THE EFFECTIVENESS OF USING FILMED COURSES IN PHYSICS AND CHEMISTRY IN ADDITION TO THE TRADITIONAL LECTURE-LABORATORY COURSES IN HIGH SCHOOL

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DISSERTATION

Presented to the Graduate Council of the
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CHAPTER I

INTRODUCTION

In the summer of 1960 the Big Spring, Texas, Independent School District, in conjunction with some of the smaller schools in its immediate area, purchased a filmed physics course and a filmed chemistry course at a combined cost of approximately $27,000. Purchase of these filmed science courses by the Big Spring Schools was part of their concentrated effort to improve the existing science program.

In Big Spring Senior High School the films were scheduled as supplements to the regular lecture-laboratory courses at a period before the usual beginning of the school day and at a noon period. The three science teachers who were connected with the project were each given an additional stipend of approximately $100 per month to preview the films and to show them at the pre-school and at the noon periods each day.

Since the films' total cost of almost $30,000 represented a considerable monetary investment, and since both students and teachers were spending a great deal of time in these courses, it was recognized that there existed a

need to determine the effectiveness of the filmed courses when used in this supplementary manner. The present study was made to meet this need.

Statement of the Problem

The problem of this study was to determine the effectiveness of using filmed courses in physics and chemistry in addition to the traditional lecture-laboratory courses in high school.

Definition of Terms

1. The Harvey White Course refers to the filmed physics course produced by Encyclopaedia Britannica Films and taught by Harvey White, consisting of 162 thirty-minute films.

2. The John Baxter Course refers to the filmed chemistry course produced by Encyclopaedia Britannica Films and taught by John Baxter, consisting of 160 thirty-minute films.

3. The Lecture-Laboratory Course refers to the science course taught in the traditional manner.

4. The Experimental Group refers to that group of students who were taught by both the filmed course and the lecture-laboratory course.

5. The Control Group refers to that group of students who were taught only by the lecture-laboratory method.

6. S.T.E.P.--Science refers to the science section of the Sequential Tests of Educational Progress.

7. P.S.S.C. Test refers to the Physical Science Study Committee Achievement Test in Physics.

8. Otis Test refers to the Otis Quick-Scoring Test of Mental Ability.

9. Otis I.Q. is used to designate the intelligence quotients for particular students as derived from their performance on the Otis Quick-Scoring Test of Mental Ability.

10. A.C.S.--N.S.T.A. Test refers to the American Chemical Society--National Science Teachers Association High School Chemistry Test-Form 1959.

11. A.I.R. Test refers to the physics achievement test designed by Educational Testing Service for the American Institute for Research.

12. Lecture-Demonstration Film refers to a film in which the lecture is illustrated with demonstrations by the instructor.

13. Laboratory-Practical Film is a film in which the laboratory experiment is the main feature with comment and guidance by the instructor.

Hypotheses--Physics Experiment

1. A group of students who have completed both the filmed course in physics and the lecture-laboratory course

in physics will show no significant difference in gain in knowledge of the facts and principles of that science when compared with a group of students who have completed only the lecture-laboratory course in physics.

2. A group of students who have completed both the filmed course in physics and the lecture-laboratory course in physics will show no significant difference in problem-solving ability in that science when compared with a group of students who have completed only the lecture-laboratory course in physics.

Sub-hypotheses--Physics Experiment

1. There will be no significant differences between the gain-scores obtained by the control group and by the experimental group on Part I of the P.S.S.C. Test as measured by a test in September and a retest in February.

2. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on Part II of the P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

3. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on Part I of the P.S.S.C. Test as measured by a test-retest at the beginning and at the conclusion of the experiment.

4. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the total P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

5. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Electricity I section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

6. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Electricity II section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

7. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Light I section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

8. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Light II section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

9. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Atomics section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

10. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Electronics section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

11. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the total A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

Hypothesis--Chemistry Experiment

A group of students who have completed both the filmed course in chemistry and the lecture-laboratory course in chemistry will show no significant difference in gain of knowledge of the facts and principles of that science when compared with a group of students who have completed only the lecture-laboratory course in chemistry.

Sub-hypothesis--Chemistry Experiment

There will be no significant difference between the gain-scores obtained by the control group and by the

experimental group on the American Chemical Society--National Science Teachers Association--High School Chemistry Test-Form 1959 as measured by test-retest at the beginning and at the conclusion of the experiment.

Limitations of the Study

This study was limited to the measuring of the effectiveness of the films in question through comparison of gains in knowledge of the facts and principles of physics and chemistry as measured by certain achievement tests and through comparison of the gains in ability to apply that knowledge in problem solving. No attempt was made to measure changes in attitude which may have resulted from use of the film courses.

Basic Assumptions

1. It was assumed that the instruments used for matching the control and experimental groups and the instruments used for measuring gain in knowledge and gain in problem solving ability were valid for their stated purpose.

2. It was assumed that the matching of pairs of students having the same teacher eliminated any difference in teaching effect which might have influenced the results of the study.

3. It was assumed that those students in the control groups and those students in the experimental groups were equally motivated.

Background and Significance

Authorities have written concerning the need for continuing evaluation of audio-visual materials. Many have specifically called for carefully controlled experiments in this area.

In 1949 Bentley stated, "If we are to secure audio-visual aids that actually enhance learning, careful experimental studies should be made, testing their value before they are made available for instructional purposes in the classroom"(2, p. 381).

