THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A COMPARISON OF THE EFFECTIVENESS OF THREE TEACHING METHODS IN HIGH SCHOOL BIOLOGY

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF EDUCATION

BY

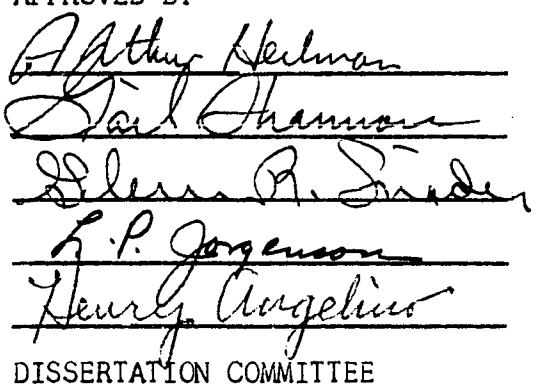
EARL NELSON NEWMAN

Norman, Oklahoma

1957

A COMPARISON OF THE EFFECTIVENESS OF THREE TEACHING METHODS IN HIGH SCHOOL BIOLOGY

APPROVED BY



DISSERTATION COMMITTEE

ACKNOWLEDGMENT

For professional guidance in the preparation of the study the writer expresses gratitude to the members of his doctoral committee: Dr. Arthur W. Heilman, Chairman; Dr. Henry R. Angelino; Dr. Lloyd P. Jorgenson; Dr. Gail Shannon; and Dr. Glenn R. Snider. Special recognition is given Dr. O. J. Rupiper for his valuable assistance with statistics for the research.

The writer wishes also to acknowledge Mr. John C. Haley, Principal, and various faculty members of College High School, Bartlesville, Oklahoma, for their cooperation and encouragement during the experiment; Mr. Charles Plunkett, for editorial assistance; and Mrs. Helen Parks Newman, for stenographic service.

TABLE OF CONTENTS

	Page
LIST OF TABLES	vi
LIST OF ILLUSTRATIONS	vii
Chapter	
I. INTRODUCTION	1
Background for the Study	1
Review of Related Research	3
Need for the Study	19
The Problem	21
Delimitation of the Problem	22
Definition of Terms	22
II. METHOD OF RESEARCH AND TREATMENT OF DATA	24
Method	24
Nature and Sources of Data	24
Securing the Information	25
III. PRETEST RESULTS	31
Initial Status of Pupils	31
Intelligence Test Scores	31
Reading Comprehension Scores	32
Reading Rate Scores	32
Biology Pretest Scores	33
Significance of Pretest Data	33
IV. POST-TEST RESULTS	40
The Gain in Information	40
Test for Significance	41
V. SUMMARY AND CONCLUSIONS	51
Summary	51
Conclusions	59
Recommendations	60

Page

BIBLIOGRAPHY 62

APPENDIX 70

LIST OF TABLES

Table		Page
1.	Comparison of Experimental Groups on Pretest Data	39
2.	Nelson Biology Pretest and Post-Test Means and Standard Deviations	41
3.	Tests of the Significance of the Difference Between Pretest and Post-test Means, Nelson Biology Test	42
4.	Comparison of Mean Improvement in Biological Knowledge	43
5.	Tests of the Significance of the Difference Between Nelson Biology Pretest and Post-test Means Classified by Intelligence and Reading Scores	45
6.	Comparison of Improvement in Biological Knowledge for Students of Upper and Lower Intelligence	46
7.	Comparison of Improvement in Biological Knowledge for Students of Upper and Lower Reading Comprehension	47
8.	Comparison of Improvement in Biological Knowledge for Students of Upper and Lower Reading Rate	48

LIST OF ILLUSTRATIONS

Figure		Page
1.	Superimposed Frequency Polygons Showing Distribution of Otis I.Q. Scores for Groups L-O, L-I, and L-N	34
2.	Superimposed Frequency Polygons Showing Distribution of Diagnostic Reading Test--Comprehension Scores for Groups L-O, L-I, and L-N	35
3.	Superimposed Frequency Polygons Showing Distribution of Diagnostic Reading Test--Rate Scores for Groups L-O, L-I, and L-N	36
4.	Superimposed Frequency Polygons Showing Distribution of Nelson Biology Test--Pretest Standard Scores for Groups L-O, L-I, and L-N	37

A COMPARISON OF THE EFFECTIVENESS OF THREE TEACHING METHODS IN HIGH SCHOOL BIOLOGY

CHAPTER I

INTRODUCTION

Background for the Study

Teaching is an activity which is both complex and variable. The activity varies with the subject, students, teacher and his purpose, class size, room and equipment, and amount of time allotted the class. However, in any given subject the instructional activities of a teacher usually tend to conform to certain plans or patterns which are referred to as special methods of teaching.

The concept of methods of teaching is very broad and includes everything the teacher does inside or out of the classroom that affects learning and over which the teacher has some control.

Various methods of teaching have had ardent supporters and just as ardent critics. Not always have attempts been made to evaluate claims on an objective basis. Too often the prevailing criteria have been teachers' judgements and *a priori* judgements.

How to teach is supplementary to what to teach. Chief emphasis, under traditional procedures, has been placed upon subject matter, but increasing concern is being given to method. The classroom itself obviously provides the best laboratory for examining methods of teaching and many studies of method have been made in various fields.

In a discussion of recent trends in research in science education Blick reports that fewer studies have been made in science teaching in recent years, more emphasis being placed on procedures for serving student need.

> In the field of science education new emphasis has been placed on the measurement of the results of instruction. This trend has been due in part to the deficiencies in the present educational system that have been revealed by the war emergency, and to a more critical attitude of the better prepared teachers of science. For too long changes have been proposed in methods of teaching and organization without valid experimental evidence that such changes would be improvement.[1]

It is a logical conclusion from available evidence that the worth or lack of worth of a teaching method in one subject does not necessarily predict its value in another subject. Many educators are ready to test the value of various methods experimentally on the basis of separate subjects. Theoretically a good case could be built for many methods. The arm chair theorist could weigh the pros and cons and tell us that a particular teaching method appears to be valuable in certain classes such as language, social studies, or sciences; or with certain groups such as elementary or secondary

---

[1]David J. Blick, "Recent Trends in Research on Science Teaching," Education LXV (March, 1945), p. 394.

school students. He might even give us valuable information on the use and misuse of the method.

It is important for school teachers to evaluate their teaching methods objectively before discarding older or more established methods of teaching for newer or more theoretical ones. Studies of teaching methods should be the basis for proposed changes in methods.

It is very difficult to control all of the variables in any experimental study involving classroom behavior. However, if improvement in teaching is to be accomplished, comparative experiments must be conducted subject by subject and method by method in the actual classrooms where these methods are applied. This study attempts to compare the effectiveness of three methods of teaching high school biology: (1) lecture-discussion with reading of text outside of class, (2) lecture-discussion with textbook reading in class, and (3) lecture-discussion with no assigned textbook reading in or out of class.

Review of Related Research

Among the early experimental studies of teaching methods is one recorded in 1918 by Wiley who stressed the fact that in the field of chemistry, in particular, no experimental studies had been made on either subject matter or methods of teaching. He used three groups of eight students each and compared the following three methods: (1) textbook

method, using no apparatus--the students read the material and the teacher questioned them immediately upon its completion, (2) lecture method--the teacher did the talking and questioning of the students who hadn't read the lesson previously; there was teacher demonstration of laboratory work, (3) laboratory method--the students were given problems with directions to guide their solution; the teacher also used questions to aid the students in grasping principles.[1]

For his criterion of superiority of knowledge acquisition and retention he used tests of chemistry information. One of these was given immediately after the completion of the experiment and another was given one month later. He equated his groups of junior and senior high school students on the basis of a pretest in chemistry and physics grades since all the subjects had completed a course in physics.

The results indicated the textbook method to be superior on immediate recall followed in order by the laboratory method and lecture method. After a month, the laboratory method showed superiority over the text and lecture methods. The textbook method required less time to complete the teaching units than the lecture method which required less time than the laboratory method. Considering the time spent in instruction the textbook method yielded best results for

---

[1]William H. Wiley, "An Experimental Study of Methods in Teaching High School Chemistry," Journal of Educational Psychology, IX (April, 1918), pp. 181-198.

immediate reproduction. For permanent results the laboratory method was slightly better but the time taken was far greater than for either other method.

In 1923 Kiebler and Woody reported a comparison of individual laboratory and demonstration methods of teaching physics.[1] The difference in these two methods was that the first group was guided by a laboratory manual and worked individually or in groups of two while the second group developed the methods of procedure in class discussion without a laboratory manual and observed the performance of the experiment.

The students had been equated on the basis of intelligence. Further requirements were perfect attendance and an attitude conducive to good work. Each group did seven experiments by the laboratory method and seven other experiments by the demonstration method. The students were given tests of immediate knowledge, delayed recall, and a test of how to apply principles.

The authors report that the demonstration group did as well or better than the laboratory group in all three types of tests given but the difference is "very small."

The individual method was better in certain types of experiments especially those difficult to perform or in which

---

[1]E. W. Kiebler and Clifford Woody, "The Individual Laboratory versus the Demonstration Method of Teaching Physics," Journal of Educational Research, VII (January, 1923), pp. 50-58.

great care is required to see the exact procedure. The authors suggest that the method used should depend on the nature of the experiment. Where the two methods yielded equal results it was suggested that demonstration be utilized as it was less expensive of time and equipment and produced enthusiasm from the class working together.

Cunningham reports a study of laboratory versus lecture-demonstration methods in the natural sciences.[1] He did the study in 1924 using ten pairs of tenth grade biology students equated on the basis of intelligence and school grades. These students did twelve experiments. In these experiments no help was given to the laboratory group outside of written instructions. He had previously done a pilot experiment in which he used two classes equated in the same manner as was used for the ten pairs of students. These students had done thirteen experiments. Both groups were graded on tests which were given after the exercises. The results of these tests of immediate knowledge favored the lecture-demonstration group.

In a follow-up study three months later the same students were asked to write all they knew of the exercises when only the topics of the exercises were given to them.[2] The

---

[1]Harry A. Cunningham, "Laboratory Methods in Natural Science Teaching, I," School Science and Mathematics, XXIV (October, 1924), pp. 709-715.

[2]Harry A. Cunningham, "Laboratory Methods in Natural Science Teaching, II," School Science and Mathematics, XXIV (November, 1924), pp. 848-851.

laboratory method produced greater retention on delayed recall. Cunningham suggests that each experiment should be tested to see whether it is best taught by demonstration or laboratory methods.

In 1922 Cooprider noted that much time had been devoted to discussion of the relative efficiency of different teaching methods, but regretted that there had been too little objective measuring or comparing of methods.[1] He used forty-two sophomore biology students and twenty-four laboratory exercises in comparing four methods of teaching. The methods he used in the order of greatest achievement results are: (1) individual work with oral instruction, (2) demonstration work with oral instruction, (3) demonstration work with written instruction, and (4) individual work with written instruction. The methods were evaluated on the basis of written reports over the exercises but the differences in group achievement were not statistically significant.

In another study he used twelve exercises, sixty-eight subjects and completion-type tests at the end of the experimental period and again one month later.[2] The author concluded from the comparison of these test results that for

---

[1]J. L. Cooprider, "Oral versus Written Instruction and Demonstration versus Individual Work in High School Science," School Science and Mathematics, XXII (December, 1922), pp. 838-844.

[2]J. L. Cooprider, "Laboratory Methods in High School Science," School Science and Mathematics, XXIII (June, 1923), pp. 526-530.

immediate retention the best results were achieved with oral instruction and with demonstration of experiments. For delayed retention the individual work produced greater gain. Demonstration work was better with oral instruction and individual work better with written instructions.

