12-1975

The Effectiveness of an Audio-Tutorial Program in High School Biology

John W. Goudie

THE EFFECTIVENESS OF AN AUDIO-TUTORIAL PROGRAM IN HIGH SCHOOL BIOLOGY

by

John Wm. Goudie

A Project Report
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Specialist in Arts Degree

Western Michigan University
Kalamazoo, Michigan
December 1975

ACKNOWLEDGMENTS

This investigator wishes to express his sincere appreciation to his project committee, Dr. Imy Holt, Dr. Paul Holkeboer and Dr. Wm. VanDeventer, and many other persons who made the production of this paper possible.

The financial support of this project was provided in large part by the Portage Public School System and by Western Michigan University for use of audio-visual materials.

Special mention is due to Robert Bale and other members of the Library and Audio-visual Staff and the Buildings Construction class at Portage Northern High School for their help in the physical set-up of the audio-tutorial program.

John Wm. Goudie

GOUDIE, John Wm.
THE EFFECTIVENESS OF AN AUDIO-TUTORIAL PROGRAM IN HIGH SCHOOL BIOLOGY.

Western Michigan University, Sp.A., 1975
Education, sciences

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The public school systems in this country, with the help of federal funds, have greatly improved their biology curricula. High school teachers, supervisors, and administrators are still concerned with the problem of modifying content, but are also probing new methods of teaching and approaches to meet the needs and interests of a larger number of those people who are not preparing for college, or those who are non-science majors.

The updating of high school teaching, the population explosion, the knowledge explosion and an increasing public awareness of the importance of education for a successful career have intensified problems in mass education. Since students represent different and varied backgrounds, interests and most important of all, capabiiities, a major problem has arisen in developing learning situations with enough flexibility to make adjustments for each student's needs.

There has been widespread introduction of new elective courses and new approaches to learning which show serious attempts by the teacher to adapt subject matter and methodology to individual needs and interests. In 1961, S.N. Postlewait introduced a system of audio-tutorial (A-T)[1] instruction. This method has had widespread use in science teaching and has been found to be one solution for presenting a flexible program. Basically, the program involves the student

---

[1]Audio-tutorial is the trademark of Burgess Publishing Company. The abbreviation A-T will be used hereon.

entering a booth which is equipped with a tape recorder and other materials appropriate for the subject matter unit. The student reviews a list of behavioral objectives for each unit and the taped voice of the instructor tutors the student through the sequence of learning activities. These activities involve reading related articles, viewing filmstrips and films, experimentation, and looking at visual displays. Other students and the instructor are present to help.

This study was made to determine the effectiveness of an A-T system at the high school level and to justify the financial and professional support of the Portage Public Schools in allowing a new type of instructional method to be tried. The A-T system was designed at Portage Northern High for those students taking General Biology, with the hope of improving their attitudes toward science in general as well as their understanding of basic biological principles. For most of these students, General Biology will be the last course in science taken at the high school level.

HISTORICAL ASPECTS

S. N. Postlewait developed the A-T system in 1961 to assist Purdue University students who had poor backgrounds in botany. Since its inception as an instructional approach, numerous investigations have been made to evaluate its effectiveness, mostly at the college level. Several evaluations have been made of the A-T biology program at Western Michigan University in the Biological Science course 107. This program, initiated at Western Michigan University in the fall of 1966, was offered as one of their science electives in the General Studies program for the non-science students. This course was patterned after the system developed by Dr. S. N. Postlewait.

Biology 107 attempts to quantitate scientific experimental results into a broadened picture of biological principles by integrating the various aspects of botany and zoology in terms of physiology, embryology, genetics, ecology and evolution. The emphasis within the course consists of what the scientist is discovering and how he is discovering.

The A-T instructional method was first discussed at Western Michigan University in 1962 and a study was undertaken to determine the feasibility of initiating this type of instructional method for Biological Science 107. After two years of preparation and planning, the A-T program in Biological Science 107 at Western Michigan University began in the fall of 1966 with an enrollment of over 900 and a staff composed of three senior staff members and four graduate laboratory instructors.

The A-T laboratory was equipped with 36 stations or booths, each containing a tape recorder with headphones, a microscope and any additional items pertinent to a particular unit. The room also contained four demonstration areas complete with table and counter space which were utilized for in-progress experiments, demonstrations, organized graphic displays, special readings and do-it-yourself showing of filmstrips and filmloops. A graduate assistant was on duty at all times for assistance. Each student was assigned a textbook for supplementary information.

The laboratory experience in this course was organized into 13 units of study, all constructed to emphasize basic principles. The students scheduled themselves in and out of the A-T laboratory when it was convenient for them and they were allowed as much time as necessary to complete the unit. The basic units of study were:

The Microscope
Inheritance
The Cell
Growth and Development
Transport Mechanisms
What is Ecology
Energy and Matter
The Community and Succession
Molecular, Cellular, and Organismic Reproduction
Biomes
The Fossil Story
Skeletal Homologies and Adaptations
Man through the Ages

Research studies on Biology 107 have indicated that the A-T method has produced levels of achievement equal to or better than the traditional methods of instruction. The following is a brief synopsis of the research studies performed on Biological Science 107 and other

studies on both the traditional instructional method and A-T instruction performed at other universities and high schools.

In 1967, F. Geoghegan performed the first analysis of the course by testing the hypothesis as to "whether student attainment levels were increased by the use of an audio-tutorial system" and if any correlation existed between the amounts of time an individual expended in the laboratory and his achievement level. His results indicated that more students acquired a greater understanding of the subject matter with the A-T program than with the previous system which consisted of lectures. He was also able to show that the amount of time spent in the laboratory in effective study was reflected in grade achievement.

W. Wissinger (1967) performed an evaluation of the A-T program in Biological Science 107 to determine the reliability of the four unit examinations used to measure student achievement levels. The results of this study indicated that the tests were too difficult for the grading scales used. A high correlation was found between time spent in the laboratory and final grades. In 1968 Wissinger performed a second study and concluded that the A-T program as it was presented in Biological Science 107 represented a valid and effective "teaching system". In this study he analyzed those factors which might influence student achievement, such as, the verbal and mathematical ability levels of students based on freshman scores on college entrance exams. He concluded that verbal ability was more influential than mathematical ability but that both abilities proved to be positive factors when correlated with the amount of time the student chose to spend in the

laboratory. Wissinger concluded that the A-T system had been successful in improving student achievement.

In 1968, Aldrich measured student attitudes, their high school backgrounds, and behavioral changes in the individual taking Biological Science 107. Her results supported the hypothesis that the students learned to adapt independent study habits as a result of the A-T form of instruction.

In 1971, D. Hackett, as a part of a continuing evaluation research project on Biological Science 107, developed a questionnaire to ascertain student attitudes toward the A-T Biological Science 107 program at Western Michigan University, reasons for entering the course, high school background of the students and their evaluation of the audio-tutorial system as an effective, educational self-discipline. Hackett concluded, as did Geoghegan, Wissinger and Aldrich, that those students who had not benefited in positive behavior modifications from the A-T system were those students at the extremes of the grade attainment scale. Hackett also concluded that the amount of effort put forth by the student in the laboratory-centered experience had steadily increased and that this increase in effort on the part of the student showed that the A-T program had been greatly improved over its initial form and now is demanding a comparable quality of student behavior in return. Of particular interest in Hackett's study is the difference indicated concerning student evaluation of the A-T program of instruction. The 1966 analysis showed a 72 percent approval by the students, whereas Hackett's study showed only a 62 percent approval. Her study pointed out that the degree of difficulty in the laboratory increased

following 1966, requiring additional time and effort on the part of the student. In both studies the percentage of approval of the A-T instructional method is an important indication of the success of the method of instruction.

The last and most important study to this investigator was a study made by VanderWal in 1972. He investigated and compared the effects of two methods of presenting biological information to students classified as non-science majors. In addition, he looked at the students' levels of achievement and attitude changes that could be attributed to the teaching methods employed. The population of students involved in this study consisted of Grand Rapids Junior College students enrolled in Biology 101 and all students in Biological Science 107 at Western Michigan University. Both courses were similar in content and both were designed to meet the liberal arts science requirements and therefore, the investigator was justified in making comparisons. The results of this study indicated that the A-T method produced levels of achievement equal to or better than the traditional or conventional method of instruction.

