AN EXPERIMENT
TO DETERMINE THE EFFECT OF A WORKBOOK ON
ACHIEVEMENT IN GENERAL SCIENCE

AN EXPERIMENT TO DETERMINE THE EFFECT OF A WORKBOOK ON ACHIEVEMENT IN GENERAL SCIENCE

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CONTENTS

INTRODUCTION

There are many kinds of guide sheets and workbooks and as many methods of using them as there are teachers. In many schools guide sheets are given to pupils to direct their study. In some cases the pupils are required to answer the exercises in writing and in others they are merely guides for study. These guide sheets vary in content. Some consist of long lists of questions, such as the teacher would ask in the ordinary recitation technique. In most of these it is found that the questions asked are answered directly in the textbook and are usually copied from the text by the pupil.

The workbook used in this study was published to accompany the science textbook and to be used in the classroom with it. It follows the unit-problem plan of organization, as does the text. For the most part it contains blank spaces to be filled in by words, phrases, sentences or paragraphs. A sample of the type of exercises found in this workbook is given, pages 9-14.

Due to the fact that the cost of the workbooks is $2785.99 in the eighth and ninth grade science classes in Tulsa, and that there is a great deal of opposition among parents and teachers against the use of a workbook, it is the purpose of this study to determine what effect, if any, the workbook has on achievement in general science.

RELATED MATERIALS

Some progress has been made toward determining learning values derived from the use of study guides. Several earlier investigations of this problem failed to produce convincing evidence because of errors in the experimental and statistical techniques employed. In a recent controlled experiment in the teaching of physics, however, Irene Blank[1] secured statistical results which indicated that pupils who had used study guides made higher scores on achievement tests than similar groups which did not use study guides.

Robertson,[2] working with paired groups under carefully controlled conditions in the elementary fields, compared the relative effectiveness of a method using study guides, combined with highly individualized instruction, with a method employing a highly socialized form of "developmental-discussion." The investigator found slight, though not statistically significant, advantages in favor of the latter method. He concludes that the results secured from the "study-guide method" at the fifth-grade level do not justify the great amount

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[1] Irene R. Blank, "An Experiment in Directed Thinking in Physics," University of Pittsburgh School of Education Journal, 5:1930, 90-96.

[2] Martin L. Robertson, "A Study of the Relative Effectiveness of Two Methods of Teaching Elementary Science," (Unpublished Study, University of Michigan, 1930). See Curtis, Digest, Vol. II, 58-61.

of work required of the teacher in constructing the study guides. He points out, however, that this "study-guide method," in contrast with the "developmental-discussion method," gives the children valuable training in study habits and in organizing materials; but on the other hand, "this developmental-discussion method gives training in oral discussion and in various phases of sozialized training which the other does not afford."

In a study made by Hurd[3] it was found that,

> Work-sheets serve to make the work definite and concise. They are usually helpful when used properly, but cannot be depended upon to remedy all the defects of poor instruction. Most pupils are interested in work-sheets when used as in this experiment. There is need for careful preparation of work-sheets so that they best serve the purposes for which they are adapted. They should be definite and concise and devised to sustain the interest of pupils using them.

In another study[4], consisting of sixteen workbook versus no workbook experiments, it was found that,

> Workbooks tend to help pupils but they are not indispensable. Other features of instruction are important. They are helpful to some teachers in increasing measured achievement. They probably are particularly useful in directing the attention of pupils and teachers to specific items of knowledge, techniques and appreciations. If the objectives are not in dispute, workbooks may serve as helpful aids in many cases.

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3 A. W. Hurd, "Teacher Opinion and Suggestions on Teaching Units in Physics," School Science and Mathematics 32:33-43; January, 1932.

4 A. W. Hurd, "The Workbook as an Instructional Aid," School Review 39:608-16; October, 1931.

PROCEDURE

The rotating parallel group method of experimental research was used with two science classes in Horace Mann Junior High School, Tulsa, Oklahoma, for a period of fourteen weeks.

The ninth grade in Horace Mann School is grouped homogeneously into nine sections. Group one is composed of those students who have the greatest capacity for achievement and group nine is composed of those students having the least capacity for achievement. This grouping is based on an average between intelligence and achievement scores. The two groups which were used in this study were groups three and four and are referred to as Group A and Group B, respectively.

Each group followed the regular course of study, except Group A had use of the workbooks during the first unit while Group B studied the first unit of the experiment without the use of a workbook. This procedure was reversed for the second unit and again for the third and fourth units, thus rotating the use of the workbook for each of the four units studied.