In the field of high school chemistry, Nash and Phillips undertook an experimental evaluation of three teaching methods.[1] The first method, called the pupil method, allowed each student to cover the course material at his own speed. The teacher method was a lecture-demonstration method in which the instructor covered all the material for the students. In the third method, which was called the combination method, there were lecture, demonstration, laboratory and recitation combined. For subjects he used fifteen pairs of pupils equated on the basis of mental ability. He used an author constructed test to measure achievement in chemistry. The results indicated that in acquiring information, the teacher method in high school chemistry was superior to the other two methods. The authors state that there may have been informational gains made under the pupil method which the test did not attempt to measure as the experiment was limited to the acquisition of certain definite fundamental information.

Lucow compared learning arising from textbook centered

---

[1]H. B. Nash and M. J. W. Phillips, "A Study of the Relative Values of Three Methods of Teaching High School Chemistry," Journal of Educational Research, XV (May, 1927), pp. 371-379.

approaches in high school chemistry.[1] The experiment was run separately for each of the two populations: thirty-six accelerated students who followed a college preparatory course and twenty-four non-accelerated students taking a course not sufficient for university entrance. An author constructed test was used for pretest and post-examination in order to compare the mean achievement and increases in variances within each of the groups. Objectives stressed by the test were recall of basic concepts, application of concepts and principles, and comprehension and interpretation. Both methods produced statistically significant changes in mean achievement of the groups.

In determining the effect of these methods of instruction upon individual differences Lucow found that the non-accelerated group profited more from the laboratory approach insofar as increase in variance of the group was concerned. Accelerated pupils as a group made statistically significant increases in variance under both methods with the laboratory approach producing greater variation. The author recommended that the laboratory approach be used for all pupils since with this method both accelerated and non-accelerated groups increased in variance indicating greater emphasis upon individual differences.

---

[1]William H. Lucow, "Estimating Components of Variation in an Experimental Study of Learning," Journal of Experimental Education, XXII (March, 1954), pp. 265-271.

In comparing experimental and demonstration methods in college physics laboratories, Kruglak used the same lecture, text, assignments, hours of work, experiments, and instructor for both the control and experimental groups.[1] One group did the experiments which were demonstrated in the other group. The initial status of the students was adjusted by analysis of covariance. He found that the demonstration method was as effective as individual experimentation in acquiring knowledge of physics as measured by his tests.

Johnson equated two groups of high school biology students on the basis of intelligence.[2] He had each of these groups do three series of eight experiments, one series in each of the following three ways: demonstration, individual laboratory, and group experimentation. The demonstration group made the greatest achievement on his tests but the differences among the methods were not statistically significant.

Anibel, in comparing the lecture-demonstration and individual laboratory methods, equated thirty pairs of students on the basis of intelligence and used examinations of

---

[1]Haym Kruglak, "A Comparison of the Conventional and Demonstration Methods in the Elementary College Physics Laboratory," Journal of Experimental Education, XX (March, 1952), pp. 293-300.

[2]Palmer O. Johnson, "A Comparison of the Lecture-Demonstration, Group Laboratory Experimentation, and Individual Laboratory Experimentation Methods in Teaching High School Biology," Journal of Educational Research, XVIII (September, 1928), pp. 103-111.

science information as a basis of measuring success.[1] He gave the same lecture to both groups, but one group had individual experimentation whereas the other had demonstrations. Although the differences in these experimental groups are not statistically significant, he concluded from this investigation that gains favored the lecture-demonstration procedure in regard to immediate retention. Indications favored the individual laboratory procedures on delayed retention.

Balcziak studied the relative effectiveness of demonstration, combined demonstration and individual laboratory, and individual methods of doing laboratory work in a general education physical science course.[2] He used a controlled modern experimental method with 2 X 3 randomized block design and analysis of variance and covariance. The one hundred forty-four students were assigned at random to six sections for the study which was of one year duration. He measured three values--scientific information, laboratory performance, and scientific attitudes. Each of the methods yielded significant gains in scientific information and laboratory

---

[1]Fred G. Anibel, "Comparative Effectiveness of the Lecture-Demonstration and Individual Laboratory Method," Journal of Educational Research, XIII (May, 1926), pp. 355-365.

[2]Louis W. Balcziak, "The Role of the Laboratory and Demonstration in College Physical Science in Achieving the Objectives of General Education" (unpublished doctoral dissertation, University of Minnesota, 1953), quoted in Herbert A. Smith, Chairman, Third Annual Review Committee, "Third Annual Review of Research in Science Teaching," Science Education, XXXIX (December, 1955), p. 362.

performance. Only with the individual method was there a significant gain in scientific attitudes. There was no significant difference in the means among the several methods in the three values measured.

Rulon studied the affect on learning of listening to stories on phonographic recordings compared with reading the story.[1] Initial gains were in favor of the reading group, but in retained gains (ascertained by a test one week later) this group was not significantly superior to the listening group. In other reports of similar research he reports conflicting results so that neither procedure was proved more effective.[2,3]

Fox analyzed pupil errors on standardized science tests in an effort to discover better teaching techniques for general science.[4] He then used three techniques (demonstration, stressing major ideas, and teaching vocabulary) to

---

[1]Philip J. Rulon, et al., "A Comparison of Phonographic Recordings with Printed Materials in Terms of Knowledge Gained Through Their Use Alone," Harvard Educational Review, XIII (January, 1943), pp. 63-76.

[2]Philip J. Rulon, et al., "A Comparison of Phonographic Recordings with Printed Material in Terms of Knowledge Gained Through Their Use in a Teaching Unit," Harvard Educational Review, XIII (March, 1943), pp. 163-175.

[3]Philip J. Rulon, et al., "A Comparison of Phonographic Recordings with Printed Material in Terms of Motivation to Further Study," Harvard Educational Review, XIII (May, 1943), pp. 246-255.

[4]Truman D. Fox, "The Discovery of Better Teaching Techniques for General Science," Science Education, XIX (February, 1935), pp. 9-12.

reduce these errors in experimental classes. Both high and low intelligence groups in which these were emphasized did better than the control groups in subsequent tests.

Research on the value of motion pictures in science teaching indicates they have worthwhile contributions to make to the educational process. In one study, Wise used five schools each of which had two biology classes taught by the same instructor.[1] The students were given a pretest over the films used and the Cooperative Biology Test. One class of each teacher saw the films and the other class did not. The students were then given a post-test over the films and the Cooperative Biology Test to measure achievement. The method of analysis of covariance was used to evaluate the differences between control (non-film) and experimental (film) groups as revealed by both tests. From this experiment Wise drew the following conclusions:

> The use of a reasonable number of sound motion pictures which are closely related to the content of a semester's work in high school biology may materially enrich, or add to, pupil learning as measured by tests administered at the end of the semester, without detracting from normal pupil accomplishment as measured by a valid and reliable standardized test also administered at the end of the semester.[2]

In a somewhat similar experiment comparing educational sound motion pictures and equivalent teacher demonstration,

---

[1]Harold E. Wise, "Supplementary Contributions of Sound Motion Pictures in High School Biology," Science Education, XXXIII (April, 1949), pp. 206-213.

[2]Ibid., p. 213.

Smith concluded that the two methods were of equal merit as instructional devices in ninth grade general science classes when they included essentially the same material insofar as merit could be determined by the techniques employed in his investigation.[1]

Jayne experimented with showing films as an integral part of the learning unit as opposed to their showing incidentally some time before the formal class study to which they pertain.[2] In this study he used thirty pupils in general science classes and twenty-seven geography students. The difference in informational learning produced using integrated films was twenty-one per cent greater in geography and forty-four per cent greater in general science than occurred with incidental film presentation. These gains are statistically significant. Evidence indicates that film contribution increases as the degree of integration of film and unit content increases.

An experiment by Anderson and others utilized films in three teaching methods with over four hundred students in each method.[3] The three methods of treatment were as follows:

---

[1]Herbert A. Smith, "A Determination of the Relative Effectiveness of Sound Motion Pictures and Equivalent Teacher Demonstration in Ninth Grade General Science," Science Education, XXXIII (April, 1949), pp. 214-221.

[2]Clarence D. Jayne, "The Integrated Versus the Non-Integrated Use of Moving Pictures in the Classroom," Journal of Experimental Education, V (September, 1936), pp. 7-16.

[3]Kenneth E. Anderson, et al., "Toward a More Effective Use of Sound Motion Pictures in High School Biology," Science Education, XL (February, 1956), pp. 43-54.

(1) control--no films or films of the teachers' own choice were used, (2) experimental--films with teachers' own preparation were used, (3) experimental--films were used bolstered by the emphasizing of principles covered or stressed in the films. In the last experimental group the teachers were given a list of principles to stress before and after the films. Random procedures were used to choose the schools for the study from the schools in the state with an enrollment from one hundred to two hundred students. The students were put into the methods groups by the same procedure. Each of these groups was divided into subgroups representing the lower, middle, and upper third of the intelligence rating of all students in the study. A standardized biology test was used for a pretest and post-test measure of achievement. The experiment was conducted for one school year.

Films used in conjunction with the stressing of principles produced greater achievement than the film method which was better than the conventional or control method. However, the differences in achievement between the three treatment groups (holding intelligence test scores and pretest scores constant) were not statistically significant.

In regard to increase of variance of the groups from pretest to post-test the group which had films with the stressing of principles produced greater variance than the film group with the teachers' own preparation. This last group produced greater variance than the group which had no

films or films of the teachers' own choice.

Jayne studied the values to learning and retention of lecture using diagrams, charts, and the blackboard as compared with silent films with no introduction or comment by the teacher.[1] Each of these methods covered the same material and required thirty minutes for presentation. He found the lecture method superior on immediate test results and on delayed retention tests following three week and fifteen week intervals.

McGill reported an experiment designed to measure the effectiveness of homework in social studies.[2] He used one hundred eighty-five pairs of students matched on the basis of the Cooperative Test of Social Studies Abilities and intelligence scores determined by the Terman-McNemar test. A pretest and a final test were given to measure achievement. The author reported there was no statistically significant difference between the groups in achievement, although the non-homework group had the higher mean achievement. He interpreted this as indicating that in the field of social studies it made little difference whether or not homework was assigned as far as achievement was concerned.

---

[1]Clarence D. Jayne, "Studies of the Learning and Retention of Materials Presented by Lecture and by Silent Film," Journal of Educational Research, XXXVIII (September, 1944), pp. 47-58.

[2]James V. McGill, "How Valuable is Homework?" High Points, XXXII (September, 1950), pp. 48-53.

Schiller devised a questionnaire in regard to the procedures used by students in getting their homework.[1] She administered this to one hundred seventeen students in the top ranking class in the seventh, eighth, and ninth grades and found that the amount of copying in doing this homework was 33 per cent, 46 per cent, and 82 per cent, respectively, for the three grades. She believes that, despite the current emphasis by many teachers on assigning homework with the expectation that research procedures will be learned, these data do not support any hope that homework encourages children to look up unknowns on their own.

In an experiment in which one high school class in economics was taught without homework and another was taught with it, Schneider found little difference in achievement, but felt there was greater opportunity to use directed study and open book techniques in the class that had no homework.[2]

In 1956 Boeck reported a study in which he sought to compare the effectiveness of three methods of teaching in developing understanding of ninth grade general science pupils.[3] The methods were discussion-demonstration without

---

[1]Belle Schiller, "A Questionnaire Study of Junior High School Students' Reaction to Homework," High Points, XXXVI (June, 1954), pp. 23-36.

[2]Samuel Schneider, "An Experiment on the Value of Homework," High Points, XXXV (April, 1953), pp. 18-19.

[3]Clarence H. Boeck, "The Relative Efficiency of Reading and Demonstration Methods of Instruction in Developing Scientific Understandings," Science Education, XL (March, 1956), pp. 92-97.

reading about the exercises, discussion-reading without demonstration, and discussion-reading-demonstration. He used sixteen science classes taught by eight teachers and measured results on an achievement test, a non-verbal performance test and an attitude scale. The unit of study was mirrors and mirror images. He used four periods of instruction between pretest and post-test. There were no statistically significant differences in the final achievement test scores for the three methods or in the retest scores eight weeks later. On the attitude scale the reading method without demonstration was regarded with least favor by the students while the demonstration method received the most favorable reaction.