At Syracuse University in 1971 Hoffman and Druger performed a study on two different types of A-T instructional methods in biology. One group of students (the direct group) received A-T lessons that involved passive note taking and very little investigation. This group received no self-evaluation and student-teacher interaction was at a minimum. A second group (the indirect group) was given A-T lessons with an investigatory approach to the tape lecture. Students in this group answered questions and formed conclusions, and student-

teacher interaction was much greater than in the direct group. The results of this study indicated that both the direct and the indirect A-T strategies were equally effective for teaching facts, concepts and principles. Both strategies resulted in significant changes in students' attitudes in favor of A-T instruction. Of prime importance to this investigator was the fact that there was a significant difference between the two strategies with regard to problem-solving ability. The results of the study suggested that the indirect teaching strategy might be more effective than the direct for developing problem-solving abilities.

One of the major objectives in teaching science is to provide the students with an opportunity to use methods of science and to apply these methods to solving problems that are significant and interesting to the individual. In secondary school science programs, biology is generally the vehicle by which students become aware of the scientific approach and problem-solving. The methods and materials used are functional and relative to the needs, capabilities and interests of the heterogenous group of general high school biology students.

The usual approach to teaching high school biology has been by means of traditional teaching strategies. A study of the efficiency of three traditional methods of teaching high school biology in 1965 by M. Oliver has shed some light on these approaches to high school biology. Oliver compared the following three methods: (1) lecture-discussion, (2) lecture-discussion and demonstrations, and (3) lecture-discussion and demonstrations in combination with laboratory exercises. Oliver used the Cooperative Science Test: Form Y to measure overall

achievement in biology. The t-test of significance was used in each analysis. No significant differences in achievement were found among the three teaching methods. Oliver pointed out that method number three probably provided students with a greater development of skills in problem-solving.

In one study by Smiley, Bush and McGaw (1972), an A-T program in high school was set up at Purdue University. Students from the area were allowed to use Postlewait's materials and facilities. The Nelson Biology tests were used to compare achievement with national norms. Achievement pre-test data indicated a mean at the 19th percentile. The post-test mean was at the 64th percentile which showed a significant change in student achievement. Problem-solving ability was not measured.

PORTAGE NORTHERN HIGH SCHOOL

The usual approach to teaching high school biology to non-science majors at Portage Northern High School was to expose them to a "watered-down" version of the college preparatory biology course. Non-science majors are those students who usually take General Biology simply to meet their high school science requirement. The fact that the non-science students' needs as well as interests were different from those of the college preparatory student was ignored by teachers and program planners. In the past several years few biology curricula have been developed to meet the needs of these non-science majors. The general biology program had become a lecture course, which was not oriented to the average student who was not language oriented and who not only suffered from reading inability but also had a shorter attention span and, as a result of one or more of the above, might become a serious discipline problem in this highly structured kind of classroom routine.

Among these non-science majors taking biology were a variety of sub-groups. One of these groups included students often referred to as "slow learners", who learn at a less rapid rate and who generally are consistently below grade level in academic progress. Another type of sub-group was comprised of those students with average or above average abilities not only in biology but also in school subjects in general and could be classified as "bright" underachievers. It was assumed that such a heterogenous group would benefit the most from the flexibility of an A-T program.

Since most A-T programs in biology have been investigated at the college level and numerous non-formal reports of success at the high school level were appearing, it was the intent of this investigator to formally evaluate the effectiveness of a high school A-T program for non-science majors. This research study utilized the traditional teaching strategy-lecture-discussion and demonstration in combination with laboratory investigations, as described by M. Oliver, as a control and compared it to the indirect A-T strategy of Hoffman and Druger which uses A-T lessons with an investigatory approach.

RESEARCH DESIGN

This investigator approached Mr. Freeman Russell, Secondary Curricula Director of the Portage Public Schools, with a request for money to initiate the above described study. The proposal was received favorably and money was given to construct study carrels much like those used in the A-T program at Western Michigan University. The actual construction of the carrels was done by the Home Building Class at Portage Northern High School. Metal boxes were made from sheet metal and mounted on the back of the study carrels to hold the cassette tape playback units. Holes were cut in the back of each carrel to expose the play, rewind and fast-forward buttons. Other equipment purchased included one slide projector, two filmstrip viewers, cassette tapes, reel to reel recording tape and a filmloop projector. Earphones were obtained from the language laboratory which no longer used them. These were placed in each carrel and connected to the cassette playback units. Sixteen carrels were placed around the perimeter of a regular biology laboratory at Portage Northern High. The bulletin boards were designated with letters to correspond to references made on the taped lecture and contained visual materials for the current unit under study. The visual materials were from teacher files or from the school library. The slide projector, filmstrip viewers and film projector were placed on tables in the laboratory for students to use.

A pamphlet was developed for each subject matter unit similar to those developed for the A-T program at Western Michigan University (Appendix D). Each pamphlet contained performance objectives, fill-in the blank questions which corresponded to the taped lecture, diagrams which were discussed on the tape, laboratory investigations, descriptions and/or questions about the films, filmstrips. In addition the pamphlets contained articles to be read, demonstrations and other audio-visual materials. All of the information was presented to allow the student to choose those materials which would best help him learn the performance objectives for that particular subject matter unit.

This investigator recorded on reel to reel tape a taped lecture for each lecture and then made sixteen copies on cassette tapes. A student could listen to the taped lecture as many times as he or she wished in that week and a half assigned for each unit. A copy was also available for use in the library.

The control group selected for the traditional approach received the same performance objectives, audio-visual materials, laboratory investigations, articles to read, but received them as a group under direct teacher supervision. This group did not use the study carrels. At the end of each subject matter unit the same multiple choice test was given to this group as the A-T group.

The data collected and used in this investigation were the results from the following instruments:

a) Cooperative Science Test, Form B Biology

b) Silance and Remers - Attitude Scale to Subject Matter

c) Finch - Attitude Scale Toward Type of Instructional Method

The number of items, mode of response, and scoring for each instrument can be found in Appendix A.

Arithmetic means for each of the two groups were computed on all instruments administered. T-tests were performed on both pre-tests and post-tests within and between groups. A Pearson Product Moment Correlation Coefficient was run between attitude toward the subject matter and achievement. The results of all statistical tests were analyzed to determine if the A-T method was a more effective instructional method for general biology at the high school level as compared to the traditional approach.

The population which participated in this study was a heterogeneous group of sophomores, juniors, and seniors enrolled in the regular biology classes[1]. The enrollment into this biology class is based on the counseling department and the course description which specifies that this class is designated for non-science majors interested in a general biological background and who wish to fulfill their high school requirements. This population displayed characteristics differing from those who major in science.

Two general biology classes were chosen for this study, one consisting of 22 subjects and the other, 29 subjects. Since the enrollment was based on the counseling department, this investigator had no control over the selection. The sex ratio and the number of subjects in each class were not controlled in this study due to scheduling

[1]Biology classes offered at Portage Northern High School, Portage, Michigan.

conflicts. Students in this population did not have prior knowledge that the study was to be conducted.

RESULTS

Since Portage Public Schools do not have Intelligence Quotient (I.Q.) scores for its students, the investigator decided to compare the control and experimental groups based upon the students' cumulative grade point average (G.P.A.) prior to entering the class. The control group of 22 students had a cumulative G.P.A. average of 1.94; the experimental group, a cumulative G.P.A. of 1.96. A simple t-test of significance showed a t-value of 0.034. On a t-distribution this indicated no significant difference.

As a result of rigid class schedules and student scheduling conflicts, sex ratios could not be controlled. The number of students per class also could not be controlled for similar reasons.

Prior to orientation of students to the course and the methods used, the _Cooperative Science Test_, Form B Biology and the Silance and Remers Attitudinal Instrument Toward Subject Matter were given as pre-tests of achievement and attitude toward biology, respectively.

The control group had an arithmetic mean of 25.2 on the achievement test while the experimental group had an arithmetic mean of 24.31. A score of 60 was possible on the achievement test. The t-test of significance was 0.0927 which indicated no significant difference between the two groups. Students in both groups scored considerably lower than the national average on this achievement test (Table I). The t-test supported the hypothesis that both groups were similar and therefore acceptable for this study.

Following an orientation period with each of the groups, the control group began a semester of biology of the traditional type, while the experimental group began with the audio-tutorial system.