In a surprisingly similar statement also in 1949 Johnson concurred with Bentley by stating, "If we are to secure audio-visual aids which actually enhance learning, careful experimental studies should be made testing the claims made for them before they are made available for instructional purposes"(6, p. 372).

Rainey in 1951 stated at the Third Stephens College Conference on the Effective Utilization of Audio-Visual Materials in College Teaching that he could detect a determination on the part of educators and educational institutions across the country to find out what there was of value and how they might more effectively use educational films for the improvement of instruction and the communication of ideas (3, p. 1).

In 1953 writing on needed research in audio-visual methods, Wittich (11, pp. 99-105) stated that the greatest

necessity was to conduct searching, validly structured studies in the role of audio-visual materials as they may be effectively used to accomplish long recognized objectives in traditional subject matter areas. In one of a number of specific recommendations for needed research, Wittich cited a pressing need for experiments which would determine to what extent retention and assimilation of facts and concepts in botany, chemistry, and physics are assisted or impeded when motivated by selected educational sound films as a supplement to traditional methods.

In 1957 Miller (7) concluded that most films were evaluated simply by having "experts" look at them. Emphasizing the point that the fate of large investments depends on the decisions of the "experts"--decisions in which there is no check of validity, he stated that quite possibly the "experts" were making wrong decisions and wasting much money. It was Miller's recommendation that the judgment of the "experts" be validated against factual data on the actual teaching value of the film or film episode (7, p. 12).

The need for careful experimental evaluation of all educational films cited by the above mentioned educators has been emphasized and made more pressing by the rapid growth of school populations coupled with the belief of some educational leaders that greater use of films is one means of meeting the crisis of many students, few teachers, and expanding curricula.

In no area has the need received greater attention than in science. The successful launching of the first Russian satellite in October, 1957, precipitated an urgent demand from almost all segments of the population of the United States for increased resources and effectiveness in the field of science teaching. It was generally recognized that there existed in this country an acute shortage of science teachers and that the science teachers then available were quite often inadequately prepared to do an effective job in the teaching of the more advanced sciences.

In an effort to find some solution for the pressing problems of science teacher shortage and inadequacy of science teacher preparation, the Fund for the Advancement of Education began a study of the feasibility of using complete filmed courses to teach science in high school (5, p. 4). The directors of the Fund for the Advancement of Education believed that these courses could help to alleviate the problem of the shortage of trained science teachers as well as provide an opportunity for the trained teacher to improve his effectiveness.

The first of these films to be produced was a course in physics entitled, Introductory Physics on Film. This film was developed under the guidance of a committee of distinguished scientist-educators recommended by the National Academy of Science. M. H. Trytten, director of the Office of Scientific Personnel of the National Academy of Science,

was designated to serve as chairman of this planning committee.

This committee felt that the most important factor in the development of an effective film course was the selection of an exceptionally well-qualified teacher. They selected Harvey White, a faculty member of the University of California at Berkeley. White has been characterized by one experienced school administrator as a teacher with complete mastery of his subject and a talent for fluent presentation (1, p. 8). He possesses over twenty years of experience in the teaching of physics and has had considerable experience in television and the production of educational films (5, p. 7).

The Harvey White course was filmed at the same time that White presented it over television in Pittsburgh, Pennsylvania in 1958. On Monday, Wednesday, and Friday of each week White gave what he termed "lecture-demonstrations", and on Tuesday and Thursday of each week he presented what he termed "laboratory-practicals."

The Harvey White course consists of 162 separate but slightly overlapping thirty-minute films. The films include forty-four on mechanics, fifteen on properties of matter, eleven on sound, three on special lessons (slide rule, algebra, and trigonometry), eighteen on light (optics), and twenty-four on electricity and magnetism, nine on atomic physics, eight on electronics, four on quantum

optics, and seven on nuclear physics. A complete list of titles and the order of presentation of the individual films can be found in Table XIII in Appendix I.

The acceptance of the Harvey White course by numerous public and private schools throughout the country prompted the production of a second filmed course, Chemistry, An Introductory Course. The teacher selected for this course was John Baxter, a faculty member of the University of Florida. One research study terms Baxter's presentation in the filmed course "clear, logical, interesting, and painstaking" (8, p. 21).

The John Baxter course, which was produced by Encyclopaedia Britannica Films at Wilmette, Illinois, consists of 160 thirty-minute films with approximately the same organization as that of the Harvey White course. Areas of chemistry covered by this course include classification, atomic theory, the mole concept, kinetic theory gases, atomic structure, chemical reactions, chemical equilibrium, rates of reactions, structures, relative reactivities, the periodic chart, and descriptive chemistry (4, p. 14). Approximately thirty per cent of the material in the John Baxter course is presented in a manner entirely different than that used in existing high school texts (10, p. 1). A complete list of titles and the order of presentation can be found in Table XIV in Appendix I.

Purchase of the Harvey White course and the John Baxter course was one part of an over-all endeavor by the Big Spring Schools to improve their science program. Of major benefit in this effort was the passage in 1958 of the National Defense Education Act which provided funds for the purchase of science equipment.

A comprehensive program of science in the elementary grades one through six has been developed with these funds made available under Title III of the National Defense Education Act. This is designed as a developmental program in scope and sequence and has been augmented and enriched with equipment and teaching tools such as science kits, portable laboratories, models, specimens, equipment and supplies for experiments, library books, film strips, and films.