The achievement of each student and of each group was obtained by administering a standardized objective test to each pupil at the beginning of each unit and again at the close of each unit. The pre-test provided for a ranking of the students in each group and a pairing of them against

each other on the basis of their knowledge of the material at the beginning of the unit. The coefficient of correlation of the pre-test score with progress is .639 with a probable error of ± .089. Since the coefficient of correlation is more than seven times the probable error, it is highly significant. The final test scores made it possible to calculate the gain made by each student and each group.

CLASSROOM TECHNIQUE WITH THE WORKBOOK: Students were not permitted to take their workbooks from the classroom. The teacher and pupil demonstration method was used in all experiments. Except for the making of drawings the students were not permitted to use their texts and workbooks simultaneously. The purpose of this rule was to prevent pupils from copying answers from the text into the workbooks.

Each unit of work was divided into four, five or six problems. The workbook was used before and after the study and discussion of each problem; before the study of the problem to give a preview and fix it in its proper relationship to the particular unit being studied; after the study of a problem to give the pupils an opportunity of expressing their ideas and to arrive at certain definite understandings relative to the biological and scientific ideas presented by the unit. The division of time for each unit was approximately ten per cent for assignment,

seventy per cent for supervised study and twenty per cent for testing and summarizing.

CLASSROOM TECHNIQUE WITHOUT THE WORKBOOK: The group using the textbook was required to finish each unit in the same length of time as the group using the text and the workbook. The teacher and pupil demonstration method was used in all experiments. Pupils were required to take notes on all experiments. Notes on other problems, assignments, and discussions were not required, however pupils were encouraged to use this practice. Approximately twenty-five per cent of the time was given for assignments, fifty per cent for supervised study, and twenty-five per cent for testing and summarizing. Experiments, demonstrations, library assignments, field trips, moving pictures in the classroom, and poster materials were the same for both groups.

CHARACTERISTICS OF THE GROUPS: Eighty pupils were used in the two groups. This gave a total of three hundred twenty pupil-units of work over the fourteen weeks of study. One hundred sixty with the workbook and one hundred sixty without the workbook.

Arrangements were made in the school office for pupils not to be transferred in or out of these groups during the time necessary to complete the experiment. There were 22 boys and 21 girls in Group A and 19 boys and 25 girls in Group B. The number in each group provided a substitute

in case a student who was in the experiment was absent more than two days during the study of a unit. Thirty-nine pairs of students were used in Unit II and forty-one pairs were used in Unit III to bring the average for each unit to forty.

Intelligence quotients of the two groups taken from scores made on the Henmon-Nelson and the Otis Intelligence tests were:

Group A ... Mean 115.4 ... Standard Deviation ... 8.8

Group B ... Mean 106.4 ... Standard Deviation ...10.6

The reading ability of the two groups was determined from scores on the Progressive Achievement Tests.

Group A

Vocabulary test, grade level .....Mean 10.9
S. D. 1.74

Composition test, grade level ..... Mean 10.7
S. D. 1.4

Group B

Vocabulary test, grade level ..... Mean 9.4
S. D. 2.3

Composition test, grade level ..... Mean 9.7
S. D. 1.75

TEXT, WORKBOOK, AND TESTS: The textbook used was Everyday Problems in Biology, by Pieper, Beauchamp and Frank. The workbook used was written by the same authors to accompany this textbook. Sample pages of the workbook are shown on pages 9-14.

The tests used were the Objective Unit Tests, Form A by Pieper, Beauchamp, and Frank. These were published by the Scott Foresman Company to accompany the text used in this experiment. Sample copies of the test are shown on pages 15-18.

Name.....*Period*.....*Number*.....*Date*.....*Rating*.....

PROBLEM 5: HOW IS THE BALANCE OF LIFE MAINTAINED?

EXERCISE 17. *Read pages 279-283 and do Experiment 51.* (**A**) 1. A female frog lays about 300 eggs and may repeat the performance for several years. Calculate the number of frogs there would be at the end of the third year if all eggs matured into adult frogs. Consider that one-half of each generation are females. Assume that each frog lives only one year.

Number of frogs first year ..... Number of females first year .....

Total number of frogs end of second year ..... No. of females .....

Total frogs end of third year ..... No. females .....

2. How do we know that such a rate of increase does not actually take place? .....

.....

.....

3. Why does this rate of increase not take place? .....

.....

(**B**) 1. Enter your results from Experiment 51. Soil A, No. of seeds .....

Soil B, No. of seeds ..... Soil C, No. of seeds .....

