AN ANALYSIS OF TWO METHODS OF TEACHING BIOLOGICAL SCIENCES LABORATORY

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BIOLOGICAL SCIENCES LABORATORY

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

A problem frequently encountered in both high school and college biology laboratories is that of introducing the laboratory exercise in such a way that all students are able to see and understand the procedures to be followed. The student seated farthest from the center of activity many times is unable to see what is written on the chalkboard, to distinguish small type on charts and diagrams, or to identify small equipment and specimens. Often he fails to follow the specified procedures or uses valuable laboratory time ineffectually in the effort to achieve the desired results solely because he was unable to see what transpired during the introductory phase of the laboratory period. Scuorzo (36) stated,

> Any science teacher who has tried to demonstrate with standard physics or chemistry apparatus knows that students in front see well; students behind them see only the backs of heads.

This observation applies equally well to demonstrations with biological materials and equipment.

Methods have been suggested for overcoming this problem and many have been employed. Among these are: teachers urged to increase the size of their writing on the chalkboard, larger charts and models, oversized demonstration equipment, and various methods of magnified projection. Lantern slides, thirty-five millimeter slides, film strips, and motion pictures have been utilized and one of the most recent innovations is the use of closed-circuit television as a magnifying device.

The present study was made in an attempt to determine the effectiveness of thirty-five millimeter color slides in conjunction with a synchronized tape recording as a method of introducing laboratory exercises in a course in general biology.

The Need for the Study

As enrollment increases in college classes and as pressure increases for qualified teaching personnel, it becomes important to utilize every available means to improve the teaching situation. With large laboratory sections in which preliminary instructions and demonstrations related to the day's exercises are given, those students seated farthest from the instructor frequently are hampered by their inability to see the demonstration. Thus there is a need, since all students cannot be seated near the instructor, to find a method by which details can be made easily visible, regardless of the student's location in the room.

Many laboratory sections in biology are taught by graduate students who, while well trained in subject matter, lack teaching experience. Methods for helping these young teachers gain experience, while providing the students with the best possible instruction, need to be developed.

The current study is concerned with the foregoing problems. It is suggested that thirty-five millimeter slides, photographed in such a way as to show the desired detail, could be projected on a screen which is clearly visible to all students in the laboratory. It is further suggested that a synchronized tape recording covering the necessary verbal instructions might possibly be an improvement over conventional methods.

The narration to be included on the tape would be prepared by a competent staff member or a group of staff members and would not only give necessary instructions to the students in the laboratory but also provide guidance in methodology for the inexperienced instructor.

The Scope of the Study

It was the scope and purpose of this study to determine whether it can be demonstrated that tape-slides are more effective in teaching biological science laboratory than conventional methods. The procedures involved in an attempt to answer this question were (1) the preparation of tape-slide presentations to be applied in a specific laboratory situation, (2) the making and validation of a testing instrument, and (3) the analysis of data collected during the experiment. The details concerning the slides, the tapes, the testing procedures, and the statistical treatment will be found in Chapters III, IV, and the appendices.

Hypothesis

The following hypothesis, stated in the null form, was tested:
H_o: The mean score obtained on an achievement test covering laboratory procedures and observations will be no higher for the experimental group, which will be exposed to the tape-slide presentations, than the mean score obtained by the control group which will be instructed by the conventional verbal-demonstration method. The alternative hypothesis thus becomes one-tailed when stated as follows: H_a: The mean score obtained on an achievement test covering laboratory procedures and observations will be significantly higher for the experimental group, which will be exposed to the tape-slide presentations, than the mean score obtained by

the control group which will be instructed by the conventional verbal-demonstration method. The level of significance upon which to base the decision to reject the null hypothesis was set at the .05 level.

The achievement test employed in the collection of data with which to test this hypothesis was designed by the investigator and following its administration in a pilot study, was subjected to item analysis. A copy of the test is included in Appendix B and discussion concerning its application and the results will be found in Chapters III and IV.

The Mann-Whitney U Test (37), a non-parametric statistical test, was used for testing the hypothesis. No attempt was made to analyze covariants.

Limitations of the Study

This study was limited to the laboratory sections of the course, Biological Sciences 114, which is offered at Oklahoma State University as a general education course for non-biology majors. A pilot study of the problem was conducted during the first semester of the academic year, 1965-66 and the principal study was undertaken during the second semester of the same year.

Definition of Terms

The following terms will be used throughout this report:

Slide as used herein refers to thirty-five millimeter color slides.

Tape is used in the sense of the recorded narration which has been placed on magnetic recording tape.

Tape-slide presentation refers to the complete program of thirty-five millimeter slides and the synchronized tape recording which has been compiled for a particular laboratory session.

Pilot study is applied to a preliminary study conducted during the first semester of the academic year, 1965-66, in which some of the tape-slide presentations were utilized with a limited number of laboratory sections of Biological Sciences 114.

Principal study refers to the study carried out during the second semester, 1965-66, in which the entire series of tape-slides were presented to half of the laboratory sections.

Experimental group consists of all the students enrolled in the laboratory sections chosen at random to be shown the tape-slide presentations.

Control group includes those students who were enrolled in the remaining laboratory sections which were taught by conventional methods.

CHAPTER II

REVIEW OF THE LITERATURE

A review of the literature has thus far failed to reveal a study of exactly this nature although a number have been done in which certain techniques of the present study were utilized. Brown (9) made use of thirty-five millimeter slides in both lecture and laboratory when he made his investigation at the University of Georgia in the first course in microbiology. His findings indicate a statistically significant difference in course grade between the experimental and the control groups.

Laun (24) gave a detailed description of the procedures involved in producing tape-slide programs but did not report any study in which he compared the results of this method of presentation with any other method. His article was concerned primarily with the techniques for preparing the slides and for recording the narration and synchronizing signals on the tape. He presented a number of suggestions for making good slides using a wide variety of media from chalkboards to pastel sticks used on construction paper and also described methods for synchronizing the slide movement with different types of tape recorders.

In a recent article entitled, "Evaluating Educational Innovation," Babcock (7) said:

> Children bring to any learning situation a great variety of backgrounds of experience. Even those who have, seemingly, a similar experiential background react to new learning situations in dissimilar ways. Degrees of readiness vary. The ways in which children learn also vary widely--they have different kinds and different degrees of sensory acuity. Which is to say,

simply, that some children gain knowledge best from the printed page; others remember best what they see; and still others retain best that which they hear. Consequently, for many there is no more effective communication medium than the printed page; for others, knowledge and understanding are strengthened when visual imagery and auditory signals trigger the mental process. The only logical conclusion is that because children learn in different ways, no one medium meets all their needs. A multi-sensory approach becomes imperative in the teaching-learning situation.

Studies Involving Non-Science Courses

The use of methods of teaching other than verbal has been studied, discussed, praised, and criticized for a long time. Fisher (15) reported that Bacon urged greater use of the senses in his New Atlantis. Bacon contended that the ears are not the only or the best means of learning, but that the other senses of sight, taste, and touch must be utilized to make instruction more effective.

Sumstine (39) in 1918 made a comparative study of visual instruction in the high school in which he compared the relative effectiveness of three methods of teaching: the silent film, film and script presented simultaneously, and a reading of the film's script exclusively. His sample included 475 randomly selected students from grades nine through twelve. The purpose of the study was to determine whether the student comprehends a subject better through the eye alone, through ear and eye combined, or through the ear alone. Following each film presentation, the students were tested twenty-four hours later, ten days later, and three months later. In each test, the highest scores were made by the film group while the film-script group scored higher than the group to which only the script was read in all except the three-month test.

A study of the comparative effectiveness of four different methods of presentation was conducted by Weber (44) at Columbia University in

1922. These methods were: films exclusively, study, lecture, and film-lecture. The results showed consistently higher averages among the students who received the film-lecture treatment. He concluded, following this study of six hundred seventh-grade students in a New York school that, (1) pictures are effective aids to the learning process, (2) visual aids are effective in concrete learning, (3) visual aids are effective in abstract learning, and (4) the validity of combining words with pictures in teaching has been established.

In 1925, Sir James Marchant (28) reported on a study in psychology classes in which film, slides, film-talk, slide-talk, and oral presentations were given, followed by an essay test. The results showed that with the pictorial, particularly film, method of presentation, the students achieved distinctly higher scores in the number of particular facts learned while the oral groups excelled in the number of general statements in an essay.

Knowlton and Tilton (21) in 1929 performed a seven-month study at Yale University contrasting the use of films in teaching history with regular classroom instruction. They reached four conclusions: (1) films made a large contribution to the teaching of an enriched course of study, (2) films increased the pupils' learning about nineteen per cent, (3) the average student with the aid of films learned as much as did bright students without them, and (4) films produced more pupil participation in classroom discussion.

The Eastman project conducted in 1929 by Wood and Freeman (47) attempted to estimate the contributions which twenty teaching films might make when used as a regular and integral part of classroom work. Nearly eleven thousand seventh-grade students from twelve different city school systems were included in the study. Geography and general science were the subjects studied and three tests were given to measure the results of the experimental treatment. In all three tests, the film-instructed groups showed a marked superiority over the non-film-instructed groups.

Knowlton and Tilton (22) in 1932 studied the relative values of presenting motion pictures in an auditorium and in a classroom and found in relation to the teaching of history, that superior results occurred from the showing in the classroom.

In 1933, Arnspiger (6) conducted a study including five cities, 2,500 students in grades five and seven, thirty-two classes, and sixty-four teachers over a period of one school year to determine the effectiveness of teaching with the aid of motion pictures in science and music as compared with usual classroom methods of instruction. The results showed a superiority for the film groups over the non-film groups in all cities combined of fifty per cent in science and thirty-one per cent in music.

In 1948, Hart (19) wrote:

> Thus during the war the use of films in the Navy grew from a limited number of subjects to libraries containing nearly four thousand subjects...
>
> While evaluation resulted in the constant modification and improvement of films, evaluation also made evident from the outset that the films were making a tremendous contribution to the training program. As more and more evidence accumulated, the Navy found definite proof that, by the efficient use of training films:
>
> (1) Men learned more. Actual tests revealed that students learned at least thirty-five per cent more in a given time than they would have learned without the aid of training films.
>
> (2) Learning time was reduced. Films are time-saving instead of time-consuming.
>
> (3) Men remembered longer. Facts learned are remembered up to fifty-five per cent longer.

(4) Interest was increased, morale was raised, and training was made more uniform.

The question of oversaturation with audio-visual materials was investigated by Vander Meer (42) in 1950. With forty-four instructional films being used as the total teaching material for one semester, he reported that this method taught the informational material as well as if the students were instructed by conventional methods.

Abramson (2) in 1952 conducted a study of instruction in elementary mechanics at a large high school. He compared a method in which recitation, demonstration, film, supervised study, and laboratory exercises were used with a method in which pictorial ideagraphs were projected as slides. Each slide was followed by thought provoking questions which focused on certain elements and relationships in the slides. The results as evaluated by achievement tests given immediately and again two months later, indicated that significantly more learning took place in the slide group than in the control group.

Vander Meer (41) in 1953 investigating the relative effectiveness of color and black and white films, found that while students seemed to prefer color films, there was not significantly greater learning by color films on immediate recall tests. Scores were higher however for three of five color films at the end of six weeks. He concluded that the use of color films does not seem to be justified in terms of increased learning.

Approximately 17,000 science and social science students in Nebraska high schools were included in a four-year study conducted by Meierhenry (29) in 1955. Motion pictures were used for about one sixth of the instructional time with the experimental groups while the control groups were taught by conventional methods. Tests which were designed to evaluate the effectiveness of the films showed the experimental groups to have made significant informational gains. On standardized subject matter tests, the experimental groups were equal to or superior to the control groups.

