THESIS

A COMPARATIVE STUDY OF TEACHING ELECTRICITY IN JUNIOR HIGH SCHOOL

Submitted by

R. F. Tucker

In Partial Fulfillment of the Requirements

For the Degree of Master of Science

Colorado State College

of

Agriculture and Mechanic Arts

Fort Collins, Colorado

May, 1937

COLORADO STATE COLLEGE

OF

AGRICULTURE AND MECHANIC ARTS

May 29, 1937

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY R. F. TUCKER

ENTITLED A COMPARATIVE STUDY OF TEACHING ELECTRICITY IN JUNIOR HIGH SCHOOL

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

MAJORING IN INDUSTRIAL ARTS EDUCATION

CREDITS

[redacted]

In Charge of Thesis

APPROVED [redacted]

Head of Department

Recommendation concurred in

Committee on Final Examination

[redacted]

Committee on Graduate Work

[redacted]

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to all those who have offered comments and constructive criticisms involved in making this study possible.

I wish to express my special appreciation to the following friends, who have given their time and advice in aiding me in this study: Dr. C. A. Prosser, Director, Dunwoody Industrial Institute; J. B. Yingling, Associate Professor of Industrial Education, Colorado State College; Andrew G. Clark, Professor of Mathematics, Colorado State College; K. G. Irwin, Professor of Chemistry, Colorado State College; and R. W. Selvidge, Professor of Industrial Education, University of Missouri.

TABLE OF CONTENTS

LIST OF TABLES

THESIS ABSTRACT

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ABSTRACT OF THESIS

BY

R. F. TUCKER

A COMPARATIVE STUDY OF TEACHING ELECTRICITY IN JUNIOR HIGH SCHOOL

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Statement of Problem

The present study undertakes to determine by the experimental procedure the relative efficiency of two recognized methods in teaching a Unit in Electricity in Industrial Arts at the junior high school level in terms of job achievement and development of student abilities. Job achievement in this study was confined to that data concerning accomplishment in project work in the school shop. The realm of abilities included those which could be readily recognized as related to industrial arts work and could be recorded by the instructor. The two methods of instruction were the use of the instruction sheets and the lecture and demonstration method. The instruction sheet was used in this study as a teaching device to present directions, facts or principles. Where this device was not used, such directions or facts were presented by the instructor. To give any definite answer to whether the use of instruction sheets are more effective in reaching certain specific objectives than would be a form of class instruction in which the information is given orally and by demonstration would be extremely difficult, due to the

large number of factors involved. This would not mean, however, that no answer could be given for the use of instruction sheets in some specific shop unit under certain school conditions that might be considered reasonably typical.

The choice of a Unit in Electricity used as the basis for the present study was partly due to a matter of convenience. The writer, an instructor in the Aaron Gove Junior High School of Denver, Colorado, has been using both the instruction method and the lecture and demonstration method in teaching electricity for sufficient length of time to become proficient in their use.

Method of Procedure

The course in electricity consisted of the learning units sponsored by the American Vocational Association. This educational organization has made an attempt on a national scope to compile and evaluate the learning experiences in certain particular fields of industry, that they might be taught as fundamental to students in shop work. Only those learning units were taught in this nine-week period in the field of electricity which seemed advisable in view of the shop facilities and carrying out an experimental procedure.

Four classes of boys were used, each class similar in number, age and intelligence quotient. The age and intelligent quotient records were available, thus aiding in shifting students between experimental classes and

other classes that were not involved in the present investigation. As a result of such shifting, the four classes were organized of closely similar size and combined into groups, experimental and control, whose dispersion in age and intelligent quotient was negligible. Fisher's table of significance[1] was referred to and such existing differences would not invalidate results.

A list of major projects was presented in connection with the class work, each student being asked to choose one from the list. These were arranged so as to take relatively the same amount of time to complete, and involved the same fundamentals.

The criteria to check the results for relative efficiency of methods used, were job achievement and development of student abilities. The checking factors used to measure job achievement were:

1. Comparative time required to do specific job.
2. Number of jobs completed.
3. Number of unsatisfactory jobs.
4. Grade of performance.
5. Number of times the assistance of the instructor was asked for.

Complete records were kept on each individual student. Tests were devised to check upon development of student abilities. These abilities were:

1. Fisher, R. A., Statistical Methods for Research Workers, Fifth Edition, Oliver and Boyd, London, England, Table of t values, p. 158.

1. Ability to plan
2. Ability to explain
3. Ability to perform
4. Ability to do quickly
5. Ability to do again
6. Ability to describe

Items 1 and 4 were tested by answers to written questions. The content of the written test was a compilation of questions covering the course. Electrical tests of different sources were searched for possible suggestions. The types were familiar to the student, that of true-false, completion and multiple-choice. The scoring upon other points involved the instructor's estimate of the student ability along these lines. Only a few students were asked to repeat the performance in items 5 and 6. Scores were placed upon the student's record card after the job or jobs had been completed.

The first step to determine the significance of the results was to treat statistically the means of all abilities combined. Then, the differences between the means of each of the six abilities were treated likewise.

Summary of the Study

The basis used for group equivalency were those of general intelligence as measured by intelligence quotient and age. Those familiar with junior high school in Industrial Arts are aware that some information, but very little manipulative skill, is shown by students previous

to instruction. Yet, it cannot be assumed that identical instruction given to those of the same age and general intelligence will result in the same gain in manipulative skill.

Since each group was not small, it would seem possible that the element of chance would be unfavorable to obtaining in one group those who might have noticeable advantage in this respect. The experimental group completed their projects in shorter time, completed a larger number of satisfactory jobs, had fewer unsatisfactory jobs and showed a greater ability to use what had been learned. They asked for more assistance of the instructor and make a slightly lower grade on performance.

As to the development of student abilities, the means of all abilities combined were treated statistically. All existing differences between means did not indicate significance. The differences between the means of each of the six abilities were treated likewise. The results indicate the experimental group favor the ability to plan. The control group favor the ability to explain. In regard to ability to do quickly, and to do again, such differences were definitely not significant. On ability to describe, the results indicate the control group made the better showing, but cannot be interpreted as definitely significant.

Recommendations

Since one study does not prove conclusive results,

but rather implications, more studies of this nature are needed to establish definite findings. After several conferences with R. W. Selvidge concerning the use of instruction sheets, the writer recommends a plan of using the instruction sheet in a somewhat different manner.

The general use of the planning procedure is to leave the planning to the individual student, with the aid of the instructor. Now, when a student selects a project of his liking, an instruction sheet[1] is placed in his hands which contains a working drawing of the project and an incomplete list of the steps necessary in planning the job which he is asked to complete. Accompanying this planning procedure is a list of the skills, and a definite list of information topics which is recommended to the student to become acquainted with. The skill and information are essential to the student in order to produce good workmanship and to answer the questions which will be presented to him when the job is completed. Before the final grade is given, the student has an opportunity to mark himself upon a checking list in regard to workmanship.

Accompanying each suggested job for the student in a particular course is a teaching plan for the instructor, which includes (1) check list of steps in job planning, (2) numbered instruction sheets possessing correct tool

1. Final Report of the Committee, Standards of Attainment in Industrial Arts Teaching, Pantagraph Printing and Stationery Company, Bloomington, Illinois, 1935, pp. 21-25.

practice pertaining to that job, (3) designated information as to a reference list which the student must read and answer questions.

It is felt among Industrial Arts teachers that industrial arts subjects, when correctly presented, have the possibility of contributing as much, if not more, to an individual's habits and attitudes than any subject offered in the high-school curriculum. Attached to each instruction sheet is an organized list of Desired Experiences[1], which the student may follow, which contribute to this success in life.

This approach seems quite logical to the writer after his experience with the instruction sheet of the former type and worthy of experimentation.

1. Final Report of the Committee, op. cit., pp. 34-35.

CHAPTER 1

INTRODUCTION TO THE STUDY

The present study represents an investigation to determine the relative efficiency of two methods of teaching a Unit of Electricity in Industrial Arts in the junior high school in terms of job achievement and the development of student abilities. The two methods are the use of instruction sheets and the lecture and demonstration method.

The instruction sheet[1] as a teaching device to present directions, facts or principles, is not new in the school shop, the science laboratory, or in industry. Where this device is not used it is necessary to present such directions or facts in an oral way. It may be expected that oral instruction and personal demonstration on the part of the teacher would be most effective where the members of the class group progress at the same rate, and each is engaged at approximately the same time in using the same tools or equipment. This situation[2] does not hold for classes in shopwork where there are marked individual differences in ability, where separate tools and equipment are not furnished to every student in the class group and where entrance is irregular.

1. Selvidge, R.W., Individual Instruction Sheets, The Manual Arts Press, Peoria, Illinois, 1926, p. 5.
2. Struck, F. T., Methods in Teaching Industrial Education, John Wiley & Sons, New York City, 1929, pp. 59-60.

It is to be expected that the use of instruction sheets might have certain advantages in shop classes. With such material already prepared it could be presumed that the teacher would be able to arrange the work of the unit in an effective learning order. From the student's standpoint the material would be brief and accurate, and could be referred to as a tangible source of information. The responsibility for obtaining the information would seem to be placed directly upon the student, and this would result in the development of a feeling of responsibility and self-reliance. From the administrative view point it could be argued that larger groups could be handled by the instructor and that more time would be permitted to the instructor in which to watch the work of the individual student.

On the other hand, it may be presumed that teachers are not trained in the technic of preparing written directions and illustrations, that the briefness of the instructions or the language used would offer difficulties to the student in obtaining information, and that the lack of class discussion would reduce opportunities for development or exchange of ideas. That some of these difficulties are encountered in the shop use of instruction sheets is evident from the reactions of teachers[1]. Additional criticisms that are offered are that the use of the instruction sheet does not give the

1. Selvidge, R.W., and Fryklund, V.C., Principles of Trade and Industrial Teaching, The Manual Arts Press, Peoria, Illinois, 1930, pp. 127-132.

atmosphere of industry, that the brighter students benefit disproportionately, that blunders are made from misunderstanding instructions, and that some students do not wish to and will not follow instructions.

To give any definite answer to the question as to whether the use of instruction sheets is relatively more effective in reaching certain specific objectives than would be a form of class instruction in which the information is given orally and by demonstration would, seemingly, be extremely difficult if not impossible, due to the large number of factors involved. This would not mean, however, that no answer could be given for the use of instruction sheets in some specific shop unit under certain school conditions that might be considered reasonably typical.

Problem

The present study undertakes to determine the relative efficiency of two recognized methods in teaching a Unit of Electricity in Industrial Arts on junior high school level in terms of job achievement and development of student abilities.

While a study by J. H. Douglass[1], carried out under the supervision of R. W. Selvidge of the University of Missouri has shown that the written instruction sheet is superior to the oral presentation of instruction material

1. Douglass, J. H., Industrial Education Magazine, Vol. 33, p. 162, Dec., 1931.

for projects in woodwork in the senior high school, no study seems to have been published which deals specifically with the efficiency of instruction sheets in any industrial phase of the junior high school. Because of the greater immaturity of junior high school students, and because habits of reading and following instructions have not been so well developed, there would be a possibility that the use of instruction sheets for such classes would not show similar results to those of the senior high school.

The choice of a Unit of Electricity used as the basis for the present study was partly due to the matter of convenience. The writer, an instructor in Aaron Gove Junior High School of Denver, Colorado, has been using both the instruction sheet method and the lecture and demonstration method in teaching electricity for sufficient length of time to become proficient in their use.

CHAPTER II

METHODS OF PROCEDURE

Course Material

Before reporting on the methods used in carrying out the present investigation a brief statement of the course content included in the Unit of Electricity will be made. This particular unit is given for nine weeks to boys in the seventh or eighth grades in the Denver junior high schools.

The course of study is flexible, and the following specific learning units selected from a larger list[1] were taught to all the classes in the study.

Operations (What the boy should be able to do)

1. How to draw the diagram of a circuit.
2. How to make a list of material.
3. How to plan procedure of a (electrical) job.
4. How to check a list of material.
5. How to uncoil wire without twisting.
6. How to remove insulation from N.E.C. wire.
7. How to connect wires to a binding post.
8. How to make a Fire Underwriters' knot.
9. How to separate and assemble a plug.
10. How to separate and assemble a lamp socket.
11. How to determine the polarity of a permanent magnet or electromagnet.

1. The complete list is given in the Appendix A, pp. 58-61.

Information (What the boy should know)

1. The source of electrical current.
2. The source of D.C.
3. The source of A.C.
4. Difference between A.C. and D.C.
5. Kinds of conductors and insulators and their uses.
6. How the electrical current gives power.
7. How the electrical current gives heat and light.
8. Kinds of fuses and their uses.
9. How the electrical bell and buzzer works.

A list of major projects was presented in connection with the class work, each student being asked to choose one from the list. These were arranged so as to take relatively the same amount of time to complete, and involved the same fundamentals.

Major Projects

1. Toy motor
2. Buzzer
3. Crystal set
4. Induction coil
5. Telegraph set

A shorter list of minor projects was suggested after the major ones were in the process of construction from which a selection might be made.

Minor Projects

6. Compass (making)
7. Making of Extension Cords

Twenty-five extension cords were made for school orchestra use in the orchestra pit as a part of the second minor project.