Bent divided a class of fourteen pupils into two equivalent groups according to sex and a group mean classification of mental, educational, chronological ages, general scholarship and scores on the Otis Classification Test.[1] He used two methods of instruction. Each group used one method for six weeks and then changed to the other method for six weeks.

The experimental group had no regular textbook but used several texts as supplementary sources. They determined their own units of work and experiments. Complete freedom was allowed them during the class periods and no task was

---

[1]Rudyard K. Bent, "Comparative Effectiveness of a Freedom Method and a Conventional Method of Teaching High School General Science," School Science and Mathematics, XXXIII (October, 1933), pp. 773-776.

imposed upon them.

The control group used a text and laboratory manual and were assigned whatever the experimental group elected to do. The instructor demonstrated experiments which the pupils observed and about which they made written reports.

Three units were studied and tests were administered, then the groups rotated for three more units followed by tests. Delayed recall tests were administered after a lapse of two weeks and another after three months.

Although the experimental group excelled on all but one immediate recall test and the control group was superior on retention tests, the differences were not statistically significant.

Need for the Study

The need for a study of the value of the methods of teaching in high school biology has grown out of the fact that there are groups of people, including both educators and parents, who think differently about the relative effectiveness of the different procedures.

As far as could be determined no studies have attempted to compare simultaneously three teaching methods in high school biology in terms of knowledge acquired in relation to intelligence and reading ability of the students involved. Many of the methodological studies have been conducted using only two methods, small groups, different teachers and

different situations.

Too often the studies have been conducted in an artificial environment--selecting small groups of special students or using equipment not readily available to the average science teacher. This reduces the effectiveness of the studies as far as the usefulness of their results to the teacher in the actual classroom is concerned.

In a recent review of research in science teaching Anderson et al. state, "Yet, as you read the descriptions of current research in our field, note that the findings do not reflect natural settings to the extent desirable, and thus have limited applicability in our science teaching."[1]

In another review Hurd expresses "disappointment concerning available research on the effectiveness of the different teaching methods commonly used in classrooms."[2]

It is believed that the interests of public education would be better served if more were known than is now the case concerning methods used at present in teaching high school biology. Use of larger experimental groups in the same school system with the same teacher for a longer experimental period than has often been used should add to the usefulness of such

---

[1]Kenneth E. Anderson et al., "Second Annual Review of Research in Science Teaching," Science Education, XXXVIII (December, 1954), p. 333.

[2]Paul Deh Hurd, "The Educational Concepts of Secondary School Science Teachers," School Science and Mathematics, LIX (February, 1954), p. 89.

a study. It is believed that such information would be helpful to biology teachers, science supervisors and coordinators, and to various organizations of science teachers. The principal purpose of the present study is to provide such information.

The Problem

The purpose of this study was to compare the effectiveness of three teaching methods in high school biological science as measured by acquisition of biological knowledge in relation to intelligence and reading ability of the students. The three teaching methods are:

1. Lecture-discussion plus reading of the assigned text outside of the class period.
2. Lecture-discussion plus reading of the assigned text during the class period with no outside reading assignments.
3. Lecture-discussion with no required reading and no assigned textbook.

In the teaching of high school biology the practice of lecturing during the class hour and assigning supplemental or text reading outside of class on a homework basis has long been practiced in American high schools. The practice of reducing the outside assignments and using class time for this reading requirement has been a more recent addition to teaching method. The effectiveness of teaching high school

biology without required reading material whether inside or outside the class period has not been definitely established. The present study attempts to provide information on this point.

Delimitation of the Problem

This study is designed to compare the effectiveness of three teaching methods used in high school biology. It is expected that the results of such a study in a particular subject area are principally of value to teachers in that particular subject area and do not offer conclusive evidence in other fields of study.

Another limitation of this study is that only tenth grade high school students were utilized as subjects in the investigation. This study was also limited to one public high school.

This study is concerned with increase in biological knowledge. Attention is given to reading ability and intelligence of the students in connection with the knowledge acquired in the public high school as taught under the three different methods.

Definition of Terms

Throughout this study, certain terms are used to convey specific meanings which should be clearly understood by the reader. To avoid misinterpretations, the following terms are defined:

Teaching Method. A means of instructional activity including all devices the teacher utilizes to encourage learning by his students.

Lecture-Discussion. The teacher assumes the principal responsibility for discussing the designated educational material in an extended discourse. During or after completion of the lecture the students clarify and expand their information through asking questions, participating in discussion and general examination of the topic. The teacher also asks questions to stimulate interest and focus attention on the problem at hand.

Outside Reading. The classroom schedule requires that assigned readings from the assigned textbook be done outside the class period with no time allowed during class meetings for this activity. This group is designated by the symbol L-O throughout this study.

Inside Reading. The classroom schedule is set up to provide a period of time for the students to do their reading assignments from the assigned textbook inside of or during class meetings for this activity. The symbol for this group using lecture with inside reading is L-I.

No Reading. The classroom schedule requires no textbook and no material is assigned to be read either inside the class period or outside of it. This group is identified by the symbol L-N.

CHAPTER II

METHOD OF RESEARCH AND TREATMENT OF DATA

Method

The experimental method of research was used in the present study because this method is best suited to the nature of the problem and the data needed.[1]

Nature and Sources of Data

There are three sources of data involved in the study, i.e., the scores obtained from the following tests:

1. Otis Quick Scoring Mental Ability Tests, Gamma A_M[2]
2. Diagnostic Reading Test[3]
3. Nelson Biology Test (Forms A_m and B_m) pretest and post-examination.[4]

---

[1]Carter V. Good and Douglass E. Scates, Methods of Research (New York: Appleton-Century-Crofts, Inc., 1954), pp. 689-725.

[2]Arthur S. Otis, Otis Quick Scoring Mental Ability Tests (New York: World Book Company, 1937).

[3]Committee on Diagnostic Reading Tests, Diagnostic Reading Tests Survey Section, Form A (Chicago: Science Research Associates, 1947).

[4]Clarence H. Nelson, Nelson Biology Test (New York: World Book Company, 1951).

Securing the Information

The subjects of this study were the students regularly enrolled in the first semester of biological sciences at the College High School in Bartlesville, Oklahoma, during the fall of 1955. The enrollees in this subject are principally sophomores. The few junior and senior enrollees were not included in the experimental data so that the groups would be more homogeneous. The school uses no particular devices such as intelligence grouping or pretests of achievement to schedule pupils in these classes. Biology is not a required subject at this particular high school.

The investigator taught the six classes of biology which were assigned by lot to the three experimental groups, two classes in each group.

In the first group, Lecture-Discussion with Outside Reading (Group L-O, N = 53), the students were given fifty-five minutes per day in lecture-discussion. This group had fifteen reading assignments from the textbook during the period of the study. The length of these assignments ranged from 4 to 21 pages with an average of 9.9 pages per assignment. The material contained in the text was covered in the lecture-discussion periods for all three groups. Reading assignments were scheduled throughout the semester so that the students might read the material prior to its treatment in the lecture-discussion periods.

The second group, Lecture-Discussion with Reading

in the Class Period (Group L-I, N = 56), was allowed approximately twenty-four minutes of class time a week in order to complete the reading assignment. The reading periods ranged in length from 10 to 25 minutes per reading session with an average of 1.50 reading periods per week and an average of 16.22 minutes per reading period. The reading periods varied in length of time since some topics or chapters require more discussion and less reading; therefore, after some assignments have been read, the discussion may last a few days.

The third group, Lecture-Discussion with No Reading Required (Group L-N, N = 52), had fifty-five minutes per day of lecture-discussion. This group had no textbook and were not required to do any reading outside or inside the class period.

The experimental period was twelve weeks in length. During this period there was a total of fifty-five teaching days. Ten of these days were utilized for collecting and dispensing general information and for pretests and post-examination. Two days were needed for unit tests or semester examinations necessary for grading purposes according to school policy. Three days were used for film presentations and eight days were used in laboratory periods. The laboratory periods, which were the same for all groups, utilized the entire class period and no text reading was done on laboratory days. Fourteen days were used in lecture-discussions which were the same for all experimental groups. The lectures covered

the text material which the two reading groups were expected to read. The discussion which accompanied these lectures centered around the student questions and comments concerning the lectures and related material. Questions by the teacher were used to ascertain the clarity or completeness with which the material had been grasped by the students.

Eighteen periods were used by Group L-I to do their reading assignments. The remainder of each of these periods was used for the lecture-discussion which duplicated that of the other two groups except in the questions asked by the students.

The same textbook and readings were assigned to both reading groups and the same discussion topics were used for all groups. These topics were developed in the lecture-discussion periods as concurrently as possible even though the methods of assigning reading work were different.

The same objectives (i.e., acquisition of biological knowledge and understanding, ability to recognize cause-effect relationships, ability to interpret data and draw conclusions therefrom, problem solving, and evaluation of experimental procedures) were set up for the three groups and were emphasized in reading materials and lecture-discussions.

At the beginning of the experimental period the subjects were given the Otis Quick Scoring Mental Ability Test, Diagnostic Reading Test and the Nelson Biology Test to determine the amount of intelligence and reading ability and the

amount of biological knowledge present before training under the various methods. An alternate form of the Nelson Biology Test was administered at the end of the experimental period to determine the amount of achievement of knowledge in biology.

The Nelson Biology Test has seventy-five multiple choice items and requires approximately forty minutes to administer. This test was chosen because it has sufficient reliability and validity for this type of study and was constructed to measure the objectives which biology teachers seek to achieve. These are in essence the objectives listed above.

Two forms of the Nelson test were used to minimize practice effect. Every other student in each class was given an A or a B form of the test to eliminate any help from neighbors during the test. The students were encouraged to do their own work and to do their best on all the tests. The teacher was always in the room during the testing and gave full attention to the testing procedure and those being tested.

The students were not familiar with the pretesting technique and were told that the tests would help the teacher discover how much biology they already knew and with what areas they were unfamiliar, thus the emphasis on material could be arranged to make the course more interesting to them. No student took the same form of the test twice; i.e., if he took Form A as a pretest, he took Form B for the

post-examination.

Since the comparative study was not of a nature which was likely to be objected to by students or parents, it was deemed advisable to make no mention of the fact that a study was being made. This should have helped to keep conditions more like those found in the normal classroom.

The Diagnostic Reading Test was used as a measure of reading rate and comprehension so that better and poorer readers could be compared in relation to the amount of acquisition of biological knowledge in each of the three experimental groups.

The Otis Quick Scoring Mental Ability Test was given so that results could be used in comparing the students in the upper and lower portions of this intelligence group with the amount of knowledge acquired in biology under the three teaching methodologies.

In an experimental situation of this nature where the experimenter is permitted to administer different methods of teaching to different public school classes, but must use the classes as they are already organized (since reorganizing them into matched classes would introduce conflicts in the students' daily schedules) it seems impractical to attempt control of concomitant variables (such as the students' intelligence scores and reading ability scores) by direct selection of subjects. Such selection of subjects also tends to reduce the effectiveness of the findings since the

normal classroom population may be altered.

Therefore, since experimental control of the variables appears impractical, the experimenter must rely upon statistical comparison of the groups to test their initial equality.

Statistical procedures utilized in this study include the "t" test which is used to test the differences between means of the experimental groups in regard to the pretest data. The "t" test is also used to test the differences in the group means of the post-examination as well as the mean improvement within the groups.

For a complete discussion of the technique and method used the reader is referred to its treatment in statistical books such as the one by Tate.[1]

---

[1]Merle W. Tate, Statistics in Education (New York: The Macmillan Company, 1955).