In 1956, Caspers (11) conducted an experiment using sixteen sound films in the area of educational psychology with 216 randomly selected students from six Kansas colleges. The group of students was divided into twelve classes of eighteen each. Especially constructed pre- and post-tests based on the films were used to evaluate the effectiveness of the method. Four results were observed following the analysis of variance and covariance: (1) all classes gained in mean achievement during the semester of experimentation, (2) the classes became more alike in overall average achievement, (3) achievement was associated directly with greater film usage, and (4) attitudes, as measured by the Minnesota Teacher Attitude Inventory, improved significantly during the semester for all classes.

The degree to which the viewer perceives usefullness to himself in a film affects learning. This was demonstrated by Greenhill and McNiven (18) in 1956 in an experiment in which they showed three films to 473 high school seniors. Following the showing, the students were asked to rate the films as to perceived usefullness. The authors concluded that the more the student perceives himself using the material presented, the more he learns from the film.

A study was made in 1960 by Wendt and Butts (45) using a series of fifty-four films on world history with tenth-graders in seven schools. One instructor in each school taught an experimental and a control group. Each teacher tried to instruct both groups in the same way with the exception of the showing of the films to the experimental group. The experimental classes covered the subject matter in one semester while the control classes spent the entire academic year in completing the course. The results of testing, upon completion of the course, showed no significant difference between the groups. A study by Cottle (12) of the data from this experiment indicated that the effect of film teaching was equally good for both low and high achievers.

Dworkin and Holden (14) in 1960 tested the effectiveness of sound filmstrips on one hundred twenty graduate engineering students. The four fifteen-minute sound filmstrips used were produced and recorded by the instructor who taught the conventionally instructed control group and the experimental class. No significant difference in achievement was found and about half of the students in the experimental group stated that they would have preferred to ask questions during the film presentation.

A series of three experiments were conducted in 1963 by Magne and Parknas (26) concerning the learning effects of pictures. That their primary concern was the influence of different types of testing is shown by their hypotheses: "(1) The method of testing defines which part of the retention we intend to measure, and (2) a method of testing, adequate to the mode of presenting the information, covers a larger part of the total retention than a method that is inadequate to this mode."

Their first experiment was aimed at making comparisons between learning with words and with pictures. The subjects were 228 boys and girls, aged thirteen, and each class was divided into two halves. Colored pictures of plants were projected on the screen and studied for three minutes. The tests, which utilized both pictorial and verbal methods, consisted of judging whether, in the second set of pictures, the petals, leaves, or roots of the plants had been changed. In three out of four items, pictorial learning was shown to be superior to verbal when retention is measured by both pictorial and verbal tests.

Experiment two utilized the same learning material as experiment one but with a somewhat different design. The subjects took part in a diploma course in education at the University of Göteburg. The participants were divided into four groups and each group formed two teams, by lot, in such a way that both instruction (pictorial and verbal instruction, respectively) and tests (pictorial and verbal tests) were varied in the groups as well as in the teams. With both experiments, the mean retention of pictorial information was greater than for verbal information.

Experiment three used 192 boys and girls, aged eleven and twelve, and as instructors, three teachers were employed who had thorough experience of the age-group in question. The information consisted of a lesson on Greenland given both with and without a filmstrip. The teachers who took part in the experiment made a joint lesson plan on the basis of the script for the filmstrip and the test. Each lesson took twenty minutes and testing occurred immediately afterwards with no time limit imposed. Magne and Parknas stated:

> We are apparently justified in concluding that, in the situation we investigated, teaching with filmstrips yielded a higher degree of combined retention than did teaching without filmstrips.

However, Vernon (43) in commenting on the article by Magne and Parknas said:

> Thus it is unwise to suppose that there can be any general answer to the question, "Is pictorial material useful in teaching?" What seems to be needed is a systematic exploration

of the situation and materials presented, the subsequent application of what is learnt, and the age and interests of the learner.

Studies Involving Science Courses

A number of studies involving the use of projected materials with science courses, elementary to graduate level, have been made. One of the earliest was conducted by Hopkins and Dawson (20) in 1932 incorporating motion pictures, film slides, and lantern slides into the regular lecture sections of general chemistry at the University of Illinois. The investigation covered one semester and included 295 freshman students in two groups of 147 and 148 each. The visual aids were used as part of the regular lecture section and the investigators felt that the students considered these as entertainment rather than as instruction. However, average final examination grades for the experimental group rose to 76.6 per cent compared to 73.9 per cent for chemistry classes of previous years. A comparison of the experimental group with students taught by other methods showed them not to have been as successful as those taught by conventional methods. The authors of this report indicate a number of weaknesses in the study and suggest that no definite conclusions could be drawn from their work.

The use of sound films produced for use with definite general science units was studied by Rulon (34) in 1933 at Harvard University. His groups consisted of one which used the textbook method, one which used textbooks and viewed the sound film, and the third group which served as the control. The film-taught group scored higher in factual tests and showed a higher retention rate than did the group which studied only the textbook.

An investigation at the University of Maryland by Beechill (8) in 1941 showed that science students demonstrated more uniform learning when taught by use of microprojectors than did control groups using individual microscopes. He reported that the students expressed a preference for the microprojector method and that the method is more effective for beginning students than for advanced students.

Studies to determine the relative effectiveness of sound and silent pictures were conducted by Maneval (27) in 1940, Curtis (13) in 1942, and by Goodman, Sturmthall, and Curtis (17) in 1943. Maneval used the same educational sound film with an experimental and control group of eighth-grade students but eliminated the sound and used only captions below the pictures with the control group. The results, while not statistically significant, favored the control group for immediate and delayed recall. The investigator further commented that students of higher mental ability learn better from silent films while those of lower ability learn better from sound films. Curtis, after reviewing a number of investigations, concluded that up to the time of the review, the values of silent and sound films as a replacement for other methods or materials of instruction had not been determined. Goodman, Sturmthal, and Curtis studied the reactions of audiences and concluded that the visual elements of a sound motion picture were more important than the sound.

McTavish (25) in 1947 studied the effect of repetitive film showing on the learning processes of 319 college freshmen enrolled in a general science survey course. The population was divided into four groups with the first group being shown four science films one time, the second group observing the films twice, the third group three times, and the fourth group viewing them four times. Pre- and post-achievement tests were administered, the results of which showed a significant difference between pre- and post-test with all groups. However, while the first repetition produced a substantial increase, three showings failed to give further increase in achievement and four showings seemed to result in a slight diminution of learning.

In 1950, Vander Meer (42), using a group of high school general science students, investigated the effectiveness of three methods: films exclusively, standard lecture methods, and films supplemented by study guides. He concluded that factual information such as is normally taught in secondary general science can be taught as well through films as through conventional classroom procedures and better if study guides are used.

Four methods of teaching high school biology were tested by Anderson, Montgomery, and Ridgway (5) in 1951. The methods were: traditional textbook method with minimum of laboratory work, using eighteen films which supplemented the textbook but with no laboratory work, using laboratory work to supplement the textbook, and utilizing both films and laboratory experiences. Achievement, as measured by the Minnesota State Board Examination, was higher for the film and laboratory group than for any of the other three groups.

Krebs (23) in 1958 used two films with an experimental group in high school chemistry to determine whether films could produce a more homogeneous perception of the specific learning situation than that found in the non-film control group. His findings were that the common experience of viewing the films helped the students to perceive facts, relationships, ideas, and answers more in the same way.

The Harvey White physics films have been evaluated by Noall and Winget (30), Anderson and Montgomery (3), and Whittich, Pella, and Wedermeyer (46). The first study was conducted in twenty Utah high schools with the experimental and control groups each consisting of three large, three medium, and four small schools. The results of the year-long investigation showed that among the medium-sized schools, the control groups were significantly better. No significant difference appeared between the two methods in the larger and smaller schools. The investigators reported an over-all loss of interest in the field of physics in the experimental groups but concluded that although the films did not improve instruction, they were as good as classroom teaching. The Anderson and Montgomery investigation tested 162 of the lecture and demonstration films in a large high school in Kansas City, Missouri, with another large school in the same district acting as control. The experimental classes consisted of 225 students taught by two teachers and the control classes, taught by two teachers using conventional methods, numbered 176. An evaluation, using standardized physics examinations as pre- and post-tests, showed no significant difference between the two groups. The authors point to the superior training of the control group teachers as a possible explanation for the lack of significant difference. No significant difference was also reported from the Whittich, Pella, and Wedermeyer study. In this experiment, a control group to appraise the "Hawthorne Effect" was included and this group, in a follow-up test three months later, had retained more knowledge.

In a study of the John Baxter Chemistry film series of 160 lectures and demonstrations, Anderson, Montgomery, and Moore (4) in 1961 used seven classes as their experimental group and twenty-six classes as their control, all from the Wichita, Kansas, school system. As a result of pre- and post-achievement and techniques testing, the investigators concluded that students in the non-film classes achieved more in high school chemistry than did students in the film classes.

An experiment using both the Harvey White physics and the John Baxter chemistry films series was conducted in twelve high schools in southeast Kansas by Popham and Sadnavitch (32) in 1961. The major criterion variable under consideration was student achievement but two additional criterion variables were also studied: student interest in the general area of physical science and student attitude toward the subject. The variables were pre- and post-tested using the Co-operative Physics Test, Co-operative Chemistry Test, Thurstone Interest Schedule, and A Scale for Measuring Attitudes Toward Any School Subject. Intellectual aptitude was measured by the Otis Quick-Scoring Mental Ability Test. Student attitude toward filmed courses in general was measured by a specially-designed Attitude Toward Film Course Scale, and teachers' reactions by especially-designed questionnaire.

In six of the twelve cooperating schools, filmed chemistry and non-film physics classes were taught, while in the remaining six, non-film chemistry and filmed physics were offered. The experimental groups included 155 physics and 234 chemistry students whose class discussions were supplemented by one thirty-minute film nearly every day. In all, 149 physics films and 132 chemistry films were utilized during the year. The control groups were composed of 157 physics and 241 chemistry students who were instructed by conventional methods.

The statistical treatment of data obtained from the achievement test involved a multiple analysis of covariance while nonparametric tests were used to analyze attitudes and interest data. On achievement, the non-film group in physics showed significantly higher scores than the film group. In chemistry, there was no significant difference between the experimental and control groups in achievement. There was also no statistically significant difference in interest in physical sciences between the experimental and control groups of either physics or chemistry. Popham and Sadnavitch expressed the opinion that the use of films developed attitudes which were more unfavorable toward physics and chemistry than did the conventional methods of instruction. They further expressed doubt as to the effectiveness of filmed science courses and suggested that further evidence is needed.

The following year, Sadnavitch, Popham, and Black (35) conducted a follow-up study of the preceeding experiment in an attempt to determine the subject matter retention by the two groups after post-learning periods of seven months and twelve months. Students included in the study were those who had participated in the previous year's experiment and who were currently enrolled in one of the participating schools. A total of three hundred students composed the sample with 215 being former chemistry students and eighty-five former physics students. One hundred fifteen of the 215 chemistry students and sixty-three of the eighty-five physics students had been in the experimental groups which had received filmed instruction. Co-operative Chemistry and Co-operative Physics tests were administered and the resulting data were examined by an analysis of covariance. The non-film group in chemistry showed slightly higher retention at the end of the seven-month period but there was no significant difference in retention between the film and non-film chemistry groups at the end of the twelve-month period nor between the film and non-film groups in physics at either the seven- or twelve-month interval.