If all of the plants grew and produced an average of 10 seeds each, how many plants would be produced at the end of the fifth year?

Soil A ..... Soil B ..... Soil C .....

2. Why does this rate of increase not take place? .....

.....

(**C**) What is meant by the term "struggle for existence"? .....

.....

.....

EXERCISE 18. *Read pages 283-289 and do Experiment 52.* (**A**) 1. What is meant by the term "balance of nature"? .....

.....

.....

2. Make up an illustration of your own to show how the balance of nature is maintained.

.....

.....

.....

3. Under what conditions will it be possible to seal the aquarium air tight in Experiment 52?

(**B**) 1. Study Figure 247 and make a list of ten facts shown by the figure.

(*a*)

(*b*)

(*c*)

(*d*)

(*e*)

(*f*)

(*g*)

(*h*)

(*i*)

(*j*)

2. Explain what the figure shows.

(**C**) 1. Write a paragraph explaining in general terms how the balance of life is maintained. (*Exercise 6, page 58, will help you do this.*)

Name..... *Period*..... *Number*..... *Date*..... *Rating*.....

2. Write a paragraph describing the danger of upsetting the natural balance of life. .....

EXERCISE 19. Write a sentence or two describing or explaining each of the following terms:

Problem 1. legume.....

tubercle.....

symbiosis.....

decay.....

Problem 3. fungi.....

Problem 5. balance of life.....

struggle for existence.....

balanced aquarium.....

REPORTS ON SUGGESTED ACTIVITIES AND ADDITIONAL EXERCISES

Name.....*Period*.....*Number*.....*Date*.....*Rating*.....

PROBLEM 2: HOW ARE LIVING THINGS FITTED TO LIVE ON LAND?

EXERCISE 6. *Read page 311 and on to the middle of page 313.*

(**A**) 1. State three facts about the physical composition of air which make an air habitat different from a water habitat? (*a*) .....

(*b*) .....

(*c*) .....

2. Why does the temperature of the air covering of the earth change much more rapidly than the water covering of the earth? (*Refer to page 216 of the text.*) .....

.....

.....

3. Why is the buoyant effect of air much less than that of water? .....

.....

.....

(**B**) 1. What characteristic of a land surface makes walking different from swimming? .....

.....

2. How does soil differ from water as a source of raw materials? .....

.....

.....

(**C**) Write a summary in answer to the question, "What conditions are present in a land habitat?" Use the answers to the various parts of this exercise as a basis for your answer. (*Refer to Exercise 6, page 58, for suggestions.*)

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.....

.....

EXERCISE 7. *Read page 313 and on to the next sub-problem on page 317.*

(**A**) 1. Why must the epidermis of the leaves of land plants be constructed differently from the leaves of hydrophytes? .....

.....

.....

2. In what two ways is the loss of water from leaves decreased?

(*a*) .....

(*b*) .....

3. Why must a land plant develop a different kind of root system from a water plant? .....

.....

.....

.....

4. Why must the structure of the stems of land plants be different from the structure of the stems of water plants? .....

.....

.....

5. Why do land plants need a well developed means of transportation for raw materials in the plant? .....

.....

.....

(**B**) 1. In what three ways do the xerophytes differ from the mesophytes in structure?

(*a*) .....

(*b*) .....

(*c*) .....

2. Why could not the plant in Figure 270 live in a desert? .....

.....

.....

3. Why are plants adapted to mesophytic conditions unable to live in a xerophytic region?

.....

.....

TESTS ON EVERYDAY PROBLEMS IN BIOLOGY

By C. J. PIEPER, W. L. BEAUCHAMP, AND O. D. FRANK

UNIT II: HOW DO LIVING THINGS USE FOOD?—FORM A

Name..... Period..... Score.....

School..... Grade..... Date.....

Directions. Each of the incomplete statements below is followed by a number of parts which might be used to complete the statement. You are to place a plus sign (+) in the parentheses opposite each part which correctly completes the statement, and a zero (0) opposite each part which does not correctly complete the statement. Remember that from one to all of the parts may be correct. Mark all parts. The sample below will show you how to mark the test.

Green plants
- make their own food..... (+)
- are saprophytes..... (0)
- can move around in search of raw materials for food..... (0)
- are independent..... (+)

Foods
- are composed of different elements from those that compose the human body..... 1 (.....)
- supply the body with oxygen..... 2 (.....)
- include alcohol because it provides energy when oxidized..... 3 (.....)
- are changed into living material by plants and animals..... 4 (.....)