CHAPTER III

PRETEST RESULTS

Initial Status of Pupils

The experimental groups are compared on intelligence, reading abilities, and biology information scores to determine their comparability on the results of the pretests of these abilities and knowledges. The appendix lists the Otis I.Q. scores, reading rate and comprehension scores, and the biology pretest scores for each pupil. The scores are listed in these tables in the same order as the students were alphabetized in the teacher's record book. With this procedure a student's score appears in the same position on each of the tables of pretest and post-test data. The scores have been placed in groups according to the experimental teaching procedure used. These same tables report the mean score and standard deviation for each group along with the mean and standard deviation for the entire student sample.

Intelligence Test Scores

Intelligence test scores for each subject as measured by the Otis Quick Scoring Mental Ability Test are found in

the Appendix. The mean Otis I.Q. score for the 161 students in the entire sample is 104.17 and these scores range from 76 to 133. Those with outside reading assignments, Group L-O, have a mean score of 104.81 and an I.Q. range of 78 to 130. The mean score for Group L-I is 103.36 and the range is 76 to 133. Group L-N, the group having no reading assignments, has a mean score of 104.58 and a range of 77 to 124 I.Q. points.

Reading Comprehension Scores

Reading comprehension scores of the 161 subjects are found in the Appendix. They are recorded in raw score form as measured by the Diagnostic Reading Test and range from 14 to 95 for the entire student sample with a mean score of 61.88. The mean score for Group L-O is 61.30 with a range of 16 to 94. Reading comprehension scores yield a mean score of 60.77 and a range of 28 to 90 for Group L-I. Group L-N has a mean score of 63.67 and a range of 14 to 95.

Reading Rate Scores

Reading rate raw scores as measured by the Diagnostic Reading Test for the 161 subjects in the experiment are reported in the Appendix. The mean for all groups is 58.71 and the range from 20 to 124. The mean reading rate for Group L-O is 60.81 with a range of 20 to 124. Group L-I has a mean score of 56.36 and a range of 28 to 89, and Group L-N has a mean reading rate of 59.10 with a range of 26 to 85.

Biology Pretest Scores

Two forms of the Nelson Biology Test, forms A_m and B_m, were used in this experiment and the scores are reported as standardized scores rather than in terms of raw scores.

Biology pretest data are reported in the Appendix. The scores for the entire student sample range from 61 to 142 with a mean of 98.85. Group L-O has a range of 65 to 142 with a mean of 101.51. Group L-I has a range of 71 to 130 with a mean of 96.61, while Group L-N has a range of 61 to 130 and a mean of 98.56.

Significance of Pretest Data

Figures 1 through 4 contain frequency polygons showing the distributions of the Otis I.Q. scores, reading rate and comprehension, and biology pretest scores. The distributions are slightly skewed, but according to Edwards, "The consensus . . . is that no serious error is introduced by non-normality in the significance levels of the F-test or of the two-tailed t-test."[1]

The Critical Ratio was used to test the difference between group means in the study. The formula from Tate is as follows:[2]

---

[1]Allen L. Edwards, Experimental Design in Psychological Research (New York: Rinehart and Company, 1950), p. 166.

[2]Merle W. Tate, Statistics in Education (New York: The Macmillan Company, 1955), p. 434.

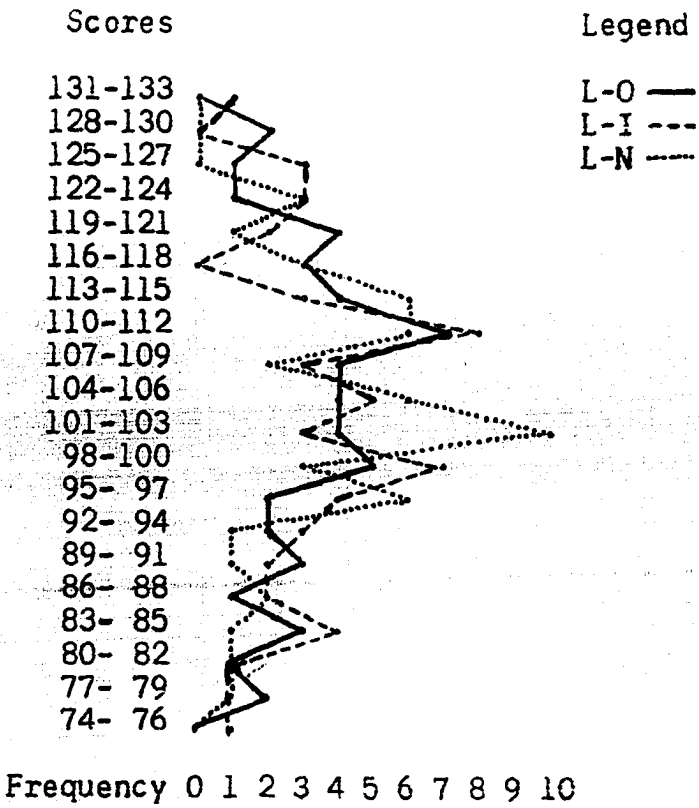


Fig. 1.--Superimposed frequency polygons showing distribution of Otis I.Q. scores for groups L-O, L-I, and L-N.

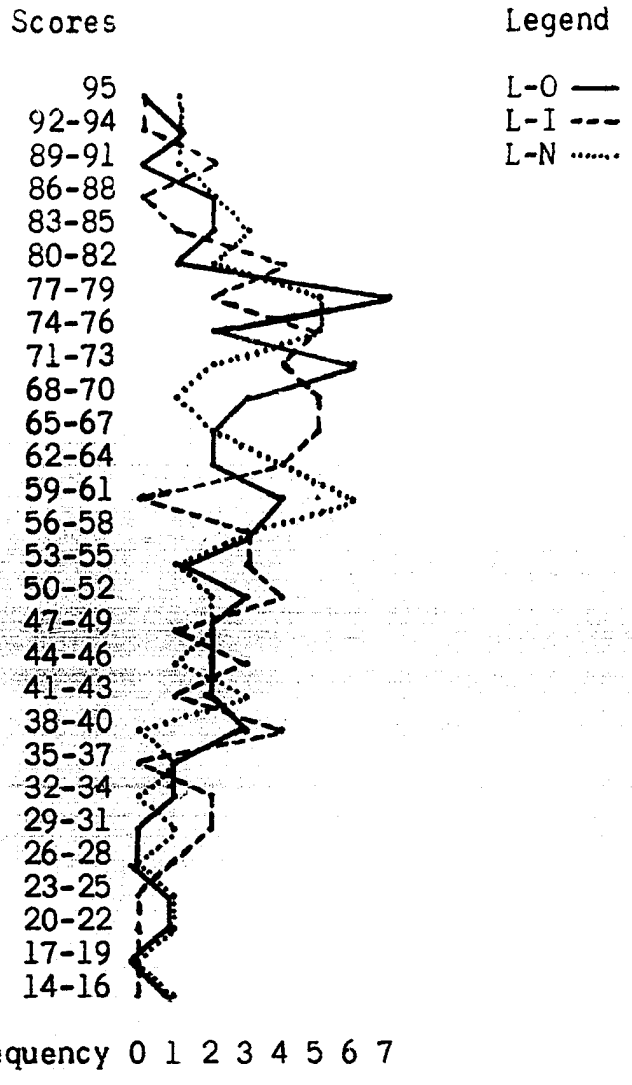


Fig. 2.--Superimposed frequency polygons showing distribution of Diagnostic Reading Test--comprehension scores for groups L-O, L-I, and L-N.

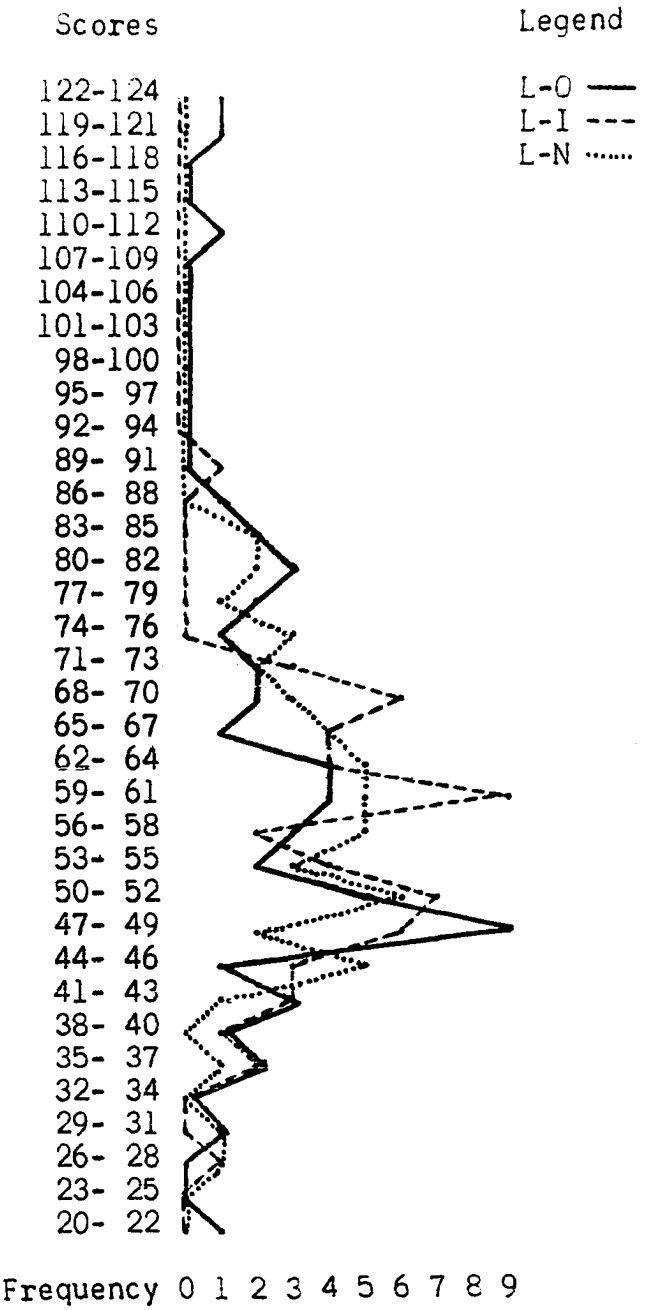


Fig. 3.--Superimposed Frequency polygons showing distribution of Diagnostic Reading Test--rate scores for groups L-O, L-I, and L-N.

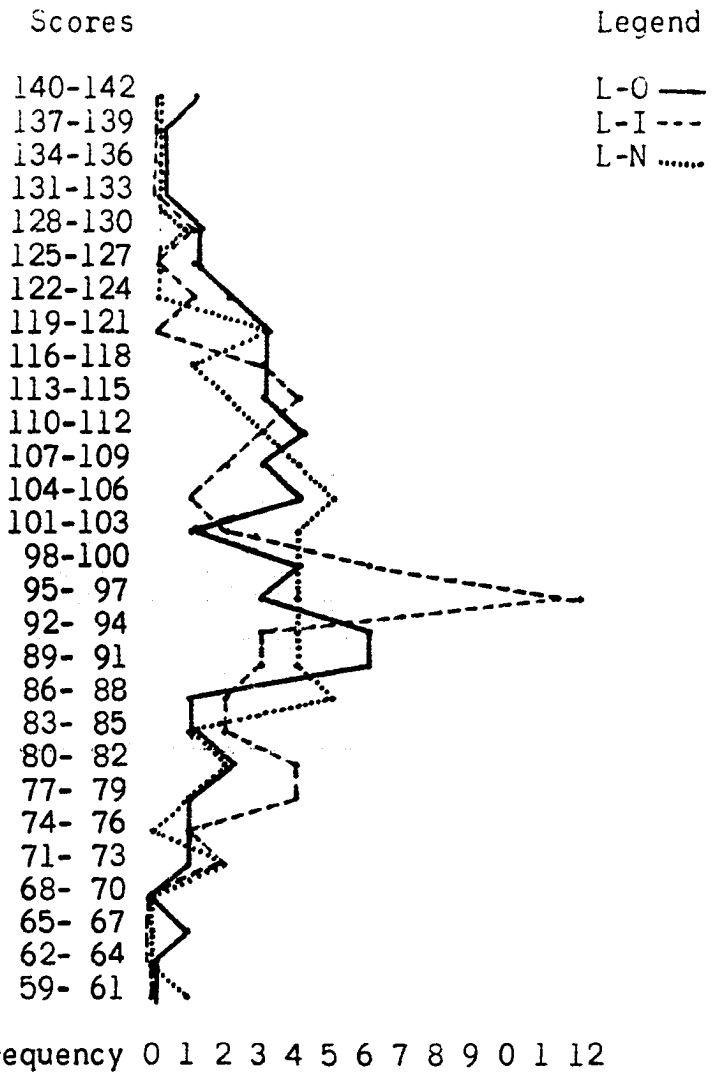


Fig. 4.--Superimposed frequency polygons showing distribution of Nelson Biology Test--pretest standard scores for groups L-O, L-I, and L-N.

$$CR = \frac{\text{difference between sample means minus hypothesized difference between population means}}{\text{standard error of difference between means}},$$

where CR is the Critical Ratio.