The program at the elementary level has paved the way for an enriched program of science in grades seven, eight, and nine--the junior high school level. Provision has been made for the more talented student in science to elect biology at the ninth-grade level in order to make it possible for him to take chemistry, physics, and a year of advanced science, in that order, in the senior high school. This provision demands adequate, fully equipped biology laboratories at the junior high schools.

Laboratories for all science courses in the junior high school have been provided. They have been adequately

equipped with laboratory furniture and necessary science equipment. The major part of this has been done under the provisions of Title III, but supplementary funds from local sources have also been used.

At the senior high school extensive remodeling of existing laboratories, furniture, and equipment has been a part of the concerted effort to improve the science program. Coupled with this has been the addition of new laboratories, science equipment, and other facilities.

There has been no concern over a danger of creating an imbalanced program because of the immediate emphasis on science. This emphasis came as a result of the recognition that this area was weaker than other areas of the curriculum due to rapid technological developments and resulting teaching lag. This weakness was made evident by data obtained in system-wide achievement testing covering the entire curricular area. Results obtained in the 1957-58 administration of the Iowa Tests of Educational Development revealed that the subject area of science fell over twenty percentile points lower than did the fields of grammar, literature, social studies, and mathematics (9).

The schools of the Big Spring system serve about 6500 students. The majority of these, over 6000, attend the nine white elementary schools, the two white junior high schools, and the white senior high school. Some 300 Negro students attend the one Negro elementary school and the

combined Negro junior-senior high school. Two Negro students attend the white senior high school.

The schools are organized on the 6-3-3 plan with block graduation from the elementary schools to the junior high schools. Graduation from junior high school to senior high school is dependent upon the number of credits earned during the ninth grade. During the year covered by the present study, 1960-61, nineteen credits were required for graduation from high school. Included were these required courses: three years of English, two and one-half years of social studies, two years of mathematics, and two years of science.

Ability grouping is used at both the junior high schools and at the senior high school in the subject of English. Those students planning to attend college are urged to take four years of English, three years of science, three years of mathematics, and three years of a foreign language. Three languages, French, Latin, and Spanish are offered.

Although the student population is not above average in ability, almost seventy per cent of the graduates enter college. This large percentage is probably a result of the presence in the community of a well-regarded junior college, Howard County Junior College.

The administration and school board of the Big Spring Public Schools have demonstrated a determination to keep

pace with the ever-increasing educational needs of the children of the community. This determination is reflected in the effort to improve the science program of the system by purchase and use of the filmed courses in physics and chemistry.

As all schools contemplating the use of these filmed courses are faced with the difficulty of scheduling them, it was assumed that this study would be of considerable value as a guide to their decisions regarding utilization. The method studied is one of the simpler and more practical ways to use these educational films. It is only through continuing studies of this nature that the fund of knowledge concerning the effective use of educational motion pictures may be expanded.

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CHAPTER II

REVIEW OF RELATED LITERATURE

Although there have been many studies made concerning the use of films in education, many of which have dealt specifically with teaching science, there has been no evaluation of the use of filmed courses comparable to the present research. For purposes of organization the studies reported in this section have been placed in three categories. These are:

A. Studies Comparing Films and Film Supplemented Instruction with Other Methods of Instruction

B. Studies Comparing Use of Films Alone with Other Methods of Instruction

C. Studies Relating to the Use of Films in Teaching Science.

Organization within each of the above categories is chronological.

A. Studies Comparing Films and Film Supplemented Instruction with Other Methods of Instruction

Several studies have compared films and film supplemented instruction with other methods of instruction.

These other methods have included such things as lectures, laboratory-experimentation, and combinations of the two.

In 1941 Bell, Cain, and Lamoreaux (3) compared groups taught using eight March of Time films with groups taught by traditional methods. The study included fifth, seventh, ninth, and eleventh-graders from the Santa Barbara, California public schools, and the matched groups ranged in size from fifty-eight to ninety pupils. These investigators found differences in informational learning in favor of groups using films at all levels. In the seventh and eleventh-grade groups this difference was significant at better than the one per cent level of confidence. In the fifth-grade groups the difference was significant at better than the six per cent level of confidence. The difference found in the ninth grade, although favoring the film groups, was not statistically significant.

Also in 1941 Krasker (13) investigated the comparative effectiveness of two methods of using educational motion pictures and the traditional instructional method. He used a controlled experiment to compare large film-taught groups, small film-taught groups, and lecture-taught groups. His conclusions were:

1. Small (classroom size) film taught groups achieve more than large (auditorium size) film-taught groups.

2. Motion pictures are an effective teaching device.

3. Merely showing an educational film does not prove effective enough to warrant stopping there.

4. In order to achieve significant learning results, students need direction in the study of the film (13, pp. 21-22).

In 1949 Bentley (4) reported a study comparing a film-taught group with a group taught by traditional methods. The film used was a sound film on the subject of home gardening. The study revealed a significant difference on informational learning in favor of the film group, however there was no difference in the amount of retention between the two groups.

The effectiveness of educational films in the instruction of plane geometry was investigated by Johnson (12) in 1949. Utilising twelve schools in his study with each school having at least two sections of plane geometry, he found no significant differences in immediate informational gain between groups using films and groups being taught traditionally. From results obtained in his study Johnson concluded that films could be used most effectively if they supplemented, but did not markedly overlap, the material presented in the regular class instruction.