In 1964, a project involving a new method of teaching general chemistry for non-chemistry majors was reported from Michigan State University (10). Approximately one thousand freshmen were shown films of experiments, some of which are usually conducted by advanced students only. While the experiments were of such a nature as to be readily understood by the students, some involved expensive apparatus, intricate manipulation, or were potentially dangerous when performed by inexperienced persons. The films were produced at Michigan State under the direction of Dr. Carl H. Brubaker, Jr. with graduate chemistry students performing the experiments. On alternate weeks, the students either attended a three-hour laboratory or saw one of the films. After viewing the film, the students were given data which they might have collected had they run the experiment themselves and were told to analyze or interpret it. This, according to Dr. Brubaker, had the advantage of reducing the amount of laboratory space and number of graduate assistants required to handle the large number of students. He further commented that, while the film-laboratory approach is effective with large numbers of students, there is no substitute for an experienced teacher.

Brown, Michaels, and Bledsoe (9) in 1965, reported on a study in which thirty-five millimeter slides were used to supplement lecture and laboratory sections at the University of Georgia. Included in the study were 261 students in four sections; two experimental and two control.

Measures of student achievement in the investigation were obtained by pre- and post-test of authors devised, department approved general knowledge tests over basic concepts in lecture and also over laboratory techniques. Science understanding was evaluated by pre- and post-tests of the Test on Understanding Science, a standardized instrument. The index of past student scholastic performance was past quarter average as compared to the final course grade in microbiology.

With the three post-tests and final course grade as the criterion variables, the analysis of variance was used to compare means of the four criteria with the main and interaction effects, whereas the analysis of covariance was employed to determine the relationship between the criterion variables and seven covariates. Of the four criteria variables, only the Test on Understanding Science did not show significance in the treatment predictor. In the other three criteria variables, the experimentally instructed groups seemed to achieve more in introductory microbiology both in lecture and laboratory, and also received higher combined overall course grades than did students in the control groups.

Two subjective instruments were administered which obtained experimental student opinion on the use of the slides as supplementary material. These instruments showed students approved of their use. When asked their opinion, graduate students and faculty members believed the use of slides had been highly successful.

Summary

It is obvious from the preceeding survey of the literature that there is some diversity of opinion concerning the value of projected materials as a teaching aid. Some investigators contend, with statistical evidence, that motion pictures, slides, film strips, or other visual aids definitely improve the learning situation. Others, also citing statistical evidence, insist that the value of visual aids cannot be demonstrated. Still others take the view that, while the value may not be statistically proved, there is no evidence to show that the learning situation is impaired through the use of visual aids.

Of the thirty-five studies and articles reviewed, twenty-two take the view that visual aids have shown themselves to be beneficial, six contend that they have no demonstrable value, and seven are reservedly favorable or noncommittal.

CHAPTER III

DESIGN AND METHODOLOGY

Biological Science 114 is a four semester-hour, general biology course offered at Oklahoma State University for non-biology majors. The classes meet three one-hour sessions per week for lecture and one two-hour session per week for laboratory.

The textbook currently in use for the course is Life: An Introduction to Biology, Second Edition, by Simpson and Beck (38), of which the first fourteen chapters are studied during the semester. These are:

Chapter 1. The Living World and Its Study
Chapter 2. Molecular Aspects of Biology
Chapter 3. The Cell: Unit of Life
Chapter 4. The Cell: Its Metabolic Machinery
Chapter 5. Reproduction: Cellular Aspects
Chapter 6. The Chromosome Theory of Heredity
Chapter 7. Genes and Their Action
Chapter 8. Development
Chapter 9. Reproduction: Organismic Aspects
Chapter 10. Organic Maintenance: I
Chapter 11. Organic Maintenance: II
Chapter 12. Organization and Integration
Chapter 13. Responsiveness
Chapter 14. Behavior

The laboratory manual being used is Laboratory Outlines in Biology, by Abramoff and Thomson (1), from which, with certain modifications, the following weekly laboratory schedule is arranged:

First week	Introduction to the Laboratory
Second week	The Microscope (Chapter 1)*
Third week	Cells and Their Organization (Ch. 2)

*Abramoff and Thompson, Laboratory Outlines in Biology

Fourth week	Physical Aspects of Life (Ch. 5)
Fifth week	Chemical Aspects of Life (Ch. 6)
Sixth week	Mitosis (Ch. 2)
Seventh week	Meiosis and Genetics (Ch. 12)
Eighth week	Genetics (continued)
Ninth week	Animal Development (Ch. 13)
Tenth week	Photosynthesis (Ch. 7)
Eleventh week	Respiration (Ch. 9)
Twelfth week	Digestion (Ch. 8)
Thirteenth week	Coordination (Ch. 11)
Fourteenth week	Biological Transport (Ch. 10)
Fifteenth week	Final Examination

A second course, Biological Science 124, follows 114 and continues with Simpson and Beck in lecture and with Abramoff and Thompson in laboratory. It is not, however, involved in the present study and will, therefore, not be discussed in this report.

Several phases were involved in this problem. The first was the discussion with the staff members involved in lecture and laboratory sections as to which laboratory exercises were to be covered and which parts of each exercise were to be stressed.

The second phase was a thorough study of the selected laboratory exercises to determine how each idea might best be presented on tape and slides. An outline of the narration was prepared with notation as to the type of picture which should be taken and where it fit with the narration.

Making the required slides was the third phase of the problem. Many of the pictures were made in the laboratories in which the students worked using the microscopes and equipment which they used. Wherever possible the pictures were composed so that details were visible. If not possible to show complete detail in a single picture, additional pictures were taken using a close-up lens to show additional detail.

Following the photography, the fourth phase was writing the script for the narration and recording it, along with the proper synchronizing signals, on tape. The presentation was now ready for viewing by the staff members, after which their suggested additions, deletions, and rearrangements were made.

The use of the tape-slide presentation with laboratory sections was the next phase of the problem. These were used with half of the laboratory sections and the traditional verbal-demonstration presentation was made with the remainder. Since several laboratory instructors were involved in teaching these laboratory sections, each instructor was assigned both experimental and control groups.

The testing procedures and statistical treatment constituted the final phase of the problem.

The Pilot Study Population and Samples

The students who enroll in Biological Sciences 114 represent several of the colleges within the university and all of the undergraduate classifications. The distribution of students by college and by classification varies from semester to semester but the College of Arts and Sciences usually contributes more than half of the total enrollment. Normally, approximately seventy-five per cent of the enrollment is freshmen.

During the first semester, 1965-66, a pilot study of the problem was conducted. The population for this study included all of the students who were enrolled in the investigator's six laboratory sections and who maintained at least seventy per cent attendance during the semester. The total enrollment was 174 and of these, 150 had the required attendance. Table I and Table II show the distribution of the enrollment by college and by classification.

Three of the six laboratory sections were designated as experimental groups and the remaining three served as control groups. An attempt was

TABLE I

THE PILOT STUDY: DISTRIBUTION OF STUDENTS BY COLLEGE AND CLASSIFICATION

College	Classification	Number	Approximate Per Cent of Grand Total
Arts and Sciences	Freshman	70	
	Sophomore	17	
	Junior	9	
	Senior	1	
Total		97	56%
Education	Freshman	39	
	Sophomore	2	
	Junior	3	
	Senior	0	
Total		44	25%
Business	Freshman	15	
	Sophomore	0	
	Junior	1	
	Senior	0	
Total		16	9%
Home Economics	Freshman	7	
	Sophomore	7	
	Junior	1	
	Senior	1	
Total		16	9%
Engineering	Freshman	1	
	Sophomore	0	
	Junior	0	
	Senior	0	
Total		1	< 1%
Grand Total		174	

TABLE II

DISTRIBUTION BY CLASSES

Classification	Number	Approximate Per Cent
Freshman	132	76%
Sophomore	26	15%
Junior	14	8%
Senior	2	1%
Total	174	

made to match the groups according to meeting time during the day and during the week but this was thought to be not too important with a pilot study.

The samples for the pilot study consisted of twenty-five students from the combined experimental groups and twenty-five from the combined control groups. The selection of the students to be included in the sample was done through the use of a table of random numbers (31). The samples thus included fifty of the 150 students who made up the population for this preliminary study.

The Principal Study Population and Samples

The principal study which was conducted during the second semester, 1965-66, included all students enrolled in Biological Sciences 114 but, as with the pilot study, only those who were absent from fewer than thirty per cent of the laboratory sessions were included in the population. Tables III and IV show the distribution of students according to college and classification. The total enrollment of 693 was accomodated in twenty-four laboratory sections which were taught by five instructors. The table of random numbers (31) was used for the assignment of twelve sections to the experimental group with the remaining twelve becoming the control group. Table V shows the arrangement of sections, whether experimental or control, the instructor (by number), and the number of students enrolled in each section at the end of the second week.

Of the 693 students enrolled, 563 (81%) met the requirements of seventy per cent attendance and were included in the population to be sampled. Two hundred seventy-nine were in the experimental group and 284 in the control group. Taking advantage of the table of random numbers

TABLE III

THE PRINCIPAL STUDY: DISTRIBUTION OF STUDENTS BY COLLEGE AND CLASSIFICATION

College	Classification	Number	Approximate Per Cent of Grand Total
Arts and Sciences	Freshman	223	
	Sophomore	57	
	Junior	18	
	Senior	8	
Total		306	44.2%
Education	Freshman	80	
	Sophomore	12	
	Junior	20	
	Senior	6	
Total		118	17.0%
Business	Freshman	113	
	Sophomore	14	
	Junior	6	
	Senior	2	
Total		135	19.5%
Home Economics	Freshman	88	
	Sophomore	21	
	Junior	9	
	Senior	3	
	Special	1	
Total		122	17.5%
Engineering	Freshman	0	
	Sophomore	3	
	Junior	2	
	Senior	1	
Total		6	0.9%
Technical Institute	Freshman	0	
	Sophomore	2	
Total		2	0.3%
Unclassified		4	
Total		4	0.6%
Grand Total		693	100.0%

(31), samples of 100 were drawn from the experimental group and from the control group.

TABLE IV

THE PRINCIPAL STUDY: DISTRIBUTION BY CLASSES

Classification	Number	Approximate Per Cent
Freshman	504	72.6%
Sophomore	109	15.8%
Junior	55	8.0%
Senior	20	2.9%
Special and Unclassified	5	0.7%
Total	693	100.0%

TABLE V

THE PRINCIPAL STUDY: LABORATORY SECTIONS,
EXPERIMENTAL OR CONTROL,
INSTRUCTOR'S NUMBER,
AND ENROLLMENT

	7:30-9:30	9:30-11:30	11:30-1:30	1:30-3:30	3:30-5:30
Mon.	Exp. Instr. 5 Enr. 29	Contr. Instr. 3 Enr. 26	Exp. Instr. 3 Enr. 31	Contr. Instr. 5 Enr. 35	Contr. Instr. 4 Enr. 29
Tue.	Exp. Instr. 1 Enr. 29	Exp. Instr. 5 Enr. 31	Contr. Instr. 2 Enr. 28	Contr. Instr. 4 Enr. 30	Exp. Instr. 1 Enr. 29
Wed.	Contr. Instr. 5 Enr. 27	Exp. Instr. 3 Enr. 27	Contr. Instr. 3 Enr. 24	Exp. Instr. 4 Enr. 32	Exp. Instr. 2 Enr. 29
Thu.	Contr. Instr. 1 Enr. 27	Exp. Instr. 5 Enr. 29	Contr. Instr. 2 Enr. 29	Contr. Instr. 4 Enr. 31	Contr. Instr. 1 Enr. 28
Fri.	Exp. Instr. 2 Enr. 25	Contr. Instr. 2 Enr. 28	Exp. Instr. 3 Enr. 28	Exp. Instr. 1 Enr. 25	

An examination of the samples was made to determine how closely the percentages, by college and classification, matched the percentages calculated for the original enrollment. The close correlation was taken to imply that the sample was representative of the population. Table VI and VII show the comparative data.