The Critical Ratio of the difference of the means was applied to the pretest data to determine if the differences in the means between groups was great enough to question the assumption that all the cases in each group were randomly selected from the same or similar populations.

The Critical Ratio values resulting from this test of the significance of the differences between the means of the experimental groups in regard to the pretest data are reported in Table 1. This table also contains the means and standard deviations of the pretest data of the experimental groups, the differences in the means, and the standard error of the difference.

The actual formula used in making these tests is:[1]

$$CR = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\sigma^2_{M_1} + \sigma^2_{M_2}}}$$

where CR is the Critical Ratio.

$\bar{X}_1$ and $\bar{X}_2$ are the means on the various tests of the experimental groups, respectively, and $\sigma^2_{M_1}$ plus $\sigma^2_{M_2}$ is the standard error of the difference in means for these groups. The standard error of the mean is $\sigma_M = \frac{\sigma}{\sqrt{N - 1}}$, where is

---

[1] Ibid., pp. 434-435.

TABLE 1

COMPARISON OF EXPERIMENTAL GROUPS ON PRETEST DATA

	$\bar{X}$	S.D.	$\bar{X}$	S.D.	Diff. in Means	S.E. Diff.	"C.R."*
	L-O	(N=53)	L-I	(N=56)			
I.Q.	104.81	13.00	103.36	13.40	1.45	2.542	.57
R.C.	61.30	17.96	60.77	16.11	.53	3.304	.16
R.R.	60.81	22.32	56.36	11.19	4.45	3.443	1.29
B.T.	101.51	15.75	96.61	14.32	4.90	2.915	1.68
	L-O	(N=53)	L-N	(N=52)			
I.Q.	104.81	13.00	104.58	10.61	.23	2.336	.10
R.C.	61.30	17.96	63.67	18.47	-2.37	3.590	.66
R.R.	60.81	22.32	59.10	12.96	1.71	3.587	.48
B.T.	101.51	15.75	98.56	14.04	2.95	2.938	1.00
	L-I	(N=56)	L-N	(N=52)			
I.Q.	103.36	13.40	104.58	10.61	-1.22	2.339	.52
R.C.	60.77	16.11	63.67	18.47	-2.90	3.377	.86
R.R.	56.36	11.19	59.10	12.96	-2.74	2.360	1.16
B.T.	96.61	14.32	98.56	14.04	-1.95	2.755	.71

*The C.R. values are not significant at the 5 per cent level of confidence.

the standard deviation of the distribution and N is the number of students in the experimental group.

No significant differences were found between the means for Groups L-O, L-I, and L-N on intelligence, reading comprehension, reading rate, and biological knowledge. This indicates that the means for these groups as measured by the Otis Quick Scoring Mental Ability Test, the Diagnostic Reading Test, and the Nelson Biology Test, respectively, are not significantly different.

CHAPTER IV

POST-TEST RESULTS

The Gain in Information

The post-test of biological information was given at the end of the twelve weeks experimental period. Each student was given the Nelson Biology Test, an alternate form from that taken during the pretesting. The aim of the testing was to determine if there were differences between teaching methods in regard to acquisition of subject matter as measured by this standardized biology test. The post-test was given under the same experimental conditions as the pretests.

The biology post-test scores are found in the Appendix with the individual scores in the same order as the pretest scores. The Nelson Biology pretest and post-test means and standard deviations for the entire sample and for each of the experimental groups are reported in Table 2.

The post-test mean of the Nelson Biology Test for the total sample is 108.03 with a range of scores from 71 to 142. Group L-O has a mean score of 109.68 with a range of 77 to 141 while Group L-I has a mean score of 106.48 with a range

TABLE 2

NELSON BIOLOGY PRETEST AND POST-TEST MEANS AND STANDARD DEVIATIONS

Group	L-O		L-I	L-N
Pretest Mean	104.81		103.36	104.58
Standard Deviation	13.00		13.40	10.61
Grand Mean	104.17	S.D.	12.45	
Post-test Mean	109.68		106.48	108.02
Standard Deviation	15.52		13.51	11.27
Grand Mean	108.03	S.D.	13.62	

of 78 to 133. Group L-N has a mean score of 108.02 and a range of 71 to 142.

Test for Significance

The differences between means for the various groups were tested for statistical significance using the "t" test for correlated data.[1] The "t" values obtained from testing the significance of the differences between the biology

[1]Allen L. Edwards, Experimental Design in Psychological Research (New York: Rinehart and Company, 1950), pp. 168-170.

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - 0}{\sqrt{\frac{\Sigma x^2}{n(n-1)}}}$$

where $(\bar{X}_1 - \bar{X}_2)$ is the difference between the pretest $(\bar{X}_1)$ and post-test $(\bar{X}_2)$ means and Σx^2 is the sum of the squares of the differences between pretest and post-test scores; and n is the number of individuals in the sample.

pretest and post-test means for the L-O, L-I, and L-N groups are reported in Table 3. The null hypothesis was used for testing the differences in these means. Since the "t" values obtained were significant beyond the .025 level of confidence, the null hypothesis of no difference in the means is rejected. This indicates that each of the teaching methods produced significant gains in biological knowledge as measured by the Nelson Biology Test.

TABLE 3

TESTS OF THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN PRETEST AND POST-TEST MEANS, NELSON BIOLOGY TEST

	N	Pretest Mean	S.D.	Post-test Mean	S.D.	Mean Diff.	S.E. of Diff.	"t"
L-O	53	101.51	15.75	109.68	15.52	8.17	1.334	6.14*
L-I	56	96.61	14.32	106.48	13.51	9.87	1.247	7.91*
L-N	52	98.56	14.04	108.02	11.27	9.46	1.210	7.82*

*Significant beyond the .025 level of confidence.

The critical ratio was used to determine whether or not any of the three methods, lecture plus reading texts outside of class, lecture plus reading text during class period, and lecture with no reading of text, produced greater improvement in biological knowledge.

The mean improvement for each of the groups and the critical ratio values are reported in Table 4. None of the

TABLE 4

COMPARISON OF MEAN IMPROVEMENT IN BIOLOGICAL KNOWLEDGE

N	Pretest Mean	S.D.	N	Pretest Mean	S.D.	Diff. in Means	S.E. of Diff.	CR*
	L-O			L-I				
53	8.17	9.62	56	9.87	9.25	.25	1.826	.14
	L-O			L-N				
53	8.17	9.62	52	9.46	8.64	.16	1.801	.09
	L-I			L-N				
56	9.87	9.25	52	9.46	8.64	.21	1.737	.12

*None of the Critical Ratio values in this table is significant at the .05 level of confidence.

critical ratio values is significant at the .05 level of confidence. Thus the null hypothesis is sustained. This indicates that no one teaching method used in this study was superior to any other teaching method, as measured by the Nelson Biology Test.

In order to determine if any of the three teaching methods was superior for either high or low intelligence, high or low reading comprehension or high or low rate of reading, each group was divided on this basis. Then the mean scores of these two classifications were tested for significance of a difference.

The upper and lower portions of the intelligence,

reading comprehension and reading rate classifications were obtained by taking all the cases that lay outside one-half standard deviation above and one-half standard deviation below the mean for each of the groups. The one-half standard deviation dividing point was used to divide the groups more equally, or to spread the groups out more equally.

Table 5 shows data for all three teaching methods with subjects grouped on the basis of high and low I.Q., high and low reading comprehension and high and low reading rate. The difference between pretest and post-test means for the various groups respectively, were tested for significance.

When the students within the three teaching methods groups were classified on the basis of high and low I.Q. scores, it was found that the "t" values yielded statistically significant differences between pretest and post-test means for all teaching methods with the exception of the low intelligence group utilizing the lecture with no reading of text. However, in this group the "t" value approached significance. In the reading comprehension group, significance was shown on all groups except low comprehension, utilizing lecture and outside reading and low comprehension using lecture and no reading of text. On the reading rate grouping all methods of teaching showed statistical significance for students in the high and low classifications.

Comparisons are made of the relative effectiveness of the three teaching methods, (1) for students in all groups

TABLE 5

TESTS OF THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN NELSON BIOLOGY PRETEST AND POST-TEST MEANS CLASSIFIED BY INTELLIGENCE AND READING SCORES

	N	Pretest Mean	S.D.	Post-test Mean	S.D.	Mean Diff.	S.E. of Diff.	"t"
I. Q. Grouping								
U-L-O	18	115.39	11.53	123.78	11.42	8.29	2.781	3.02*
U-L-I	18	109.00	10.40	119.33	8.46	10.33	3.129	3.30*
U-L-N	19	107.73	12.10	119.47	9.39	11.74	3.244	3.62*
L-L-O	16	90.12	12.70	99.06	13.98	8.94	3.996	2.24*
L-L-I	18	86.39	10.78	93.78	9.83	7.39	2.830	2.61*
L-L-N	13	83.61	10.37	89.92	11.66	6.31	3.207	1.97
Reading Comprehension Grouping								
U-L-O	21	112.52	12.47	120.33	7.01	7.81	2.472	3.16*
U-L-I	21	107.71	10.54	117.57	9.25	9.86	2.755	3.58*
U-L-N	20	108.45	10.57	119.15	9.93	10.70	3.206	3.34*
L-L-O	17	86.82	8.89	94.64	10.17	7.82	3.753	2.08
L-L-I	20	86.35	10.65	93.75	9.85	7.40	3.022	2.45*
L-L-N	14	85.07	10.08	91.00	12.21	5.93	3.065	1.94
Reading Rate Grouping								
U-L-O	14	113.29	13.67	121.29	13.23	8.00	3.080	2.60*
U-L-I	16	105.50	14.65	115.37	11.04	9.87	3.203	3.08*
U-L-N	14	105.35	13.04	116.14	12.06	10.79	3.314	3.26*
L-L-O	19	89.95	12.51	102.42	14.90	12.47	3.946	3.16*
L-L-I	20	88.45	9.19	97.20	12.23	8.75	3.154	2.77*
L-L-N	18	90.39	12.18	98.22	14.71	7.83	2.733	2.87*

*Significant beyond the .025 level of confidence.

who were in the high intelligence classification, (2) for students in all groups who were in the low intelligence classification, and the data is presented in Table 6. The "t"

TABLE 6

COMPARISON OF IMPROVEMENT IN BIOLOGICAL KNOWLEDGE FOR STUDENTS OF UPPER AND LOWER INTELLIGENCE

N	Pretest Mean	S.D.	N	Pretest Mean	S.D.	Diff. in Means	S.E. Diff.	"t"*
	U-L-O			U-L-I				
18	8.39	8.06	18	10.33	8.10	1.94	2.772	.70
	U-L-O			U-L-N				
18	8.39	8.06	19	11.74	7.68	3.35	2.664	1.25
	U-L-I			U-L-N				
18	10.33	8.10	19	11.74	7.68	1.41	2.672	.53
	L-L-O			L-L-I				
16	8.94	12.87	18	7.39	9.20	1.55	4.002	.39
	L-L-O			L-L-N				
16	8.94	12.87	13	6.31	9.31	2.63	4.274	.62
	L-L-I			L-L-N				
18	7.39	9.20	13	6.31	9.31	1.08	3.494	.31

*None of these "t" values is significant at the .05 level of confidence.

values resulting from these six showed no statistical significance for any teaching method with either the high or the low intelligence groups.