Instruction Sheets

The instruction sheets used for the present study were prepared by the writer, the style of presentation following that suggested by R. W. Selvidge[1]. Some of the instruction sheets were developed under the personal supervision of Dr. V. C. Fryklund[2]. All of the sheets had been submitted to former students for their criticism. Their suggestions aided in revising the sheets before being used in the present investigation. Samples of these are in the appendix[3].

Experimental Procedure

In carrying out the investigation, use was made of parallel grouping. Four classes of boys were chosen for the purpose, two in grade 7A, the other two in grade 8B. Three of these classes had the Electricity Unit from April 6, 1936, to June 7, 1936, the other from January 27, 1936, to April 3, 1936. The instruction sheet method was used with one 7A and one 8B class, the lecture and demonstration method being used with the corresponding classes.

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1. Selvidge, R.W., Individual Instruction Sheets, The Manual Arts Press, Peoria, Illinois, 1926, p. 9.
2. Formerly of Nebraska State Teachers College, now of the University of Minnesota. Sheets prepared as a part of course in Instruction Sheet Writing.
3. Appendix A, pp. 62-66

Since all of the boys came from the same section of Denver, and all had been subjected to closely similar school training, it was felt that the use of two criteria of group equivalency would be sufficient. The criteria chosen were those of age and intelligence quotient, administrative records of which were available for all students.

Age and intelligence quotient records[1] were available and used to establish classes into groups which were mathematically equivalent. Some shifting of students was possible between the experimental classes and other classes that were not involved in the present investigation. As a result of such shifting four classes were organized of closely similar size. An attempt is made by the administration to control the span of such differences in every class into a homogeneous grouping rather than heterogeneous. This aided in the present investigation.

Teaching Procedure

The class period for all classes was fifty minutes in length. Thirty minutes of this time was given to the student to work on his particular project or projects. Ten minutes at the beginning of each period of each day was spent reading instructions by the group subjected to the instruction sheet method. The same amount of time was devoted to oral instructions by the second group.

1. Complete list in Appendix A, pp. 71-72.

Both groups were given the same teaching units at the same time. Students were permitted to contact other members in their class during the working period, thereby gaining knowledge and help from each other. Data on members in the four classes entering or withdrawing during the regular scheduled nine-week period were omitted from this study.

Testing Procedure

The purpose of the investigation was to determine which of the two teaching methods--using the lecture and demonstration or using the instruction sheet--was relatively superior in terms of job achievement and the development of student abilities. A testing procedure was devised to measure each of these objectives.

Testing of Job Achievement

After consultation with the research instructor, Dr. C. A. Prosser[1], the following checking factors were selected to measure job achievement:

I. Comparative time required to do a specific job.

II. Number of jobs completed.

III. Number of unsatisfactory jobs.

IV. Grade of performance.

V. Number of times the assistance of the instructor was asked for.

A class card for each student was prepared upon

1. Dr. C. A. Prosser, Director of Dunwoody Industrial Institute, Minneapolis, Minnesota.

which the above facts could be quickly recorded.

In addition to the above, it was desired to determine whether the student could use what had been learned. To determine this, at the completion of a particular job oral questions were used following definite lines of inquiry. An estimated score[1] upon this point was added to the student record. The questions took approximately the following form:

I. How did you make this device?

II. Why did you do that particular thing?

III. What difficulties did you have? How did you meet them?

IV. How does the theory of magnetism apply in this case?

V. How does the theory of electricity apply?

Testing of Student Abilities

It was desired to test certain student abilities in connection with the work. While it is to be recognized that all of these abilities were not affected equally by the methods used in class teaching, yet, a measure of the possession of these abilities at the end of the experiment was presumed to indicate the superiority of one teaching procedure over the other.

The particular abilities to be measured were determined upon after consultation with the research instructor:

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1. Complete list of scores in Appendix B, pp. 74-77.

I. Ability to explain.

II. Ability to perform.

III. Ability to plan.

IV. Ability to describe.

V. Ability to do again.

VI. Ability to do quickly.

Items I and IV were tested by answers to written questions. The content of the written test was a compilation of questions covering the course. Electrical tests of different sources were searched for possible suggestions. The types were familiar to the student, that of true-false, completion and multiple-choice. A copy of this test is included in the appendix[1]. The scoring[2] upon other points involved the instructor's estimate of the student's ability along these lines. Only a few students were asked to repeat the performance in items V and VI. In other cases the instructor made an estimate as to whether the student would probably possess the ability. Estimates upon all of these points were placed upon the student's record card after the job or jobs had been completed.

Statistical Procedure

As mentioned previously, the members of different classes were shifted to establish groups of similar number, and the age and intelligence records of students was available before entrance into class for

1. A copy of written test in Appendix A, pp. 67-70.
2. Complete list of scores in Appendix B, pp. 85-95.

experimentation. Students, whose age or intelligence quotient, or both, would cause dissimilar frequency distribution between groups, were shifted to other classes not in the study. Thus, the dispersion in age and intelligence quotient between groups in this investigation was negligible. Fisher's formula for significance[1] was applied to indicate such existing differences would not invalidate results.

Only the data taken from the individual cards in regard to student abilities was subjected to statistical treatment to indicate which of the two teaching methods was the more effective. The data from the two classes subjected to the lecture and demonstration method, the control group, were combined; likewise for the group using the instruction sheets, which group will be referred to as the experimental group in this study. The first step was to treat the existing differences of means of all abilities combined of each group statistically; then the differences between the means of each of the six abilities were treated likewise. It should be clear that the material has not been grouped in a frequency distribution or this is a small sampling.

1. Fisher, R.A., Statistical Methods for Research Workers, Oliver and Boyd, London, England, Fifth Edition, p. 158.

CHAPTER III

GROUP EQUIVALENCY

As stated in the previous chapter, the classes involved in the investigation were arranged on the basis of age and intelligence. The present section relates to the statistical treatment applied to the class groups to indicate their equivalency.

Table I gives the data relating to age and intelligence quotients for the four classes. In this and following table, classes A and B are referred to as the control group, with which the lecture and demonstration method was used. With classes C and D, referred to as the experimental group, the instruction sheet method was used.

TABLE I. COMPARATIVE DATA FOR CONTROL AND EXPERIMENTAL GROUPS

	Control Group		Experimental Group	
	A	B	C	D
Number in class	25	27	21	24
Span of I Q	87-137	83-153	77-145	89-136
Mean I Q	112.76	101.38	105.47	106.13
Age range, in years and months	12;1-15;5	11;7-15;0	12;4-14;11	11;6-13;10
Mean Age, in years	13;2	12.6	12.8	12.5

The intelligence quotient record of all students in the Denver Public Schools is placed upon the Student Index Card. For the present purpose, the age of each student was that of date in entrance into the course. As will be noted in the table, no exact equivalence between classes was secured either in age or in intelligence, class A being higher in mean age and intelligence than the others. On the other hand, class B also of the control group had the lowest mean intelligence quotient.

In the present study it was not desired to compare classes with each other, but to compare the combined control group with the combined experimental group. A statistical treatment was therefore applied to the two combined groups to determine whether such differences as exist were less than those that could be ascribed to chance.

Tables II and III give the mean[1] and standard deviation[1] for the two groups in reference to intelligence quotients, while Tables IV and V give the results for age. Table VI compares the findings for the two groups in terms of significance.

1. Arkin, Herbert and Colton, Raymond, An Outline of Statistical Methods, Barnes and Noble, Inc., 1935, pp. 11, 37, 120, 212.

TABLE II. DISTRIBUTION OF INTELLIGENCE QUOTIENT IN THE CONTROL GROUP

I Q Score A & B	Number of students (f)	Deviation from Mean (d')	fd'	fd'^{2}
81	1	-24	-24	576
83	2	-22	-44	968
84	1	-21	-21	441
87	1	-18	-18	324
88	1	-17	-17	289
90	2	-15	-30	450
91	1	-14	-14	196
92	1	-13	-13	169
93	1	-12	-12	144
95	1	-10	-10	100
96	1	- 9	- 9	81
97	2	- 8	-16	128
98	1	- 7	- 7	49
99	1	- 6	- 6	36
100	2	- 5	-10	72
101	1	- 4	- 4	16
102	4	- 3	-12	36
109	1	4	4	16
110	4	5	20	100
111	2	6	12	72
112	1	7	7	49
113	2	8	16	128
115	2	10	20	200
116	1	11	11	121
117	1	12	12	144
119	1	14	14	196
120	2	15	30	450
122	2	17	34	578
123	1	18	18	324
124	1	19	19	361
125	1	20	20	400
130	2	25	50	1250
131	1	26	26	676
137	1	32	32	1024
153	1	48	48	2304
	51		126	12,468

Estimated mean above was 105.

$$\bar{X} = 105 + \frac{126}{51} = 105 + 2.47^{+} = 107.47^{+}$$

$$\sigma = c\sqrt{\frac{\Sigma f(d'^2)}{N} - \left(\frac{\Sigma fd'}{N}\right)^2} = 1\sqrt{\frac{12468}{61} - \left(\frac{126}{51}\right)^2} =$$

$$1\sqrt{244.4705 - 6.1033} = 1\sqrt{238.3672} = 15.43$$

$$\sigma_{\bar{x}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{15.43}{7.0711} = 2.18211$$

TABLE III. DISTRIBUTION OF INTELLIGENCE QUOTIENT IN THE EXPERIMENTAL GROUP

I Q Score C & D	Number of students (f)	Deviation from mean (d')	fd'	fd'^2
77	1	-28	-28	784
84	1	-21	-21	441
86	1	-19	-19	361
87	1	-18	-18	324
89	1	-16	-16	256
90	1	-15	-15	225
92	3	-13	-39	507
95	1	-10	-10	100
97	1	- 8	- 8	64
98	1	- 7	- 7	49
99	1	- 6	- 6	36
100	1	- 5	- 5	25
101	1	- 4	- 4	16
102	1	- 3	- 3	9
105	1	0	0	0
107	4	2	8	16
108	1	3	3	9
109	2	4	8	32
110	3	5	15	75
111	1	6	6	36
113	1	8	8	64
116	2	11	22	242
117	1	12	12	144
118	1	13	13	169
120	2	15	30	450
121	1	16	16	256
122	1	17	17	289
126	1	21	21	441
128	1	23	23	529
129	1	24	24	576
132	1	27	27	729
136	1	31	31	961
145	1	40	40	1600
	43		125	9,815

Estimated mean above was 105.

$$\bar{X} = 105 + \frac{125}{43} = 105 + 2.90 = 107.90+$$

$$\sigma = c\sqrt{\frac{\Sigma f(d'^2)}{N} - \left(\frac{\Sigma fd'}{N}\right)^2} = 1\sqrt{\frac{9815}{43} - \left(\frac{125}{43}\right)^2} =$$

$$1\sqrt{228.2558 - 8.4500} = 1\sqrt{219.8058} = 14.82$$

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{N-1}} = \frac{14.82}{6.4807} = 2.2867$$

TABLE IV. DISTRIBUTION OF AGE IN THE CONTROL GROUP

Student Number	Age in Years Yrs.-Mo.	Decimal	Deviation from Mean	No. of Students (f)	fd^1	fd^2
45	11 - 7	11.58	-1.92	1	-1.92	3.6864
46	11 - 8	11.66	-1.84	1	-1.84	3.3856
30	11 - 10	11.83	-1.67	1	-1.67	2.7889
8	12 - 10	12.08	-1.42	1	-1.42	2.0164
44	12 - 7	12.58	- .92	1	- .92	.8464
34	12 - 8	12.83	- .67	1	- .67	.4489
28,33	12 - 9	12.75	- .75	2	-1.50	1.1250
43,51	12 - 10	12.83	- .67	2	-1.34	.8978
23,29	12 - 11	12.91	- .59	2	-1.18	.6962
19	13	13.00	- .50	1	- .50	.2500
17,32,35, 36,37,40, 42	13 - 1	13.08	- .42	7	-2.94	1.2348
7	13 - 2	13.16	- .34	1	- .34	.1156
47	13 - 3	13.25	- .25	1	- .25	.0625
24,38,39	13 - 4	13.33	- .17	3	- .51	.0867
9,14,16, 22,49	13 - 5	13.41	- .09	5	- .45	.0405
5	13 - 6	13.50	.00	1	0	0
1, 6	13 - 7	13.58	.08	2	.16	.0128
11,20,41	13 - 8	13.66	.16	3	.48	.0768
18,48	13 - 9	13.75	.25	2	.50	.1250
3	13 - 10	13.83	.33	1	.33	.1089
15	13 - 11	13.01	.41	1	.41	.1681
4,21	14 - 1	14.08	.58	2	1.16	.6728
27	14 - 3	14.25	.75	1	.75	.5625
12	14 - 4	14.33	.83	1	.83	.6889
2,10,13	14 - 11	14.91	1.41	3	4.23	5.9643
26	15	15.00	1.50	1	1.50	2.2500
25	15 - 5	15.41	1.91	1	1.91	3.6481
31	15 - 11	15.91	2.41	1	2.41	5.8081
				51	-2.78	37.7680

$\bar{X} = 13.5 - \left(\frac{-2.78}{51}\right) = 13.5 - (-.05) = 13.45$

$\sigma = c\sqrt{\frac{\Sigma f(d'^2)}{N} - \left(\frac{\Sigma fd'}{N}\right)^2} = 1\sqrt{\frac{37.7680}{51} - \left(\frac{-2.78}{51}\right)^2} =$