The audio-tutorial group received a handout consisting of performance objectives (Appendix B) at the beginning of each unit. They also received diagrams and questions for each unit tape, laboratory experiments and a checklist of materials available for study. All materials were integrated for each weekly unit of work.

The control group received similar handout materials and laboratory exercises. They also observed filmstrips and films.

The following general subject areas were studied during the first semester of study:

a) Metric System and Introduction to Laboratory Procedure
b) Microscopy
c) Ecology
d) Cell Structure and Physiology
e) Human Genetics
f) Populations

Following the first semester the Cooperative Science Test Form B was again given as a post-test of achievement and the Silance and Remers attitudinal instrument measuring students' attitude toward the subject matter. Each student also took Finch's attitudinal test to assess the type of instruction. The results indicated a significant difference between the control and experimental group, with the experimental group scoring higher on both the achievement and attitudinal instruments (Table I). The t-tests between pre and post-test and instruments indicated that the attitude of the experimental group toward the A-T method was significantly higher than the control group's attitude toward the traditional instructional approach.

Tests of significance using t-tests were computed between the pre- and post-test means within the control and experimental groups. No significant differences were found between the pre- and post-achievement means in the control group. On the other hand, a significant difference between pre- and post-achievement means was indicated at the 0.05 percent level of significance by the experimental group.

Similar results were also found in the results of the attitudinal instrument toward the subject matter. No significant difference was found between pre- and post-means for the control but a significant increase was found in the experimental group at the 0.05 percent level of significance (Table I).

The final statistical measure taken in this investigation was a Pearson Product Moment Correlation Coefficient between Finch's instrument to assess attitude toward the type of instructional method and the <u>Cooperative Science</u> achievement test. The results indicated a higher correlation in the experimental group than in the control group. The correlation for the experimental group was 0.94 whereas the correlation within the control group was 0.61.

The results strongly indicate that the A-T system used in biology is a positive method of instruction for the high school Biology students used in this study.

TABLE I

A SUMMARY OF STATISTICAL DATA

Subject	Control	Experimental	Value of t-test	Level of Significance on t-test	Pearson Product Moment Correlation Coefficent
Cumulative Grade Point Average	$\bar{x}$ = 1.94	$\bar{x}$ = 1.96	0.034	No Significant Difference	——
Cooperative Science Test Pre-Achievement Test	$\bar{x}$ = 25.20	$\bar{x}$ = 24.31	0.0927	No Significant Difference	——
Post-Achievement Test	$\bar{x}$ = 27.54	$\bar{x}$ = 30.7	1.56	0.1	——
Silance and Remers Attitude Instrumental Toward Subject Matter Pre-	$\bar{x}$ = 6.84	$\bar{x}$ = 7.10	0.6	.4 No Significant Difference	——
Post-	$\bar{x}$ = 6.81	$\bar{x}$ = 7.65	1.68	0.5 Acceptable Significant Difference	——
Finch-Attitude Instrument Toward Type of Instrumental Method (Post Test After 1st Semester)	$\bar{x}$ = 98.18	$\bar{x}$ = 115.79	2.35	.025 Significant Difference	——
Pearson Product Moment Correlation Coefficent (Between Attitude Toward Instructional Method and Achievement)	Attitude $\bar{x}$ = 98.18 Achievement $\bar{x}$ = 27.54	Attitude $\bar{x}$ = 115.79 Achievement $\bar{x}$ = 30.7	— —	-- —	Control r = .61 Experimental r = 194
Finch-Attitude Instrumental Toward Type of Instructional Method (Post Test After 2nd Semester)	* $\bar{x}$ = 112.2	** $\bar{x}$ = 80.79	4.1	0.001 Significant Difference	——

* This group was the control group 1st semester, having had traditional approach, then switching 2nd semester to A-T approach.

** This group was the experimental group 1st semester, having had the A-T approach, then switching 2nd to traditional approach.

DISCUSSION

The results of this study appear to disagree with one conclusion reached by Champagne (1972) who indicated that the A-T and programmed learning methods were too complex for the slower students. The results in this study concerning the attitudes toward the subject matter alone show that students are motivated by the system and their post-achievement scores bear this out on a quantitative fashion.

Almost all the students in both the control and experimental groups showed improvement in their achievement scores (Figures 1 and 2). T-tests between pre and post-achievement scores shows that there was a difference between pre- and post-achievement in both groups (Appendix C). The control group showed a slight difference at the 0.25 level of significance and the experimental group, a significant difference at the 0.001 level.

On the other hand, Champagne's conclusions may be correct if one assumed that those students with the lower achievement scores are slow students. Both Figures 1 and 2 indicate little or no change and occasionally a lower score for the slower student.

Both the control and experimental groups are considered to be heterogenous. Figure 1 shows a greater increase in achievement for the middle and upper scores for those subjects using the A-T method.

Using a five point scale from strongly agree to strongly disagree in measuring attitude toward the type of instruction, students using the A-T system responded more positively toward the type of instruction

than did those students in the traditional type of instruction class. Figure 3 shows the comparison of attitudes toward the respective types of instruction. This instructor feels strongly that these attitudes create a friendlier atmosphere with fewer behavior problems than in the traditional setting.

Finally, Figures 4 and 5 show the correlation between the students' achievement and attitudes toward the type of instruction. There is a good correlation between attitudes and achievement. Correlation of attitudes and achievement in the A-T approach was 0.94 as compared to 0.61 in the traditional approach. These figures reveal, if all variables are controlled, that the attitude reflected by students in the A-T situation had a great deal to do with the increasing achievement. Figures 4 and 5 both point out that there was little difference in correlation between attitudes and achievement at the extremes. This seems to both confirm and conflict with Sister Champagne's conclusions. Those students at the lower achievement levels in both types of instructional methods, if considered slow learners, showed little increases.

The data from all tests administered strongly indicate that the A-T system is a valid method of instruction at the high school level. However, this type of instructional method may not be a total answer for all high school biology courses.

This investigator strongly feels that teacher personalities, student composition, and cooperation with administrators and counselors certainly will have some bearing on the success of an A-T system.

Secondly, A-T systems are only one tool, not a wholesale solution to teaching biology in high school.

Since this study was completed, Portage Central High has begun an A-T system, but results of their program are not yet known.