Table 7 compares the relative effectiveness of the three teaching methods, (1) for students in all groups who scored high in reading comprehension, and (2) for students who scored

TABLE 7

COMPARISON OF IMPROVEMENT IN BIOLOGICAL KNOWLEDGE FOR STUDENTS OF UPPER AND LOWER READING COMPREHENSION

N	Pretest Mean	S.D.	N	Pretest Mean	S.D.	Diff. in Means	S.E. Diff.	"t"*
	U-L-O			U-L-I				
21	7.81	8.00	21	9.86	7.70	2.05	2.483	.83
	U-L-O			U-L-N				
21	7.81	8.00	20	10.70	9.30	2.89	2.784	1.04
	U-L-I			U-L-N				
21	9.86	7.70	20	10.70	9.30	.84	2.741	.31
	L-L-O			L-L-I				
17	7.82	12.95	20	7.40	11.02	.42	4.107	.10
	L-L-O			L-L-N				
17	7.82	12.95	14	5.93	9.47	1.89	4.168	.45
	L-L-I			L-L-N				
20	7.40	11.02	14	5.93	9.47	1.47	3.645	.40

*None of these "t" values is significant at the .05 level of confidence.

low in reading comprehension. The "t" values resulting from these six comparisons showed no statistical significance for any teaching method with either the high or the low reading comprehension classifications.

Table 8 compares the relative effectiveness of the three teaching methods, (1) for the students in each of the

TABLE 8

COMPARISON OF IMPROVEMENT IN BIOLOGICAL KNOWLEDGE FOR STUDENTS OF UPPER AND LOWER READING RATE

N	Pretest Mean	S.D.	N	Pretest Mean	S.D.	Diff. in Means	S.E. Diff.	"t"*
	U-L-O			U-L-I				
14	8.00	7.99	16	9.87	7.90	1.87	3.012	.62
	U-L-O			U-L-N				
14	8.00	7.99	14	10.79	5.89	2.79	2.753	1.01
	U-L-I			U-L-N				
16	9.87	7.90	14	10.79	5.89	.92	2.613	.35
	L-L-O			L-L-I				
19	12.47	11.53	20	8.75	10.78	3.72	3.674	1.01
	L-L-O			L-L-N				
19	12.47	11.53	18	7.83	8.31	4.64	3.383	1.37
	L-L-I			L-L-N				
20	8.75	10.78	18	7.83	8.31	.92	3.190	.29

*None of these "t" values is significant at the .05 level of confidence.

experimental groups who scored high in reading rate, and (2) for students who scored low in reading rate. The "t" values resulting from these six comparisons showed no statistical significance for any teaching method with either the high or the low reading rate classifications.

In testing the hypothesis of no significant difference

between the biology pretest and post-test means when these data are grouped according to the upper intelligence and reading comprehension and reading rate test scores, the hypotheses were rejected. Students in these upper ability groupings made improvement in biological knowledge which was statistically significant at the .025 level of confidence regardless of the method of teaching which was used.

In regard to the students in the lower ability groupings, the null hypothesis of no difference between the pretest and post-test means is rejected in all but three instances. In the lower intelligence classification students in Group L-N fail to make gains in information which would be statistically significant at the .05 level of confidence. In the lower reading comprehension grouping both Group L-O and Group L-N fail to make gains significant at the .05 level of confidence.

Only the students in Group L-I made gains in information which were statistically significant at the .025 level of confidence in the lower portions of all three of the ability groupings, intelligence, reading rate and comprehension.

The teaching method which did not use a textbook was not effective in this study with students in the lower intelligence and reading comprehension groupings. The method requiring outside reading assignments did not result in sufficient acquisition of information in the lower reading comprehension group.

No method has been proven superior in producing gain in amount of biological knowledge among the more intelligent students or those with better reading rate and comprehension. The same situation is true of the poorer students in regard to these abilities in as far as can be determined by the tests used, the time limit imposed on the experiment, and the statistical procedures applied.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This study was designed to compare the effectiveness of three teaching methods used in high school biology. These methods are lecture-discussion with reading assignments to be done by the students outside of the class period, Group L-O; lecture-discussion with reading assignments to be done inside the class period, Group L-I; and lecture-discussion with no reading assigned or expected since no textbooks were given to the students in this group, Group L-N.

Six biology classes were randomly assigned, two classes each, to the three experimental groups. There were 161 tenth grade students in these classes. Intelligence tests, examinations of reading comprehension and reading rate, and biology information were given as pretests. An alternate form of the biology information test was given as a post-test. The experimenter administered all the tests and taught all of the classes.

Results of the Critical Ratio test indicate there were no statistically significant differences between the

means of the three groups, L-O, L-I, and L-N, in intelligence, reading comprehension, reading rate, and biology subject matter information. Thus the experimental groups were considered initially comparable in regard to these factors.

At the end of the twelve weeks experimental period each student was given an alternate form of the Nelson Biology Test. The Critical Ratio test of significance of the difference between the mean biology information pretest and post-test scores revealed that each of the experimental teaching methods had resulted in a statistically significant increment in biological knowledge. The difference between the pretest and post-test means were significant beyond the .025 level of confidence.

Another purpose of the study was to determine if either of the methods proved superior for students who scored high or low in intelligence. For this purpose the students who scored one-half standard deviation above or below the mean were considered the upper and lower portions, respectively. When the students were grouped according to scores on intelligence tests, the upper group made gains significant at the .025 level of confidence under each of the methods; the lower group made significant gains at the .025 level of confidence under each method except the one which did not use textbooks.

When the students were grouped according to reading comprehension scores, the upper group made significant gains

under each method; but both the group with outside reading assignments and the group without textbooks failed to make significant gains in the lower portion.

When classified according to reading rate, both the upper and lower ability portions made gains significant at the .025 level of confidence under each of the methods.

In the lower portion of each of the ability groups, gains significant at the .025 level of confidence were made by Group L-I, lecture plus reading of text in class. In the lower portion of the intelligence classification, Group L-O, lecture plus reading text outside of class, also made gains significant at the .025 level of confidence.

Students in the lower reading comprehension classification did not make gains significant at the .025 level of confidence in the group with reading assignments outside of class. Students in both the lower intelligence and lower reading comprehension classification failed to make gains significant at the .025 level of confidence in the group that had no reading assignments.

Although the more intelligent students and those in the upper reading comprehension classification seemed to have been able to produce significant gains in information without the use of textbooks, the students in the lower intelligence classification and those with poor reading comprehension did not produce significant gains in information without textbooks. Nor did the students with poor reading comprehension

make significant gains when given reading assignments outside of class.

The students in the upper ability classifications without books produced as much mean improvement as the other groups, but those in the lower ability classifications always produced a slightly smaller mean gain than the other groups. Taking a biology class without a book may be a challenge to the students with better abilities, but it appears to be a hindrance to the students in the lower intelligence and reading comprehension classifications.

The difference in the mean amount of improvement between groups was tested with the Critical Ratio test of significance of the differences of independent sample means to determine if the gains in information produced by one group were significantly greater than those produced by another group. At the .05 level of confidence, there existed no statistically significant differences in the mean amount of improvement in biology information among the teaching methods. Apparently, none of the three experimental methods is sufficiently superior to produce a mean improvement which is statistically significant over that produced by another method, at least in as much as we are concerned with mean accomplishment of the experimental groups as a whole.

Even when the groups were divided into upper and lower intelligence, reading comprehension and reading rate classifications and compared for mean amount of improvement

no statistically significant differences were revealed within the .05 level of confidence.

The amount of gain from biology pretest mean to post-test mean for each of the groups is as follows:

Group L-O	8.17
Group L-I	9.87
Group L-N	9.46
Total Sample	9.18

Although the differences in these group means are not significant, it is interesting to note that the greatest gain has been made by the group which did their reading assignments inside of the class period. Having shortened their lecture period in order to have time for the reading period, they made gains in information slightly greater than those who utilized the entire period for discussion of the topic. Of course, differences this small could be attributed to chance.

The least amount of gain was shown by the group which utilized the entire period for discussion and questions pertaining to the various topics and in addition was expected to do their reading assignments outside the class period. This, in effect, gave Group L-O a time advantage of a full class period of lecture-discussion plus whatever time the students wished to take from their study halls or other time outside of class to read the assignments. This could be an indication that the assignments outside of class are not

always done as regularly or as thoroughly as a teacher might expect they would be.

Group L-I was provided study time within the class period which shortened their discussion periods, but the students could (though they were not encouraged to do so) read or study the assignments outside of class if they so desired. If it is reasonable to assume that many of the students in Group L-O did not study as much outside of class as the teacher expected, it is reasonable to assume that the average student in Group L-I would not have done much of the extra study either. Although certain of the students may have felt that special treatment was provided them (by giving them study time within the class period) and therefore have been willing to do the extra unexpected outside reading, it is more likely that the student having once read the material in class and realizing that it would be discussed later would not take his own time to reread much of the material.

The investigator also feels that some of the students may read their assignments as the lecture-discussion is taking place and that by providing time before the lecture for this reading, the student is left free to devote his full attention to the discussion rather than to both the reading and the discussion at the same time.

For the group without a text, which would normally be considered quite a disadvantage, to achieve as much as another group which was provided texts and required to bring them

to class is an interesting finding of this study.

The very newness of the idea of taking a course without a textbook or required reading assignments outside of class may have encouraged students to work harder. Possibly a twelve week period was not long enough, but newness of an instructional plan could surely not explain the results coming from a period this long.

Without a textbook the class was more dependent on the classroom activities, wall charts, models, demonstrations (which were the same for all classes), and the lecture-discussion than were the other groups which could depend partially upon the textbooks they had been provided. Although the lectures were the same for each of the classes, at least in as much as it was humanly possible for the teacher to make them so, the discussion part depended upon the questions asked by the students and upon their comments. The group without textbooks seemed to ask more questions, often asking for repetitions and correct spelling of words. This took much of their discussion time, but was indicative of more note-taking than appeared to be true of classes who could rely upon their books for this information.

It is possible that some of the students in Group L-N may have been guided in their note-taking by the questions of the better students and thereby have been more specific or selective in their notes. Having only notes to study and no textbook, a student with a good set of notes covering the

most important topics would have less material to review and learn than one dependent upon the complete chapter or unit of a textbook. However, this does not appear to be true of the poorest of the students, since those in the lower portion of the intelligence and reading comprehension classifications did not make significant gains in information from pretest to post-test in Group L-N.

Although the differences in the mean amount of improvement between the groups do not reach a point of statistical significance, at the .025 level of confidence, certain trends are in evidence.

In the upper portion of the entire student sample, considering the data as divided by intelligence, reading comprehension, and reading rate, Group L-N consistently shows more gain in information than Group L-I which in turn produces more gain than Group L-O. In the upper portion of the ability classifications students without a textbook do not seem to be handicapped; in fact they acquire as much or more knowledge than students with textbooks, and those who take part of their class time to do their reading assignments do as well or better than their fellow students who are expected to read assignments outside of class.