$1\sqrt{.7405 - .0025} = 1\sqrt{.7380} = .8589$

$\sigma_{\bar{X}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{.8589}{7.0711} = .1214$

TABLE V. DISTRIBUTION OF AGE IN THE EXPERIMENTAL GROUP

Student Number	Age in Years Yrs.-Mo.	Decimal	Deviation from Mean	No. of Students (f)	fd^1	fd^2
33	11 - 6	11.50	-2.0	1	-2.0	4.0
2	11 - 11	11.91	-1.59	1	-1.59	2.5281
17	12 - 4	12.33	-1.17	1	-1.17	1.3689
39	12 - 6	12.50	-1.00	1	-1.00	1.0000
28	12 - 7	12.58	- .92	1	- .92	.8464
32,42	12 - 8	12.66	- .84	2	-1.68	1.4112
18,21,26, 36	12 - 9	12.75	- .75	4	-3.00	2.2500
20,30,31	12 - 10	12.85	- .67	3	-2.01	1.3467
27,43	12 - 11	12.91	- .59	2	-1.18	.6962
7,12,13, 29,35	13	13.00	- .50	5	-2.50	1.2500
41	13 - 1	13.08	- .42	1	- .42	.1764
15,25,37	13 - 2	13.16	- .34	3	-1.02	.3468
40	13 - 3	13.25	- .25	1	- .25	.0625
19	13 - 4	13.33	- .17	1	- .17	.0289
38	13 - 5	13.41	- .09	1	- .09	.0081
6,11,22, 24	13 - 6	13.50	.00	4	00	0000
23	13 - 8	13.66	.16	1	.16	.0256
4,34	13 - 10	13.83	.33	2	.66	.2178
14	14	14.00	.50	1	.50	.2500
1,10	14 - 3	14.25	.75	2	1.50	1.1250
5	14 - 4	14.33	.83	1	.83	.6889
8	14 - 10	14.83	1.33	1	1.33	1.7689
3, 9	14 - 11	14.91	1.41	2	2.82	3.9762
16	15 - 2	15.16	1.66	1	1.66	2.7556
				43	-9.54	28.1282

$$\bar{X} = 13.5 - \left(\frac{-9.54}{43}\right) = 13.5 - (-.22) = 13.28$$

$$\sigma = c\sqrt{\frac{\Sigma f(d'^2)}{N} - \left(\frac{\Sigma fd'}{N}\right)^2} = 1\sqrt{\frac{28.1282}{43} - \left(\frac{-9.54}{43}\right)^2} =$$

$$1\sqrt{.6541 - .0484} = 1\sqrt{.6057} = .7783$$

$$\sigma_{\bar{x}_e} = \frac{\sigma}{\sqrt{N-1}} = \frac{.7783}{6.4807} = .1216$$

TABLE VI. GROUP DIFFERENCES IN I Q AND AGE AS RELATED TO SIGNIFICANCE

	Control Group	Experimental Group
I Q		
Mean	107.47	107.90
Standard Deviation	15.43	14.82
Standard Error of Mean	2.182	2.287
Significance[1] of Difference	t = .1321 (not significant)	
AGE		
Mean	13.45	13.28
Standard Deviation	.8589	.7783
Standard Error of Mean	.1214	.1216
Significance[2] of Difference	t = 1.00 (not significant)	

1. I Q $t = \frac{107.90 - 107.47}{\sqrt{2.182^2 + 2.287^2}} = .1321$

2. Age $t = \frac{13.45 - 13.28}{\sqrt{.1214^2 + .1216^2}} = 1.00$

Criterion of significance: $t = 2$ for $p = .05$

Since the value of t in the case of I Q was much less than 2, as given in Statistical Methods for Research Workers[1] by R. A. Fisher, as the criterion of significance, any differences in this respect between the groups canbe attributed solely to chance. In the case of age the value of t, while greater than in the preceding case, is but half that of the value needed to prove the differences significant. It may, therefore, be assumed that such diferences as exist would not invalidate any findings of the investigation.

1. Fisher, R. A., Statistical Methods for Research Workers, Oliver and Boyd, London, England, Fifth Edition, p. 158.

CHAPTER IV

ANALYSIS OF RESULTS

A. Job Achievement

As stated at an earlier point the record card of the individual student was filled out during the progress of the investigation so as to carry information as to the time required to do each specific job, the number of jobs completed, the number of jobs handled in an unsatisfactory manner, the grade of performance, and the number of times that the assistance of the instructor was requested.

Data were taken from these individual records and recorded upon a master chart for each class, so that a comparison of the job achievement of the separate classes might be made.

Comparative Time Needed for Specific Jobs

Table VII shows the time needed by the members of the four classes in doing the specific jobs. Since considerable choice was permitted as to the projects that each student might select a variation is indicated in the table as to the number involved in each project. In the case of the crystal set, a project selected by at least ten members of each class, the average time required for the members of classes A and B was greater than for classes C and D, varying for 10.9 hours for class D to 17.2 hours for class B.

Considering the two control classes A and B together and the two experimental classes C and D together

TABLE VII. COMPARATIVE TIME NEEDED TO DO SPECIFIC JOBS

Projects	Control Group						Experimental Group					
	Ave. Time	No. of Jobs	Ave. Time	No. of Jobs	Ave. Time	No. of Jobs	Ave. Time	No. of Jobs	Ave. Time	No. of Jobs	Ave. Time	No. of Jobs
Crystal Set	15.4	15	17.2	11	16.2	26	14.4	10	10.9	13	12.4	23
Buzzer			17.1	7	17.1	7			17.5	2	17.5	2
Motor	18.5	7	14.8	4	17.2	11	15.8	11	18.2	10	16.9	21
Extension Cord	5.0	6	3.0	1	4.7	7	4.3	7	5.0	7	4.7	14
Compass	7.8	3	8.6	3	8.2	6	10.0	1	4.0	6	4.8	7
Telegraph Set			18.5	1	18.5	1						
Induction Coil	15.0	1			15.0	1						
Total of all Projects	12.3	32	13.2	27	12.70	59	11.1	29	11.3	38	11.2	67

much less time on the average was required by the experimental group for the completion of this job, the values being 12.4 as against 16.2 hours.

In the motor project, selected by 11 students of the control group and 21 of the experimental group, the time differences were but slight, being 17.2 for the control group as against 16.9 for the experimental group. In the extension cord project the seven students of the control group selecting it had the same average time as the 14 of the experimental group, the average time being 4.7 hours in each case.

For the compass project the experimental group finished the job in an average time of 4.8 hours as compared with 8.2 hours for the control group.

For other projects the number involved was relatively small and little effective comparison can be made.

Job Completion

Table VIII gives data for three other factors relating to job performance, number of satisfactory and unsatisfactory jobs, grade on performance on satisfactory jobs, number of times assistance of the instructor was asked for, and comparative ability of the student to use what had been learned. The grade on performance represented the instructor's estimate. The ability to use what had been learned was scored on answers given to oral questioning, as explained in the previous chapter.

The experimental group finished, on the average, a larger number of satisfactory jobs per pupil (1.49 as

TABLE VIII. DATA RELATING TO JOB COMPLETION, FOR CONTROL AND EXPERIMENTAL GROUPS

	Control Group			Experimental Group		
	A	B	Total	C	D	Total
Total number of satisfactory jobs	32	27	59	29	38	67
Total number of unsatisfactory jobs	5	3	8	0	2	2
Number of satisfactory jobs per pupil	1.28	1.00	1.13	1.40	1.58	1.49
Number of unsatisfactory jobs per pupil	.20	.11	.15	.00	.08	.04
*Grade of performance on satisfactory jobs (average percent)	89.15	81.96	85.83	85.93	84.76	85.26
Number of times assistance of instructor was desired	0	0	0	16	2	18
Comparative ability to use what had been learned (average percent)	81.60	79.09	80.45	85.47	88.40	87.13

*Individual list in Appendix B, pp.

compared with 1.13), had fewer unsatisfactory jobs (.04 as compared with .15), received a slightly lower grade on the jobs performed (85.26% as compared with 85.85%), asked for considerable assistance, while the other group asked for none, and showed greater ability to use what had been learned (87.13% as compared with 80.45%).

It may therefore be concluded that the experimental group completed their projects in shorter time, completed a larger number of satisfactory jobs, had fewer unsatisfactory jobs and showed a greater ability to use what had been learned. They asked more assistance of the instructor and made a slightly lower grade on performance.

B. Student Abilities

As stated in the chapter on method each student was scored at the time of completing a job or jobs on the abilities he showed in connection with the work. These abilities were:

Ability to plan
Ability to describe
Ability to explain
Ability to perform
Ability to do again
Ability to do quickly

Each student was scored on each of these points.

The data for the entire control group are given in Table IX and those for the experimental group in Table

X. In each case the mean of the scores made on the six factors has been determined.

The data from these tables have been used statistically to determine whether any significant differences existed between the groups (1) in relation to the mean of the scores, and (2) in relation to each of the individual abilities.

Significance of Differences in the Mean of Scores

Tables XI and XII show the scores listed in a frequency table. The mean, standard deviation, and standard error of the mean have been computed for the application of the significance formula.

$$t = \frac{\text{Difference of Means}}{\sigma \text{ Difference}} = \frac{72.33 - 71.46}{\sqrt{\bar{X}_c^2 + \bar{X}_E^2}}$$

$$= \frac{.87}{\sqrt{(1.0041)^2 + (1.1279)^2}} = \frac{.87}{\sqrt{1.0182 + 1.2721}}$$

$$= \frac{.87}{1.4991} = .55$$

Since the value of t is .55, which is much less than 2, the criterion of significance, there is no evidence to indicate that one group has received higher scores than the other.

TABLE IX. DISTRIBUTION OF SCORES OF CONTROL GROUP ON SIX ABILITIES

Group A & B No.	Ability to Plan	Ability to Describe	Ability to Explain	Ability to Perform	Ability to do Again	Ability to do Quickly	Mean Ability
1.	90	56	36	90	85	85	73
2.	80	64	72	85	80	80	77
3.	85	50	45	90	85	90	74
4.	80	38	63	85	80	80	71
5.	90	38	72	90	90	95	72
6.	85	56	90	90	90	95	84
7.	90	44	72	85	85	80	76
8.	85	58	81	90	85	80	79
9.	90	82	54	90	80	80	79
10.	80	26	36	80	80	80	63
11.	90	38	63	90	85	85	75
12.	80	53	45	90	85	75	71
13.	90	50	90	70	90	90	80
14.	85	38	36	90	90	90	71
15.	80	56	63	85	95	95	79
16.	90	53	81	95	90	75	80
17.	95	47	72	95	90	90	81
18.	90	58	90	85	85	85	82
19.	70	26	36	75	70	70	57
20.	85	70	81	80	85	85	81
21.	95	61	63	90	85	85	79
22.	85	64	81	90	90	85	82
23.	80	44	54	85	85	80	71
24.	90	58	36	95	95	80	75
25.	85	41	54	90	95	95	76

TABLE IX (CONTINUED). DISTRIBUTION OF SCORES OF CONTROL GROUP ON SIX ABILITIES

Group A & B No.	Ability to Plan	Ability to Describe	Ability to Explain	Ability to Perform	Ability to do Again	Ability to do Quickly	Mean Ability
26.	73	38	45	85	94	92	71
27.	72	35	65	73	92	92	71
28.	77	53	45	77	95	90	73
29.	80	44	36	75	82	82	66
30.	75	44	45	81	75	62	63
31.	92	32	54	91	95	92	76
32.	72	32	63	73	82	78	66
33.	82	32	36	85	87	85	68
34.	85	67	54	89	90	90	79
35.	63	20	36	72	72	70	50
36.	80	29	54	80	87	94	70
37.	75	58	54	78	75	85	71
38.	82	56	54	78	90	90	75
39.	93	47	72	92	95	90	81
40.	78	38	27	78	85	87	65
41.	82	64	63	77	82	92	76
42.	82	56	45	80	80	82	71
43.	70	14	36	72	85	72	58
44.	75	41	63	75	70	72	66
45.	75	61	72	75	92	95	78
46.	82	14	36	82	85	95	65
47.	80	38	36	78	90	90	68
48.	92	38	54	90	92	92	76
49.	80	58	72	82	87	82	77
50.	75	58	72	82	87	82	64
51.	72	41	54	68	85	80	66

TABLE X. DISTRIBUTION OF SCORES OF EXPERIMENTAL GROUP ON SIX ABILITIES

Group C & D No.	Ability to Plan	Ability to Describe	Ability to Explain	Ability to Perform	Ability to do Again	Ability to do Quickly	Mean Ability
1.	75	62	72	80	70	77	72
2.	95	70	90	90	85	93	87
3.	75	47	27	80	70	72	62
4.	95	47	36	80	75	85	70
5.	95	52	45	80	80	83	72
6.	75	50	63	80	80	85	72
7.	85	56	63	90	95	83	78
8.	80	59	36	95	95	77	73
9.	85	59	54	85	80	76	73
10.	80	50	54	85	85	83	73
11.	85	44	54	90	85	88	74
12.	90	62	72	90	90	85	81
13.	90	35	36	70	70	72	62
14.	75	76	45	95	95	92	79
15.	90	32	36	80	80	82	66
16.	85	62	45	90	90	92	77
17.	90	64	72	90	90	92	83
18.	90	52	63	85	90	78	76
19.	80	56	72	90	90	80	78
20.	80	67	72	95	95	92	83
21.	95	56	63	90	90	92	81

