENT IN GROUP C

Number of Pupil	Comprehensive Test I	Comprehensive Test II	Gains
1	53	54	-1
2	62	62	0
3	74	74	0
4	70	75	5
5	56	55	-1
6	56	63	7
7	70	77	7
8	55	61	6
9	68	55	-13
10	63	56	- 7
11	56	62	6
12	62	58	-4
13	68	61	-7
14	60	75	15
15	58	55	-3
16	62	74	12
17	54	61	7
18	51	56	5
19	70	72	2
20	60	60	0

Tables I, II, and III are chiefly self explanatory. The number on the left represents the individual students in the various groups. Columns two and three represent the individuals grades made on the first and second comprehensive test respectively. The column on the right gives the increase of the grades made by each student. As can be readily seen, the students in Group A and Group B made greater gains on the whole than did the students in Group C. Several of the students in Group C, in fact, made lower scores on the second comprehensive test than they did on the first test. This is rather difficult to explain; whatever explanation we might give would be merely an assumption.

Almost every student in Group A made some increase in his grade as shown by the figures in the right hand column of each of the Tables I, II, and III. The range of these points of increase was from -3 to 25 in A. The gains made by the students in Group B showed a range from 3 to 22, while the range of the gains in Group C was -15 to 12.

TABLE IV

TOTAL NUMBER OF POINTS GAINED IN EACH GROUP

Group A	151
Group B	127
Group C	38

The second comprehensive test showed that eighteen of the students in Group A made gains in their grades. The total number of points gained was 151. Nineteen of the students in Group B made an increase in their grades, and the aggregate number of points gained was 127. Only 50 per cent of the students in Group C made any increase in their grade, and these ten made a total gain of only 38 points. The figures in Table IV seem to indicate a considerable gain of Group A and Group B over that of Group C.

TABLE V

THE AVERAGE OF THE PSYCHOLOGICAL AND COMPREHENSIVE TESTS

	Psychological Test	Comprehensive Test I	Comprehensive Test II
Group A	48.1	61.75	69.25
Group B	50.39	63.25	69.25
Group C	49	62	64.3

According to the average scores made on the psychological test, the three groups of students appeared to be of approximately equal rank. The lowest average, which was that of Group A, was 48.1. The average of Group B approximated that with an average of 50.39. As can be readily seen, then, the range between the average of the highest and the lowest psychological grade is 2.29. The average grades of the three

groups made on the first comprehensive test showed no marked degree of difference. The average score for Group A was 61.75; for Group B, 63.25; and for Group C, 62. Considering the average grade made, then, on the psychological test and on the first comprehensive test, we see that the three groups have fairly comparable ability.

On the second comprehensive test, the average scores of Group A and Group B were the same. Both of these groups, however, scored 4.95 points higher than did group C. Comparing the average of the first and second comprehensive tests, we note that Group A made an increase of 7.5; Group B made an increase of 6.0; and Group C made an increase of only 2.3.

TABLE VI

THE PER CENT OF STUDENTS IN EACH GROUP WHOSE GRADE EQUALS OR EXCEEDS THE AVERAGE OF EACH OF THE OTHER GROUPS.

	Comprehensive Test I	Comprehensive Test II
Per Cent in Group A Whose Grade Equals or Exceeds Average of Group B	30	45
Per Cent in Group A Whose Grade Equals or Exceeds Average Of Group C	35	55
Per Cent in Group B Whose grade Equals or Exceeds Average of Group A	30	40
Per Cent in Group B Whose Grade Equals or Exceeds Average of Group C	35	65
Per Cent in Group C Whose Grade Equals or Exceeds Average of Group A	50	30
Per Cent in Group C Whose Grade Equals or Exceeds Average of Group B	30	30

The average grades of the three groups of students on the first and second comprehensive tests have been stated in Table V. The per cent of students in Group A whose grades equal or exceed the average of Group B is 30 as based on the first comprehensive test. If we base the comparison upon the average of the second comprehensive test, the per cent in Group A whose grades equal or exceed the average of Group B is 45. The gain that the students in Group A made over the average of Group B was 15 per cent. The per cent of students in Group A whose grades equal or exceed the average of Group C

is 35 per cent as based on the first comprehensive test. Making the comparison upon the average of the second comprehensive test, the per cent in Group A that equals or exceeds the average of Group C is 55. Obviously, then, the gain in this case is 20 per cent. A similar comparison might be made for Group B and C.