The chief kinds of energy-producing foods are:
- carbohydrates..... 5 (.....)
- minerals..... 6 (.....)
- fats..... 7 (.....)
- proteins..... 8 (.....)

Minerals in food
- aid in carrying on the activities inside living things..... 9 (.....)
- supply the body with calcium, phosphorus, and iron..... 10 (.....)
- supply the body with hydrogen, carbon, and nitrogen..... 11 (.....)
- are destroyed if the food is heated to a high temperature..... 12 (.....)

All living cells
- contain protoplasm..... 13 (.....)
- are similar in shape and size..... 14 (.....)
- perform the same duties..... 15 (.....)
- need energy..... 16 (.....)

16

Enzymes

are used up in digesting food..... 17 (.....)
are obtained by eating fruits and vegetables..... 18 (.....)
are used by bacteria in obtaining nourishment..... 19 (.....)
are produced by plants as well as by animals..... 20 (.....)
are the same as digestive juices..... 21 (.....)

When an animal eats food containing starch, the starch must be digested

because it is not soluble..... 22 (.....)
by the chemical action of vitamins..... 23 (.....)
so that it can pass into the cells of the animal's body..... 24 (.....)

The intestines

of man are about ten times the length of the body..... 25 (.....)
pass undigested food out of the body..... 26 (.....)
are the most important digestive organs in the body..... 27 (.....)
are the most important organs for absorbing digested food..... 28 (.....)
have their inside surface area increased by lacteals..... 29 (.....)

The distribution of food to all parts of organisms

takes place more rapidly in plants than it does in animals..... 30 (.....)
is aided by the lungs..... 31 (.....)
depends on diffusion..... 32 (.....)
is speeded up by circulatory systems..... 33 (.....)

The blood is assisted in absorbing food by

the large amount of surface provided by the villi..... 34 (.....)
the process of diffusion..... 35 (.....)
the thinness of the capillaries..... 36 (.....)
the pancreas..... 37 (.....)

The amount of energy used by a living thing

is increased during hibernation of an animal..... 38 (.....)
should regulate the amount of food which is eaten..... 39 (.....)
determines the amount of carbon dioxide given off..... 40 (.....)

Undigested food forms a waste product which

is partly decomposed by bacteria if not promptly eliminated..... 41 (.....)
is known as chemical waste..... 42 (.....)
is the result of broken-down cellular matter from the body..... 43 (.....)

The elimination of wastes from the body is usually aided by

physical exercise..... 44 (.....)
drinking sufficient water..... 45 (.....)
long continued rest..... 46 (.....)
eating plenty of fruits and vegetables..... 47 (.....)

Directions. For each phrase or word in the right-hand column below there is in the left-hand column a lettered word that belongs with it. Write the letter of the word (or words) in the parentheses opposite the phrase (or word) with which it belongs. Any word (or words) in the left-hand column may be used more than once, but use only *one* letter for each parentheses.

(*a*) fats
(*b*) carbohydrates
(*c*) proteins
(*d*) vitamins
(*e*) minerals

Building material for bones and teeth..... 48 (.....)
Found in large amounts in cod-liver oil and in orange juice..... 49 (.....)
Give off most energy when used in the body..... 50 (.....)

(*a*) veins
(*b*) lacteals
(*c*) capillaries
(*d*) arteries
(*e*) corpuscles

Float in the blood..... 51 (.....)
Carry blood from the heart..... 52 (.....)
Put blood in close contact with cells..... 53 (.....)

(*a*) paramecium
(*b*) ox
(*c*) bird
(*d*) earthworm
(*e*) man

No digestive organs..... 54 (.....)
Very long digestive system..... 55 (.....)
Intestine straight rather than coiled..... 56 (.....)

(*a*) diffusion
(*b*) digestion
(*c*) respiration
(*d*) oxidation
(*e*) circulation

The taking in and using of oxygen and giving out of carbon dioxide. 57 (.....)
Movement of materials into and out of cells..... 58 (.....)
The dissolving of food..... 59 (.....)

(*a*) beetle
(*b*) earthworm
(*c*) clam
(*d*) paramecium
(*e*) bird

Excretion through contractile vacuoles..... 60 (.....)
Respiration by means of gills..... 61 (.....)
Respiration by means of spiracles..... 62 (.....)

Directions. Complete each sentence or answer each question with a single word, if possible. There are some, but not many, which will require two words or more for an answer. In answering the questions which contain words in *italic* type, use one of the *italicized* words or groups of words for your answer.