Anderson (1) in 1951 compared the effectiveness of four methods of teaching biology in high school. In a controlled experiment he compared the gain in achievement of a group taught by the lecture-demonstration method, a group

taught entirely by film (eighteen films), a group taught entirely by laboratory experimentation, and a group combining film and laboratory instruction. The study revealed no significant difference in achievement among the lecture-demonstration group, the film group, and the laboratory group, but the film-laboratory group made a significantly greater gain in achievement.

In 1956 Anderson (2) again compared the effectiveness of different methods of teaching biology in high school. In this study he compared the gain in achievement of a group taught by the traditional lecture-laboratory method, a group using film supplemented instruction, and a group in which important areas of the supplementary films were stressed before and after viewing. Although this study revealed no significant difference in achievement among the three groups, there was some indication that important parts of educational films need to be stressed if optimum effectiveness is to be attained.

B. Studies Comparing Use of Films Alone with Other Methods of Instruction

The majority of recent studies dealing with the use of educational films have compared the use of films alone with a variety of other methods of instruction. The most recent studies have concerned themselves with the evaluation of complete filmed courses.

In 1939 Lapp (15) compared a sound film, Electrostatics, shown twice with intervening comments by the instructor to direct attention to certain points before the second showing, with a "superior type lecture" of fifty minutes' duration on the same material. The two college physics classes in which the different methods were used were asked to read that portion of the textbook covering the material.

Lapp reported a difference favoring the film-taught group, but the fact that the groups were not equated and that the number and method of selection were not reported makes the validity of this study difficult to ascertain.

In 1943 Hoban (10) in one portion of a two-part experiment conducted by the Research Section, Army Pictorial Service, of the United States Army, compared a lesson taught entirely by a sound film, Prelude to War, with a demonstration lesson taught by an instructor. Using data from groups matched on the basis of age and educational level, Hoban concluded that teaching by film was equal to teaching by the average teacher.

In 1947 Hall and Cushing (9) investigated the relative efficacy of a sound film presentation and a lecture with enlarged illustrations in instructing matched groups of college freshmen in three science topics, Malaria, The Principles of the Diesel Engine, and The Use of the Micrometer. These researchers found no significant differences in the effectiveness of the two methods and theorized that

superiority in learning results from the relationship of the peculiar qualities of the learner to the method and is not inherent in the method alone.

Vandermeer (21) in 1949 made an extensive study of the relative effectiveness of three methods of teaching ninth-grade science. In the first method the group saw forty-four sound films twice. In the second method the group saw the forty-four sound films twice with this instruction supplemented by specially prepared study guides. The third method utilized the traditional lecture-demonstration. Vandermeer found no significant differences when he compared gains in knowledge of three matched groups each utilizing one of the above methods. He did point out, however, that the film-alone group finished the material to be covered about twenty per cent quicker than did the other two groups while experiencing no reliable decrement in learning.

In a pilot evaluation study of Encyclopaedia Britannica Films' Introductory Physics on Film, Science Research Associates, Inc. (5) in 1958 compared traditional and film-taught groups in forty-nine high schools. Analysis of scores obtained by 1161 students revealed a statistically significant difference between the gain-scores of those students taught by the film and those students taught by the traditional method. This difference was in favor of the film-taught group.

Englehart, Schwachtgen, and Nee (6) in 1939 conducted an extensive comparison of the relative efficacy of Introductory Physics on Film and traditional physics instruction. The study included approximately 1600 students in twenty-five Chicago public high schools. In the first part of the experiment the achievement of 692 students who were taught entirely by viewing the 162 half-hour sound films via television was compared with the achievement of 906 students who were taught by the traditional method. The film-taught group had an average score of 72.0 and the traditional method group had an average score of 66.7 on a test designed to measure knowledge and understanding of numerous important principles and their applications. Although the groups were not equated in any way, the investigators concluded that these data were evidence of the decided effectiveness of filmed instruction (6, p. 2).

In another portion of the Chicago study two groups of 307 students, each matched on the basis of intelligence, were taught by the above outlined methods. Using the same test as in the first part of the experiment, the investigators found that the film-taught group had an average score of 71.4 while the traditional group had an average score of 71.5 (6, p. 2). The investigators concluded that when equivalent groups are compared, the group taught by films does as well as that receiving traditional instruction.

In discussing the results of this portion and of the overall study, Englehart, Schwachtgen, and Nee point out three factors which they feel handicapped the learning of the film group. These factors included: (1) the film group was younger, (2) the film group had less preparation in mathematics, and (3) the film group carried a twenty-five per cent heavier class load. The validity of these factors as handicaps is questionable. One study, (Homman, 1961), found that neither prior science nor mathematics preparation was significant in achievement of film-taught or traditionally taught science classes.

The third portion of the Chicago study compared the scores obtained by the film-taught group on a standardized physics test with national norms based on the scores of 2181 students in seventy-seven high schools in nineteen states. The group of 117 film-taught students achieved a national percentile rank of seventy-eight. In the absence of an equated control group this reported result is of little significance, however the investigators made this comment, "The average I.Q. of our group was 116, while that of the 2181 students just referred to was 114, hardly a sufficient difference to explain the gratifying achievement of our group of 117 students..." (6, p. 2). Of particular interest in relation to the present research was the conclusion reached by Englehart, Schwachtgen, and Nee that as a result of the Chicago experiment, a type of instruction

making use of filmed courses and adequate teacher supplementation could be envisioned that might excel in effectiveness both the filmed instruction and the traditional instruction.