TABLE VI

THE PRINCIPAL STUDY: COMPARISON BY COLLEGE OF ENROLLMENT OF THE POPULATION WITH THE SAMPLES

	Population		Experimental		Control	
College	Number	Per Cent	Number	Per Cent	Number	Per Cent
A. & S.	306	44.2%	43	43.0%	41	41.0%
Educ.	118	17.0%	15	15.0%	21	21.0%
Bus.	135	19.5%	21	21.0%	21	21.0%
Home Ec.	122	17.5%	19	19.0%	17	17.0%
Engin.	6	0.9%	1	1.0%	0	0.0%
Tech. Inst.	2	0.3%	1	1.0%	0	0.0%
Unclassified	4	0.6%	0	0.0%	0	0.0%
Total	693	100.0%	100	100.0%	100	100.0%

TABLE VII

THE PRINCIPAL STUDY: COMPARISON BY CLASSIFICATION OF THE POPULATION WITH THE SAMPLES

	Population		Experimental		Control	
Classification	Number	Per Cent	Number	Per Cent	Number	Per Cent
Freshman	504	72.6%	69	69.0%	72	72.0%
Sophomore	109	15.8%	21	21.0%	18	18.0%
Junior	55	8.0%	7	7.0%	8	8.0%
Senior	20	2.9%	3	3.0%	2	2.0%
Special and Unclassified	5	0.7%	0	0.0%	0	0.0%
Total	693	100.0%	100	100.0%	100	100.0%

The Slides

Ten tape-slide presentations were prepared for use in the laboratory sessions of weeks two, three, four, five, six, seven, ten, eleven, twelve, and fourteen. The number of slides in each presentation varied with the fewest being eleven and the greatest being thirty-two. The average number was about twenty.

The slides were photographed with an Aires Penta-35 single-lens reflex camera with a five centimeter, f-2.8 lens. For close-up photography, Kodak Portra lenses, +2 and +3, were used singly and in combination.

The film employed in producing the slides was Eastman Kodak Company's KODACHROME II Professional Film, Type A, which has an ASA rating of forty when used with photoflood lamps. When exposed in daylight with a No. 85 filter, the speed rating of the film is twenty-five. This film was found to give excellent color rendition with either floodlight or with daylight. Processing was done by Kodak Processing Laboratory, 3131 Manor Way, Dallas, Texas.

For projection of the slides, a Kodak Carousel Projector Model 550, with Kodak Projection Zoom Ektanar lens, was utilized.

Appendix A contains the first tape-slide presentation which has as its subject the operation and care of the microscope and the method for preparing temporary mounts. Colored prints of the slides are included with the narration which accompanied each. The entire set of ten presentations may be examined by contacting the author at Odessa College, Odessa, Texas.

The Tapes

For recording and playing the tapes, a Wollensak Magnetic Tape Recorder, Model T-1500, was employed. Recordings were made on Scotch 1.5 mil recording tape at three and three-fourths inches per second. This recording speed was found to produce satisfactory fidelity with considerably less expenditure of tape during the study.

A Kodak Cavalcade Programmer, Model 1, was utilized for synchronizing the movement of the slides with the narration on the tapes. During the recording of the tapes, a high-pitched signal is recorded when the proper switch on the programmer is depressed. During play-back, the programmer detects this signal and sends an impulse to the projector causing the slide to be advanced. Rather careful adjustment of the sensitivity is required to prevent the slide mechanism being advanced by sibilant speech sounds. For the individual who enjoys electronic tinkering, the plans for a tape-slide synchronizer which can be adapted to any automatic slide projector have been presented by Todd (40).

The Presentation of the Tape-Slides

At the beginning of the laboratory period, each laboratory instructor made such introductory remarks as he deemed necessary then showed the tape-slides to the experimental groups. For control groups, the explanation of the day's exercise was done verbally accompanied by any demonstrations the instructor thought it appropriate to make. All instructors were asked, in so far as possible, not to alter their presentations with the control groups to conform to the tape-slide presentations shown to the experimental groups.

Following the tape-slide presentation, the instructor gave additional directions concerning location of equipment and supplies and special instructions for any modification, deletions, or additions to the exercises for the day.

During the remainder of the laboratory period, the instructor moved about the room, assisting students with procedures, asking and answering questions, and helping with the analysis of data.

Each instructor gave unannounced short quizzes in addition to two or three longer announced examinations during the semester but no attempt was made to study the results statistically since there was no correlation between instructors as to the time of examinations or material covered.

The Achievement Test

Testing at the end of the semester of the pilot study and again at the end of the semester of the principal study was done with an achievement test. A standardized test which satisfactorily covered the material under investigation was not found therefore a special test was designed for this study, a copy of which is shown in Appendix B. This was an objective test consisting of multiple choice and matching questions which emphasized laboratory observations and procedures. The original test consisted of one hundred questions but since some of the material was not covered in the laboratory during the first semester pilot study, ten of the questions were deleted, leaving a total of ninety.

The test was administered to 163 students in the pilot study, after which the results were subjected to item analysis. For this analysis, the papers in the top twenty-seven per cent of the scores and those in the bottom twenty-seven per cent, a total of eighty-eight papers were taken. None of the items failed to show positive discrimination but those for which $\underline{r}$ was less than .15 were discarded and those with $\underline{r}$ between .16 and .30 were rewritten in an attempt to improve upon their discriminating power.

The validity of the items was determined by having each staff member read and criticize the examination. Only minor changes were suggested and following consultation with the staff, some of the changes were incorporated into the revised test for use at the end of the principal study.

The Opinion Survey

At the end of the pilot study and again at the end of the principal study, the students who were exposed to the tape-slide presentations were asked to check a prepared evaluation sheet, a copy of which is contained in Appendix C. On this form the students were asked to rate a number of aspects of the presentations such as whether the pictures illustrated the laboratory instructions well, adequately, or poorly; if the quality of the pictures was good, average, or poor; whether the speed of narration was too fast, satisfactory, or too slow; etc. Complete anonymity was maintained in an attempt to achieve the unbiased opinions of the students. The results of the survey following the pilot study were tabulated and studied carefully for indications as to improvements and corrections which could be made prior to the employment of the tape-slide presentations in the principal study. The laboratory instructors were also asked to give suggestions for improvements which they thought should be made.

The tabulated results of the opinion survey from the pilot study and the principal study will be included in Chapter IV which is concerned with the results of the study.

The Statistical Treatment

Since some doubt existed that the data from the achievement test represented interval scaling or followed a normal distribution, it was decided that these data should be analyzed with the aid of the Mann-Whitney *U* Test. According to Siegel (37), this is one of the most powerful of the nonparametric tests and is the most useful alternative to the parametric t test.

The procedure in using the Mann-Whitney U Test as outlined by Siegel is as follows:

1. Determine the values of n_1 and n_2. n_1 equals the number of cases in the smaller group; n_2 equals the number of cases in the larger group.

2. Rank together the scores for both groups, assigning the rank of 1 to the score which is algebraically lowest. Ranks range from 1 to $N = n_1 + n_2$. Assign tied observations the average of the tied ranks.

3. Determine the value of U by applying the formula

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \qquad (1a)$$

or the formula

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2 \qquad (1b)$$

where R_1 and R_2 equal the sum of the ranks assigned to group one and two respectively. Formulas (1a) and (1b) yield different values for U, the smaller of which is the value applied in further calculations.

4. The method for determining the significance of the observed value of U depends on the size of n_2. If n_2 is larger than twenty, the probability associated with a value as extreme as the observed value of U may be determined by computing the value of z by the formula

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{(n_1)(n_2)(n_1+n_2+1)}} \qquad (2)$$

and testing this value by referring to a table of probabilities associated with values as extreme as observed values of z in the normal distribution. If the proportion of tied observations is very large or if the obtained p is very close to alpha, rather than formula (2) the following formula should be applied:

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\left(\frac{n_1 n_2}{N(N-1)}\right)\left(\frac{N^3 - N}{12}\right) - \Sigma T}} \qquad (3)$$

where $T = \frac{t^3 - t}{2}$ and t is the number of observations tied for a given rank. ΣT is found by summing the T's over all groups of tied scores.

5. If the observed value of U has an associated probability equal to or less than alpha, the null hypothesis is rejected in favor of the alternative hypothesis. For this study the value of alpha was set at the .05 level.

Summary

This chapter has listed the topics studied in lecture and laboratory sessions of Biological Sciences 114, has dealt with the population and samples of pilot and principal study, with the preparation of the slides and tapes and the method of their presentation. The achievement test and opinion survey have been discussed and the statistical method for handling the data obtained has been outlined.

Chapter IV will present the results of the pilot and principal study together with the outcome of the statistical treatment of the data.

CHAPTER IV

PRESENTATION AND ANALYSIS OF RESULTS

During the first semester of the academic year, 1965-66, a pilot study was conducted on the problem. For this study, three of six laboratory sections taught by the investigator were designated as experimental groups while the remaining three served as controls. Approximately half of the tape-slide presentations were completed in time to be used during the first semester so the study represented only a partial trial run of the entire project.

The population, according to the designation previously described, that is, those who had attended at least seventy per cent of the laboratory sessions, consisted of one hundred fifty students, of whom seventy-five were in the experimental groups and seventy-five were in the control groups.

Samples of twenty-five were drawn, using the table of random numbers (31), from the combined experimental groups and the control groups. The score obtained on the achievement test by each student included in the samples was then recorded. A table giving the sample numbers and the scores for the two groups is shown in Appendix D. The scores, ranks, and the sum of ranks for the experimental and control groups of the pilot study are also contained in Appendix D.

The sum of the ranks for the control group was found to be 597.8 and for the experimental group was 679.2. When formula 1.b is applied to these data, a U value of 352.2 is obtained which, inserted into formula 2, produces a z value of 0.7703. From Table A in Siegel's Nonparametric Statistics (37), it is found that the probability associated with values as extreme as the observed value of z is .2206 and consequently the null hypothesis cannot be rejected. It should be noted, however, that although the difference between the experimental and control groups was not statistically significant in the pilot study, there was a slight trend favoring the experimental group.

On the subjective analysis, a copy of which is contained in Appendix C, the students in the experimental groups of the pilot study were generally favorable toward the tape-slide presentations. Eighty students marked the evaluation sheet, although not all chose to mark every item. As to how well the pictures illustrated the laboratory instructions, forty-four marked "well," thirty-five marked "adequately," and one chose "poorly." Sixty thought the quality of the pictures was "good" while twenty chose "average." When asked to compare the tape-slide presentations with verbal presentations with demonstrations as a method of introducing the laboratory exercise, fifty-one thought the tape-slide method was "better," twenty-one saw "no difference," and eight checked "worse." Fifty-eight marked that the pictures made small details such as color changes in test tubes "easy to recognize," sixteen chose "no effect," and six marked "difficult to recognize." Fifty-seven said the narration on the tape was "good," twenty-two marked "adequate," and one chose "poor." Fourteen found the synchronizing signal on the tape "distracting" but sixty-six said it was "ignored." The narrator's voice was "pleasing" to forty-three, "adequate" to thirty-seven, and the speed of narration was "too fast" for thirty, "satisfactory" for fifty. Twenty-eight said they could follow the directions for the day's laboratory exercise "well," fifty could follow "partially," and two said "not at all." When asked their preference, fifty marked "more" tape-slide presentations and eighteen marked "fewer." Thirty-four recommended that tape-slide presentations be "used more," forty-two chose "used about as they were," and three marked "not used at all."