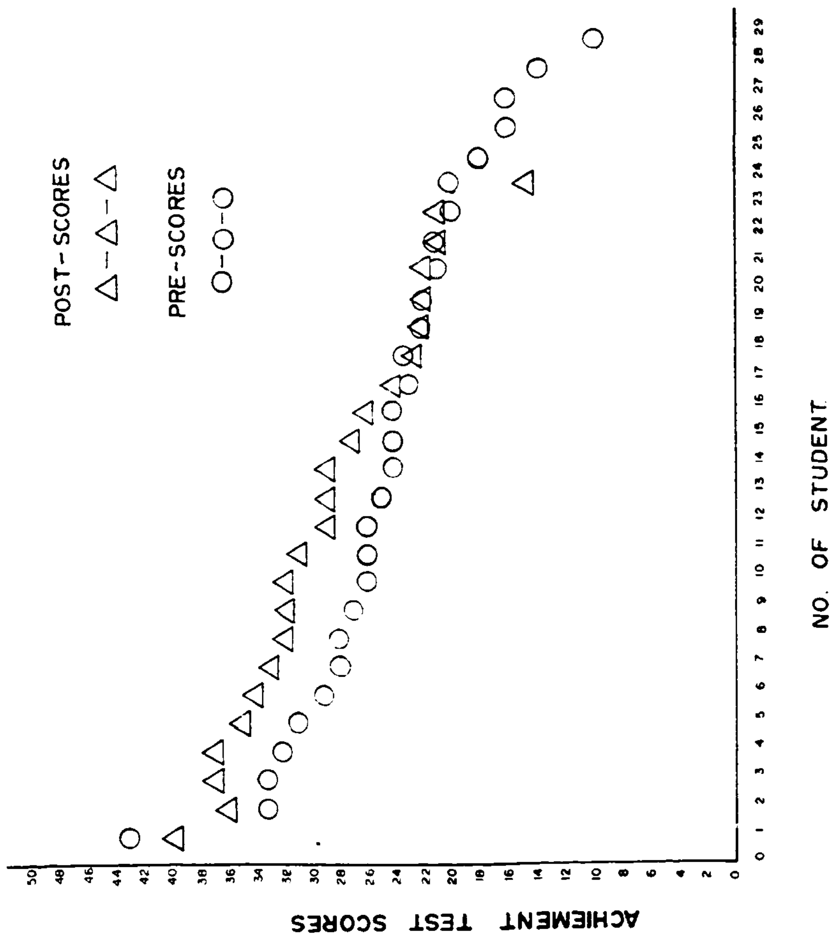


FIGURE I ACHIEVMENT TEST SCORES FOR THE EXPERIMENTAL GROUP

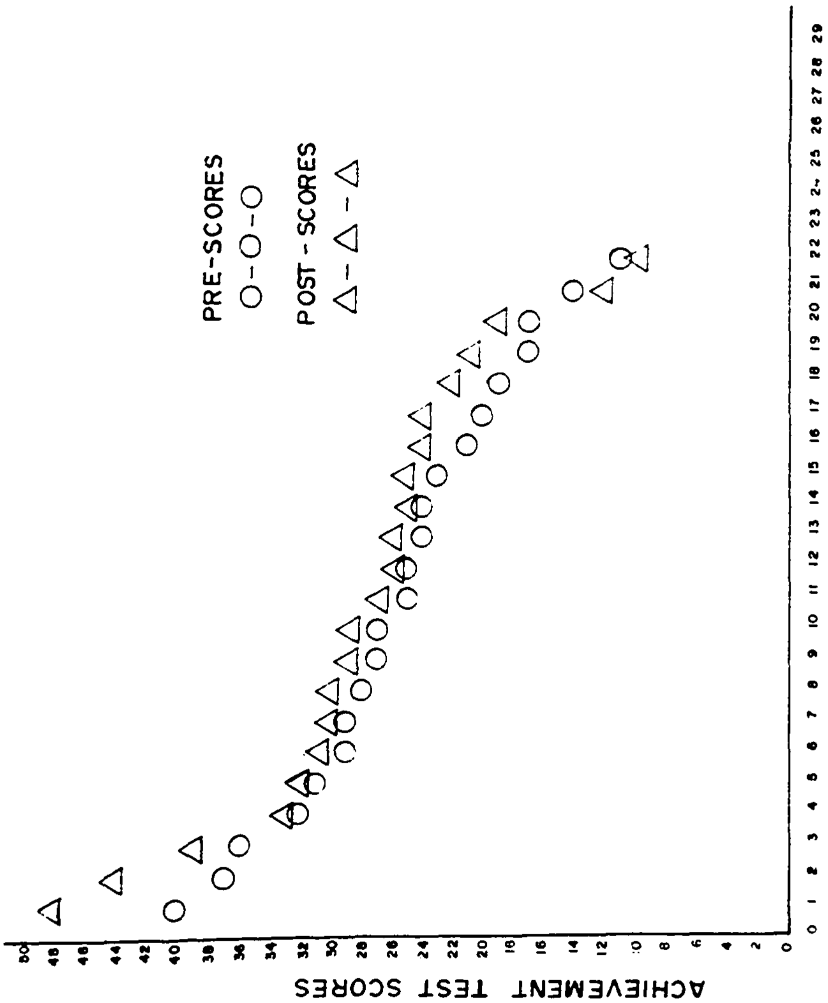


FIGURE 2. ACHIEVEMENT TEST SCORES FOR CONTROL GROUP

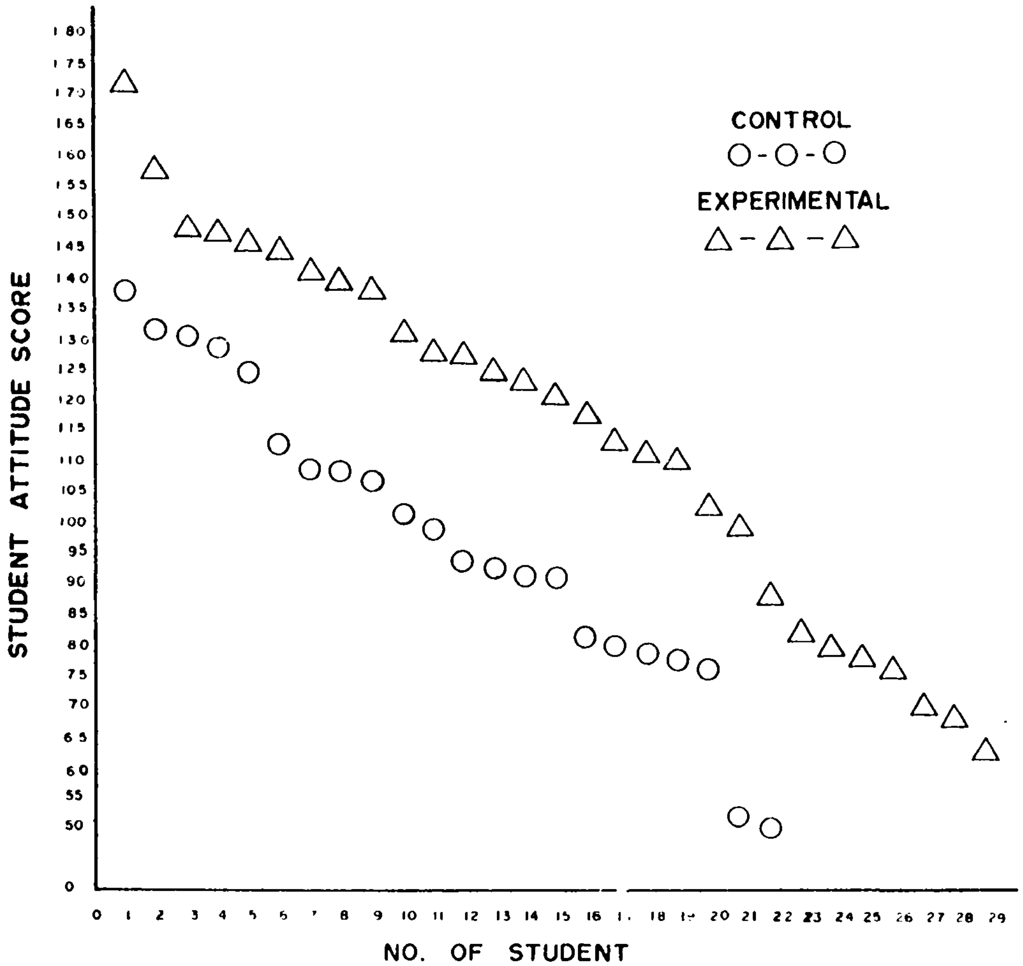


FIGURE 3. ATTITUDE SCALE TOWARD TYPE OF INSTRUCTION

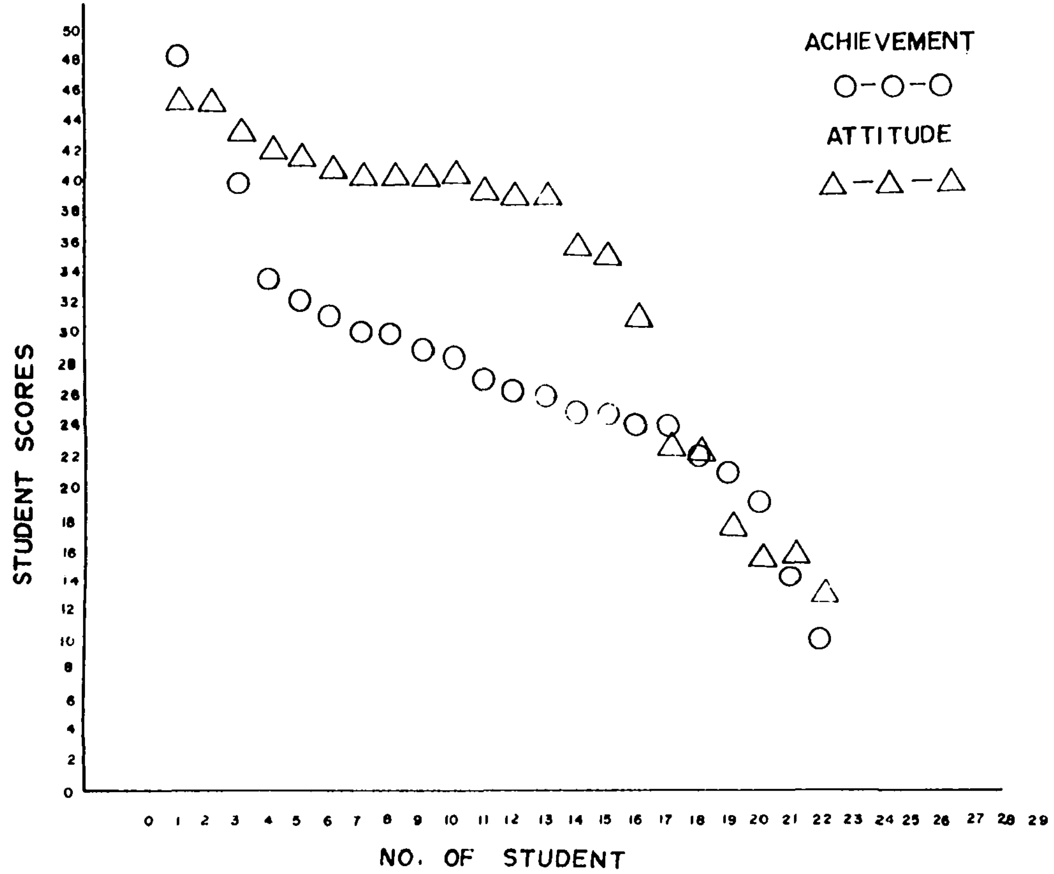


FIGURE 4. CONTROL GROUP CORRELATION COEFFICIENT ACHIEVEMENT SCORES VS ATTITUDE TOWARD TYPE OF INSTRUCTION

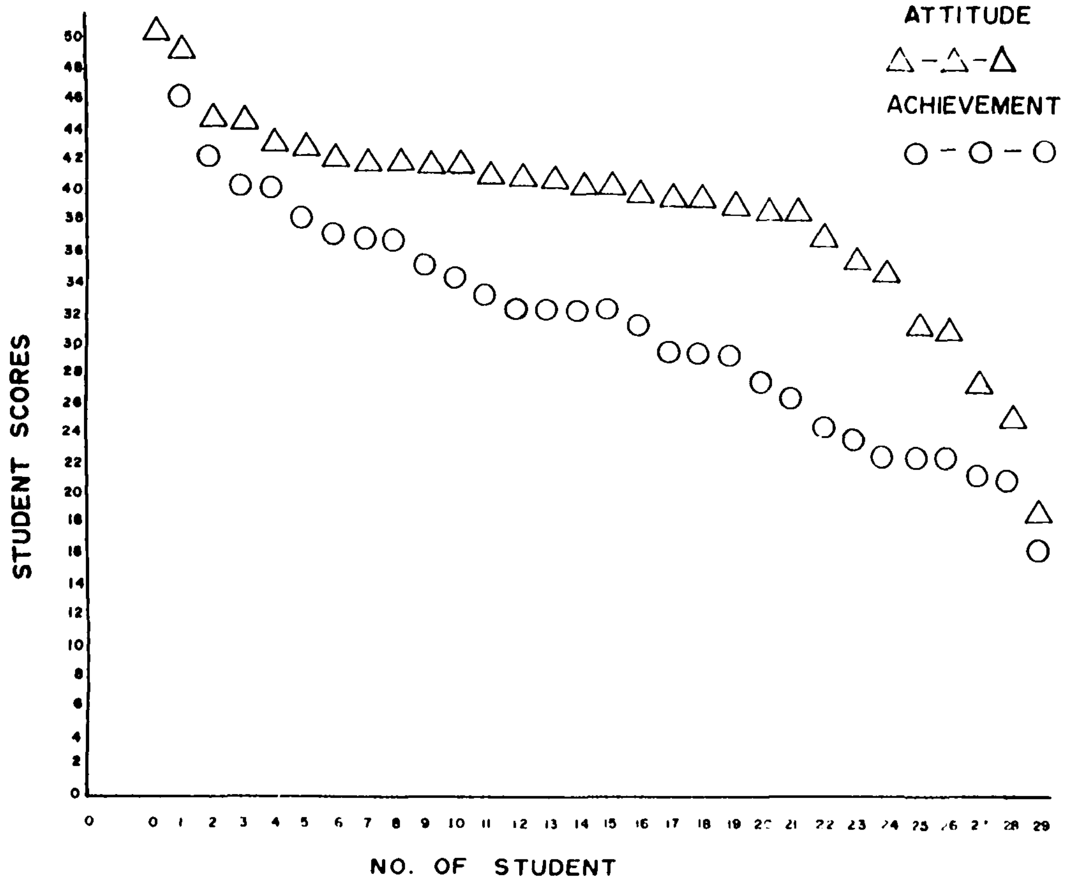


FIGURE 5. EXPERIMENTAL GROUP CORRELATION COEFFICIENT ACHIEVEMENT SCORE VS ATTITUDE TOWARD TYPE OF INSTRUCTION

APPENDIX A

Tests and Instruments Used in This Study

Achievement Test:	Cooperative Science Tests Form B: Biology Part 1. Educational Testing Service Cooperative Test Division Princeton, N.J. Berkeley 4, California 60 - item Response Mode: Multiple choice Scoring: number correct
Attitude to Subject Matter:	Silance and Remers 45 - item Response Mode: Check items with which they agree. Scoring: Median score of those statements endorsed by the person.
Attitude Toward Instructional Method:	47 - item Response Mode: (Specify the degree to which you agree or disagree with the the statements about the type of instructional method.) Strongly Agree (SA) Agree (A) Neutral (N) Disagree (D) Strongly Disagree (SD)

Scoring:

positive statements

SD	D	N	A	SA
0	1	2	3	4

negative statements

SD	D	N	A	SA
4	3	2	1	0

APPENDIX B

Performance Objectives

Given several objects, be able to measure their height, length and width in meters, centimeters or millimeters with 100% accuracy.

Given metric-English conversion factors, solve simple problems of conversion with 60% accuracy.

Demonstrate your ability to use a triple-bean balance by weighing several objects in grams to within 0.1 grams.

Discuss the advantages of the metric system over the English System of measurement.

Demonstrate your ability to measure and read volumes in milliliters by using a graduated cylinder within 1/2 milliliter.

Locate the parts of a microscope on an oral or matching test with 100% accuracy.

Demonstrate your skill in using a microscope by making a wet mount of a letter e and locating under low and high power objectives to satisfaction of teacher.

Be able to recite simple rules of proper care and handling of a microscope to satisfaction of teacher.