In a study conducted at the University of Wisconsin under a grant from the Fund for the Advancement of Education, Garside (7) compared students taught by Introductory Physics on Film with students taught by traditional methods. With data from 1332 students from sixty non-metropolitan high schools in Wisconsin, he found no significant differences in gain between the two groups on a standardized test of achievement in physics. When the film-taught students were compared with control students on special tests containing the additional material found in the films, a significant difference favoring the film-taught group was found. On tests of retention it was revealed that the group taught by traditional methods was significantly superior.

Schenberg (18) in a study conducted in Erasmus Hall High School in New York City in 1959-60 compared the effectiveness of the Encyclopaedia Britannica Films' complete film course in chemistry with the traditional method of instruction. Utilizing sixteen pairs of high ability students matched on the basis of three factors, the student's intelligence quotient, the average of the final marks in major

subjects at the end of the fall term of their sophomore year, and the average of the final marks in major subjects at the end of the spring term of their sophomore year, the investigator concluded that there was no significant difference in achievement of the two groups as measured by test-retest technique using a standardized test of chemistry achievement.

Schenberg concluded that films cannot replace the teacher but that under carefully controlled conditions they can supplement his efforts. He found a major limitation of filmed courses in that they cannot anticipate the many and varied questions that inevitably arise in the minds of the viewers nor can they stop and answer these questions. As a result of this study, he recommended that a similar experiment be made to determine whether the filmed course would be as successful with a group of average ability students (18, p. 21).

Grassell (8) in 1960 compared the effectiveness of a complete filmed course in physics with the effectiveness of a traditionally taught course. His study utilized data obtained from twenty-one physics classes in sixteen Oregon high schools. With control and experimental groups matched on the basis of scores obtained on the Terman-McNemar Test of Mental Ability, the Scientific Tests for Aptitudes (Scientific Aptitude section only), the Sequential Tests of

Educational Progress (Science section only), and the Dunning Physics Test. Grassell used the pre-test, post-test technique to determine differences in gain between the two teaching methods. Using simple analysis of variance and Chi-square to test for significance of obtained differences, this investigator found that although the filmed course was no more effective than the traditional course in teaching the facts and principles of physics, it contained presentations and demonstrations that neither time nor money permit in the more typical classroom situation. Grassell also reported that although the statistical data revealed Harvey White, the teacher of the filmed course, to be only about equally as effective as the average high school physics teacher, the teachers and students involved in this study were of the opinion that he was markedly superior.

Norman (11) in 1961 compared the effectiveness of a conventional course in high school chemistry with that of a filmed course, Encyclopaedia Britannica Films' Chemistry, An Introductory Course. Using the American Chemical Society--National Science Teachers Association Chemistry Test, Form 1959, for pre-testing and post-testing of matched control and experimental groups, he found that those students taught by the traditional method made significantly greater gains in achievement than did the

film-taught group. In addition to his finding concerning effectiveness, Homman reported (1) that neither science nor mathematics preparation was a significant factor in achievement, (2) that instruction by films needs to be critically analyzed and teachers should be trained in the use of filmed courses, (3) that girls are as capable as boys in learning from filmed instruction, and (4) that the quality of prior preparation in science is a much more important factor in achievement than is the quantity of such preparation.

C. Studies Relating to the Use of Films in Teaching Science

A preponderance of research with educational films has dealt with their use in teaching science. It seems apparent that educators have long recognized that this medium of instruction was peculiarly adaptable for use with this portion of the curriculum.

Three studies conducted by Lapp (14, 15, 16) concerned the use of films in teaching physics. The first study was to determine the effectiveness of using a film, Molecular Theory of Matter, as a review of material previously covered. Although the control and experimental groups were not equated, the control group had the best record on prior classwork in physics. Results indicated a significant difference on a test of information favoring

that group of physics students which had used the film for review purposes.

The second study by Lapp (14) also made in 1939 was to determine the effectiveness of a sound motion picture, Electrodynamics, as a means of teaching a lesson in college physics. A pre-test and post-test technique using a thirty-seven item objective test of information covered by the film was used for the dual purpose of matching the control and experimental groups and of determining the difference in gain between the two groups. Both groups saw the film twice, but prior to the second showing the experimental group was given a study sheet listing important things to look for. Scores on the objective test revealed that the group using the study sheet had a ten per cent larger gain than the control group. An analysis of the data brought to light the interesting fact that the upper quartile gained most by the use of the study sheet while the lowest quartile indicated confusion as a result of using the study sheet.

In 1941 Lapp (16) repeated his second experiment with changes in the film evaluated and in the design of the study sheet. Using control and experimental groups matched on the basis of a fifty-seven-item test of factual information contained in the second film, The Electron, he investigated the comparative effectiveness of viewing the film with and without the aid of a study sheet. Data

obtained from a post-experiment administration of the test revealed a gain significant at the five per cent level of confidence in favor of the group using the study sheet. Further analysis of the data showed the study sheet to be most effective in the lower three quartiles. Lapp attributed this last result to improvements made in the study sheet so that it would not have the undesirable effect of directing attention away from some parts of the film.