TABLE X (CONTINUED). DISTRIBUTION OF SCORES OF EXPERIMENTAL GROUP ON SIX ABILITIES

Group C & D No.	Ability to Plan	Ability to Describe	Ability to Explain	Ability to Perform	Ability to do Again	Ability to do Quickly	Mean Ability
22.	80	32	27	80	80	75	62
23.	90	35	45	85	85	80	70
24.	85	20	18	85	85	80	62
25.	95	44	54	95	95	90	79
26.	80	11	27	80	80	80	59
27.	75	5	18	80	80	80	56
28.	95	58	27	90	95	90	76
29.	95	47	54	90	90	90	77
30.	80	35	65	85	80	85	71
31.	75	17	36	75	80	75	59
32.	90	50	36	90	90	90	74
33.	75	38	45	80	80	80	66
34.	80	29	54	75	80	75	66
35.	75	20	54	80	80	75	64
36.	80	44	45	85	85	85	71
37.	85	29	18	90	90	85	66
38.	80	9	18	90	90	85	63
39.	85	38	36	85	85	85	69
40.	85	11	36	90	90	95	68
41.	95	58	27	85	85	80	71
42.	85	44	27	90	90	85	70
43.	90	50	72	95	95	90	82

TABLE XI. DISTRIBUTION OF SCORES OF MEAN ABILITY OF CONTROLLED GROUP

Group A & B Student No.	Mean Ability	Frequency	Deviation from Mean	fd'	fd'^2
35	50	1	-20	-20	400
19	57	1	-13	-13	169
43	58	1	-12	-12	144
10,30	63	2	- 7	-14	98
50	64	1	- 6	- 6	36
40,46	65	2	- 5	-10	50
29,32,44,51	66	4	- 4	-12	64
33,47	68	2	- 2	- 4	8
36	70	1	0	0	0
4,12,14,23 26,27,37,42	71	8	1	8	8
5	72	1	2	2	4
1,28	73	2	3	6	18
3	74	1	4	4	16
11,24,38	75	3	5	15	75
7,25,31, 41,48	76	5	6	30	180
2,49	77	2	7	14	98
45	78	1	8	8	64
8, 9,15,21 34	79	5	9	36	405
13,16	80	2	10	20	200
17,20,39	81	3	11	33	363
18,22	82	2	12	24	288
6	84	1	14	14	196
		51		119	2,864

$$\bar{X} = \bar{Z} + \frac{\Sigma(fd)}{N} = 70 + \frac{119}{51} = 70 + 2.33 = 72.33$$

$$\sigma = C\sqrt{\frac{\Sigma f(d'^2)}{} - \left(\frac{\Sigma fd'}{N}\right)^2} = C\sqrt{\frac{2864}{51} - \left(\frac{119}{51}\right)^2} =$$

$$1\sqrt{56.15 - 5.4289} = \sqrt{50.7211} = 7.12$$

$$\sigma_{\bar{X}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{7.12}{\sqrt{50}} = \frac{7.12}{7.0711} = 1.0091$$

TABLE XII. DISTRIBUTION OF SCORES OF MEAN ABILITY OF EXPERIMENTAL GROUP

Group C & D Student No.	Mean Ability	Frequency	Deviation from Mean	fd'	fd'^2
27	56	1	-14	-14	196
26,31	59	2	-11	-22	242
3,13,22,24	62	4	- 8	-32	256
38	63	1	- 7	- 7	49
35	64	1	- 6	- 6	36
14,33,34,37	66	4	- 4	-16	64
40	68	1	- 2	- 2	4
39	69	1	- 1	- 1	1
4,23,42	70	3	0	0	0
30,36,41	71	3	1	3	3
1, 5, 6	72	3	2	6	12
8, 9,10	73	3	3	9	27
11,32	74	2	4	8	32
18,28	76	2	6	12	72
16,29	77	2	7	14	98
7,19	78	2	8	16	128
14,25	79	2	9	18	162
12,21	81	2	11	22	242
43	82	1	12	12	144
17,20	83	2	13	26	338
2	87	1	17	17	289
		43		63	2,395

$$\bar{X} = \bar{Z} + \frac{\Sigma (fd)}{N} = 70 + \frac{63}{43} = 1.46 = 71.46$$

$$\sigma = c\sqrt{\frac{\Sigma f(d'^2)}{N} - \left(\frac{\Sigma fd'}{N}\right)^2} = 1\sqrt{\frac{2395}{43} - \left(\frac{63}{43}\right)^2} =$$

$$1\sqrt{55.69 - (1.46)^2} = \sqrt{53.5584} = 7.31$$

$$\sigma_{\bar{x}_E} = \frac{\sigma}{\sqrt{N-1}} = \frac{7.31}{6.4807} = 1.1279$$

Significance of Differences in Relation to Individual Abilities

In the following tables (XIII to XXIV) the scores made on each of the six abilities have been subjected to statistical analysis. The results of these tables are summarized in Table XXV.

As may be seen in Table XXV the superiority of the experimental group was shown in the ability to plan, the value of t being 1.78 and approaching significance.

On the other hand, the control group's superiority was shown in the ability to explain; in this case the value of t was 1.90, closely approaching significance. The superiority of the control group was also shown in the ability to describe, although the value of 1.13 for t indicated no definite significance.

In regard to the other abilities, the ability to perform, the ability to do quickly, and the ability to do again, the values of t are so low as to indicate that group differences may be due solely to chance.

TABLE XIII. DISTRIBUTION OF SCORES ON PLANNING ABILITY OF CONTROLLED GROUP

Planning Ability A & B	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	2	12.9	166.41	332.82
93	1	10.9	118.81	118.81
92	2	9.9	98.01	196.02
90	9	7.9	62.41	561.69
85	8	2.9	8.41	67.28
82	5	- .1	.01	.05
80	10	- 2.1	4.41	44.10
78	1	- 4.1	16.81	16.81
77	1	- 5.1	26.01	26.01
75	5	- 7.1	50.41	252.05
73	2	- 9.1	82.81	165.62
72	2	-10.1	102.01	204.02
70	2	-12.1	146.41	292.82
63	1	-19.1	364.81	364.81
	51			2,642.91

Mean = 82.1

$$\sigma = \sqrt{\frac{\Sigma F x^2}{N}} = \sqrt{\frac{2642.91}{51}} = \sqrt{51.82} = 7.20$$

$$\sigma_{\bar{x}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{7.2}{\sqrt{50}} = \frac{7.2}{7.0711} = 1.01$$

TABLE XIV. DISTRIBUTION OF STUDENT SCORES ON PLANNING ABILITY OF EXPERIMENTAL GROUP

Planning Ability C & D	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	8	10.3	106.09	848.72
90	8	5.3	28.09	224.72
85	9	.3	.90	8.10
80	10	4.7	22.09	220.90
75	8	9.7	94.09	752.72
	43			2,055.16

Mean = 84.7

$$\sigma = \sqrt{\frac{\Sigma Fx^2}{43}} = \sqrt{\frac{2055.16}{43}} = \sqrt{47.79} = 6.91$$

$$\sigma_{\bar{x}_E} = \frac{\sigma}{\sqrt{N-1}} = \frac{6.91}{6.4807} = 1.06$$

$$\bar{x}_C - \bar{x}_E = 8.21 - 8.47 = 2.6$$

$$\sigma_{diff} = \sqrt{\sigma_{x_C}^2 + \sigma_{x_E}^2} = \sqrt{1.0201 + 1.1236} = 1.46$$

$$t = \frac{Diff}{\sigma Diff} = \frac{2.6}{1.46} = 1.78$$

Planning Ability approaches significance, but cannot be said to be definite.

TABLE XV. DISTRIBUTION OF STUDENT SCORES ON EXPLAINING ABILITY OF CONTROLLED GROUP

Explaining Ability A & B	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
90	3	36.2	1310.44	3931.32
81	4	27.2	739.84	2959.36
72	7	18.2	331.24	2318.68
65	1	11.2	125.44	125.44
63	7	9.2	84.64	592.48
54	11	.2	. 4	4.40
45	6	8.8	77.44	464.64
36	11	17.8	316.84	3485.24
27	1	26.8	718.24	718.24
	51			14,599.80

Mean = 53.8

$$\sigma = \frac{\sqrt{\Sigma Fx^2}}{N} = \frac{\sqrt{14,599.80}}{51} = \sqrt{286.27} = 16.91$$

$$\sigma_{\bar{x}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{16.91}{7.0711} = 2.45$$

TABLE XVI. DISTRIBUTION OF STUDENT SCORES ON EXPLAINING ABILITY OF EXPERIMENTAL GROUP

Explaining Ability C & D	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
90	1	43.3	1874.89	1874.89
72	6	25.3	640.09	3840.54
65	1	18.3	334.89	334.89
63	4	16.3	265.69	1062.76
54	7	7.3	53.29	373.03
45	6	1.7	2.89	17.34
36	8	10.7	114.49	915.92
27	6	19.7	388.09	2328.54
18	4	28.7	823.69	3294.76
	43			14,042.67

Mean = 46.7

$$\sigma = \sqrt{\frac{\Sigma F x^2}{N}} = \sqrt{\frac{14,042.67}{43}} = \sqrt{326.57} = 18.07$$

$$\sigma_{\bar{x}_E} = \frac{\sigma}{\sqrt{N-1}} = \frac{18.07}{6.4807} = 2.78$$

$$\sigma \text{ Diff} = \sqrt{\sigma_{x_c} + \sigma_{\bar{x}_E}} = \sqrt{6.0025 + 7.7284} = 3.70$$

$$t = \frac{\text{Diff.}}{\sigma \text{ Diff.}} = \frac{53.8 - 46.7}{3.70} = 1.9$$

Explaining Ability approaches significance but not definite.

TABLE XVII. DISTRIBUTION OF STUDENT SCORES ON PERFORMANCE ABILITY OF CONTROLLED GROUP

Performance Ability A & B	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
92	1	9.	81.	81.
95	3	12.	144.	432.
91	1	8.	64.	64.
90	13	7.	49.	637.
89	1	6.	36.	36.
85	8	2.	4.	32.
82	2	-1.	1.	1.
81	1	-2.	4.	4.
80	4	-3.	9.	36.
78	4	-5.	25.	100.
77	2	-6.	36.	72.
75	4	-8.	64.	256.
73	2	-10.	100.	200.
72	2	-11.	121.	242.
70	1	-13.	169.	169.
68	2	-15.	225.	450.
	51			2,812.

Mean = 83.

$$\sigma = \sqrt{\frac{\Sigma F x^2}{N}} = \sqrt{\frac{2812}{51}} = \sqrt{55.13} = 7.42$$

$$\sigma_{\bar{x}c} = \frac{\sigma}{\sqrt{N-1}} = \frac{7.42}{7.0711} = 1.04$$

TABLE XVIII. DISTRIBUTION OF STUDENT SCORES ON PERFORMANCE ABILITY OF EXPERIMENTAL GROUP

Performance Ability C & D	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	1	13.2	174.24	174.24
93	1	11.2	125.44	125.44
92	5	10.2	104.04	520.20
90	5	8.2	67.24	336.20
88	2	6.2	38.44	76.88
85	8	3.2	10.24	81.92
83	3	1.2	1.44	4.32
82	1	.2	.40	.40
80	7	-1.8	3.24	22.68
78	1	-3.8	14.44	14.44
77	2	-4.8	23.04	46.08
76	1	-5.8	33.64	33.64
75	4	-6.8	46.24	184.96
72	2	-9.8	96.04	192.08
	43			1,813.48

Mean = 81.8

$$\sigma = \sqrt{\frac{\Sigma F x^2}{N}} = \sqrt{\frac{1813.48}{43}} = \sqrt{42.17} = 6.49$$

$$\sigma_{\bar{x}E} = \frac{\sigma}{\sqrt{N-1}} = \frac{6.49}{6.4807} = 1.00$$

$$t = \frac{Diff}{\sqrt{\sigma_{\bar{x}C} + \sigma_{\bar{x}E}}} = \frac{1.2}{\sqrt{2.0816}} = \frac{1.2}{1.44} = .83$$

TABLE XIX. DISTRIBUTION OF STUDENT SCORES ON ABILITY TO DO QUICKLY OF CONTROLLED GROUP

Ability to do Quickly A & B	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	6	10.5	110.25	661.50
94	1	9.5	90.25	90.25
92	6	7.5	56.25	337.50
90	9	5.5	30.25	272.25
87	1	2.5	6.25	6.25
85	8	.5	.25	2.00
82	3	- 2.5	6.25	18.75
80	9	- 4.5	20.25	182.25
78	1	- 6.5	42.25	42.25
75	2	- 9.5	90.25	180.50
72	3	-12.5	156.25	468.75
70	2	-14.5	210.25	420.50
	51			2,682.75

Mean = 84.5

$$\sigma = \frac{\sqrt{\Sigma F x^2}}{N} = \frac{\sqrt{2682.75}}{51} = \sqrt{52.60} = 7.25$$

$$\sigma_{\bar{x}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{7.25}{7.0711} = 1.02$$