Show that you can use scientific equipment and supplies in the laboratory including (1) simple microscope (2) bunsen burner (3) handling chemicals (4) test tubes and other glassware (5) thermometers on a laboratory test to satisfaction of teacher.

Identify the roles of living organisms that act as food producers and organisms that act as herbivores, first, second or third order food consumers (carnivores) on a matching test with 70% accuracy.

Identify relationships which exist between animals and animals, animals and plants, and plants and animals with the non-living environment on a matching test with 70% accuracy.

Show knowledge of the major biomes by giving examples of dominant plant and animals types, and major factors of climate orally and on a matching test with 70% accuracy.

Show knowledge of basic interrelationships by diagraming and recognizing diagrams of food chains, food webs, and photosynthesis and respiration on an essay test within a 70% accuracy level or satisfaction of teacher.

Identify from a list the proper order of ecological levels of complexity within 100% accuracy.

Be able to describe changes, to satisfaction of teacher, in population densities by defining population density and by identifying the major population factors that increase and that decrease population density.

Given graphs or descriptions of population changes, recognize changes that show the growth of a new population, a stable population, or a dying population within 70% accuracy.

Given a growth curve, be able to label the various phases within 100% accuracy.

Given an example of a change, be able to recognize whether it is a physical or chemical change, to the satisfaction of the teacher.

Describe the effect on atoms' parts when a chemical change takes place to satisfaction of teacher.

Using acceptable laboratory techniques, identify 2 out of 3 unknown chemicals.

Given lists of chemical elements, identify the chemical elements commonly found in living things with 100% accuracy.

Given a definition of the terms: electrons, protons, neutrons, molecule, compound, mixture, atomic weight, atomic number, chemical bonds, ion, orbits, isotope, PH symbol, choose from a list the term which best matches the description with a 90% accuracy level for the class with no student below a 70% accuracy level.

Given the atomic weight and number, determine the number of neutrons in the atom, with 70% accuracy.

Given a chemical equation, identify the reactants and products with 100% accuracy.