The previously reported studies of Hall and Cushing (9) in 1947 and of Vandermeer (21) in 1949, dealt with the use of films in teaching science. These investigators studied the areas of physiology, physics, and general science.

Smith (20) in 1949 utilized data from the Nebraska Progress of Educational Enrichment Through the Use of Films to investigate the relationship between intelligence and the learning which results from the use of educational sound motion pictures. His study of the gains made by general science and biology students in five Nebraska high schools indicated that a positive correlation existed between intelligence and amount of gain in achievement resulting from educational films. He found that although the brighter children learned more whether taught by film or by more traditional methods, the highest gain occurred in those students taught by film.

Scott (19) in 1949 investigated the effectiveness of certain films in science and social studies. His most important finding was that the influence of films tended to be specific to the areas covered by those films and was less evident on a standardized test of achievement. When he compared film and traditional groups he found a reliable superiority for the film groups in all measures of specific areas dealt with in the films, but he found a reliable difference in only about one-third of the standardized tests.

The conclusion reached by Scott (19) was confirmed by research done by Meierhenry (17) in 1949. In an extensive study utilizing data obtained from over 40,000 students, he examined the effectiveness of enriching the curriculum through the use of educational motion pictures. The areas of investigation included general science, biology, physics, world geography, world history, American history, and Convocation. His data indicated that film-enriched instruction was significantly more effective than traditional instruction in all subjects when measured by instruments patterned from information covered by the film. When results of standardized achievement tests were used as the criterion, the study revealed significant differences in only two subject areas, and these only occurred in one year of the two-year experiment.

With the exception of Anderson's studies (1, 2) of the use of films in teaching biology, all recent studies

relating to the use of films in teaching science have been concerned with the use of complete filmed courses in the areas of physics and chemistry. These studies, including the Science Research Associates Inc. Study of 1958 (5), the study of Englehart, Schwachtgen, and Nee (6), Carside's study (7), the study of Grassell (8), Schenberg's study (18), and Homman's study (11), have been reported in detail in that section of this chapter dealing with research in the extensive use of films for instructional purposes.

All research on the use of complete filmed courses in science has dealt with the comparison of the effectiveness of filmed courses with the effectiveness of traditional courses. All studies concerning the Encyclopaedia Britannica Films' course, Introductory Physics on Film, have indicated that the film course is at least equally as effective as a traditional course. The two studies investigating Encyclopaedia Britannica Films' Chemistry, An Introductory Course, those of Schenberg (18) and Homman (11) revealed somewhat contradictory results. Schenberg's study of sixteen matched pairs in New York City found no significant differences between groups taught by film and groups taught by traditional methods. Homman, however, in a similar study found a significant difference in favor of the traditional group. Two factors which might account for

these apparently conflicting results are the difference in intelligence level of the students used in each experiment and the differences inherent in the measuring instruments used to obtain gain scores.

The present research is not concerned with a comparison of the relative efficacy of Introductory Physics on Film and Chemistry, An Introductory Course as compared with traditional methods, but is devoted to the investigation of one way in which these filmed courses may effectively be used in the curriculum not as substitutes for the traditional courses but as supplements to them. The results of this study should be of benefit to those schools contemplating the purchase and use of these educational films.

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CHAPTER III

PROCEDURE

The Physics Experiment

Three lecture-laboratory classes of physics were included in this section of the study. These classes had fifty-four students enrolled with twenty-three taking only the lecture-laboratory course and with the remaining thirty-one taking both the lecture-laboratory course and the Harvey White course. All students had previously completed general science, biology, and chemistry. Each of the classes included some students who were taking both the regular course and the filmed course and some students who were taking only the regular course. All three of the classes were taught by the same instructor.

No attention was given to the films in the lecture-laboratory classes other than to cover the particular areas of physics at about the same time that they were being covered in the film course. Although no specific effort was made to parallel the filmed instruction with the regular classroom instruction, the approach taken by the regular classroom instructor was basically the same as that taken by White.

The filmed course was scheduled for a period from 7:45-8:20 each morning and from 12:00-12:40 during the noon period. There was no time allotted for discussion of the film or for explanation by the teacher who showed the film. Enrollment in the filmed course was on an elective basis, and no special encouragement was offered to get students into the classes.

A control group composed of students taking only the traditional lecture-laboratory course in physics was matched with an experimental group composed of students taking both the traditional physics course and the Harvey White course. The matching was done pair-by-pair on the basis of intelligence and prior science knowledge as measured by pre-test scores obtained on the Otis Test and the S.T.E.P.-Science Test in September. These tests were administered by the classroom instructor in each class under the direction of the research director. Pairs were matched within one standard error of the particular instrument being used. Fifteen matched pairs were obtained by this method. Detailed results of the matching of the control and experimental groups are reported in Table XV in the Appendix (p. 86).

The test-retest method was used to obtain the difference in gain in knowledge of the facts and principles of physics and to obtain the difference in gain in problem solving ability in physics between the control and

experimental groups. The two instruments used for this purpose were the P.S.S.C. Test and the A.I.R. Test.