The students in Group A and Group B show practically the same progress as indicated by Table VI. Group A made an increase of 15 per cent over the average of Group B, while Group B made an increase of 10 per cent over the average of Group B. Group B made a 10 per cent higher gain over the average of Group C than was made by Group A. The students in Group C failed to make any increase in their grades as based on the average of Group B, and if based on the average of Group A we find that they really lose 20 per cent.

TABLE VII

A COMPARISON OF THE INCREASE IN THE GRADES MADE BY THE THREE GROUPS OF STUDENTS

	Low 25 Per Cent		Middle 50 Per Cent		High 25 Per Cent	
	Per Cent Gaining	Average Gain	Per Cent Gaining	Average Gain	Per Cent Gaining	Average Gain
Group A	100	14.6	93	5.4	100	14.6
Group B	83⅓	8.2	100	7.1	100	4.6
Group C	62½	5.0	33⅓	15.5	50	4.6

After dividing the students into a low, middle, and

high percentiles, note was made of the number in each classification who made gains. There was practically 100 per cent gain in the low, middle, and high grade students of both Group A and Group B. The average gain, however, was some greater in the lower and higher percentile of Group A than it was in Group B or Group C. The smallest number of students making gains was found in Group C. The middle percentile of this Group showed that only 33 1/3 per cent of the students made gains. Their average gain, however, was 13.5 points as compared with 14.6 points made by the lower and upper percentile of Group A. The aggregate average gain of the students in the lower, middle, and high percentiles was 27.8. 26.0, and 23.8 respectively. These figures show that the aggregate average gains of the three classes of students are approximately the same. They also show the aggregate gain of Group A to be decidedly greater than that of the other two groups.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

It costs more to teach a student one hour in laboratory than it does one hour in recitation. This higher cost is due chiefly to the greater amount of supplies required in laboratory work, and also to the smaller classes and increased floor space demanded.

The cost depends to a great extent upon the method used in the instruction of laboratory work. During the past few years a number of experiments have been carried on with the purpose of studying the relative merits of certain methods of instruction. As a result of these studies, advocates of the lecture-demonstration method contend that large sums of money are being wasted in the unprofitable purchase of equipment in sufficient quantities for individual laboratory work. The saving of much time is also claimed.

Another way to prevent great expenditures in the laboratory work would be to group the students. This grouping may be done indiscriminately with regard to the weak and strong students. If this grouping is carried out, one instructor could handle twice as many students in laboratory and thus save one half of the expense in apparatus and materials.

The three groups of students selected for study in this experiment rated approximately the same on the psychological test and on the first comprehensive test. The second comprehensive test seemed to indicate that the accomplishments of Group A and B were about the same, while that of Group C was slightly below the two groups just mentioned.

Conclusions

From the data collected in this experiment, the cost of teaching a student one hour in laboratory is apparently greater than the cost of teaching a student one hour in recitation.

As a result of studies thus far made, we might conclude that the lecture-demonstration method of instruction is slightly more desirable than the individual laboratory method.

Students could possibly be grouped in laboratory work without concern as to their strength or weakness. This would probably be cheaper and just as efficient as it would be to have them ungrouped.

Considering the observations made in this particular experiment the writer was led to believe that there was apparently little difference in the accomplishments of students in the one and two hour laboratory classes.

The students without laboratory work seem to have been handicapped somewhat in their progress made in Geography 101.

Recommendations

In view of the fact that this study has its limitations, further research work should be done on this subject. If a number of experiments similar to this one were carried out, the results should prove of great value.

Further study to determine the best method of instruction in laboratory work would doubtless bring about many changes in this particular type of school work.

Bowers, W. G., "Grouping Students for Work in the Chemical Laboratory," Education, XLV (March, 1925), 429-437.

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