Do the higher plants have systems of special structure for the transportation of food and other materials? (*Yes* or *No*)..... 63 .....

Do the vitamins in cod-liver oil prevent *growth, beri-beri, scurvy, rickets,* or *pellagra?*..... 64 .....

When compared with the blood flowing toward the cells of a person's foot, the blood flowing away contains *more less about the same* amount of oxygen..... 65 .....

Ordinary dry corn grains contain little or no sugar, but much oil and starch and some protein. When the grains have begun to sprout or germinate, tests show that a good deal of sugar is present. Is this sugar produced from the *oil*, the *starch*, the *proteins*, or *raw materials* in the soil?..... 66 .....

In general, is the rate of oxidation in plants *higher* or *lower* than in animals?.. 67 .....

From the capillaries does blood flow into the *veins*, *arteries*, *lymph ducts*, or *heart?*..... 68 .....

If the breath is blown through some limewater, the limewater becomes milky. This result indicates that the breath contains..... 69 .....

In comparison with the earthworm, is the method of distributing food in the hydra *more simple*, *more complex*, or *about the same?*..... 70 .....

Cells which are entirely surrounded by a plasma membrane must take in food by..... 71 .....

The blood vessels which could not be discovered until the microscope was invented are..... 72 .....

The energy value of foods is measured in terms of..... 73 .....

Are *vegetable* foods or *animal* foods more difficult to digest?..... 74 .....

Oxygen comprises about *15 25 65 75* per cent of the human body..... 75 .....

A large number of similar cells grouped together in the body make up..... 76 .....

The liquid part of the blood when outside the blood vessels and in the spaces around the cells is called..... 77 .....

One side of the heart pumps blood to the muscles, intestines, and brain, while the other side pumps it to the..... 78 .....

Is the method by which the sugar was produced in the corn grains of question 66 known as *photosynthesis*, *digestion*, *oxidation*, or *diffusion?*..... 79 .....

The material which causes the limewater to turn milky is brought to the lungs by..... 80 .....

Does the drinking of plenty of water aid in the elimination of body wastes through the lungs? (*Yes* or *No*)..... 81 .....

Insects are different from most animals in that they obtain oxygen through... 82 .....

The energy stored in coal and foods came from..... 83 .....

When a man exhales, the chest cavity is made smaller by the movements of the diaphragm and..... 84 .....

The waste products eliminated through the lungs, kidneys, and skin are formed in the..... 85 .....

Small bodies which float in the blood and carry oxygen are..... 86 .....

The chemical energy stored in foods is released in the body by the process of.. 87 .....

Does respiration in plants produce *carbon dioxide* or *oxygen*, or does the product *vary* with the condition of light or darkness?..... 88 .....

RESULTS

UNIT I How do Plants and Animals Live Together?

Forty pairs of students

Time required to complete the unit - fifteen days

	Group A With use of workbook	Group B Without use of workbook
Total score on pre-test	1068	904
Total score on final test	1666	1458
Total gain	598	554
Average gain per pupil	14.9	13.8
Number who gained more than the student in the opposite group against whom they were ranked and paired	22	18

UNIT II How are Living Things Fitted to Their Surroundings?

Thirty-nine pairs of students

Time required to complete the unit - ten days

	Group A Without use of workbook	Group B With use of workbook
Total score on pre-test	736	735
Total score on final test	1067	1238
Total gain	331	503
Average gain per pupil	8.3	12.6
Number who gained more than the student in the opposite group against whom they were ranked and paired	8	30

UNIT III Why do Living Things Behave as They do?

Forty-one pairs of students

Time required to complete the unit - twenty-two days

	Group A With use of workbook	Group B Without use of workbook
Total score on pre-test	988	784
Total score on final test	1737	1463
Total gain	749	679
Average gain per pupil	18.2	16.8
Number who gained more than the student in the opposite group against whom they were ranked and paired	26	15

UNIT IV How does Man Provide Favorable Conditions and Necessary Materials for Living Things?