Be able to list the differences and similarities in structures between plant and animal cells to satisfaction of teacher.

Demonstrate that you can properly use a compound microscope when examining cells, to satisfaction of teacher.

Learners will average 80% correct on identification on parts of a cell, with no student below 60% correct.

Be able to recite the names of the 10 basic systems of the human body with 100% accuracy.

The students will be able to list the formed elements of human blood with 100% accuracy.

The students will be able to match the following formed elements to their function, with at least 80% accuracy:

erythrocyte (red blood cells)
leukocytes (white blood cells)
platelets

Given the blood type of an individual, all students will be able to list possible donor blood types.

Given a cross section view of the human heart, be able to trace the path of blood, indicating by arrows.

Be able to explain in essay form the method by which oxygen and carbon dioxide is transported to and from the lungs.

Learners will label the parts of the human heart on a quiz with 90% accuracy for a class average, with no student scoring less than 70% accuracy.

Learners will discuss in an essay the difference between an open and closed circulatory system giving examples of animals with both types.

Students will demonstrate knowledge of the following terms to their general meaning on a quiz with 60% accuracy:

coronary
stroke
arthrosclerosis
cerebral hemorrhage
anemia
sickle-cell anemia
blood group
lymphatic system
pacemaker
plasma
formed elements
capillaries
erythrocytes
leukocytes
open-closed circulatory
veins
arteries
hemoglobin

Learners will demonstrate blood typing procedure to teacher by typing partner's blood and explaining orally the reaction observed.

Students will demonstrate ability to make a blood smear and stain by showing instructor the blood smear and locating white and red blood cells to satisfaction of teacher.

Each student will take the cardio-vascular step test, determine value, and share this score with the class to determine fitness of class.

Be able to describe the two basic activities of digestion, physical and chemical, on an essay to the satisfaction of the teacher.

Given a diagram of the head, be able to label with 70% accuracy the following:

nasal cavity
mouth cavity
teeth
the 3 salivary glands
epiglottis
hard palate
soft palate
tongue
nerves that initiate swallowing

Given a diagram of the human digestive system, be able to label the following parts with 70% accuracy:

esophagus
liver
stomach
small intestine
large intestine
pancreas
bile duct
gall bladder
appendix
rectum
anus
sphincters

Students will demonstrate a 70% level of accuracy in matching the following digestive tract organs to their functions:

colon
small intestine
sphincter
esophagus
tongue
epiglottis
pancreas

teeth
stomach
gall bladder
liver

Each student must complete laboratory experiments on lipid, protein and starch digestion by writing a laboratory report and answering questions on laboratory experiments to a 60% proficiency.

Be able to match the stage of cell division with a description of a cell at that stage, or a picture of a cell at that stage of division with 60% accuracy.

Be able to distinguish between meiosis and mitosis, in terms of the resulting chromosomal material and the difference in the process of division on a short answer test.

Show your understanding of how enzymes work by using labeled diagrams of puzzle pieces to explain.

Given an experiment on enzymes to perform, record all observations. Be able to put the collected data in graph form. Be able to explain all results in written form with 70% accuracy.

Given an example of an experiment, be able to describe the control group and the experimental group.

Given a description of Mendel's experiments, recognize examples of the following on a matching test with 70% accuracy:

a. dominant traits and recessive traits
b. pure breeding and hybridization
c. P_1, F_1, F_2, F_3 ...generation
d. homozygous and heterozygous genotypes

Given the genotype of the parents and a list of possible genotype and phenotype combinations, predict the probable ratios of the genotypes and phenotypes of the offspring.

APPENDIX C

Statistical Data

Cumulative Grade Point Average

Control Group	Experimental Group
N=22	N=29
$\bar{X}$=1.94	$\bar{X}$=1.96

t=0.034

on a t-distribution this indicates no significant difference between G.P.A. of both the control and experimental group.

Pre-Achievement Test

Control (traditional)	Experimental (experimental)
N=22	N=22
$\bar{X}$=25.2	$\bar{X}$=24.31

t=0.0927

t-distribution indicates
no significant difference.

Post-Achievement Test

Control	Experimental
N=22	N=29
$\bar{X}$=27.54	$\bar{X}$=30.7

t=1.56

t-distribution indicates that
this is significant at the 0.1
level of significance.

Pre-Attitude Toward Subject

Control (traditional)	Experimental (A-T)
N=22	N=29
$\bar{X}$=6.84	$\bar{X}$=7.10

t=0.6

on a t-distribution this value is significant at the 0.4 level of significance indicating no significant difference in pre-attitude toward the subject matter.

Post-Attitude Toward Subject

Control (traditional)	Experimental (A-T)
N=22	N=29
$\bar{X}$=6.81	$\bar{X}$=7.65

t=1.68

on a t-distribution this is significant at the 0.5 level of significance indicating an acceptable significant difference between groups.

Attitude Toward Instructional Method

Post Test (End of 1 semester)

Control (traditional)	Experimental (A-T)
N=22	N=29
$\bar{X}$=98.18	$\bar{X}$=115.79

t=2.35

on a t-distribution this indicates the results obtained are significant at the 0.25 level. This means that the results obtained would happen by chance only 2 times out of 100.

Attitude Toward Instructional Method

End of Second Semester

Control*	Experimental**
N=29	N=22
$\bar{X}$=112.2	$\bar{X}$=80.79

t=4.1

the t-distribution indicates that this is significant at the 0.001 level of significance.

*this group was the experimental group 1st semester having had the A-T approach but switching to the traditional approach.

**this group was the control group 1st semester. Having had the traditional approach but switching to the A-T approach.

Correlation of Attitude Toward
Instructional Method of Achievement

Control		Experimental	
Attitude	Achievement	Attitude	Achievement
$\bar{X}$=98.18	$\bar{X}$=27.54	$\bar{X}$=115.79	$\bar{X}$=30.7
r=.61		r=.94	

*r=Pearson Product-Moment Correlation Coefficient

t- Test Between Pre- and Post-Attitude Toward Subject Matter for Control Group

Pre-Test = 6.84

Post-Test = 6.81

t = .0447

Not Significant

t- Test Between Pre- and Post-Attitude Toward Subject Matter for Experimental Group

Pre-Test = 7.10

Post-Test = 7.65

t = 1.833

Significant at .05 Level of Significance

t- Test Between Pre- and Post-Achievement
Test Control Group

Pre-Achievement $\overline{x}$ = 25.20

Post-Achievement $\overline{x}$ = 27.54

t = .25

t- distribution significant at .25 level of significance

t- Test Between Pre- and Post-Achievement
Tests of Experimental Group

Pre-Achievement $\overline{x}$ = 24.31

Post-Achievement $\overline{x}$ = 30.7

t = 3.40

Highly Significant at .001 Level of Significance on t- Distribution

APPENDIX D

Sample A-T Biology Unit

POPULATIONS

Performance Objectives:

1. Be able to describe the major characteristics of a population:
   a. death rate-mortality
   b. birth rate-natality
   c. immigration-emmigration

2. Given graphs or descriptions of a population change: Recognize changes that show the growth of a new population, a stable population, or a dying population.

3. Be able to label the various phases of the growth curve.

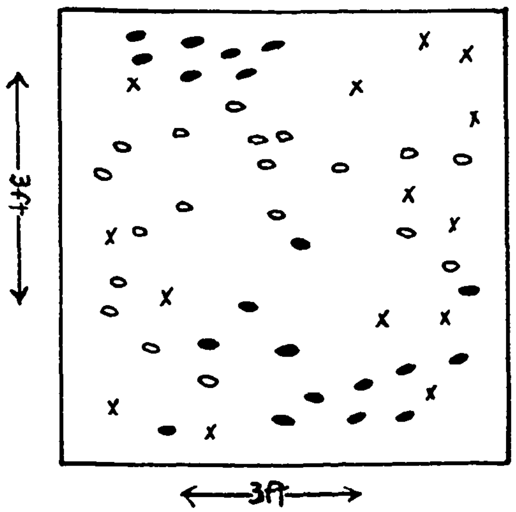
4. Distinguish between the following ecological interactions on a multiple choice test:
   a. biotic potential-environmental resistance
   b. competition-cooperation

5. On a matching test, be able to match the following terms with their meaning or definition:
   a. lag, growth, stationary, and death phase
   b. competition-cooperation
   c. limiting factors
   d. migration
   e. birth rate-death rate
   f. open-closed population
   g. density
   h. total count-sampling method
   i. biotic potential-environmental resistance
   j. biomass
   k. carrying capacity

1. A population is defined as:______________________________________
____
____

2. Characteristics of a population:
   a. Density-number of individuals in a given________________

   STOP TAPE:
   b. Perform the following exercise to help you understand DENSITY. Answer all the questions below, which are based on the following diagram.