In the lower portion of the intelligence and reading ability classifications, the reverse of this trend is in evidence. Group L-O (lecture-outside reading) produces slightly greater gains than Group L-I (lecture-reading in

class) which produces slightly greater mean improvement than Group L-N (lecture-no reading). In the lower portion of the ability classifications the students without textbooks appear to have been hampered in their learning and those allowed and encouraged to take their books home to read and study have done better (though not significantly so at the .025 level of confidence) than either of the other groups.

Conclusions

On the basis of the techniques of statistical analysis used in this study, and within the limitations imposed by the tests employed and the length of the experimental period used, the following conclusions are drawn:

1. All three methods--L-O (lecture-outside reading), L-I (lecture-reading in class), and L-N (lecture-no reading) --produced significant gains in biological knowledge from pretest to post-test in twelve weeks of instruction.

2. None of the methods produced a mean gain which was sufficiently greater than that of any other method to be considered statistically significant at the .025 level of confidence.

3. All methods produced significant gains among students scoring high on intelligence as measured by the Otis Quick Scoring Mental Ability Test, although no method was found to be superior to the other methods with students of high intelligence.

4. With students who scored low on intelligence, the method utilizing lecture-discussion with no assigned reading failed to produce significant gains in information between pretest and post-test. Students who scored low in intelligence made significant gain in the other methods.

5. All methods produced significant gains in biological knowledge among students scoring high in reading comprehension as measured by the Diagnostic Reading Test. However, no method was found to be significantly superior to any other method with this group.

6. With students scoring low on reading comprehension, both the methods utilizing lecture-discussion with reading outside of class and no reading assignments failed to produce significant gains in information. The method using inside reading produced significant gains.

7. Each method produced significant gains in biological knowledge among students scoring high and those scoring low in reading rate although no method produced gains statistically superior to those produced by another method.

Recommendations

A review of the findings of this study suggests a need for additional investigation as follows:

1. The experimental time allotment might be extended to one full academic year in an effort to determine differences in achievement between groups.

2. The addition of a group for testing and comparison to which reading instruction or aid were given to determine the amount of gain in biological knowledge with this additional help.

3. Future research in this area might well make use of a technique which would give consideration to student attitude as it relates to learning under different teaching methods.

4. Similar studies relating to teaching effectiveness should be carried on in other science areas and in the various academic course areas.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

Committee on Diagnostic Reading Tests. Diagnostic Reading Tests Survey Section, Form A. Chicago: Science Research Associates, 1947.

Curtis, Francis D. Investigations in the Teaching of Science. Philadelphia: P. Blakiston's Son and Co., 1926.

Edwards, Allen Louis. Experimental Design in Psychological Research. New York: Rinehart and Company, Inc., 1950.

Good, Carter V., and Scates, Douglas E. Methods of Research. New York: Appleton-Century-Crofts, Inc., 1954.

Lindquist, Everett F. Design and Analysis of Experiments in Psychology and Education. Boston: Houghton Mifflin Company, 1953.

Nelson, Clarence H. Nelson Biology Test. New York: World Book Company, 1951.

Otis, Arthur S. Otis Quick Scoring Mental Ability Tests. New York: World Book Company, 1937.

Tate, Merle W. Statistics in Education. New York: The Macmillan Company, 1955.

Articles and Periodicals

Anderson, Kenneth E., et al. "Toward a More Effective Use of Sound Motion Pictures in High School Biology," Science Education, XL (February, 1956), pp. 43-54.

Anderson, Kenneth E., et al. "Second Annual Review of Research in Science Teaching," Science Education, XXXVIII (December, 1954), pp. 333-365.

Anibel, Fred G. "Comparative Effectiveness of the Lecture-Demonstration and Individual Laboratory Method," Journal of Educational Research, XIII (May, 1926), pp. 355-365.

Bair, Fredrick H., and Young, William E. "Curriculum: Methods and Materials (Above Grade VI)," Review of Educational Research, XVIII (June, 1948), pp. 265-272.

Baker, Woolford B. "Science Teaching and the World of Tomorrow," Science Education, XXXIV (February, 1950), pp. 7-15.

Balcziak, Louis W. "The Role of the Laboratory and Demonstration in College Physical Science in Achieving the Objectives of General Education" (unpublished doctoral dissertation, University of Minnesota, 1953), quoted in Herbert A. Smith, Chairman, Third Annual Review Committee, "Third Annual Review of Research in Science Teaching," Science Education, XXXIX (December, 1955), pp. 335-371.

Barnard, J. Darrell, Chairman, Committee on Research in Secondary-School Science Teaching. "Problems Related to the Teaching of Problem-Solving That Need to be Investigated," Science Education, XXXIV (April, 1950), pp. 180-184.

Bent, Rudyard K. "Comparative Effectiveness of a Freedom Method and a Conventional Method of Teaching High School General Science," School Science and Mathematics, XXXIII (October, 1933), pp. 773-776.

Bingham, N. Eldred. "A Direct Approach to the Teaching of the Scientific Method," Science Education, XXXIII (April, 1949), pp. 241-249.

Blackwood, Paul E., and Brown, Kenneth E. "Science Education Research--1954," The Science Teacher, XXII (September, 1955), pp. 199-202.

Blackwood, Paul E., and Brown, Kenneth E. "Science Education Research Studies--1945," Science Education, XXXIX (December, 1955), pp. 372-389.

Blick, David J. "Recent Trends in Research on Science Teaching," Education, LXV (March, 1945), pp. 391-398.

Boeck, Clarence H., Chairman, Secondary School Sub-Committee. "Review of Recent Research in the Teaching of Science at the Secondary School Level II," Science Education, XXXIX (December, 1955), pp. 344-356.

Boeck, Clarence H. "The Relative Efficiency of Reading and Demonstration Methods of Instruction in Developing Scientific Understandings," Science Education, XL (March, 1956), pp. 92-97.

Brown, Kenneth E., Blackwood, Paul E., and Johnson, Philip G. "Science Education Research Studies--1953," Science Education, XXXIX (March, 1955), pp. 141-156.

Bullington, Robert A. "Trends in the Teaching of High School Biology," School Science and Mathematics, LVI (February, 1956), pp. 100-108.

Burnett, R. Will. "The New and the Old in Science Teaching," Science Education, XXXV (February, 1951), pp. 43-54.

Cooprider, J. L. "Laboratory Methods in High School Science," School Science and Mathematics, XXIII (June, 1923) pp. 526-530.

Cooprider, J. L. "Oral versus Written Instruction and Demonstration versus Individual Work in High School Science," School Science and Mathematics, XXII (December, 1922), pp. 838-844.

Cunningham, Harry A. "Laboratory Methods in Natural Science Teaching. I," School Science and Mathematics, XXIV (October, 1924), pp. 709-715.

Cunningham, Harry A. "Laboratory Methods in Natural Science Teaching. II," School Science and Mathematics, (November, 1924), pp. 848-851.

Curtis, Francis D. "Some Practical Suggestions for the Teaching of Biology," School Science and Mathematics, LI (February, 1951), pp. 95-104.

Downing, Elliot R. "A Comparison of the Lecture-Demonstration and the Laboratory Methods of Instruction in Science," School Review, XXXIII (November, 1925), pp. 688-697.

Engelhart, Max D. "Classroom Experimentation," Review of Educational Research, IX (December, 1939), pp. 555-562.

Engelhart, Max D. "Physical and Biological Sciences," Review of Educational Research, II (February, 1932), pp. 21-28.

Eurich, Alvin C., Pace, Robert C., and Ziegfield, Edwin. "Evaluative Studies," Review of Educational Research, XII (December, 1942), pp. 521-533.

Fitzpatrick, Frederick L., and Edmiston, Vivian. "Teaching of Science in Senior High School and Junior College," Review of Educational Research, XII (October, 1942), pp. 412-424.

Fox, Truman D. "The Discovery of Better Teaching Technics for General Science," Science Education, XIX (February, 1935), pp. 9-12.

Frazer, Thomas P., Chairman. "Review of Recent Research in the Teaching of Science at the College Level III," Science Education, XXXIX (December, 1955), pp. 357-371.

Hurd, Paul Deh. "The Educational Concepts of Secondary School Science Teachers," School Science and Mathematics, LIX (February, 1954), pp. 89-96.

Jayne, Clarence D. "Study of the Learning and Retention of Materials Presented by Lecture and by Silent Film," Journal of Educational Research, XXXVIII (September, 1944), pp. 47-58.

Jayne, Clarence D. "The Integrated versus the Non-Integrated Use of Moving Pictures in the Classroom," Journal of Experimental Education, V (September, 1936), pp. 7-16.

Johnson, Palmer O. "A Comparison of the Lecture-Demonstration, Group Laboratory Experimentation, and Individual Laboratory Experimentation Methods in Teaching High School Biology," Journal of Educational Research, XVIII (September, 1928), pp. 103-111.

Kiebler, E. W., and Woody, Clifford. "The Individual Laboratory versus the Demonstration Method of Teaching Physics," Journal of Educational Research, VII (January, 1923), pp. 50-58.

Kruglak, Haym. "A Comparison of the Conventional and Demonstration Methods in the Elementary College Physics Laboratory," Journal of Experimental Education, XX (March, 1952), pp. 293-300.

Kyte, George C. "Methods of Teaching," Review of Educational Research, XV (June, 1945), pp. 218-226.

Lev, Joseph. "Research Methods and Designs," Review of Educational Research, XVIII (December, 1948), pp. 410-423.

Lucow, William H. "Estimating Components of Variation in an Experimental Study of Learning," Journal of Experimental Education, XXII (March, 1954), pp. 265-271.

Mallison, George G., and Buck, J. V. "Some Implications and Practical Applications of Recent Research in Science Education: No. 2," School Science and Mathematics, LVI (May, 1956), pp. 357-369.

Mallison, George G., and Buck, J. V. "Survey of Research in Secondary School Science Education," School Science and Mathematics, LV (June, 1955), pp. 439-445.

Mallison, Jacqueline B., Chairman. "Review of Recent Research in the Teaching of Science at the Elementary Level I," Science Education, XXXIX (December, 1955), pp. 336-343.

Mason, John M., and Angell, George W. "An Experiment on Evaluation in Biological Science," Journal of Educational Psychology, XLIV (May, 1953), pp. 296-304.

McGill, James V. "How Valuable is Homework?" High Points, XXXII (September, 1950), pp. 48-53.

McKibben, Margaret J. "An Analysis of Principles and Activities of Importance for General Biology Courses in High Schools," Science Education, XXXIX (April, 1955), pp. 187-196.

Melby, Ernest O., and Lien, Agnes. "A Practicable Technique for Determining the Relative Effectiveness of Different Methods of Teaching," Review of Educational Research, XIX (April, 1949), pp. 255-264.

Melton, Joseph R. "Using Textbooks Wisely," High School Journal, XXXVI (February, 1953), pp. 138-144.

Monroe, Walter S. "Controlled Experimentation as a Means of Evaluating Methods of Teaching," Review of Educational Research, IV (February, 1934), pp. 36-42.

Monroe, Walter S., and Marks, Arlyn. "General Methods of Teaching," Educational Administration and Supervision, XXIV (October, 1938), pp. 497-512.

Morley, H. M. "Discussion of 'Oral versus Written Instruction and Demonstration versus Individual Work in High School Science' (Cooprider)," School Science and Mathematics, XXIII (June, 1923), pp. 522-524.

Nash, Harry B., and Phillips, M. J. W. "A Study of the Relative Value of Three Methods of Teaching High School Chemistry," Journal of Educational Research, XV (May, 1927), pp. 371-379.

Noll, Victor H. "Measuring the Scientific Attitude," Journal of Abnormal and Social Psychology, XXX (July-September, 1935), pp. 145-154.

Owens, J. Harold. "The Ability to Recognize and Apply Scientific Principles in New Situations," Science Education, XXXV (October, 1951), pp. 207-213.