Forty pairs of students

Time required to complete the unit - eighteen days

	Group A Without use of workbook	Group B With use of workbook
Total score on pre-test	1394	1207
Total score on final test	1830	1829
Total gain	436	622
Average gain per pupil	10.9	15.5
Number who gained more than the student in the opposite group against whom they were ranked and paired	14	24

Results on the four units

One hundred sixty pairs of students

Time required to complete the experiment - sixty-five days

	Students With use of workbooks	Students Without use of workbooks
Total points scored on pre-tests	3998	3818
Total points scored on final tests	6470	5818
Total gain	2472	2000
Average gain per pupil	15.6	13.3
Total number who gained more than the student in the opposite group against whom they were ranked and paired	102	55

Results of the calculation of the means and sigmas of the achievement or points gained in the two groups for the four units:

	No. of Cases	Mean	Sigma of Dis.
Students with use of workbooks	160	15.6	7.28
Students without use of workbooks	160	13.3	9.09

Achievement Average by Units

Green - With the Workbook

Black - Without the Workbook

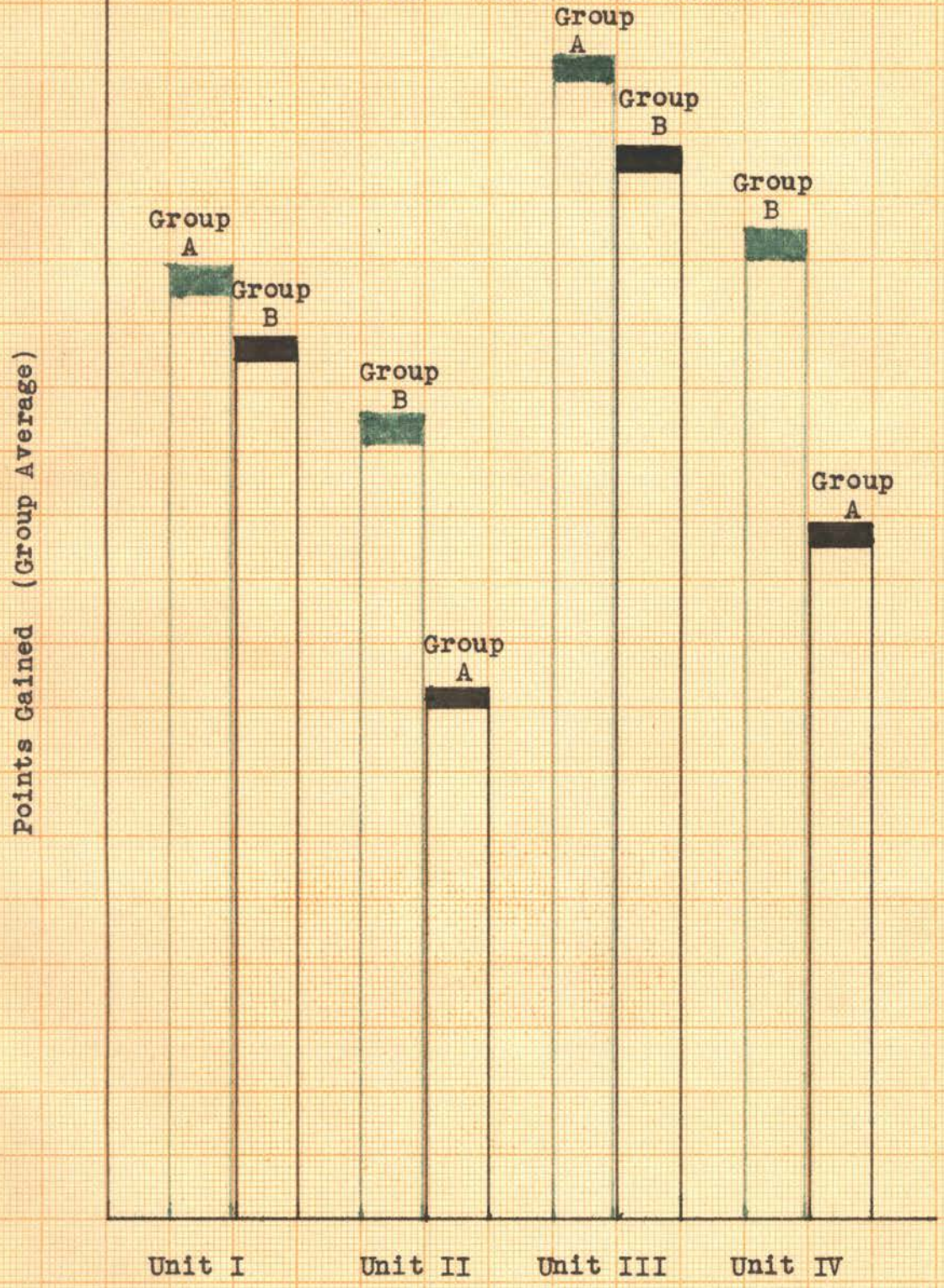

Figure I

Results of Pairing of Students

Green - Students Who Used Workbooks and Outgained Their Opponents Who Did Not Use the Workbooks