The student evaluation was studied and efforts were put forth to improve the presentations in the areas which showed the lowest acceptability. For example, an attempt was made to reduce the speed of narration without causing it to drag. Also the directions for the day's laboratory exercise in certain instances were rewritten. Thus the pilot study, while not producing statistically significant results, provided guidelines for the principal study which followed.

Results of the Principal Study

The principal study was conducted during the second semester of the academic year, 1965-66, and included all the twenty-four laboratory sections of Biological Sciences 114. The method for the arrangement of sections into experimental and control groups was described in Chapter III.

As previously described, the population included all students who had attended at least seventy per cent of the laboratory sessions and consisted of 563 persons, of whom 284 were in the control groups and 279 in the experimental groups. The names of the students in the combined experimental and combined control groups were arranged alphabetically then sequentially assigned numbers which were used in the selection of the random sample.

From each of these two groups, a sample of 100 was drawn, using the table of random numbers (31). The score obtained on the achievement test by each student included in the samples was then recorded. A table in Appendix D shows the sample numbers and the scores for the two groups. Following the procedure outlined in Chapter III, the scores for both groups were ranked together with the lowest score being assigned the rank of one and tied scores being assigned the average of the tied ranks. The scores with their assigned ranks were then recompiled into experimental and control groups and the ranks for each group were summed. Tables in Appendix D give the scores, ranks, and sums of ranks for the two groups.

The sum of the ranks for the control group was found to be 9306.0 and for the experimental group was 10794.0. When formula 1.b is applied to these data, a $\underline{U}$ value of 4256 is obtained which, inserted into formula 2, produces a $\underline{z}$ value of 1.8179. Consulting Table A in Siegel's Nonparametric Statistics (37), it is found that the probability associated with values as extreme as the observed value of $\underline{z}$ is less than .0351 and consequently the null hypothesis is rejected in favor of the alternative hypothesis at the .05 level of significance.

Using formula 3 which takes into account the tied scores, a $\underline{z}$ value of 1.819 is obtained which has a probability only slightly less than the previously calculated value. Table VIII presents the results of the statistical treatment.

The results of the subjective analysis, in which the students in the experimental sections checked the evaluation sheet, showed percentages similar to those obtained from the pilot study experimental sections. Table IX compares the responses, expressed as per cents, for the pilot

TABLE VIII

RESULTS OF STATISTICAL TREATMENT USING MANN-WHITNEY U TEST

	Pilot Study		Principal Study	
	Control	Experimental	Control	Experimental
Sum of Ranks	597.8	679.2	9306.0	10794.0
U value	352.2		4256.0	
z value	0.7703		1.8179	
p value	0.2206 not significant		0.0351 significant	

study and principal study experimental groups. Two hundred ninety-one students in the principal study population marked the evaluation sheet but, as with the pilot group, some chose not to mark every item. On the question related to how well the pictures illustrated the laboratory instructions, 182 checked "well," 107 checked "adequately," and two marked "poorly." Two hundred twenty-six thought the quality of the pictures was "good," sixty-three marked "average," and two checked "poor." Comparing verbal presentation and demonstrations with tape-slide presentations, 165 indicated that the tape-slides introduced the laboratory exercise "better," eighty-five saw "no difference," and forty thought the tape-slides "worse." Two hundred fifty-one checked that the pictures made small details such as color changes in test tubes "easy to recognize," thirty-two marked "no effect," and eight selected "difficult to recognize." The narration on the tape was rated "good" by 176, "adequate" by 106, and "poor" by nine. The synchronizing "beep" on the tape was "distracting" to forty-four but was "ignored" by 246. One hundred-four rated the narrator's voice as "pleasing," 164 checked "adequate," and, to the chagrin of

TABLE IX

STUDENT RESPONSES ON THE SUBJECTIVE ANALYSIS OF THE TAPE-SLIDE PRESENTATIONS

			Pilot Group	Principal Group
1.	Pictures illustrated the laboratory instructions	well	55.0%	62.5%
		adequately .	43.8	36.8
		poorly . . .	1.2	0.7
2.	Quality of the pictures was	good	75.0%	77.6%
		average . .	25.0	21.7
		poor		0.7
3.	Compared with verbal presentation with demonstration, the tape-slide presentation introduced the laboratory exercise	better . . .	63.5%	57.0%
		no difference.	26.0	29.3
		worse . . .	10.0	13.7
4.	The pictures made small details such as color changes in test tubes	easy to recognize . . .	72.5%	86.4%
		no effect	20.0	11.0
		difficult to recognize.	7.5	2.6
5.	The narration on the tape was	good	71.0%	60.5%
		adequate . .	27.4	36.4
		poor	1.2	3.1
6.	The synchronizing "beep" on the tape was	distracting .	17.3%	15.1%
		ignored . . .	82.7	84.9
7.	The narrator's voice was	pleasing . .	54.0%	46.0%
		adequate . .	46.0	56.5
		irritating .		7.7
8.	The speed of narration was	too fast . . .	37.6%	23.4%
		satisfactory .	62.4	72.8
		too slow . . .		3.8
9.	I was able to follow the directions for the day's laboratory exercise	well	35.0%	41.5%
		partially. .	62.4	56.4
		not at all .	2.6	2.1
10.	I would prefer to have had tape-slide presentations.	more	73.5%	66.3%
		fewer . . .	26.5	33.7

Table IX (Continued)

11.	I recommend that the tape-slide presentations be used more	43.1%	28.7%
	used about as they were . .	53.1	63.0
	not used at all . . .	3.8	8.3
12.	In general, laboratory exercises were valuable . .	30.4%	38.1%
	average . .	58.4	53.5
	valueless .	1.2	8.4
13.	The laboratory instructor was helpful	77.1%	89.0%
	moderately helpful.	21.6	9.8
	not helpful	1.3	1.2
14.	The laboratory instructor was usually well prepared. .	74.8%	86.0%
	adequately prepared . .	24.0	12.9
	usually poorly prepared .	1.3	1.1
15.	Laboratory facilities and equipment were good	21.5%	46.0%
	adequate . .	57.0	44.5
	poor	21.5	9.5
16.	The time allotted for laboratory was too long . .	37.3%	39.0%
	adequate . .	51.4	54.4
	too short .	1.3	6.6

the investigator who recorded the tapes, twenty-two rated the voice as "irritating." The speed of narration was "too fast" for sixty-eight, "satisfactory" to 212, but "too slow" for eleven. One hundred twenty-one indicated that they were able to follow the directions for the day's laboratory exercise "well," 164 checked "partially," and six marked "not at all." One hundred seventy-one indicated that they would prefer to have "more" tape-slide presentations and eighty-seven marked "fewer." When checking their recommendations concerning future use of tape-slide presentations, eighty-three recommended that they be "used more" while twenty-four recommended that they "not be used at all." One hundred eighty-three thought that they should be used "about as they were."

Summary

This chapter has been concerned with the results, statistical and subjective, of the pilot study and the principal study. The statistical analysis of the pilot study failed to show a significant difference between the control and experimental groups but did show a trend favoring the experimental group. The principal study revealed a difference favoring the experimental group which was significant at the .035 level.

Both pilot and principal study experimental groups gave favorable evaluation to the tape-slide presentations with a very small per cent recommending that they not be used at all. The laboratory instructors also stated that they thought the use of tape-slide presentations had been valuable.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine whether the use of tape-slide presentations could be demonstrated to be superior to conventional methods for introducing laboratory exercises in biological science laboratories. With this purpose in view, tape-slide presentations consisting of thirty-five millimeter color slides with a synchronized tape recording were prepared. These covered the introductory material for ten of the laboratory exercises executed in Biological Sciences 114 laboratory sessions at Oklahoma State University.

The subjects of the investigation were students enrolled in Biological Sciences 114 during the academic year, 1965-66. The first semester was devoted to a pilot study utilizing only one instructor's six laboratory sections and five of the tape-slide presentations. The principal study was carried on during the second semester and involved all twenty-four laboratory sections taught by five instructors.

For purposes of evaluation, the investigator designed an achievement test emphasizing laboratory observations and procedures and submitted it to the laboratory instructors for criticism. Any question which was thought to be invalid or slanted toward the experimental group was revised or deleted. After administration of the test to the pilot groups, the results were subjected to item analysis and all items showing weak discrimination were deleted or rewritten. The revised form was utilized for testing the students involved in the principal study.

An opinion survey was made to sound out student feelings toward the tape-slide presentations. Opinions of the laboratory instructors and senior staff members were also solicited.

Conclusions

It was not surprising to the investigator that the pilot study failed to show a statistically significant difference between experimental and control groups since only half of the tape-slide presentations were used. It should be noted, however, that there was a trend favoring the experimental group. The favorable response of the pilot study participants to the opinion survey was taken as evidence that this method of presentation is acceptable to the students.

The principal study produced a difference in favor of the experimental group which was significant at the .0351 level. From this it may be concluded that for this particular population of students in the given situation, tape-slide presentations were superior to conventional methods of introducing biological sciences laboratory exercises. Whether this conclusion may be extrapolated to include other populations of students in different situations is beyond the scope of this investigation. It is the opinion of the investigator, however, that similar results would be obtained in similar situations.

On the opinion survey, there was a tendency for the students in the principal study to rate certain items lower than did the pilot group. Two of these concerned the speed and the quality of the narration. Thirty-eight per cent of the pilot group rated the speed of narration as "too fast" and none rated it "too slow," therefore, during revision the narrator attempted to be somewhat more deliberate in delivery. When the principal study group rated this item, only twenty-three per cent checked "too fast" while four per cent marked "too slow." This reduction in speed may have been responsible for their lower rating on the quality of the narration and the narrator's voice.

The pilot study group was exposed to only five of the presentations while the principal study group saw tape-slides for ten of the twelve different laboratory exercises performed. This possibly accounts for the fact that a larger percentage of the pilot group indicated that they would prefer to have had more tape-slide presentations and recommended that they be used more.

From the laboratory instructors and senior staff members, the comments on the method were favorable. An occasional suggestion that a particular point was not adequately covered or was belabored resulted in revision when possible. The consensus of opinion was that the tape-slide method of presentation has merit and one laboratory assistant who will be working with biological sciences laboratories next semester asked about the possibility of using them with her sections.

Based upon the results of the statistical treatment of the data and upon the favorable responses in the subjective analysis, it is concluded that tape-slide presentations represent an improvement over conventional methods for introducing the laboratory exercises in biological sciences laboratories.

Recommendations

First, it is recommended that, based upon its apparent success in the present situation, the tape-slide method, with certain refinements and improvements as indicated below, be adopted for all sections of Biological Sciences 114 laboratories. Some of the pictures included in the existing presentations lack clarity and detail and should be rephotographed. A few pictures could be eliminated without damage to the continuity and in some instances, additional pictures would be an improvement. A more dependable synchronizer would also be an asset. The narration on the tapes should be revised each semester in the light of the students' success in performing the laboratory exercises.

Before completely adopting the tape-slide method in a new situation, it is recommended that a study similar to the present investigation be conducted in which the method is utilized with only part of the laboratory sections. If the tape-slide method appears to produce superior results, it may then be adopted for all sections.

One disadvantage in the use of slides is the lack of motion. While this may be partially overcome through skillful use of slides, some laboratory procedures could be demonstrated more quickly and clearly with motion pictures. With the appearance on the market of the new eight millimeter motion picture size called Super-8, it seems feasible that short film clips could be interspersed in the tape-slide presentation. Whether the instrumentation necessary to carry out such a presentation would become too unwieldy for use in the laboratory is a subject for further investigation.