QUESTIONS:

1. What is the area of the plot shown?__________sq./ft.

2. How many individuals are indicated in the area?_____

3. These individuals can most obviously be grouped into ________ populations.
(number)

4. What is the density of the organism indicated by ?______X______

5. What is the density of the organism indicated by ?______●______

6. Which of the populations shown in the plot has the greatest density?_______________

c. Another characteristic of a population is the ________ ________ which scientists also call ____________. This characteristic is simply the rate at which ____________ individuals are __________ to a population by ____________________.

d. The population may be increased by individuals <u>coming in</u>, this is called ____________________ or it may be decreased by individuals leaving or going to other places, this is called ____________________.

e. The ____________ ____________ is also a population characteristic. It is also called the <u>mortality rate</u> - the rate at which individuals are lost by death.

Ecological Interactions

f. The population size of any group of organisms is a direct result of: ____________, ____________, ____________, ____________. Ecologists call these four rates ____________ ____________ because two of them: ____________ and ____________ increase the population size.

g. In terms of providing enough <u>food</u>, <u>space</u> and <u>shelter</u> and so on, any particular area can support only so many organisms of a kind. This number is known as the "____________ ____________."

<u>Notes</u>:

h. It is easy to get into the habit of thinking about populations in terms of numbers of organisms: 1000 fish in a lake; 35 persons in a class, but populations can also be measured in another way. For example, a population can be measured in terms of total weight of organisms, this total weight is called ____________.

Notes:

i. Any population has a certain potential for increasing its numbers. This is called _________ _________. On the other hand, many things tend to keep a population from increasing. Such factors make up what is known as environmental resistance also called

___________ ___________.

j. ___________ and ___________ are two more kinds of interactions that occur between members of a species.

k. Every organism is involved in __________________ with one or more organisms and its physical environment.

Notes:

l. What is "territory"?

Types of Populations

There are two basic types of populations:

m. ______________ populations. These types are found chiefly in

___________________.

Phases of a closed population: (TAKE NOTES)

1. __________

2. __________

3. ________

4. __________

n. The second type of population is called a __________ population.

This population type is found chiefly in ____________.

List differences between these two types of populations.

The diagrams on the following page show two types of populations:

figure a----natural population

figure b----natural population

figure c----closed population

These diagrams will be discussed in class.

Determining Population Size

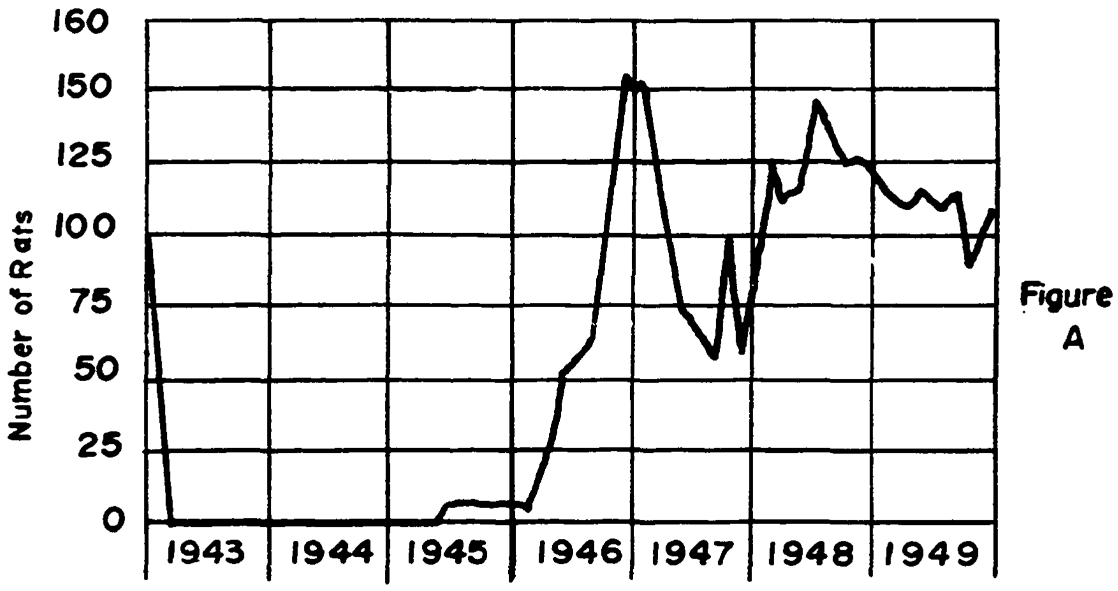
o. Population size can be determined by three methods:

1. ____________________

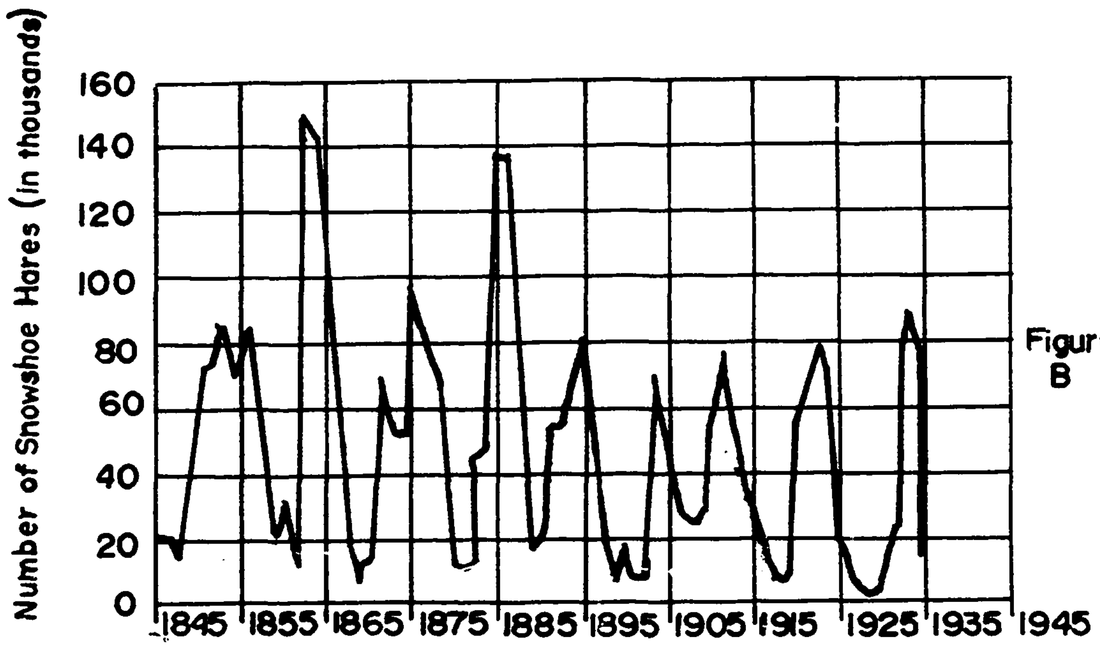
2. ____________________

3. ____________________

These methods will be discussed by your instructor in group session. However, perform the following laboratory investigation which uses one of the above methods to estimate the size of a population.



Graph of brown rats in a city block, Baltimore, Maryland



Graph of a snowshoe hare population in Canada.