Eleven null hypotheses derived from the sub-sections of the above mentioned instruments were tested using the small sample technique developed for determining the significance of the difference between the means of correlated groups by Fisher (1, p. 59). The formula which was used is given below:

$$t = \frac{M_d}{\sqrt{\frac{\Sigma x^2_d}{N(N-1)}}}.$$

All eleven null hypotheses were used in the determination of the significance of the difference in gain in knowledge of the facts and principles of physics between the control group and the experimental group. The four null hypotheses derived from the P.S.S.C. Test were used to determine the significance of the difference in gain in problem-solving ability in physics between the control group and the experimental group.

The eleven null hypotheses tested using the statistical technique outlined above included tests of the difference in gain obtained as measured by test-retest using (1) Part I of the P.S.S.C. Test administered in September and readministered in February, and (2) Part I of the

P.S.S.C. Test, Part II of the P.S.S.C. Test, the total P.S.S.C. Test, the Electricity I section, the Electricity II section, the Light I section, the Light II section, the Atomics section, and the Electronics section of the A.I.R. Test, and the total A.I.R. Test administered at the beginning and at the conclusion of the experiment.

The level of significance required for rejection of the null hypotheses was set as .01.

The Chemistry Experiment

Seven lecture-laboratory classes of chemistry were included in this section of the study. Each class included some students who were taking both the regular course and the John Baxter course and some students who were taking only the regular lecture-laboratory course.

The total number of students who completed the entire course and who wrote all of the tests used for matching and for measuring gain in knowledge of the facts and principles of chemistry was 140. Eighty-three of these students took only the traditional lecture-laboratory course in chemistry, and fifty-seven of the students took both the regular chemistry course and the filmed course. Five of the seven classes were taught by the same teacher, while two other teachers each taught one of the classes. All students included in the study had completed one year of algebra and one year of biology prior to their enrollment in chemistry.

The filmed course was scheduled for a period from 7:45-8:20 each morning and from 12:00-12:40 during the noon period. There was no time allotted for discussion of the film or for explanation by the teacher who showed the film. Enrollment in the filmed course was on an elective basis, and no special encouragement was offered to induce students to enroll.

No attention was given to the films in the lecture-laboratory classes other than to cover the particular areas of chemistry at about the same time that they were being covered in the filmed course. It is important to note that the approach taken to teaching chemistry by the classroom teachers was traditional and differed radically from the approach taken by Baxter.

A control group composed of students taking only the traditional lecture-laboratory course in chemistry was matched with an experimental group composed of students taking both the traditional chemistry course and the John Baxter course. The matching was done pair-by-pair on the basis of intelligence and prior science knowledge as measured by pre-test scores obtained on the Otis Test and the S.T.E.P.-Science Test. These tests were administered to the entire group in an auditorium setting by the research director. Pairs were matched within one standard error of the particular instrument being used.

In order to minimize any effect upon the results of the study caused by differences in the effectiveness of the three teachers who participated in the chemistry experiment, students in the control group were matched with students in the experimental group who had the same instructor.

By matching pair-by-pair on the basis of intelligence and science background as described in the two preceding paragraphs, it was possible to obtain a control group and an experimental group consisting of forty-two matched pairs. A detailed report of this matching is presented in Table XVI in the Appendix (p. 86).

The test-retest method was used to obtain the difference in gain in knowledge of the facts and principles of chemistry between the control and experimental groups. The instrument used for this purpose was the A.C.S.-N.S.T.A. Test.

A null hypothesis was derived from the above described measuring instrument and was tested using the small sample technique developed by Fisher (1, p. 59) for determining the significance of a difference between the means of related groups. The formula which was used with this technique follows:

$$t = \frac{M_d}{\sqrt{\frac{\Sigma x^2_d}{N(N-1)}}}.$$

The level of significance required for rejection of the null hypothesis was set as .01.

Eleven null hypotheses were tested in the physics experiment and one null hypothesis was tested in the chemistry experiment. Results of this testing is given in the following chapter.

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CHAPTER IV

RESULTS

The Physics Experiment

Eleven hypotheses were tested in this portion of the study. These are given below:

1. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on Part I of the P.S.S.C. Test as measured by a test-retest covering the period from September to February.

2. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on Part II of the P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

3. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on Part I of the P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

4. There will be no significant difference between the gain-scores obtained by the control group and by the

experimental group on the total P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

5. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Electricity I section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

6. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Electricity II section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

7. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Light I section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

8. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Light II section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

9. There will be no significant difference between the gain-scores obtained by the control group and by the

experimental group on the Atomics section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

10. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the Electronics section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

11. There will be no significant difference between the gain-scores obtained by the control group and by the experimental group on the total A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

Each of the eleven hypotheses was tested using Fisher's small sample technique for determining the significance of a difference between the means of correlated groups. The findings for Hypothesis 1 are presented in Table I.

TABLE I

FINDINGS OF HYPOTHESIS 1

Md	t	Level of Significance
.47	.39	N.S.*

*Less than .60 level of significance

Examination of Table I reveals a t of .39 which is not significant at the .01 level of confidence. The difference in achievement between the two groups on Part I of the P.S.S.C. Test was not significant.

Hypothesis 2 was tested to determine if there was a significant difference in the gain-scores obtained by the two groups on Part II of the P.S.S.C. Test. Results are given in Table II.

TABLE II

FINDINGS OF HYPOTHESIS 2

Md	t	Level of Significance
.50	.40	N.S.*

*Less than .60 level of significance

The t of .40 shown in Table II does not reach the required level of significance. The difference in gain-scores obtained by the control group and by the experimental group on Part II of the P.S.S.C. Test was not significant.