TABLE XX. DISTRIBUTION OF STUDENT SCORES ON ABILITY TO DO QUICKLY OF EXPERIMENTAL GROUP

Ability to do Quickly C & D	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	1	9.8	96.04	96.04
93	1	7.8	60.84	60.84
92	5	6.8	46.24	231.20
90	5	4.8	23.04	115.20
88	2	2.8	7.84	15.68
85	8	- .2	.40	3.20
83	3	- 2.2	4.84	14.52
82	1	- 3.2	10.24	10.24
80	7	- 5.2	27.04	189.28
78	1	- 7.2	51.84	51.84
77	2	- 8.2	67.24	134.48
76	1	- 9.2	84.64	84.64
75	4	-10.2	104.04	416.16
72	2	-13.2	174.24	288.48
	43			1,711.80

Mean = 85.2

$$\sigma = \sqrt{\frac{\Sigma Fx^2}{N}} = \sqrt{\frac{1711.80}{43}} = \sqrt{39.80} = 6.30$$

$$\sigma_{\bar{x}E} = \frac{\sigma}{\sqrt{N-1}} = \frac{6.30}{6.4807} = .97$$

$$t = \frac{Diff}{\sigma Diff} = \frac{85.2 - 84.5}{\sqrt{\sigma_{\bar{x}C} + \sigma_{\bar{x}E}}} = \frac{.7}{\sqrt{1.9813}} = .50$$

TABLE XXI. DISTRIBUTION OF STUDENT SCORES ON ABILITY TO DO AGAIN OF CONTROLLED GROUP

Ability to do Again A & B	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	6	9.2	84.68	507.84
94	1	8.2	67.24	67.24
92	3	6.2	38.44	115.32
90	10	4.2	17.64	176.40
87	3	1.2	1.44	4.32
85	14	- .8	.64	8.96
82	3	- 3.8	14.44	43.32
80	6	- 5.8	33.64	201.84
75	2	-10.8	116.64	233.28
72	1	-13.8	190.44	190.44
70	2	-15.8	249.64	499.28
	51			2,048.24

Mean = 85.8

$$\sigma = \sqrt{\frac{\Sigma F_x{}^2}{N}} = \sqrt{\frac{2048.24}{51}} = \sqrt{40.16} = 6.33$$

$$\sigma_{\bar{x}_c} = \frac{\sigma}{\sqrt{N-1}} = \frac{6.33}{7.0711} = .89$$

TABLE XXII. DISTRIBUTION OF STUDENT SCORES ON ABILITY TO DO AGAIN OF EXPERIMENTAL GROUP

Ability to do Again C & D	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
95	5	9.2	84.64	423.20
90	15	4.2	17.64	264.60
85	9	- .8	.64	5.76
80	11	- 5.8	33.64	370.04
75	2	- 10.8	116.64	233.28
70	1	- 15.8	249.64	249.64
	43			1,546.52

Mean = 85.8

$$\sigma = \sqrt{\frac{\Sigma F x^2}{N}} = \sqrt{\frac{1546.52}{43}} = \sqrt{35.96} = 5.99$$

$$\sigma_{\bar{x}E} = \frac{\sigma}{\sqrt{N-1}} = \frac{5.99}{6.4807} = .92$$

$$t = \frac{Diff}{\sigma Diff} = \frac{85.8 - 85.8}{\sqrt{\sigma_{\bar{x}C} + \sigma_{\bar{x}E}}} = \frac{0}{\sigma Diff} = 0$$

TABLE XXIII. DISTRIBUTION OF STUDENT SCORES ON DESCRIBING ABILITY OF CONTROLLED GROUP

Describing Ability A & B	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
82	1	35.8	1281.64	1281.64
70	1	23.8	566.44	566.44
67	1	20.8	432.64	432.64
64	3	17.8	316.84	950.52
61	2	14.8	219.04	438.08
58	5	11.8	139.24	696.20
56	5	9.8	96.04	288.12
53	3	6.8	46.24	138.72
50	2	3.8	14.44	28.88
47	2	.8	.64	1.28
44	4	- 2.2	4.84	19.36
41	3	- 5.2	27.04	81.12
38	9	- 8.2	67.24	605.16
35	1	-11.2	125.44	125.44
32	3	-14.2	201.64	604.92
29	1	-17.2	295.84	295.84
26	2	-20.2	408.04	816.08
20	1	-26.2	686.44	686.44
14	2	-32.2	1036.84	2073.68
	51			10,130.56

Mean = 46.2

$\sigma = \sqrt{\frac{\Sigma Fx^2}{N}} = \sqrt{\frac{10,130.56}{51}} = 14.09 \qquad \sigma_{\bar{x}_c} = \frac{14.09}{7.0111} = 1.99$

TABLE XXIV. DISTRIBUTION OF STUDENT SCORES ON DESCRIBING ABILITY OF EXPERIMENTAL GROUP

Describing Ability C & D	Frequency	Deviation from Mean (x)	(x^2)	Fx^2
Score				
76	1	33.6	1128.96	1128.96
70	1	27.6	761.76	761.76
67	1	24.6	605.16	605.16
64	1	21.6	466.56	466.56
62	3	19.6	384.16	1152.48
59	2	16.6	275.56	551.12
58	2	15.6	243.36	486.72
56	3	13.6	184.96	554.88
52	2	9.6	92.16	184.32
50	4	7.6	57.76	231.04
47	2	4.6	21.16	42.32
44	4	1.6	2.56	10.24
41	1	- 1.4	1.96	1.96
38	2	- 4.4	19.36	38.72
35	3	- 7.4	54.76	164.28
32	2	-10.4	108.16	216.32
29	2	-13.4	179.56	359.12
20	2	-22.4	501.76	1003.52
17	1	-25.4	645.16	645.16
11	2	-31.4	985.96	1971.92
9	1	-33.4	1115.56	1115.56
5	1	-37.4	1398.76	1398.76
	43			13,090.88

Mean = 42.4

TABLE XXIV. DISTRIBUTION OF STUDENT SCORES ON DESCRIBING ABILITY OF EXPERIMENTAL GROUP (CONTINUED)

$$\sigma = \sqrt{\frac{\Sigma F x^2}{N}} = \sqrt{\frac{13,090.88}{43}} = \sqrt{264.29} = 17.44$$

$$\sigma_{\bar{x}E} = \frac{\sigma}{\sqrt{N-1}} = \frac{17.44}{6.807} = 2.69$$

$$t = \frac{Diff}{\sigma Diff} = \frac{3.8}{\sqrt{\sigma_{\bar{x}C} + \sigma_{\bar{x}E}}} = \frac{3.8}{\sqrt{3.9601 + 7.236}} =$$

$$\frac{3.8}{3.34} = 1.13$$

TABLE XXV. DISTRIBUTION OF SCORES ON SIX ABILITIES IN RELATION TO SIGNIFICANCE OF DIFFERENCES

	Mean			t	Significance
Ability to Plan					
Control Group	82.1	7.20	1.01		
Experimental Group	84.7	6.91	1.06	1.78	Approaches significance
Ability to Explain					
Control Group	53.8	16.91	2.45		
Experimental Group	46.7	18.07	2.78	1.90	Approaches significance
Ability to Perform					
Control Group	83.0	7.42	1.04		
Experimental Group	81.8	6.49	1.00	.83	Not significant
Ability to do Quickly					
Control Group	84.5	7.25	1.02		
Experimental Group	85.2	6.30	.97	.50	Not significant
Ability to do Again					
Control Group	85.8	6.33	.89		
Experimental Group	85.8	5.99	.92	.00	Not significant
Ability to Describe					
Control Group	46.2	14.09	1.99		
Experimental Group	42.4	17.44	2.69	1.13	Not definitely significant

Discussion of Results

It is possible that the superiority of the experimental group in the ability to plan and the inferiority of the same group in the ability to explain and the ability to describe could be explained on some other basis than that of the method of instruction used. No pre-tests of these abilities were made. The bases used for group equivalency were those of general intelligence as measured by I Q and age. Those familiar with junior high school students in Industrial Arts are aware that some information, but very little manipulative skill, is shown by students previous to instruction. Yet, it cannot be assumed that identical instruction given to those of the same age and general intelligence will result in the same gain in manipulative skill.

On the other hand, since each group was not small, it would seem possible that the element of chance would be unfavorable to obtaining in one group those who might have a noticeable advantage in this respect.

As to the time required in which to perform the jobs, it is possible that the relative complexity of the job itself might have had some observable effect upon the result. With the extension cord job the average time of 4.7 hours required by the two groups was identical; with the crystal set project, the group having instruction sheets had a definite advantage, as they required but 12.4 hours while the group using the lecture and

demonstration method required 16.2 hours.

It was noticeable that the group using instruction sheets asked help of the instructor, the group using lecture and demonstration asked none. Yet the first group finished a larger number of satisfactory jobs and had fewer unsatisfactory jobs. These results might be expected from the lack of opportunity on the part of the second group to be able to refer to previous directions as a means of checking up on the correct procedure.

CHAPTER V

SUMMARY

The present study undertakes to determine the relative efficiency of two recognized methods in teaching a Unit of Electricity in Industrial Arts on junior high school level in terms of job achievement and development of student abilities. Since each method possesses certain recognized advantages, this study may aid in their determination in terms of the above criterion and designate the method or methods to be used.

The large number of students available, and the course -- learning units sponsored by the A.V.A. in the field of electricity -- presented a situation favorable for carrying out an experimental procedure. Four classes of boys were used, each group similar in number, age and intelligence quotient. Two classes were in the experimental group, and two in the control group. The differences existing between age and mean intelligence quotient between respective groups in the study, were treated statistically. Such differences were not significant, therefore results were valid.

Instruction sheets were developed based upon the learning units which were used by the experimental group, and the same learning units were presented to the control group by the lecture and demonstration method. Each group worked on the same projects during the length of the course of nine weeks.

The checking factors used to measure job achievement were:

1. Comparative time required to do a specific job.
2. Number of jobs completed.
3. Number of unsatisfactory jobs.
4. Grade of performance.
5. Number of times the assistance of the instructor was asked for.

Complete records were kept on each individual student and results indicate the experimental group completed their projects in shorter time, completed a larger number of satisfactory jobs, had fewer unsatisfactory jobs and showed a greater ability to use what had been learned. They asked for more assistance of the instructor and made a slightly lower grade on performance.

Tests[1] were developed to check upon development of student abilities. The first step to determine the significance of the results was to treat statistically the means of all abilities combined. These differences did not indicate significance. Then, the differences between the means of each of the six abilities was treated likewise, the results indicate the experimental group favor the ability to plan. The control group favor the ability to explain. In regard to ability to perform, to do quickly, and to do again, such differences were definitely not significant. On ability to describe, the

1. Complete tests in Appendix B, pp. 85 - 87.

results indicate the control group made the better showing but cannot be interpreted as definitely significant.

RECOMMENDATIONS

Since one study does not prove conclusive results but rather implications, more studies of this nature are needed to establish definite findings. After several conferences with R. W. Selvidge concerning the use of instruction sheets, the writer recommends a plan of using the sheets in somewhat different manner than in this study, such as will follow.

The planning procedure, heretofore, has been left to the individual student, with the aid of the instructor. In this recommended method, a student selects a project of his liking. An instruction sheet[1] is placed in his hands which contains a working drawing of the project and an incomplete list of the steps necessary in planning the job which he is asked to complete. Accompanying this planning procedure is a list of the skills, and a definite list of information topics which is recommended to the student to become acquainted with. The skills and information are essential to the student in order to produce good workmanship and to answer the questions which will be presented to him when the job is completed. Before the final grade is given, the student has an opportunity to mark himself upon a checking list in regard to workmanship.

1. Final Report of the Committee, Standards of Attainment in Industrial Arts Teaching, Pantagraph Printing and Stationery Company, Bloomington, Illinois, 1935, pp. 21-25.

Accompanying each suggested job for the student in a particular course is a teaching plan for the instructor, which includes (1) check list of steps in job planning, (2) numbered instruction sheets possessing correct tool practice pertaining to that job, (3) designated information as to a reference list which the student must read and answer questions.

It is felt among Industrial Arts teachers, the subject presented correctly has the possibility of contributing as much, if not more, to an individual's habits and attitudes than any subject offered in the high school curriculum. Attached to each instruction sheet is an organized list of Desired Experiences[1], which the student may follow, which contribute to his success in life. They are:

I. "Industry. This means a habit of careful, thoughtful work, without loitering or wasting time.

II. Cooperation. This means an attitude of readiness to assist others when they need help, and to join in group undertakings.

III. Consideration of Others. This means a thoughtful attitude in the matter of making things easy and pleasant for others, such as keeping things in order, putting tools away in good condition, and always doing your full share of work where others are involved.

1. Final Report of the Committee, op. cit. pp. 34-35.

IV. Self-reliance. This attitude is a very important factor in success. It means that you should develop the habit of planning your tasks carefully and thoughtfully, and carrying them out with the least possible assistance. Be sure the problem is too difficult for you before you call for help.

V. Readiness to Assume Responsibility. This means that you should not refuse to undertake a task because it is difficult, and when once undertaken you should carry it through to completion".

This approach seems quite logical to the writer after his experience with the instruction sheet of the former type and worthy of experimentation.

If similar experiments are conducted these suggestions may be helpful.

A. An instructor should be thoroughly familiar with both methods before attempting to conduct an experiment to measure the comparative efficiency.

B. Instruction sheets should be tested on students before tried in an experiment.

C. Statistical treatment should be used on data to prove significance.

D. Tests should be tried, revised, and evaluated before used in an experiment.

E. Broader, yet definite, criteria should be used as a basis for testing the relative efficiency of

methods used.

F. Groups should be given a pre-course test that knowledge and skills gained through exposure to the course can be measured.