Perlman, James S. "An Historical versus Contemporary Problem Solving Use of the College Physical Science Laboratory Period for General Education," Journal of Experimental Education, XXXI (March, 1953), pp. 251-257.

Peters, Charles C., Townsend, Agatha, and Traxler, Arthur E. "Research Methods and Designs," Review of Educational Research, XV (December, 1945), pp. 377-393.

Powers, Samuel R. "Science," Review of Educational Research, IV (December, 1934), pp. 473-478.

Powers, Samuel R. "Science," Review of Educational Research, VIII (February, 1938), pp. 60-66.

Powers, Samuel R. "Science Education," Review of Educational Research, I (December, 1931), pp. 379-386.

Powers, Samuel R., and Blick, David J. "Teaching of Science in Senior High School and Junior College," Review of Educational Research, XV (October, 1945), pp. 301-309.

Reiner, William B. "Evaluating Ability to Recognize Degrees of Cause and Effect Relationships," Science Education, XXXIII (December, 1949), pp. 329-333.

Reiner, William B. "Evaluating Ability to Recognize Degrees of Cause and Effect Relationships," Science Education, XXXIV (February, 1950), pp. 15-28.

Richardson, John S., and Barnard, J. Darrell. "Methods and Materials in the Teaching of Science," Review of Educational Research, XVIII (October, 1948), pp. 323-336.

Rulon, Phillip J., et al. "A Comparison of Phonographic Recordings with Printed Material in Terms of Knowledge Gained through Their Use Alone," Harvard Educational Review, XIII (January, 1943), pp. 63-76.

Rulon, Phillip J., et al. "A Comparison of Phonographic Recordings with Printed Material in Terms of Knowledge Gained through Their Use in a Teaching Unit," Harvard Educational Review, XIII (March, 1943), pp. 163-175.

Rulon, Phillip J., et al. "A Comparison of Phonographic Recordings with Printed Material in Terms of Motivation to Further Study," Harvard Educational Review, XIII (May, 1943), pp. 246-255.

Schiller, Belle. "A Questionnaire Study of Junior High School Students' Reaction to Homework," High Points, XXXVI (June, 1954), pp. 23-36.

Schneider, Samuel. "An Experiment on the Value of Homework," High Points, XXXV (April, 1953), pp. 18-19.

Shores, J. Harlan, and Saupe, J. L. "Reading for Problem Solving in Science," Journal of Educational Psychology, XLIV (March, 1953), pp. 149-158.

Smith, Herbert A. "A Determination of the Relative Effectiveness of Sound Motion Pictures and Equivalent Teacher Demonstration in Ninth Grade General Science," Science Education, XXXIII (April, 1949), pp. 214-221.

St. Laurence, Francis. "Are Heavy Textbooks Necessary," Science Teacher, XVIII (March, 1951), pp. 72-73.

Sutton, Traver C. "Laboratory Work Is Essential," School Science and Mathematics, XLIX (May, 1949), pp. 351-358.

Ter Keurst, Arthur J., and Bugbee, Robert E. "A Test on the Scientific Method," Journal of Educational Research, XXXVI (March, 1943), pp. 489-501.

Weaver, Richard L. "Improvement of Biology Teaching," School Science and Mathematics, LVI (April, 1956), pp. 257-263.

Wiley, William H. "An Experimental Study of Methods in Teaching High School Chemistry," Journal of Educational Psychology, IX (April, 1918), pp. 181-198.

Wise, Harold E. "Supplementary Contributions of Sound Motion Pictures in High School Biology," Science Education, XXXIII (April, 1949), pp. 206-213.

Woolever, John D. "Is Homework One Answer?" School Science and Mathematics, LV (December, 1955), pp. 704-706.

APPENDIX

OTIS I.Q. SCORES OF 161 BIOLOGY STUDENTS CLASSIFIED ACCORDING TO TEACHING METHOD

Method	L-O		L-I		L-N	
	I.Q.		I.Q.		I.Q.	
	112	129	112	114	105	102
	100	96	98	106	102	112
	115	93	93	95	97	124
	105	104	127	95	97	80
	102	110	100	120	106	109
	121	108	123	123	85	88
	130	114	112	88	95	102
	110	88	99	114	124	107
	85	91	101	101	102	88
	96	108	84	104	112	112
	83	110	85	91	97	94
	99	113	104	112	104	100
	110	89	123	99	113	103
	89	112	111	110	104	112
	120	99	105	98	104	119
	98	103	84	97	114	114
	120	124	94	99	111	113
	101	108	108	112	100	101
	125	117	96	98	114	112
	114	93	111	110	124	101
	108	78	78	109	103	118
	82	104	133	106	117	97
	118	78	80	127	103	101
	112	121	76	121	89	114
	118	98	107	113	95	
	106		91	92	117	
	103		87	85	77	
	85		101	126	104	
Mean	104.81		103.36		104.58	
S.D.	13.00		13.40		10.61	
Grand Mean			104.17			
S.D.			12.45			

READING COMPREHENSION RAW SCORES OF 161 BIOLOGY STUDENTS CLASSIFIED ACCORDING TO TEACHING METHOD

Method	L-O		L-I		L-N	
	R.C.		R.C.		R.C.	
	79	86	76	67	78	62
	58	49	44	70	54	71
	81	54	45	53	25	83
	65	64	90	51	61	21
	71	84	67	74	75	76
	78	58	71	80	43	43
	87	79	77	39	50	75
	39	42	72	82	94	64
	16	46	70	71	57	37
	59	75	53	65	60	86
	39	71	62	43	31	57
	21	70	76.	70	59	51
	52	51	75	51	87	70
	37	72	80	52	83	67
	79	45	65	62	61	79
	61	72	33	38	75	79
	94	77	39	48	76	62
	48	67	50	63	80	42
	83	79	57	55	95	80
	75	60	72	58	89	63
	69	32	28	62	67	79
	41	56	78	31	84	61
	73	24	34	76	57	60
	78	64	30	84	44	73
	69	71	80	69	47	
	60		39	58	77	
	51		45	69	14	
	38		65	89	47	
Mean	61.30		60.77		63.67	
S.D.	17.96		16.11		18.47	
Grand Mean			61.88			
S.D.			17.56			

READING RATE RAW SCORES OF 161 BIOLOGY STUDENTS CLASSIFIED ACCORDING TO TEACHING METHOD

Method	L-O		I-I		L-N	
	R.R.		R.R.		R.R.	
	47	121	58	60	62	50
	42	49	52	60	58	75
	124	36	72	44	26	83
	53	58	70	60	45	30
	67	83	67	69	61	67
	61	49	89	62	65	68
	87	82	52	43	70	62
	39	47	68	66	63	44
	47	37	47	61	62	50
	47	82	50	50	53	75
	52	59	62	58	43	66
	57	70	65	60	52	50
	69	50	71	43	55	60
	41	64	60	52	73	68
	81	48	55	49	55	60
	61	51	38	37	61	81
	110	73	49	50	52	56
	52	63	45	59	85	45
	83	77	53	42	81	72
	56	52	48	69	75	49
	53	29	48	70	58	66
	48	63	70	59	56	79
	77	20	44	64	59	50
	63	47	28	73	48	58
	76	45	63	51	36	
	73		36	60	64	
	43		49	55	45	
	59		66	55	46	
Mean	60.81		56.36		59.10	
S.D.	22.32		11.19		12.96	
Grand Mean			58.71			
S.D.			15.45			

NELSON BIOLOGY PRETEST STANDARD SCORES OF 161 STUDENTS CLASSIFIED ACCORDING TO TEACHING METHOD

Method	L-O		L-I		L-N	
	105	114	98	95	96	92
	105	95	90	89	86	105
	125	98	71	96	84	108
	118	92	115	78	96	73
	92	108	97	112	108	93
	116	89	118	98	87	95
	116	124	109	84	89	106
	87	71	96	113	106	105
	75	90	96	106	101	80
	97	101	80	78	103	98
	95	112	100	114	73	77
	93	111	111	96	100	96
	108	65	118	98	121	112
	82	120	98	77	113	109
	129	89	111	96	101	111
	113	115	77	71	103	92
	142	106	89	100	108	80
	90	93	82	109	118	89
	124	92	84	97	119	120
	106	111	103	96	130	100
	110	89	93	97	105	120
	90	77	113	93	112	86
	98	80	75	130	89	89
	120	120	92	118	86	115
	109	98	101	95	100	
	98		80	87	87	
	84		87	97	61	
	93		82	124	92	
Mean	101.51		96.61		98.56	
S.D.	15.75		14.32		14.04	
Grand Mean			98.85			
S.D.			14.86			

NELSON BIOLOGY POST-TEST STANDARD SCORES OF 161 STUDENTS CLASSIFIED ACCORDING TO TEACHING METHOD

Method	L-O		L-I		L-N	
	123	129	101	113	128	109
	112	89	87	108	93	112
	128	108	95	84	80	121
	112	95	124	92	108	90
	101	118	108	109	110	109
	116	109	128	109	82	104
	141	125	124	78	106	104
	103	93	110	127	120	121
	90	87	105	105	104	71
	112	104	101	108	110	113
	87	118	103	113	73	89
	95	127	116	112	105	106
	109	100	115	97	135	121
	104	124	119	103	129	122
	133	112	113	113	113	114
	122	111	80	90	110	104
	134	121	92	95	119	109
	96	96	101	113	114	89
	129	104	98	110	133	120
	108	118	119	104	142	109
	118	78	98	108	116	121
	110	95	131	116	119	97
	113	77	80	128	89	98
	129	134	92	123	89	128
	110	118	123	120	98	
	109		86	98	118	
	87		95	113	82	
	92		97	133	111	
Mean	109.68		106.48		108.02	
S.D.	15.52		13.51		11.27	
Grand Mean			108.03			
S.D.			13.62			

BIOLOGY PRETEST AND POST-TEST SCORES OF 161 BIOLOGY STUDENTS CLASSIFIED ACCORDING TO TEACHING METHOD

Method L-C				L-I				L-N			
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
105	123	114	129	98	101	95	113	96	128	92	109
105	112	95	89	90	87	89	108	86	93	105	112
125	128	98	108	71	95	96	84	84	80	108	121
118	112	92	95	115	124	78	92	96	108	73	90
92	101	108	118	97	108	112	109	108	110	93	109
116	116	89	109	118	128	98	109	87	82	95	104
116	141	124	125	109	124	84	78	89	106	106	104
87	103	71	93	96	110	113	127	106	120	105	121
75	90	90	87	96	105	106	105	101	104	80	71
97	112	101	104	80	101	78	108	103	110	98	113
95	87	112	118	100	103	114	113	73	73	77	89
93	95	111	127	111	116	96	112	100	105	96	106
108	109	65	100	118	115	98	97	121	135	112	121
82	104	120	124	98	119	77	103	113	129	109	122
129	133	89	112	111	113	96	113	101	113	111	114
113	122	115	111	77	80	71	90	103	110	92	104
142	134	106	121	89	92	100	95	108	119	80	109
90	96	93	96	82	101	109	113	118	114	89	89
124	129	92	104	84	98	97	110	119	133	120	120
106	108	111	118	103	119	96	104	130	142	100	109
110	118	89	78	93	98	97	108	105	116	120	121
90	110	77	95	113	131	93	116	112	119	86	97
98	113	80	77	75	80	130	128	89	89	89	98
120	129	120	134	92	92	118	123	86	89	115	128
109	110	98	118	101	123	95	120	100	98		
98	109			80	86	87	98	87	118		
84	87			87	95	97	113	61	82		
93	92			82	97	124	133	92	111		
Pretest Mean		104.81				103.36				104.58	
S.D.		13.00				13.40				10.61	
Grand Mean				104.17		S.D.		12.45			
Post-test Mean		109.68				106.48				108.02	
S.D.		15.52				13.51				11.27	
Grand Mean				108.03		S.D.		13.62			

X = Pretest Y = Post-test