Black - Students Who Did Not Use the Workbook and Out-Gained Their Opponents Who Used the Workbook

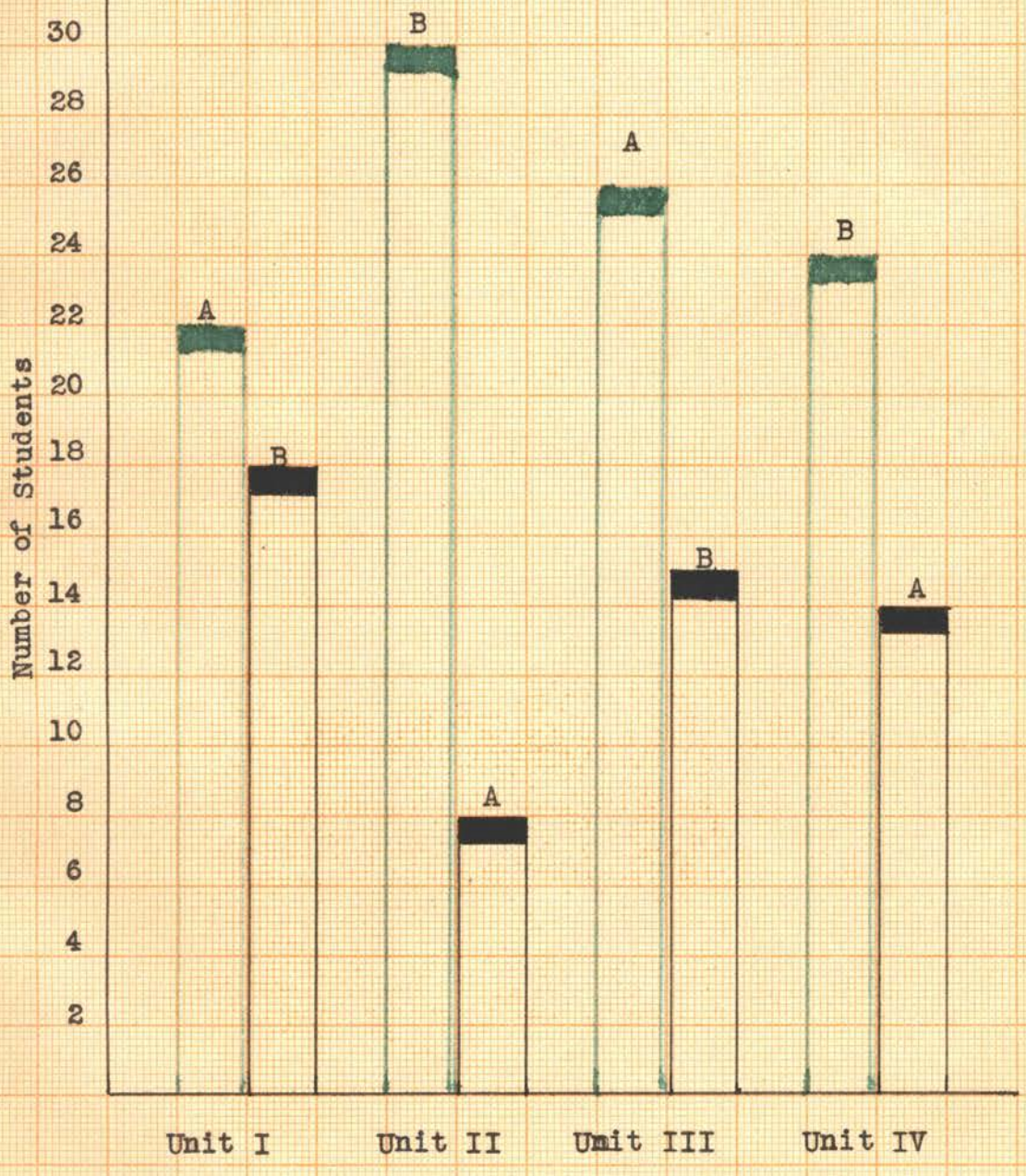

Figure II

FINDINGS AND CONCLUSIONS

The difference between the two obtained averages of the two groups is 2.3 in favor of the students who used the workbook. The reliability of this difference is found by the equation:[1]

$$\sigma(\text{diff.}) = \sqrt{\sigma^2(\text{av. } 1) - \sigma^2(\text{av.}2)}$$

The standard errors of the two averages are,

For students with use of the workbook,

$$\sigma \text{av.} = \frac{7.28}{160} = .5777$$

For students without use of the workbook,

$$\sigma \text{av.} = 9.09 = .7214$$

Substituting these values in the formula above,

$$\sigma(\text{diff.}) = \sqrt{(.5777)^2 - (.7214)^2} = .2918$$

The chances are 68 in 100 that the obtained difference of 2.3 does not diverge from the true difference by more than ± .2918. Or the chances are 99 in 100 that 2.3 does not differ from the true difference by more than three times (plus or minus) .2918, or by more than ± .8754.