G. A group should consist of at least one hundred students.

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APPENDIX A

Page

Instructional Aids

CHART I. LEARNING UNITS SPONSORED BY THE A. V. A.

The following "learning units" were sponsored by the American Vocational Association on "Standards of Attainment in Industrial Arts Teaching"[1].

I. The Things You Should Be Able to Do

Group I

1. "Read a wiring-diagram.
2. Make a wiring-diagram.
3. Plan the procedure in doing a job.
4. Remove insulation or covering from wire.
5. Make a rat-tail splice.
6. Make a Western Union splice.
7. Make a tap splice.
8. Solder and tape a splice.
9. Attach wire to a binding-post.
10. Uncoil wire without twisting.
11. Connect dry-cells in series.
12. Connect dry-cells in parallel.
13. Plan and construct a simple electric circuit, which may be opened and closed at one point.
14. Plan and construct an electric circuit which may be opened and closed at either or both of two points.
15. Plan and install electric devices in a circuit in series.
16. Plan and install electric devices in a circuit in parallel.

---

1. Pantagraph Printing and Stationery Company, Bloomington, Illinois.

17. Plan and construct circuits to give selective control of devices in the circuit.

18. Attach a cord to a lamp-socket.

19. Attach a cord to a plug.

20. Test and replace fuses.

21. Read an electric meter.

22. Interpret the identity marks on a motor.

23. Administer first aid in case of shock.

Group II

24. Attach a terminal to a wire.

25. Provide a 'make and break' in a circuit, as in a timer.

26. Apply the principle of electromagnetic force in order to operate mechanisms, as in a buzzer or bell.

27. Employ resistance to generate heat, as in a toaster, or soldering-copper.

28. Wire a circuit so as to prevent a dangerous rise in temperature, due to resistance.

29. Reduce voltage on a line.

30. Locate a break in a circuit.

31. Tie an underwriter's knot.

32. Calculate the resistance of a circuit, using Ohm's Law.

II. <u>The Things You Should Know</u>

Group I

1. The properties of the magnet and the characteristics of the magnetic field.

2. The source of electric current, or pressure.

3. The characteristics of the electric current.

4. How the electric current is conveyed.

5. Kinds of conductors and their uses.
6. The meaning of voltage.
7. The meaning of ampere.
8. The meaning of watt.
9. How the electric current gives power.
10. How the electric current gives light.
11. How the electric current gives heat.
12. The difference between direct current and alternating current.
13. The sources of direct current.
14. The source of alternating current.
15. The meaning of phase and cycle.
16. The meaning of 'series' and 'parallel'.
17. Resistance and its effect.
18. Ohm's Law.
19. How the electric bell works.
20. Why splices should be soldered.
21. Importance of proper insulation.
22. Sizes of wire.
23. The effect of an overload.
24. Symbols used in wiring-diagrams.
25. Safety rules in working with electricity or electrical appliances.

Group II

26. How the rheostat works.
27. How the volt-meter works.
28. How the ammeter works.
29. How the electric meter works.

30. The construction of the dry-cell and how it works.
31. The construction of the wet-cell and how it works.
32. The kinds of fuses and their uses.
33. Kinds of electric lamps and how they are made.
34. Causes and effects of short circuits."

CHART II. INSTRUCTION SHEETS

Operation Sheet #2 - Gove Junior High School
Department of Industrial Arts

How to Make Common Splices With N.E.C. Wire

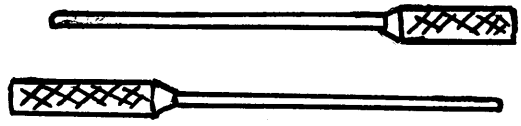


Fig. 1

I. End splice.
1. Remove four (4) inches of insulation from the end of each exhibit of splices.
2. Examine the exhibit of splices.
3. Grasp one wire in the right hand and the other in the left hand. Cross the wires one (1) inch from the insulation as in Fig. 2.

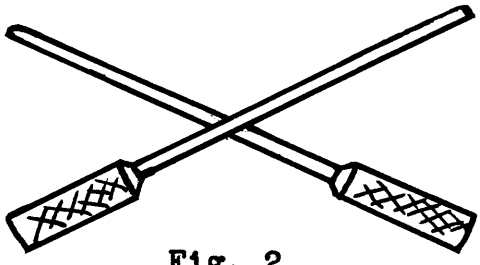


Fig. 2
Cross the wire one inch from the insulation.

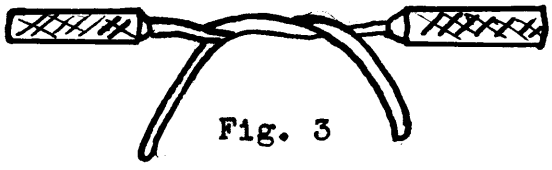


Fig. 3

Twist the wires around each other

4. Give the wire one complete twist tightly around each other with the fingers as in Fig. 3. This is called a neck turn.

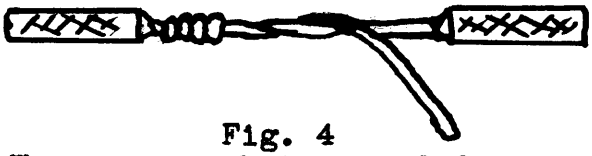


Fig. 4
Wrap one neck turn and four end turns

5. Grasp the pliers in the right hand and hold the wire near the end. Pull and twist this tightly about the other, making at least four (4) end turns, keeping them close together as in Fig. 4.
6. Repeat step 5 to twist other wire.

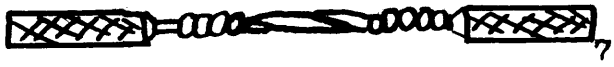


Fig. 5.
Cut off surplus wire and press down ends with pliers

7. Clip off any surplus wire with side cutting pliers and press the ends down tight as in Fig. 5.
8. Solder the splice.
9. Tape the splice.

Operation Sheet #2

II. Tap Splice.

1. Remove four (4) inches of insulation from one end of one wire. Remove one and one-half (1½) inches of insulation from the other wire as in A, Fig. 6.

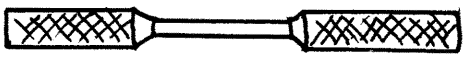


Fig. 6 A

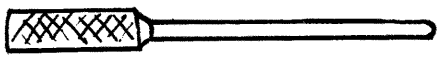


Fig. 6 B

Grasp the wire A, Fig. 6, in the left hand and wire B, Fig. 6, in the right hand. Cross the wires at right angles, keeping insulation on Wire B against wire A. With the fingers of the right hand against wire A. With the fingers of the right hand twist wire B about wire A, making two neck turns.

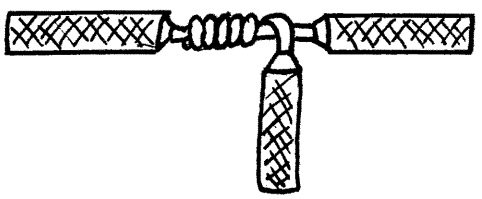


Fig. 7
Two neck turns and two end turns

Grasp the pliers in the right hand and hold the wire near the end. Pull and twist this wire tightly about the other, making at least four end turns as in Fig. 7.

Remove surplus wire and press the ends down tight as in Fig. 7.

Solder the splice.

Tape the splice.

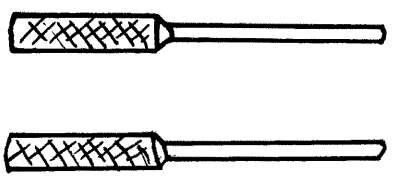


Fig. 8

Fig. 8 and Fig. 9 show the appearance of a rat tail splice when made correctly.

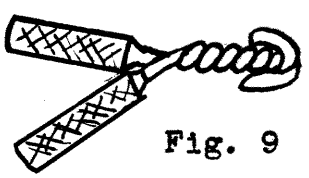


Fig. 9

Bend the ends back

Operation Sheet #3

Fig. 1
A blow torch is commonly used

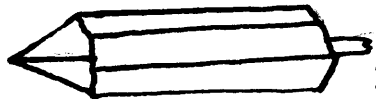


Fig. 2.
Copper well tinned

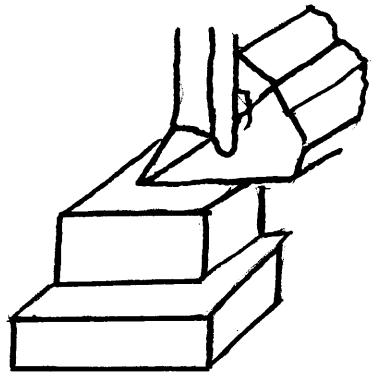


Fig. 3.
Melting some solder on salammoniac

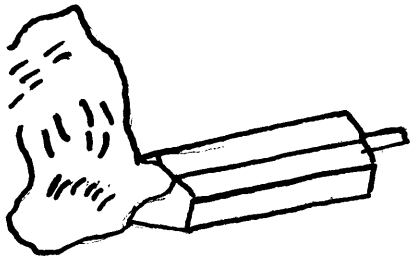


Fig. 4
Wiping a copper clean with a damp cloth

III. Rat tail (pig-tail) splice.

1. Remove two (2) inches of insulation from the end of each wire.
2. Examine the exhibit of splices.
3. Cross the wires near the insulation. Hold the insulated ends of the wire in this position with the left hand.
4. Grasp the pliers in the right hand and with them hold both wires at the ends.
5. Twist the wires together. Make at least three (3) full turns as in Fig. 8.
6. Bend back sharp ends of wire on opposite sides of the twist with pliers as in Fig. 9.
7. Solder the splice.
8. Tape the splice.

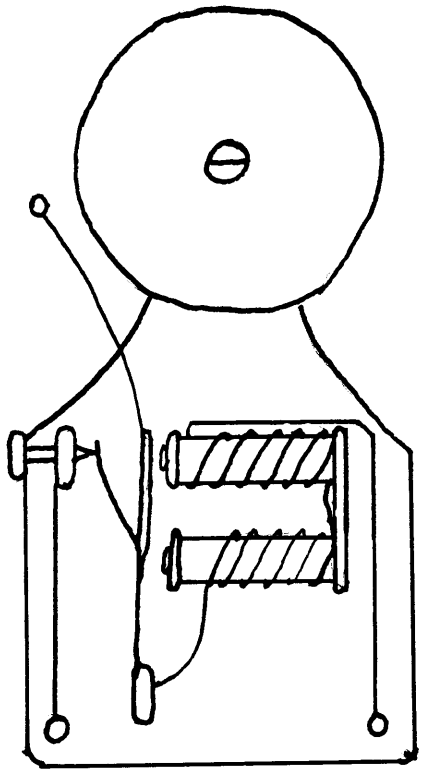
How to Tin a Soldering Copper

1. A soldering copper may be heated in a gas furnace, blow torch, coals of a coal or wood fire, or by electricity. The point should be well shaped to do good work, as in Fig. 2. If the copper does not resemble Fig. 2 ask the instructor to shape the point for you. When it has been approved heat to a "dark red" color.
2. Clamp in vise and file sparingly to a smooth surface.
3. Reheat the copper to a "dark red" color and melt some solder in a hole in the cake of salammoniac, as in Fig. 3.
4. Rub and rotate the copper on the salammoniac. It may be necessary to heat again before it is tinned on all four sides.
5. Do not allow a copper to become "bright red" at any time or it will be necessary to repeat the tinning again.
6. Wipe the point clean with a damp cloth or waste as in Fig. 4. The surface must be bright and clean.

GOVE JUNIOR HIGH SCHOOL
DEPARTMENT OF INDUSTRIAL ARTS
R. F. Tucker

Information Sheet #15

How the Bell and Buzzer Works



Details of a door bell

"Few applications of electricity to common uses are as widespread as electric bells and buzzers. In the picture at the left where the cover is removed, the parts of the bell are readily visible. The two coils of enameled magnet wire on soft iron cores become magnetized and attract the piece of iron to which the hammer is attached. This piece of iron, called the armature, is fastened to the piece of spring brass which can be seen below and at the left of the lower coil. The spring holds the armature away from the cores of the magnets , and the small extension of the spring in contact with the contact point at the upper left-hand part of the frame of the bell. This contact piece is insulated from the metal frame of the bell and is connected to one end of the magnet wire. The path of flow of electric current thru the bell parts is illustrated in Fig. 2. Electric current entering binding post "A" flows thru the small wire, insulated from the frame, to the coils of the electromagnets. The windings are connected so the direction of the current thru one is opposite to that thru the other so there will be a north pole and a south pole near the armature and hence greater pull or attraction. From the second coil the current flows to the contact point "C", thru the spring brass in contact with it, down into the frame, and back to binding post "B" which is in contact with the frame.

When electric current is forced thru this circuit, the cores of the magnets become magnetized and attract the armature causing the hammer to strike the bell. But the spring is pulled away from the contact point "C". This opens the circuit and the magnets lose their magnetism. The armature and hammer are then drawn back into place by the spring and are again pulled toward the bell as the circuit is closed. This process continues as long as sufficient current is furnished. Electric buzzers are similar to electric bells except the bell and hammer are omitted and a buzzing sound is heard instead of the ring

Information Sheet #15

How the Bell and Buzzer Works (Continued)

of a bell".

(Willoughby-Essentials of Electrical Work, pp. 13, 14, 15.)

CHART III. QUESTIONS OF WRITTEN TEST

Gove Junior High School
Department of Industrial Arts

True, False statements.