The Department of the Biological Sciences of Purdue University, under the direction of Dr. Postlethwait (33), has introduced a new approach to laboratory work in freshman botany which is called an integrated experience approach to learning. It appears that tape-slide presentations could be adapted and coordinated into the program in such a way as to make a definite contribution.

Finally, the investigator would like to see tape-slide presentations tried and evaluated in other general biology, botany, or zoology laboratory situations in college or high school. It would be most interesting to see whether the results of such investigations paralleled those of this study.

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APPENDIX A

THE MICROSCOPE AND THE INTRODUCTION TO THE CELL

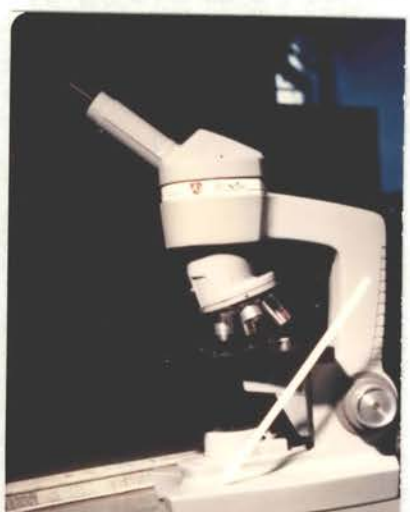
"As all of you are well aware, this is a microscope. It is called a compound microscope because it has a combination of several lenses. In its present form, it represents some 250 years of improvement and refinement on Leewenhoek's first single-lens instrument. It is ruggedly built to withstand many years of use when properly cared for but can be damaged easily by thoughtless mishandling. In order that you may not be the person responsible for one of these instruments failing to live out its useful life, here are a few hints on proper handling of the microscope.

"This is the way a microscope should be carried when moving it from the storage cabinet to your working area and back again. Notice that one hand has a firm grip on the arm of the microscope while the other hand is beneath the base. Always set the microscope down gently and avoid bumping it against cabinet walls since jarring may damage its working parts.

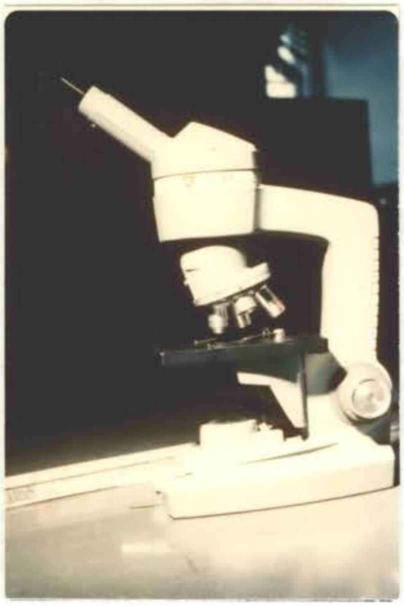
"Different manufacturers of microscopes vary the design of the instrument so the placement of some of the parts and controls may not always be the same as they are on this one. However, once you are thoroughly familiar with the operation of one type of 'scope,' you will be able to switch easily to another.

"Observe carefully as the various parts are identified.

"The light source for this microscope is a built-in electric light. Many microscopes make use of a mirror to reflect light through the condenser but since you will not be using that type, we will not take time to discuss the method for manipulating it. The light is turned on and off by depressing the switch indicated here. Should your light fail to turn on, notify your laboratory instructor.

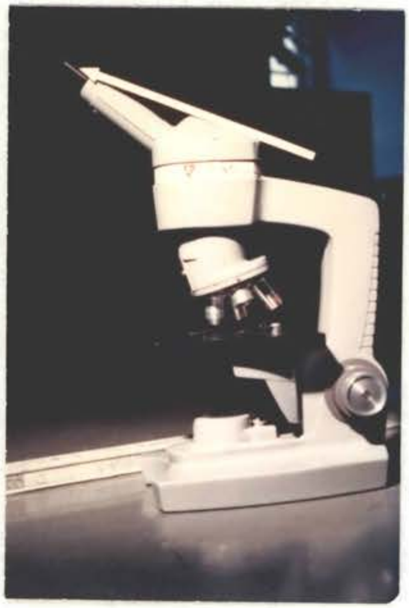


"This is the base.

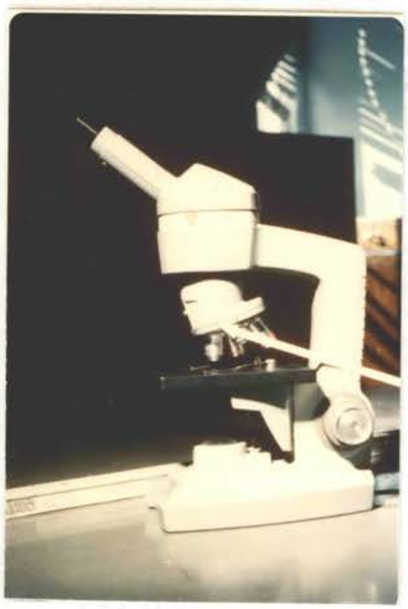


"This is the pillar.

"This is the arm.



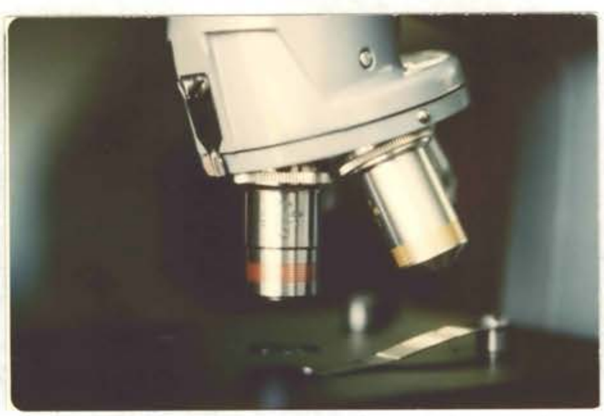
"This is the ocular or eyepiece. On this instrument, the ocular is marked 10X which means that it magnifies ten times. Other oculars may be used which magnify five times or fifteen times but the 10X is the most commonly used eyepiece. Your instruments have the oculars fastened into the tube to prevent their falling out when the microscope is moved so do not attempt to remove them.



"This is the nosepiece which allows one to change easily from one objective to another. When rotating the nosepiece to change objectives, an audible click will be heard when the objective is properly positioned.

"This is the low power objective which on this instrument is marked with green lines. As you can see, it bears the number 10X which indicates that its magnifying power is ten. When used with a 10X ocular, the total magnification is 100 diameters.

"This objective, color-coded with yellow lines, is marked 43X and is called the high power objective. When used with a 10X ocular it gives a total magnification of 430. It is occasionally referred to as the 'high-dry' to distinguish it from the oil immersion objective.



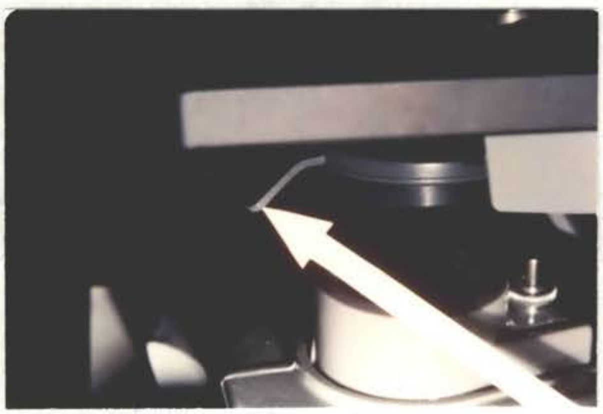
"The microscopes which you will normally use in the laboratory are not equipped with this objective but you may have occasion to use the oil immersion objective. This is marked with red lines and bears the number 97X. The magnification is thus 970 when used with a 10X eyepiece. To use this objective, a drop of special oil is placed on the slide and the objective lens is lowered into the oil. The refractive index of this oil is approximately the same as glass which results in less light being scattered outside the cone entering the objective.

"Since the working distance (that is, the distance between the objective lens and the slide) is extremely small, this objective <u>must</u> be used with great care to prevent driving the lens into the slide.

"A useful objective sometimes called a scanning lens or a low-low lens and bearing the number 4X, is used to give low magnification while allowing you to view a larger area. You will find this quite helpful when observing comparatively large objects or when searching for a particular area of a section.

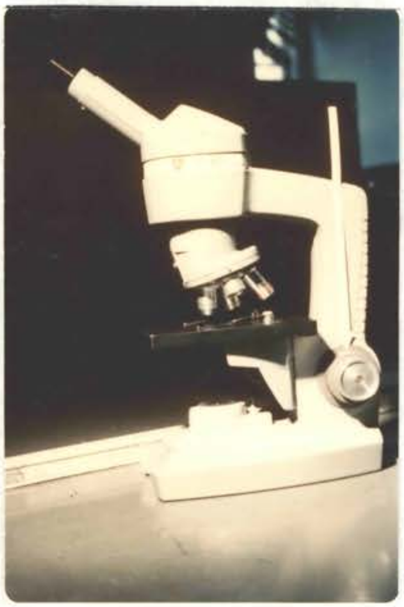
"This is called the stage. It is fitted with two stage clips for holding the slide in place. Visible through the hole in the center of the stage is one of the condenser lenses which concentrates the light on the specimen.

"The amount of light entering the condenser is controlled by this lever.



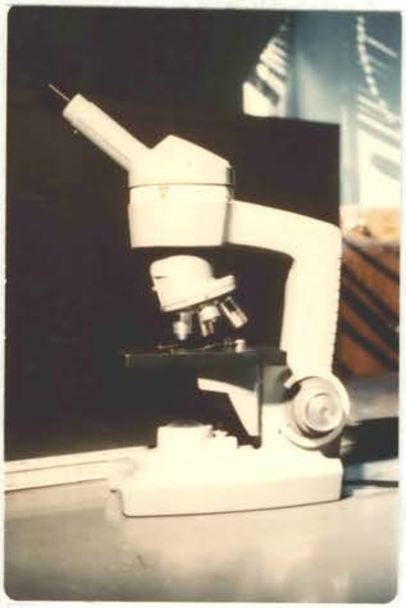
"You will need to experiment with this control since the amount of light is important to best viewing. Too much light may be as bad as too little.

"This is the sub-stage condenser which contains the iris diaphragm. The diaphragm is controlled by the lever shown in the previous picture.



"The gray outer knob is the coarse adjustment (spelled COARSE) which moves the body, nosepiece, and objectives up and down rapidly. With this particular type of microscope, it is not possible to touch the slide with the scanner or the low power objective but it is possible with the high power and the oil immersion objectives. Therefore, it is good microscope technique never to focus downward with the coarse adjustment while looking into the eyepiece.

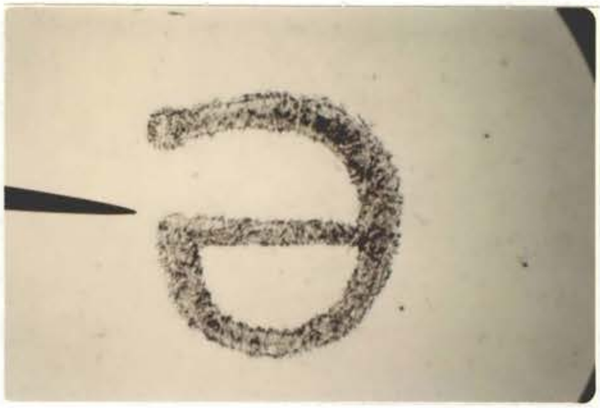
"The proper method is to rack the objective downward while watching from the side to see that it is not being driven into the slide,



"then look into the eyepiece and focus upward.