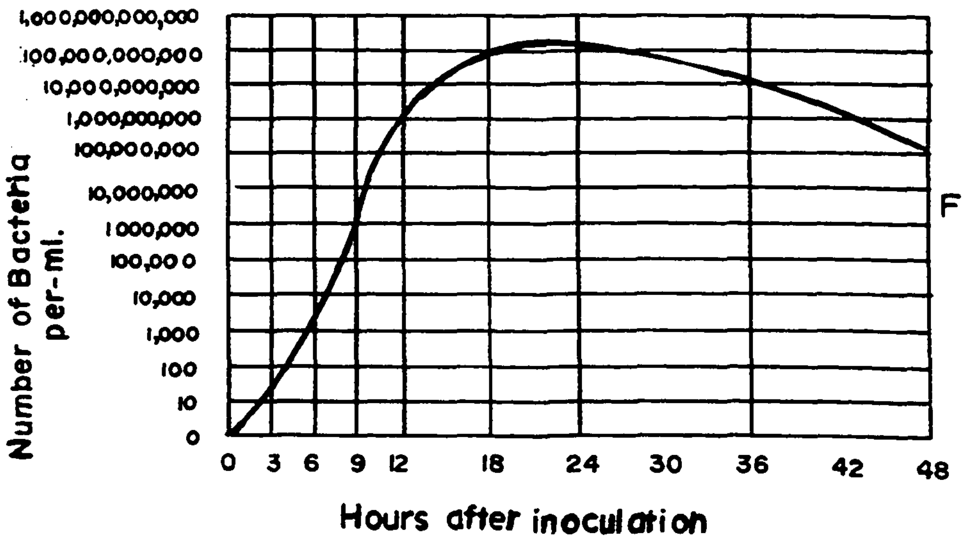

1,000,000,000,000
100,000,000,000
10,000,000,000
1,000,000,000
100,000,000
10,000,000
1000,000
100,000
10,000
1,000
100
10
0
Number of Bacteria per-ml.
0
3
6
9
12
18
24
30
36
42
48
Hours after inoculation

Figure C

A LABORATORY EXERCISE IN POPULATION SAMPLING

On the laboratory tables you should find a paper divided into 100 squares one meter on each side, a beaker with beans in it and another beaker with numbers from one to one hundred on pieces of paper. The slips of paper are used to select squares at random so that our population estimate will not be prejudiced. We prejudice our estimate by allowing human decision to select squares. Please follow the instructions listed below.

1. Spill the beans onto the PAPER and distribute about the paper.
2. Draw TEN (10) numbers from the beaker and enter the number in the FIRST COLUMN of the table below.
3. For each number in the first column, find the identically numbered square on the paper, COUNT the BEANS on that square and ENTER THE NUMBER COUNTED in the table in the space next to the number of the square.

	Square Number	Number of Beans	
1.	________	________	
2.	________	________	
3.	________	________	
4.	________	________	
5.	________	________	
6.	________	________	
7.	________	________	
8.	________	________	
9.	________	________	
10.	________	________	
	A=	________	The Total of Column 2

A Laboratory Exercise in Population Sampling (Cont'd.):

4. Add Column 2 for a number we will call A.

5. Multiply the number A found in step 4 by 10.

6. Count all beans on the whole piece of paper. ALL OF THEM!

7. Enter answer from Step 5 _______. This is the ESTIMATED POPULATION.

8. Enter count from Step 6 _______. This is the ACTUAL POPULATION.

On Back, WHAT DO YOU FEEL CAUSED THE DIFFERENCE IN THE TWO KINDS OF COUNTS.

Sunday, September 19, 1971 KALAMAZOO GAZETTE A-3

CENSUS DIRECTOR'S FORECAST:

"World Population Double in 30 Years"

WASHINGTON (AP) -
World population is growing so fast that it will double within 30 years despite slower growth rates in the more industrialized societies, Census Director George Hay Brown says.

Even if births were to decline so that families were barely replacing themselves within the next decade, it would take another 60 years before the population would stop growing, Brown said studies indicate.

"It is a matter for serious attention and serious concern," he said in an interview.

"The question of when you sound the alarm is a matter of individual judgments. There's obviously got to be some limit to the total number of people that can be accommodated on a limited-resource institution, the spaceship world."

Brown said the question of limiting population "deserves study and debate."

In the United States, he said, population growth will continue based on present fertility rates, but not nearly as fast as the rest of the world.

"It appears unlikely that the U.S. will reach zero population growth in this century," he said.

For the nation to reach zero population growth, birth rates must come down from the present 2.4 children per family to 2.1 children. With immigration, which makes up 20 percent of the yearly increase in the nation's population growth, zero population growth is pegged at about 1.9 children per family.

Brown said once this level in the United States is reached "it would take 30 to 60 years before the population finally leveled out."

"The facts are that the rate of population growth outside the United States, is on the average, much higher than inside the U.S.," he said.

The population is growing by 1 to 1.5 percent in the United States, Western Europe and Japan, which would indicate a 50 percent population growth in these countries within the next 20 to 30 years.

But, including the population growth of the remainder of the world indicates a doubling of world population by the year 2,000, he said.

A study released by the Census Bureau shows that if fertility rates began to decline so that zero population growth were reached by 1980, it would be 2040 before Brazil's population would become stable at 196.9 million; 2050 before Red China's population stabilized at 1.4 billion; and 2045 before India's population stopped growing at 1.2 billion.

If present birth rates continue unchecked, the study said Brazil would have 1.2 billion people in 2040, China 10.1 billion in 2050, and India, 9.3 billion in 2045.

Brown said a recent study by a Washington-based population group indicating the nation may be on the verge of reaching zero population growth, failed to take immigration into account.

CHECKLIST

1. Tape on Populations ____________
2. View film "Population" ____________
3. Lab. Investigation on Sampling Populations ____________
4. Articles to Read:
    a. Science World article "The Population Explosion-Overwhelming or Overrated" ____________
    b. Kalamazoo Gazette article "World Population Double in 30 Years" ____________
    c. Nature and Science article "Animal Arithmetic" ____________
5. Filmstrip: Crisis in the Environment: The Population Problem ____________

LITERATURE CITED

1. Aldrich, B., "Pilot Research Project in Biological Science". Unpublished research paper, Western Michigan University, Kalamazoo, Michigan, March, 1968.

2. Champagne, Sister Marie Agatha, "An Investigation of the Merits of Multi-Sensory Remedial Work in the Teaching of Tenth Grade Biology". Unpublished research paper, Western Michigan University, Kalamazoo, Michigan, August, 1972.

3. Educational Testing Service, "Cooperative Science Tests". Cooperative Test Division, Princeton, New Jersey, 1963.

4. Finch, Curtis R., "An Instrument to Assess Student Attitude Toward Instruction". Journal of Educational Measurement, 6(4): 257-258, 1969.

5. Geoghegan, F., "A Comparative Study of the A-T Teaching Method in Biological Science with the Lecture Approach". Unpublished research paper, Western Michigan University, Kalamazoo, Michigan, April, 1967.

6. Hackett, Dorothy, "Biological Science as an Audio-Tutorial System of Instruction for the Non-Science Major". Science Education, 57(4):499-516, 1973.

7. Hoffman, F. E., and M. Druger, "Relative Effectiveness of Two Methods of Audio-Tutorial Instruction in Biology". Journal of Research in Science Teaching, 8(2):149-156, 1971.

8. Muthiani, Elizabeth, "An Analysis Towards Audio-Tutorial Method of Teaching". Unpublished research paper, Western Michigan University, Kalamazoo, Michigan, August, 1970.

9. Oliver, M.J., "Efficiency of Three Methods of Teaching High School Biology". Journal of Experimental Education, 33(3):289-300, 1965.

10. Postlewait, S. N., "The Audio-Tutorial System". The American Biology Teacher, 32(1):31-33, 1970.

11. Shaw, M. E. and J. M. Wright, Scales for the Measurement of Attitudes, McGraw-Hill, Inc., 1967. Pp. 294-297.

12. Sherill, D. and M. Druger, "Relationships Among Student Variables in an Audio-Tutorial Biology Course". Journal of Research in Science Teaching, 8(2):191-194, 1971.

13. Smiley, C., K. Bush and D. McGraw, "An A-T Program in High School Biology". The American Biology Teacher, 34(2):84-89, 1972.

14. Wissinger, W., "A Systematic Statistical Analysis of Achievement Tests used in the Biological Science Program to Determine Their Validity and Reliability". Unpublished research paper, Western Michigan University, Kalamazoo, Michigan, June, 1967.

15. Wissinger, W., "A Statistical Analysis of the Factors Influencing Student Achievement and Instructional Effectiveness in the Audio-Tutorial Biological Science Program at Western Michigan University", Unpublished specialist thesis, Western Michigan University, Kalamazoo, Michigan, August, 1967.

16. VanderWal, J. N., "A Graphical Analysis of Student Attitudes in Biological Science 107". Unpublished research paper, Western Michigan University, Kalamazoo, Michigan, April, 1972.