1. T.F. A natural magnet is made by rubbing a piece of hard steel against a permanent magnet.

2. T.F. Storage batteries store electrical energy.

3. T.F. All magnets must have two poles.

4. T.F. The liquid in the storage battery is called an electrolyte.

5. T.F. The bell transformer is used only on direct current.

6. T.F. The strength of an electro-magnet depends chiefly upon the number of turns of wire wrapped around the core.

7. T.F. Electricity can be controlled by conductors and insulators.

8. T.F. A wire carrying a current of electricity has a magnetic field about it.

9. T.F. Dilute sulphuric acid is used in dry cells.

10. T.F. The core of an electro-magnet is made of hard steel.

11. T.F. There is a commutator on all generators.

12. T.F. Magnetism will not act through paper or glass.

13. T.F. Wires are classified according to their lengths.

14. T.F. Houses are wired according to the specific rules laid down by specialists and are known as the National Code.

15. T.F. Potential, electromotive force, and voltage means electrical pressure.

16. T.F. The commutator carries the current from the armature wires to the outside circuit.

17. T.F. All A.C. generators have rings instead of commutators.

18. T.F. A rheostat is a device used for the control of currents.

19. T.F. Heat is one of the effects of electricity.

20. T.F. A voltmeter measures electrical power.

21. T.F. The moving parts of an A.C. motor is called the rotor.

Multiple Choice.

1. The machine that transforms electrical energy into mechanical energy is a

   a. motor b. generator c. transformer d. choke coil

2. The device that changes alternating current to direct current is called

   a. motor b. generator c. commutator d. slip rings

3. A transformer can only be used on

   a. direct current b. indirect current
   c. alternating current d. pulsating

4. A permanent magnet is used in a telephone

   a. transmitter b. fuse c. bell d. receiver

5. A fuse placed in the circuit is used for

   a. protection b. increasing the voltage
   c. decreasing the amperage d. increasing the resistance

6. A bell transformer is usually a

   a. step-down transformer b. step-up transformer
   c. direct current transformer d. current-changing transformer

7. An electromagnet is
   a. permanent magnet b. artificial magnet
   c. natural magnet d. induced magnet

8. If we add to the number of turns on an electromagnet, the strength of the magnet is

   a. increased b. decreased c. the same
   d. disappears entirely

9. A tungsten filament is more efficient than a carbon filament because

   a. tungsten lamps cost more b. the resistance of tungsten is higher than that of carbon
   c. tungsten lamps are harder to make than the carbon lamps d. tungsten is harder to break

10. The unit of electrical power is the

    a. watt b. volt c. ampere d. ohm

11. A motor gives

    a. mechanical power b. electrical power
    c. heat d. electricity

12. By rubbing the ends of a fountain pen on the sleeve of your coat, there is produced

    a. D.C. electricity b. static electricity
    c. A.C. electricity d. induced current

13. The core of a transformer must be

    a. laminated b. welded
    c. spliced d. soldered

14. Resistance wires used in electrical heating devices are made of

    a. copper b. nichrome c. nickel d. steel

15. The ampere is the measure of

    a. air pressure b. resistance
    c. current d. temperature

16. Wire used for house wiring is usually

    a. No. 18 b. No. 14 c. No. 12 d. No. 10

17. The storage battery stores

    a. chemical energy b. electricity
    c. heat d. mechanical energy

18. Battery lightning is used most extensively in

    a. houses b. mines c. automobiles d. factories

19. In using electricity one pays for the number of

a. volts b. amperes c. ohms d. kilowatt hours

20. "Like poles repel and unlike poles attract" is a law of

a. Ohm b. magnetism c. Edison d. friction

Completion Test.

1. Connecting the positive and negative wires without suitable resistance causes a _____

_____

2. The resistance of any copper wire may be found by the rule; Resistance equals _____ divided by _____

3. _____fuses are made in two common standard types _____and

_____

4. Reversing the direction of current in an electro-magnet reverses its _____

CHART IV. GROUPING ACCORDING TO I Q, AGE AND NUMBER IN CLASS

Class A Number	I Q	Age Year	Month	Class B Number	I Q	Age Year	Month
1.	100	13	7	26.	112	15	
2.	84	14	11	27.	81	14	3
3.	109	13	10	28.	91	12	9
4.	97	14	1	29.	96	12	11
5.	120	13	6	30.	120	11	10
6.	130	13	7	31.	88	15	11
7.	131	13	2	32.	90	13	1
8.	110	12	1	33.	90	12	9
9.	101	13	5	34.	111	12	8
10.	87	14	11	35.	95	13	1
11.	122	13	8	36.	98	13	1
12.	93	14	4	37.	97	13	1
13.	119	14	11	38.	102	13	4
14.	110	13	5	39.	115	13	4
15.	113	13	11	40.	99	13	1
16.	110	13	5	41.	122	13	8
17.	137	13	1	42	89	12	7
18.	125	13	9	43.	100	13	1
19.	130	13		44.	102	12	10
20.	124	13	8	45.	116	12	7
21.	115	14	1	46.	153	11	8
22.	110	13	5	47.	83	11	7
23.	123	12	11	48.	102	13	3
24.	117	13	4	49	113	13	9
25.	102	15	5	50.	92	13	5
				51.	83	14	
				52.	111	12	10

CHART IV. (CONTINUED) GROUPING ACCORDING TO I Q, AGE AND NUMBER IN CLASS

Class C Number	I Q	Age Year	Age Month	Class D Number	I Q	Age Year	Age Month
1.	92	14	3	22.	95	13	6
2.	116	11	11	23.	110	13	8
3.	86	14	11	24.	107	13	6
4.	90	13	10	25.	107	13	2
5.	110	14	4	26.	97	12	9
6.	105	13	6	27.	100	12	11
7.	92	13		28.	136	12	7
8.	102	14	10	29.	113	13	
9.	87	14	11	30.	107	12	10
10.	92	14	3	31.	101	12	10
11.	98	13	6	32.	126	12	8
12.	110	13		33.	112	12	6
13.	109	13		34.	117	11	6
14.	77	14		35.	89	13	10
15.	128	13	2	36.	120	13	
16.	84	15	2	37.	111	12	9
17.	109	12	4	38.	114	13	3
18.	122	12	9	39.	116	13	2
19.	132	13	4	40.	120	13	5
20.	129	12	10	41.	107	12	6
21.	145	12	9	42.	118	13	3
				43.	108	13	1
				44.	99	12	8
				45.	121	12	11

APPENDIX B

Page

Data from Instructional Aids

CHART V. COMPARATIVE TIME, JOBS AND GRADE ON JOBS OF CLASSES

Class A Number	No. of Sat. jobs	Time in hours	Grade	No. of Unsat. Jobs	Time in Hours	Need Assistance
1.	2-S,E	12½,7½	B,A			
2.	2-S,C	10½,9½	B,B			
3.	2-S,E	16½,3½	B,B			
4.	2-S,E	16½,3½	B,B			
5.	2-M,E	16 ,4	B,B			
6.	2-S,C	11 ,9	B,B/			
7.	1-S,P	15	C/	1	5	
8.	1-M	16	B			
9.	1-M	20	B-			
10.	1-M	20	D			
11.	1-S	16½	B-			
12.	1-M	20	A-			
13.	0-S	0	0	1	20	
14.	2-S,E	15 ,5	B/,B			
15.	1-S	20	A			
16.	1-M	17½	A			
17.	1-S,C	13	B	1	6	
18.	0-M	0	0	1	20	
19.	1-S	18	C			
20.	1-M	20	B-			
21.	2-I,C	15 ,5	A,B			
22.	1-S	20	C			
23.	1-S	20	A			
24.	2-S,E	13½,6½	B,B			
25.	1-S,C	13	A	1	7	
Total 32		12.346 = Average				

Code

S - Crystal Set
C - Compass
I - Induction Coil
M - Motor
E - Extension Cord
P - Ear Phones
Sat - Satisfactory
Unsat - Unsatisfactory

CHART V. (CONTINUED) COMPARATIVE TIME, JOBS AND GRADE ON JOBS OF CLASSES

Class B Number	No. of Sat. jobs	Time in hours	Grade	No. of Unsat. Jobs	Time in Hours	Need Assis-tance
26.	1-B	11½	C,C			
27.	1-S	20	D			
28.	1-B	19½	C			
29.	1-B	17½	C			
30.	1-S	16½	C/			
31.	1-T	18½	A			
32.	1-B	20	D			
33.	1-S	19	B			
34.	1-S	8½	B			
35.	1-S	20	D			
36.	1-S	11½	C			
37.	1-B	16½	C			
38.	1-S	19	C			
39.	3-M,C,E.	11½,5,3	B,B/,A			
40.	1-B	20	C			
41.	1-M	19	C/			
42.	1-C	11	C			
43.	1-S	18½	C			
44.	1-S	17	C			
45.	0-S	0	0	1	20	
46.	2-C,M	10 ,10	D,C			
47.	1-S	19	C			
48.	1-M	18½	C			
49.	1-B	15	C			
50.	0-M	0	0	1	20	
51.	0-S	0	0	1	20	
52.	1-S	20	B			
Total 27		13.20 = Average				

Code

S - Crystal Set
C - Compass
I - Induction Coil
M - Motor
E - Extension Cord
P - Ear Phones
Sat - Satisfactory
Unsat - Unsatisfactory

CHART V. (CONTINUED) COMPARATIVE TIME, JOBS AND GRADE ON JOBS OF CLASSES

Class C Number	No. of Sat. jobs	Time in hours	Grade	No. of Unsat. Jobs	Time in Hours	Need Assis-tance
1.	2-S,E	17 ,3	C,C			2
2.	1-M	13½	A			
3.	1-M	12½	D			
4.	1-S	20	B			
5.	2-M,C	7½,10	B,A			
6.	2-S,E	7 , 8	B,C			2
7.	1-M	17	B,B			
8.	2-S,E	10 , 5	B,C			1
9.	2-S,E	5 , 5	B,C			1
10.	1-S	18½	C			1
11.	1-M	16	B-			
12.	1-M	18½	B			
13.	1-M	18½	B/			
14.	1-M	15	D			
15.	1-M	18	B/			
16.	1-M	18½	B-			
17.	2-S,E	18½,1½	B,B			2
18.	2-S,E	12½,5	B,B			3
19.	1-M	16½	C			
20.	1-S	18½	C			1
21.	2-S,E	17 ,3	B,B			3
Total 29		11.12/ = Average				

Code

S - Crystal Set
C - Compass
I - Induction Coil
M - Motor
E - Extension Cord
P - Ear Phones
Sat - Satisfactory
Unsat - Unsatisfactory

CHART V. (CONTINUED) COMPARATIVE TIME, JOBS AND GRADE ON JOBS OF CLASSES

Class D Number	No. of Sat. jobs	Time in hours	Grade	No. of Unsat. Jobs	Time in Hours	Need Assistance
22.	1-M	19	C			
23.	2-S,C	15 , 3½	B,B			
24.	1-M	17½	C/			
25.	3-S,E,E	10 , 5 ,5	B,A,A			
26.	1-B	17	C			
27.	1-B	18	C			
28.	3-S,C.E	8½, 5 ,5	B,C,A			
29.	2-S,E	5 , 5	B,B			1
30.	1-M	10	B	1	5	
31.	1-M	20	D			
32.	2-S,E	7½, 7	B,B			1
33.	1-S	9½	B	1	3	
34.	1-M	20	C			
35.	1-M	19	C/			
36.	1-S	16½	D			
37.	2-S,C	15 , 5	B,C			
38.	3-S,C,E	12½, 3½,3	B,B,A			
39.	1-M	19	B			
40.	1-M	19	C/			
41.	2-S,C	12½, 3	B,B			
42.	2-S,C	15 , 5	B,B			
43.	3-S,S,E	10 , 5 ,5	B,B/,B			
44.	1-M	19½	C			
45.	1-M	19	C			
Total	38	11.32 = Average				

Code

S - Crystal Set
C - Compass
I - Induction Coil
M - Motor
E - Extension Cord
P - Ear Phones
Sat - Satisfactory
Unsat - Unsatisfactory

CHART VI. COMPARATIVE TIME TO DO SPECIFIC JOBS OF CLASS

Crystal Set	Motor	Buzzer	Compass	Ext. Cord	Tele. Set	Ind. Coil
Class A						
12½				7½		
10½			9½			
16½				3½		
16½				3½		
	16			4		
11			9			
15						
	16					
	20					
	20					
16½						
	20					
15				5		
20						
	17½					
13						
18						
	20					
			5			15
20						
20						
13½				6½		
13						
15/231 =	7/129.5 =		3/23.5 =	6/30 =		1/15 =
15.4	18.5		7.83	5		15

CHART VI. (CONTINUED) COMPARATIVE TIME TO DO SPECIFIC JOBS OF CLASS

Crystal Set	Motor	Buzzer	Compass	Ext. Cord	Tele. Set	Ind. Coil
Class B						
		11½				
20						
		19½				
		17½				
16½					18½	
		20				
19						
8½						
20						
11½		16½				
19						
	11½		5	3		
		20				
	19		11			
18½						
17						
	10		10			
19						
	18½					
		15				
20						
$11\sqrt{189}=$	$4\sqrt{59}=$	$7\sqrt{120}=$	$3\sqrt{26}=$	$1\sqrt{3}=$	$1\sqrt{18.5}=$	
17.8	14.75	17.14	8.66	3	18.5	

CHART VI. (CONTINUED) COMPARATIVE TIME TO DO SPECIFIC JOBS OF CLASS

Crystal Set	Motor	Buzzer	Compass	Ext. Cord	Tele. Set	Ind. Coil
Class C						
17				3		
	13½					
	12½					
20						
	7½		10			
7				8		
	17					
10				5		
5				5		
18½						
	16					
	18½					
	18½					
	15					
	18					
	18½					
18½				1½		
12½						
				5		
	16½					
18½						
17				3		
10/144 =	11/173.5 =		1/10 =	7/30.5 =		
14.4	15.77		10	4.34		

CHART VI. (CONTINUED) COMPARATIVE TIME TO DO SPECIFIC JOBS OF CLASS

Crystal Set	Motor	Buzzer	Compass	Ext. Cord	Tele. Set	Ind. Coil
Class D						
	19					
15			3½			
	17½					
10				5,5		
		17				
		18				
8½			5	5		
5				5		
	10			5		
	20					
7½				7		
9½						
	20					
	19					
16½						
15			5			
12½			2½	3		
	19					
	19					
12½			3			
15						
10, 5						
	19½					
	19					
$13/\overline{142}$ =	$10/\overline{182}$ =	$2/\overline{35}$ =	$6/\overline{24}$ =	$7/\overline{35}$ =		
10.9	18.2	17.5	4.	5.		