"The smaller silver-colored knob is the fine adjustment and is just what the name implies. This control allows one to make fine adjustment of the focus after the object being observed has been located and roughly focused using the coarse adjustment.

"With this introduction, you are now ready to begin using the microscope. Obtain a letter "e" slide and place it on the stage with the "e" right-side up and as near the center of the hole in the stage as you can estimate. Be sure that the slide is placed with the cover glass side up. If you have not already done so, turn on the sub-stage lamp. Using the 4X objective and following the proper technique for focusing, the entire letter "e" should be visible in the field.



"Does it still appear right-side up? Follow the instructions in your laboratory manual concerning moving the slide to determine the direction of apparent motion.

"When changing from one objective to another, the image should stay in focus or should require only minor adjustment with the fine adjustment. This is because the objectives are parfocal.

"To make a temporary preparation, or wet mount, a clean slide and cover glass should be used. Place a drop or two of water containing the specimens in the center of the slide or add the specimens to water on the slide.

"Hold the cover glass at an angle with the lower edge touching the slide.

"Lower it slowly with a dissecting needle to exclude air bubbles. Use this method when making temporary preparations of hairs and of water from Theta Pond.

"According to the cell theory, the cell is the basic structural, functional, and developmental unit of life. In this and the next laboratory periods, you will be introduced to a number of different cell types and will study some of their characteristic structural features and functions.

"The cells of onion are good examples of a type of plant cell and are easily prepared for examination. Here you see the method for removing a piece of the epidermis from the inner surface of one of the thick modified leaves which make up the bulb.

"Place a small piece of epidermis in a drop of water and tease it out flat.

"Carefully lower a cover glass on the tissue. Try to exclude air bubbles but do not apply pressure to the cover glass because this will smash the cells. The preparation is now ready to examine with the microscope.

"This is a plant which is found growing in lakes and streams and is used as a decorative and oxygenating plant in aquaria. It is called Elodea or Anacharis. The leaves of this plant are useful for study since they are made up of only two layers of cells. No special preparation is necessary because the thinness of the leaf allows light to be transmitted through it.

"Remove a young leaf near the tip of the plant.

"Mount this in a drop of water as you did the onion tissue, add a cover glass, and examine with the microscope. Observe closely the small green bodies called chloroplasts. If you watch closely, you will see the chloroplasts move. This movement is due to the moving of the cytoplasm of the cell and is called cyclosis or protoplasmic streaming."

APPENDIX B

BIOLOGICAL SCIENCES 114
FINAL LABORATORY EXAMINATION

Directions: Be sure to use electrographic pencil as the tests are machine scored. Make a heavy mark between the lines under the number.

Note: There may be more than one correct answer on some questions.

1. The objective of your microscope which is called the high power is marked (1) 5X (2) 10X (3) 43X (4) 97X.

2. If one were using a 15X ocular with the low power of your microscope, the total magnification would be (1) 60X (2) 150X (3) 545X (4) 1445X.

3. Correct microscope technique dictates that, while looking into the eyepiece and using the coarse adjustment, one should focus (1) upward (2) downward (3) either way.

4. The leaves of Elodea were used for cellular study because (1) the nucleus is always in the center of the cell (2) the vacuoles contain phycocyanin (3) the chromosomes are unusually large (4) the leaf is only two cells thick.

5. The movement of protoplasm within a living cell is called (1) pyarthosis (2) translocation (3) cyclosis (4) nucleolus.

6. A structure characteristically found in most plant cells but lacking in animal cells is (1) Golgi complex (2) cell wall (3) mitochondria (4) asteral rays.

7. Deeply staining, threadlike structures visible in the nucleus of dividing cells are (1) cytosomes (2) chromosomes (3) karyosomes (4) neutrosomes.

8. Cambium cells belong to a cell type called (1) parenchyma (2) meristematic (3) collenchyma (4) sclerenchyma.

9. Tracheids and vessels are cell types associated with (1) xylem (2) phloem (3) pith (4) epidermis.

10. The rate of diffusion depends upon which of these? (1) particle size (2) concentration of diffusing particles (3) permeability of the medium of dispersal (4) none of these.

11. In diffusion through air, how does the rate of diffusion of ammonium ions compare with that of chloride ions? (1) same (2) ammonium ions diffuse about twice as fast as chloride ions (3) chloride ions diffuse about twice as fast as ammonium ions (4) none of these.

12. A differentially permeable membrane bag is filled with 40% sugar solution after which the open end is attached to a rubber stopper through which a long glass tube is inserted. When the bag is lowered into water, the liquid inside the tube (1) rises (2) falls (3) stays the same (4) turns blue.

13. To determine whether light is necessary for photosynthesis, we covered part of a leaf for several days, then removed the leaf, extracted its chlorophyll, and tested it for the presence of (1) sugar (2) fat (3) starch (4) protein.

14. We used the process called paper strip chromatography to (1) test for starch (2) color a manometer (3) separate plant pigments (4) isolate protozoa.

15. Which of the following is <u>not</u> one of the pigments found in green leaves? (1) xanthophyll (2) melanin (3) chlorophyll a (4) chlorophyll b (5) carotene.

16. Chemically, digestion is a process of (1) dialysis (2) hydrolysis (3) autolysis (4) hemolysis.

17. An enzyme (1) acts as a catalyst (2) is used up in the reaction (3) is a complex carbohydrate molecule (4) catalyzes a reaction in one direction only.

18. Boiling has which of these effects on enzyme activity? (1) increases the activity (2) decreases the activity (3) destroys the activity (4) none of these.

19. An intermediate breakdown product in the digestion of starch to maltose is (1) glycogen (2) glucose (3) dextrin (4) deoxyribose.

20. When enxymes are diluted they (1) cease to function (2) function at a slower rate (3) function at an unaltered rate (4) are altered in structure.

21. During anaerobic respiration in muscle tissue (1) alcohol (2) carbon dioxide (3) water (4) lactic acid (5) citric acid is formed.

22. In aerobic respiration about (1) 5 (2) 15 (3) 25 (4) 45 (5) 65 times as much energy is released as in anaerobic respiration.

23. One product common to both aerobic respiration and fermentation is (1) water (2) simple sugar (3) alcohol (4) lactic acid (5) carbon dioxide.

24. Which of the following factors affect the transpiration rate in plants? (1) temperature (2) light intensity (3) humidity (4) none of these.

25. The blind spot in the eye is located at the entrance of the (1) optic muscle (2) optic nerve (3) optic artery (4) ciliary muscle (5) ciliary nerve.

26. Meiosis differs from mitosis in that during meiosis the chromosome number is (1) unchanged (2) doubled (3) halved (4) tripled.

27. Albinism in plants is (1) unimportant (2) lethal (3) sex-linked (4) unknown.

28. When the blood donor and recipient belong to the same group and any possibility of additional adverse reactions have been eliminated by "cross-matching," they are said to be (1) homozygous (2) phenotypic (3) heterozygous (4) compatible.

29. The appearance of an organism with respect to a particular trait is its (1) genotype (2) phenotype (3) prototype (4) linotype.

30. A tall pea plant is crossed with a dwarf plant. If the offspring are half tall and half dwarf, the genotype of the tall parent was (1) heterozygous (2) homozygous (3) impossible to determine.

31. Hemophilia and color-blindness are (sex-influenced (2) non-hereditary (3) sex-linked (4) autosomal.

32. If two individuals, each having the genotype AaBb are crossed, the expected ratio of the offspring is (1) 2:1 (2) 1:1 (3) 3:1 (4) 9:3:3:1 (5) 9:7.

33. Assume red color (R) in four-o'clock to be incompletely dominant to white (r). A pink flower would have the genotype (1) RR (2) Rr (3) rr.

34. A white flower would have the genotype (1) RR (2) Rr (3) rr.

35. A plant producing pink flowers is crossed with one producing white flowers. The possible genotypes of the offspring would be (1) RR only (2) Rr only (3) rr only (4) RR and rr only (5) RR and Rr only (6) Rr and rr only (7) RR, Rr, and rr.

36. The ratio of the phenotypes of the offspring would be (1) all red (2) all white (3) all pink (4) 3 red to 1 white (5) 1 red, 2 pink, 1 white (6) 3 white to 1 red (7) 1 pink to 1 white.

37. In sweet peas, the dominant gene, C, produces a colorless color base called chromogen and the dominant gene, E, produces an enzyme which acts upon the chromogen to produce a color. Mark all of the following genetic combinations which would produce colored flowers. (1) CCEE (2) CCEe (3) CCee (4) CcEE (5) CcEe (6) Ccee (7) ccEE (8) ccEe (9) ccee.

38. A man whose blood type is A has a genotype of AO. His wife is type B with genotype BO. Mark all the possible blood types of their children. (1) A (2) B (3) AB (4) O.

39. Most animals have (1) open (2) closed growth.

40. The uppermost part of a frog's egg as it floats in water is the (1) animal pole (2) vegital pole (3) vegetable pole (4) animate pole.

41. First cleavage of a frog's egg occurs in (1) a horizontal (2) a vertical (3) either plane.

42. In embryonic development, the hollow ball stage is the (1) cleavage (2) morula (3) blastula (4) gastrula (5) neurula.

43. An archenteron is present in the (1) cleavage (2) morula (3) blastula (4) gastrula.

44. During prophase of meiosis I, homologous chromosomes come to lie adjacent to each other. This phenomenon is called (1) chiasma (2) gametogenesis (3) maturation (4) synapsis.

45. In the chicken embryo, the vessels which carry food material from the yolk to the embryo are called (1) placental veins (2) umbilical veins (3) vitelline veins (4) chorionic veins.

46. On the basis of our observations in the laboratory, the best estimate of the number of stomata per square inch of Rhoeo leaf would be (1) 5-10 (2) 50-100 (3) 500-1,000 (4) 5,000-10,000 (5) 50,000-100,000.

47. Air is composed of approximately (1) 52% (2) 68% (3) 79% (4) 88% nitrogen gas.

48. Oxygen makes up about (1) 5% (2) 10% (3) 20% (4) 40% of the air.

49. The source of oxygen released during photosynthesis is (1) water (2) carbon dioxide (3) chlorophyll (4) radiant energy (5) sugar.

50. The carbon source for the process of photosynthesis is (1) water (2) carbon dioxide (3) chlorophyll (4) radiant energy (5) sugar.

51. Most of the water lost from plants by transpiration escapes from the (1) stem (2) upper surface of the leaf (3) lower surface of the leaf (4) root.

52. Human erythrocytes differ from frog erythrocytes in that they contain (1) hemoglobin (2) phycocyanin (3) no nucleus (4) oxyhemoglobin.

Match by marking in the proper blank the number corresponding to your choice of the answers on the left.

53.	Contains chlorophyll	1.	leucoplast
		2.	chloroplast
54.	May contain various colors	3.	myeloplast
		4.	cytoplast
55.	Thought to be storage depot for starch	5.	chromoplast

Match the terms on the right with the statements on the left.

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

56. The two members of the previously doubled chromosomes separate, one moving toward one side of the cell, the other toward the opposite side.

57. The chromosomes become distinguishable in the nucleus, the nuclear membrane breaks down, and the chromosomes become distributed haphazardly throughout the cytoplasm.

58. If the process is occurring in a plant cell, a cell plate starts to form across the center of the cell.

59. The chromosomes arrange themselves near the center of the cell.

Choose the term on the right which describes the solution in which the cell is when it behaves as described on the left.

60.	A red blood cell bursts	1.	Hypertonic
		2.	Hypotonic
61.	A red blood cell becomes crenated	3.	Isotonic
62.	A cell neither shrinks nor bursts		
63.	The protoplasm of a plant cell shrinks away from the cell wall		

Match the terms on the right with the statement on the left. Terms on the right may be used more than once.