We can be almost certain that the true difference between the averages of the two groups lies within the limits 2.3 (plus or minus) .8754 or between 1.42 and 3.17.

$$\frac{\text{Obtained difference}}{\sigma(\text{diff.})} = 7.8$$

It is found that the obtained difference is from two to three times as much as is necessary in order to insure complete reliability.

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[1] Henry E. Garrett, Statistics in Psychology and Education, p. 128.

Intelligence quotients of the two groups (page 7) show that Group A with an average I. Q. of 115.4 is slightly higher than Group B with an average I. Q. of 106.4. A standard deviation in Group A of 8.8 and Group B 10.6 indicates that Group B is a little more variable than Group A. The reading scores, taken from the Progressive Achievement Tests (page 7), showing Group A with a grade level of 10.8 and Group B with a grade level of 9.1, indicates that Group A is also slightly higher than Group B in reading ability.

From a study of the achievement in each unit made by both groups in this experiment (Figure I), it is found that the variations in achievement of Group A, working with and without the workbook, are much greater than the variations shown by Group B. Group A ranked high in those units in which it used the workbook and low in those units in which it used the textbook only, while Group B ranked fairly high with the workbook and slightly lower without it.

This variation in gains made by the two groups in the different units cannot be considered as significant for two reasons: first, the nature of the materials studied in the different units is such that a group would not be expected to show the same gain on each; second, it must be assumed that the workbook is variable in its adaptibility to the materials studied. Should this not be the

case and should we assume that the units studied and the workbook were constant in their relationship to achievement, then, we must conclude that the use of a workbook provides for a substantial gain with pupils having an I. Q. of 115 and normal or slightly higher reading ability, and a slight gain with pupils having an I. Q. of 106 and normal or slightly lower reading ability.

The results of the pairing of students (Figure II) in the two groups on the basis of the pre-tests indicate that approximately two-thirds of the students using a workbook in general science will achieve more than the students without a workbook and one-third of the students without the use of a workbook will achieve more than those using a workbook.

The fact that the difference in the two achievement averages of 2.3 is shown to be statistically reliable does not necessarily hold that this difference is great enough to be of importance or to have practical significance; however, it is the opinion of the writer that this difference is great enough to justify the use of a workbook in the teaching of general science.

Some probable reasons why students will achieve more with the use of a workbook:

1. It provides for a preview of every unit and problem.
2. It indicates the method of study which the pupil should employ in finding a solution to the problem.

3. It directs his attention to previously acquired concepts which may aid in solving the problem.
4. It indicates pitfalls which must be avoided in doing a high quality of thinking.
5. It ties up the material in the text with observation of similar phenomena in the environment.
6. It informs the pupil as to whether or not he is ready to proceed and can understand that which follows.
7. It gives the teacher objective evidence of the progress of each pupil.
8. It furnishes a definite basis for self-activity.
9. It gives the pupil training in measuring his own accomplishments.
10. It provides a place for each student to write his ideas.
11. It induces a student to read more carefully and recognize the important points in each problem as he finds them.
12. It shows how a scientist proceeds in solving problems, thus providing a basis for the understanding of scientific method.

Some probable reasons why students will achieve more without the use of a workbook:

1. The workbook may lack coherence.
2. It has too many technical words and phrases to be assimilated by the student.

3. The problems and exercises are not clear.
4. Assignments and references are not clear.
5. Some students learn better from their own outlines and notes.
6. The student thinks of the workbook as so many blank spaces to be filled in for credit.
7. The problems are solved by dictation from the teacher.
8. The student copies all materials from the text or other references.

The teacher of science, ambitious to increase the effectiveness of his instruction, will welcome the invention of each new method, device, or plan, or each improvement of an older technique as a potential means of increasing his classroom efficiency; he will master many and varied teaching techniques to the end that he may more effectively adapt his methods and the instructional materials to the individual differences of the pupils in his charge. It is clear, however, considering the somewhat limited experimental evidence thus far available, that the use of any new method exclusively would find little more justification than the retention of any conventional procedure for exclusive classroom use.

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