CHART VII. GRADE OF PERFORMANCE ON JOBS BY CLASS

Grade of Performance

It is necessary to change grades in letters to their numerical value.

A/ equals 99	C/ equals 83
A equals 95	C equals 80
A- equals 94	C- equals 76
B/ equals 92	D/ equals 74
B equals 90	D equals 70
B- equals 84	D- equals 64

CLASS A

Extension Cord Grade	Compass Grade	Crystal Set Grade
1 A = 95	1 B/ = 92	3 A = 285
5 B = 450	2 B = 108	1 A- = 94
		1 B/ = 92
		7 B = 630
		1 B- = 84
		1 C = 80
545	272	1,265

Induction Coil Grade	Motor Grade	Totals
1 A = 95	1 A = 95	1,265
	2 B = 180	676
	2 B- = 168	545
	1 C/ = 83	272
	1 C = 80	95
	1 D = 70	
95	676	32/2,853 = 89.15%

CHART VII. (CONTINUED) GRADE OF PERFORMANCE ON JOBS BY CLASS

CLASS B

Extension Cord Grade		Compass Grade		Crystal Set Grade	
1 A	= 95	1 B/	= 92	3 B	= 270
		1 C	= 80	1 C/	= 83
		1 D	= 70	5 C	= 400
				2 D	= 140
	95		242		893

Buzzer Grade		Motor Grade		Telegraph Set Grade	
6 C	= 480	1 B	= 90	1 A	= 95
1 D	= 70	1 C/	= 83		
		2 C	= 160		
	550		333		95

Totals

95
893
550
333
242
95
27/2,213 = 81.96%

CLASS C

Extension Cord Grade		Compass Grade		Crystal Set Grade	
3 B	= 270	1 A	= 95	7 B	= 630
4 C	= 320			3 C	= 240
	590		95		870

Motor Grade				Totals
1 A	= 95	2 B-	= 168	870
2 B/	= 184	1 C	= 80	937
3 B	= 270	2 D	= 140	590
	549	plus	388 = 937	95
				29/2,492 = 85.93%

CHART VII. (CONTINUED) GRADE OF PERFORMANCE ON JOBS BY CLASS

CLASS D

Extension Cord Grade	Crystal Set Grade	Buzzer Grade
4 A = 380	1 B/ = 92	2 C = 160
3 B = 270	11 B = 990	
650	1 D = 70	160
	1,152	

Motor Grade	Compass Grade	Totals
2 B = 180	4 B = 360	1,152
3 C/ = 249	2 C = 160	160
4 C = 240		739
1 D = 70		650
739	520	520
		38/ 3,221 = 84.76%

CHART VIII. CRITERIA OF ABILITY TEST

Set up checking factors determining what kind of tests of understanding and of procedures in testing should be used.

	Contents Answer Questions	Procedure Written or Oral
I. Ability to explain		
A. Nature of magnet		
1. Natural magnet	True-False	Written
2. How many poles	True-False	Written
3. Strength of electro-magnet	True-False	Written
4. Where find magnetic field	True-False	Written
5. Substance of electro-magnet	True-False	Written
6. Action of magnet	True-False	Written
7. Where permanent magnet is used	Multiple-Choice	Written
8. How increase strength of an electro-magnet	Multiple-Choice	Written
9. Classifications of an electro-magnet	Multiple-Choice	Written
10. Law of magnetic poles	Multiple-Choice	Written
11. Reversing current thru electro-magnet causes change of polarity	Completion	Written
II. Ability to perform		
A. Make an electro-magnet	Inspection	Present material
B. To remove insulation from N.E.C. wire	Inspection	Present material
C. Separate and assemble a plug	Inspection	Present material
D. Separate and assemble a socket	Inspection	Present material
E. How to connect cells in series and parallel	Inspection	Present material
F. How to make Fire Underwriter's knot	Inspection	Present material
G. How to connect wires to binding post	Inspection	Present material
H. Separate, assemble feed-thru switch	Inspection	Present material

CHART VIII. (CONTINUED) CRITERIA OF ABILITY TEST

III. Ability to plan		
A. Material needed for his job	Inspection	Present job
B. Order of making parts for his job	Inspection	Present job
C. Order of assembling his job	Inspection	Present job
IV. Ability to describe		
1. Purpose of generator	Multiple-Choice	Written
2. Purpose of motor	Multiple-Choice	Written
3. Source of static electricity	Multiple-Choice	Written
4. Purpose of storage battery	Multiple-Choice	Written
5. How pay for electricity	Multiple-Choice	Written
6. Contents of storage battery	True-False	Written
7. What do storage batteries store	True-False	Written
8. Contents of dry cells	True-False	Written
9. Purpose of fuses	Multiple-Choice	Written
10. Where is D.C. used extensively	Multiple-Choice	Written
11. Terminology used to explain current	Multiple-Choice	Written
12. Purpose of bell transformer	Multiple-Choice	Written
13. Characteristic of core of transformer	Multiple-Choice	Written
14. What kind of current does bell transformer use	True-False	Written
15. Rules governing house wiring is known as	True-False	Written
16. Classify wire according to resistance	True-False	Written
17. Purpose of rheostat	True-False	Written
18. Commutator is characteristic of D.C. generator	True-False	Written
19. Slip rings are characteristic A.C. generators	True-False	Written
20. How to change A.C. to D.C.	Multiple-Choice	Written

CHART VIII. (CONTINUED) CRITERIA OF ABILITY TEST

21.	Terminology used to express electric power	Multiple-Choice	Written
22.	Size of house wiring	Multiple-Choice	Written
23.	Effect of overloading wire carrying current	True-False	Written
24.	Devices used to measure electric pressure	True-False	Written
25.	Terminology used to express moving parts of A.C. motor	True-False	Written
26.	Purpose of commutator on a generator	True-False	Written
27.	Terminology used to express electrical pressure	True-False	Written
28.	What kind of a current a transformer uses	Multiple-Choice	Written
29.	Why tungsten is used in lamp filament	Multiple-Choice	Written
30.	Kind of wires used in heating devices	Multiple-Choice	Written
31.	Electricity is controlled by conductors and insulators	True-False	Written
32.	Connecting + and - wires without resistance causes shorts	Completion	Written
33.	To find resistance in any circuit	Completion	Written
34.	Fuses come in two general types	Completion	Written
V.	Ability to do it again		
A.	Remove insulation from N.E.C. wire	Inspection	Present material
B.	Separate and assemble a plug	Inspection	Present material
C.	Separate and assemble a socket	Inspection	Present material
D.	Connect wires to a binding post	Inspection	Present material
VI.	Ability to do it quickly		
A.	Remove insulation from N.E.C. wire	Inspection	Present material
B.	Separate and assemble a plug	Inspection	Present material
C.	Separate and assemble a socket	Inspection	Present material
D.	Connect wires to a binding post	Inspection	Present material

CHART IX. SCORES ON ABILITIES MEASURED - CLASS A

Abilities	Student Numbers												
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Ability to plan	90	80	85	80	90	85	90	85	90	80	90	80	90
2. Ability to describe	56	64	50	38	38	56	44	58	82	26	38	53	50
3. Ability to explain	36	72	45	63	72	90	72	81	54	36	63	45	90
4. Ability to perform	90	85	90	85	90	90	85	90	90	80	90	90	70
5. Ability to do it again	85	80	85	80	90	90	85	85	80	80	85	85	90
6. Ability to do it quickly	85	80	90	80	95	95	80	80	80	80	85	75	90
All around ability	73	77	74	71	72	84	76	79	63	75	71	80	71

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS A

Abilities	Student Numbers											
	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
1. Ability to plan	85	80	90	95	90	70	85	95	85	80	90	85
2. Ability to describe	38	56	53	47	58	26	70	61	64	44	58	41
3. Ability to explain	36	63	81	72	90	36	81	63	81	54	36	54
4. Ability to perform	90	85	95	95	85	75	80	90	90	85	95	90
5. Ability to do it again	90	95	90	90	85	70	85	85	90	85	95	95
6. Ability to do it quickly	90	95	75	90	85	70	85	85	85	80	80	95
All around ability	79	80	81	82	57	81	79	82	71	75	79	76

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS B

Abilities	Student Numbers												
	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.
1. Ability to plan	73	72	77	80	75	92	72	82	85	63	80	75	82
2. Ability to describe	38	35	53	44	44	32	32	32	67	20	29	58	56
3. Ability to explain	45	65	45	36	45	54	63	36	54	36	54	54	54
4. Ability to perform	85	73	77	75	81	91	73	85	89	72	80	78	78
5. Ability to do it again	94	92	95	82	75	95	82	87	90	72	87	75	90
6. Ability to do it quickly	92	92	90	82	62	92	78	85	90	70	94	85	90
All around ability	71	71	73	66	63	76	66	68	79	50	70	71	75

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS B

Abilities	Student Numbers													
	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.
1. Ability to plan	93	78	82	72	82	70	75	75	82	80	92	80	75	72
2. Ability to describe	47	38	64	26	56	14	41	61	14	38	38	58	38	41
3. Ability to explain	54	72	27	63	27	45	36	63	72	36	36	54	72	54
4. Ability to perform	92	78	77	-	80	72	75	75	82	78	90	82	68	68
5. Ability to do it again	95	85	82	-	80	85	70	92	85	90	92	87	80	85
6. Ability to do it quickly	90	87	92	-	82	72	72	95	95	90	92	82	72	80
All around ability	81	65	76		71	58	66	78	65	68	76	77	64	66

Note: Student No. 42 omitted from experiment.

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS C

Abilities	Student Numbers 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Ability to plan	75	95	75	95	95	75	85	80	85	80	85
2. Ability to describe	62	70	47	47	52	50	56	59	59	50	44
3. Ability to explain	72	90	27	36	45	63	63	36	54	54	54
4. Ability to do it again	80	90	80	80	80	80	90	95	85	85	90
5. Ability to do it quickly	70	85	70	75	80	80	95	95	80	85	85
6. Ability to perform	77	93	72	88	83	85	83	77	76	83	88
All around ability	72	87	62	70	72	72	78	73	73	73	74

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS C

Abilities	Student Numbers									
	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
1. Ability to plan	90	90	75	90	85	90	90	80	80	95
2. Ability to describe	62	35	76	32	62	64	52	56	67	56
3. Ability to explain	72	36	45	36	43	72	63	72	72	63
4. Ability to do it again	90	70	95	80	90	90	85	90	95	90
5. Ability to do it quickly	90	70	95	80	90	90	90	90	95	90
6. Ability to perform	85	72	92	82	92	92	78	80	92	92
All around ability	81	62	79	66	77	83	76	78	83	81

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS D

Abilities	Student Numbers											
	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.
1. Ability to plan	80	90	85	95	80	75	95	95	80	75	90	90
2. Ability to describe	32	35	20	44	11	5	58	41	35	17	50	-
3. Ability to explain	27	45	18	54	27	18	27	54	65	36	36	-
4. Ability to do it again	80	85	85	95	80	80	90	90	85	75	90	90
5. Ability to do it quickly	80	85	85	95	80	80	95	90	80	80	90	90
6. Ability to perform	75	80	80	90	80	80	90	90	85	75	90	85
All around ability	62	70	62	79	59	56	76	77	71	59	74	-

Note: Student No. 33 omitted from experiment.

CHART IX. (CONTINUED) SCORES ON ABILITIES MEASURED - CLASS D

Abilities	Student Numbers											
	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.
1. Ability to plan	75	80	75	80	90	85	85	85	85	95	85	90
2. Ability to describe	38	29	20	44	-	29	9	38	11	58	44	50
3. Ability to explain	45	54	54	45	-	18	18	36	36	27	27	72
4. Ability to do it again	80	75	80	85	90	90	90	85	90	85	90	95
5. Ability to do it quickly	80	80	80	85	90	90	90	85	90	85	90	95
6. Ability to perform	80	75	75	85	90	85	85	85	95	80	85	90
All around ability	66	66	64	71	-	66	63	69	68	71	70	82

Note: Student No. 38 omitted from experiment.