64.	Reagent used for fat test	1.	Biuret
		2.	Iodine solution
65.	Reagent used for polypeptide test	3.	Sudan IV
		4.	Benedict's
66.	Reagent used for protein test		
67.	Reagent used for starch test		
68.	Reagent used for reducing sugar test		

Match the color on the right with the substance for which it is the positive test.

69. Starch
70. Protein
71. Polypeptide
72. Fat
73. Reducing sugar

1. violet
2. dark blue
3. brick-red
4. purple or pink
5. red ring

Choose the number corresponding to the term which fits in each blank.

Blood enters the heart from the _(74)_ which returns blood from the systemic circulation. The first chamber of the heart which the blood enters is the _(75)_. From there it passes through the _(76)_ valve to the chamber called the _(77)_. Leaving this chamber, the blood passes through the _(78)_ valve into the _(79)_ which carries the blood to the lungs. Returning to the heart from the lungs, blood is carried in the _(80)_ to the _(81)_. It passes from this chamber through the _(82)_ valve to the _(83)_ from which, after going through the _(84)_ valve, it enters the major vessel leaving the heart, the _(85)_.

1. tricuspid valve
2. pulmonary semilunar valve
3. aortal semilunar valve
4. vena cava
5. pulmonary vein
6. pulmonary artery
7. aorta
8. right auricle
9. left auricle
10. right ventricle
11. left ventricle
12. bicuspid valve

From which of the primary germ layers listed on the right does each of the tissues or organs on the left originate?

86. epidermis
87. brain
88. muscle
89. lining of stomach
90. bone

1. ectoderm
2. mesoderm
3. endoderm

APPENDIX C

BIOLOGICAL SCIENCES LABORATORY EVALUATION

Concerning the tape-slide presentations:

1. Pictures illustrated the laboratory instructions
   well_____
   adequately _____
   poorly _____

2. Quality of the pictures was
   good _____
   average _____
   poor _____

3. Compared to verbal presentation with demonstration, the tape-slide presentation introduced the laboratory exercise
   better _____
   no difference _____
   worse _____

4. The pictures made small details such as color changes in test tubes
   easy to recognize _____
   no effect _____
   difficult to recognize _____

5. The narration on the tape was
   good _____
   adequate _____
   poor _____

6. The cynchronizing "beep" on the tape was
   distracting _____
   ignored _____

7. The narrator's voice was
   pleasing _____
   adequate _____
   irritating _____

8. The speed of narration was
   too fast _____
   satisfactory _____
   too slow _____

9. I was able to follow the directions for the day's laboratory exercise
   well _____ not at all _____
   partially _____

10. I would prefer to have had
    more _____
    fewer _____ tape-slide presentations

11. I recommend that the tape-slide presentations be
    used more _____
    used about as they were _____
    not used at all _____

Concerning the laboratory:

1. In general, laboratory exercises were
   valuable _____
   average _____
   valueless _____

2. The laboratory instructor was
   helpful _____
   moderately helpful _____
   not helpful _____

3. The laboratory instructor was
   usually well prepared _____
   adequately prepared _____
   usually poorly prepared _____

4. Laboratory facilities and equipment were
   good _____
   adequate _____
   poor _____

5. The time allotted for laboratory was
   too long _____
   adequate _____
   too short _____

APPENDIX D

THE PILOT STUDY SAMPLE NUMBERS
ARRANGED NUMBERICALLY WITH
THE SCORE FOR EACH

Experimental Number	Experimental Score	Control Number	Control Score
1	63	1	59
3	42	3	53
6	54	6	71
7	64	12	65
8	51	14	43
15	42	15	46
16	51	16	58
18	63	18	49
20	66	20	51
22	51	23	58
24	70	26	47
29	69	29	45
31	50	30	64
36	60	33	54
38	50	34	69
41	59	35	66
47	58	36	58
50	63	38	49
59	49	39	63
66	59	50	59
67	73	51	43
70	61	60	47
71	50	61	56
74	51	62	54
80	59	71	60

SCORES, RANKS, AND SUM OF RANKS FOR
EXPERIMENTAL AND CONTROL GROUPS
OF THE PILOT STUDY

Experimental Score	Experimental Rank	Control Score	Control Rank
42	1.5	43	3.5
42	1.5	43	3.5
49	10.0	45	5.0
50	13.0	46	6.0
50	13.0	47	7.5
50	13.0	47	7.5
51	17.0	49	10.0
51	17.0	49	10.0
51	17.0	51	17.0
51	17.0	53	20.0
54	22.0	54	22.0
58	26.5	54	22.0
59	31.4	56	24.0
59	31.4	58	26.5
59	31.4	58	26.5
60	34.5	58	26.5
61	36.0	59	31.4
63	38.5	59	31.4
63	38.5	60	34.5
63	38.5	63	38.5
64	41.5	64	41.5
66	44.5	65	43.0
69	46.5	66	44.5
70	48.0	69	46.5
73	50.0	71	49.0
	R_1=679.2		R_2=597.8

THE PRINCIPAL STUDY SAMPLE NUMBERS
ARRANGED NUMERICALLY WITH
THE SCORE FOR EACH

Experimental						Control					
No.	Score	No.	Score	No.	Score	No.	Score	No.	Score	No.	Score
005	65	100	61	189	79	006	51	112	86	199	67
006	66	101	67	190	73	009	90	113	55	200	50
009	78	105	51	197	57	010	71	117	48	202	85
012	52	108	92	204	85	011	77	121	33	203	71
028	86	109	59	208	57	012	75	124	65	204	75
032	86	116	78	214	63	016	66	126	74	207	76
034	77	121	79	215	88	019	67	129	65	218	56
035	81	123	79	219	68	020	39	131	60	220	65
041	72	126	61	223	62	026	78	135	78	221	35
043	56	131	67	224	56	031	75	139	40	222	58
047	70	137	84	225	79	032	62	140	63	226	52
049	34	138	48	231	68	035	66	141	91	230	77
051	48	139	73	235	68	037	67	142	62	231	65
053	74	140	76	237	52	045	73	144	63	232	61
054	64	142	86	242	71	049	73	146	90	234	47
056	74	144	60	243	73	050	62	151	91	236	78
058	58	145	54	244	58	061	84	153	60	240	91
061	82	148	87	245	80	062	57	154	47	242	52
062	66	151	83	249	51	064	67	156	69	248	43
064	73	152	69	251	63	075	77	158	90	252	56
068	61	153	54	252	79	076	84	163	71	254	75
072	57	156	53	254	77	077	79	164	51	257	41
078	65	164	63	257	39	081	57	165	67	262	88
080	88	168	71	261	56	087	73	168	68	263	49
084	60	169	78	263	93	092	78	174	81	264	54
085	76	170	84	265	69	093	77	176	58	266	78
088	79	171	61	268	84	094	71	177	50	267	49
089	55	172	79	270	92	099	56	178	81	270	57
091	84	176	87	271	77	101	58	180	48	278	71
092	55	177	78	272	66	102	66	184	62	281	46
097	65	183	68	273	69	103	78	185	50	283	69
098	78	184	42	274	68	104	63	186	59	288	56
099	43	188	65	276	74	105	73	192	61	290	62
				284	69					292	75

SCORES, RANKS, AND SUM OF RANKS
FOR THE EXPERIMENTAL GROUP
OF THE PRINCIPAL STUDY

Score	Rank	Score	Rank	Score	Rank
34	2.0	63	76.5	77	146.0
39	4.5	64	80.0	77	146.0
42	8.0	65	84.5	77	146.0
43	9.5	65	84.5	78	155.0
48	15.5	65	84.5	78	155.0
48	15.5	65	84.5	78	155.0
51	24.5	66	91.5	78	155.0
51	24.5	66	91.5	78	155.0
52	28.5	66	91.5	79	164.5
52	28.5	67	98.0	79	164.5
53	31.0	67	98.0	79	164.5
54	33.0	68	104.5	79	164.5
54	33.0	68	104.5	79	164.5
55	36.0	68	104.5	79	164.5
55	36.0	68	104.5	79	164.5
56	41.0	68	104.5	80	169.0
56	41.0	69	110.5	81	171.0
56	41.0	69	110.5	82	173.0
57	47.5	69	110.5	83	174.0
57	47.5	69	110.5	84	177.5
57	47.5	70	114.0	84	177.5
58	53.0	71	118.0	84	177.5
58	53.0	71	118.0	84	177.5
59	56.5	72	122.0	85	181.5
60	59.5	73	126.5	86	184.5
60	59.5	73	126.5	86	184.5
61	64.5	73	126.5	86	184.5
61	64.5	73	126.5	87	187.5
61	64.5	74	132.5	87	187.5
61	64.5	74	132.5	88	190.0
62	70.5	74	132.5	88	190.0
63	76.5	76	141.0	92	198.5
63	76.5	76	141.0	92	198.5
				93	200.0
				Sum of Ranks	10794.0

SCORES, RANKS, AND SUM OF RANKS
FOR THE CONTROL GROUP OF
THE PRINCIPAL STUDY

Score	Rank	Score	Rank	Score	Rank
33	1.0	60	59.5	73	126.5
35	3.0	60	59.5	73	126.5
39	4.5	61	64.5	73	126.5
40	6.0	61	64.5	74	132.5
41	7.0	62	70.5	75	137.0
43	9.5	62	70.5	75	137.0
46	11.0	62	70.5	75	137.0
47	12.5	62	70.5	75	137.0
47	12.5	62	70.5	75	137.0
48	15.5	63	76.5	76	141.0
48	15.5	63	76.5	77	146.0
49	18.5	63	76.5	77	146.0
49	18.5	65	84.5	77	146.0
50	21.0	65	84.5	77	146.0
50	21.0	65	84.5	78	155.0
50	21.0	65	84.5	78	155.0
51	24.5	66	91.5	78	155.0
51	24.5	66	91.5	78	155.0
52	28.5	66	91.5	78	155.0
52	28.5	67	98.0	78	155.0
54	33.0	67	98.0	79	164.5
55	36.0	67	98.0	81	171.0
56	41.0	67	98.0	81	171.0
56	41.0	67	98.0	84	177.5
56	41.0	68	104.5	84	177.5
56	41.0	69	110.5	85	181.5
57	47.5	69	110.5	86	184.5
57	47.5	71	118.0	88	190.0
57	47.5	71	118.0	90	193.0
58	53.0	71	118.0	90	193.0
58	53.0	71	118.0	90	193.0
58	53.0	71	118.0	91	196.0
59	56.5	73	126.5	91	196.0
				91	196.0
				Sum of Ranks	9306.0

VITA

Lyle Keith Requa

Candidate for the Degree of

Doctor of Education

Thesis: AN ANALYSIS OF TWO METHODS OF TEACHING BIOLOGICAL SCIENCES LABORATORY

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Education: Attended grade school in Newberg, Missouri; Buffalo, Missouri; and Mt. Vernon, Missouri; graduated from Marionville, Missouri High School in 1934; received the degree of Bachelor of Arts from Park College in 1938 and the degree of Bachelor of Science in Education from Southwest Missouri State College in 1940. Graduate study in Zoology summers 1949-1954, University of Southern California. Received the degree of Master of Science from Oklahoma State University in 1957.

Professional Experience: Taught high school science in Glasgow, Missouri, prior to service in the United States Navy from 1943 to 1946. Following military service, taught science in high school in Jal, New Mexico, until 1956 and from 1957 to 1962. Taught Biology at Odessa College, Odessa, Texas, until 1964.

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