Hypothesis 3 was tested to determine the significance of the difference in gain in achievement of the control group and the experimental group on Part I of the P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment. Results are given in Table III.

TABLE III

FINDINGS OF HYPOTHESIS 3

Md	t	Level of Significance
.13	.08	N.S.*

*Less than .90 level of significance.

The t of .08 shown in Table III is not significant. Differences in gain-scores obtained by the two groups on Part I of the P.S.S.C. Test were not significant.

Hypothesis 4 was tested using the statistical technique designated above. The findings are reported in Table IV.

TABLE IV

FINDINGS OF HYPOTHESIS 4

Md	t	Level of Significance
1.20	.52	N.S.*

*Less than .60 level of significance.

The findings shown in Table IV indicate that the obtained difference in Hypothesis 4 was not significant at the .01 level of confidence.

The results of the testing of Hypothesis 5 are reported in Table V.

TABLE V

FINDINGS OF HYPOTHESIS 5

Md	t	Level of Significance
2.47	1.10	N.S.*

*Less than .20 level of significance.

The obtained difference in the testing of Hypothesis 5 is shown by Table V to be not significant at the .01 level of confidence. The control group and the experimental group did not differ in the amount of gain on Electricity I section of the A.I.R. Test. The findings are reported in Table VI.

TABLE VI

FINDINGS OF HYPOTHESIS 6

Md	t	Level of Significance
1.00	.88	N.S.*

*Less than .30 level of significance.

The findings given in Table VI indicate no significant difference between the control group and the experimental group in achievement as measured by performance on the Electricity II section of the A.I.R. Test. The obtained t did not approach the required level of significance.

Table VII reports the results obtained in testing Hypothesis 7.

TABLE VII

FINDINGS OF HYPOTHESIS 7

Md	t	Level of Significance
1.50	.78	N.S.*

*Less than .40 level of significance.

Findings reported in Table VII indicate no significant difference between the two groups' achievement on the Light I section of the A.I.R. Test.

By use of the previously described small sample technique, Hypothesis 8 was tested. The level of significance of the difference in gain-scores obtained by the two groups is reported in Table VIII.

TABLE VIII

FINDINGS OF HYPOTHESIS 8

Md	t	Level of Significance
.80	.42	N.S.*

*Less than .90 level of significance.

Examination of Table VIII reveals that there was no significant difference in gain-scores obtained by the

control group and by the experimental group on the Light II section of the A.I.R. Test.

Hypothesis 9 was tested to determine the significance of the difference in achievement between the two groups on the Atomics section of the A.I.R. Test. Table IX reveals the findings obtained in this test.

TABLE IX

FINDINGS OF HYPOTHESIS 9

Md	t	Level of Significance
.80	.42	N.S.*

*Less than .60 level of significance.

The t reported in Table IX does not approach the required level of significance. Difference in achievement between the two groups is not significant.

Hypothesis 10 was tested using the statistical technique described above. Findings are given in Table X.

TABLE X

FINDINGS OF HYPOTHESIS 10

Md	t	Level of Significance
.13	.08	N.S.*

*Less than .90 level of significance.

The *t* of .08 reported in Table X is not significant at the .01 level. There was no significant difference in the achievement of the two groups on the *Electronics* section of the *A.I.R. Test*.

The results of the testing of Hypothesis 11 are reported in Table XI. Hypothesis 11 was tested to determine the significance of differences in achievement made by the control group and the experimental group on the total *A.I.R. Test*.

TABLE XI

FINDINGS OF HYPOTHESIS 11

Md	*t*	Level of Significance
1.87	.42	N.S.*

*Less than .60 level of significance.

The *t* of .42 reported in Table XI indicates that the difference tested in Hypothesis 11 is not significant at the required level.

None of the eleven hypotheses tested in the physics experiment revealed significant differences between the control group and the experimental group either in gain in knowledge of the facts and principles of physics or in gain in problem-solving ability in that science.

The Chemistry Experiment

The hypothesis that there would be no significant difference between the gain-scores obtained by the control group and by the experimental group on the A.C.S.-N.S.T.A. Test as measured by test-retest at the beginning and at the conclusion of the experiment was tested using the small sample technique devised by Fisher for determining the significance of a difference between the means of related groups. The findings of this test are reported in Table XII.

TABLE XII

FINDINGS OF THE CHEMISTRY EXPERIMENT

Md	t	Level of Significance
8.76	4.58	.001

Examination of Table XII reveals that the difference in gain-scores between the control group and the experimental group on the chemistry achievement test is significant at better than the .001 level of confidence.

The chemistry experiment revealed a highly significant difference between the control group and the experimental group in gain in knowledge of the facts and principles of chemistry. This difference favored the experimental group.

CHAPTER V

FINDINGS AND CONCLUSIONS

Findings of the Physics Experiment

1. There is no significant difference between gain-scores obtained by students who have completed both the Harvey White film course and the traditional lecture-laboratory course in physics and students who have completed only the lecture-laboratory course in physics on Part I of the P.S.S.C. Test as measured by testing in September and retesting in February.

2. There is no significant difference between gain-scores obtained by students who have completed both the Harvey White film course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on Part II of the P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

3. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White film course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on

Part I of the P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

4. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on the total P.S.S.C. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

5. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White film course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on the Electricity I section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

6. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on the Electricity II section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

7. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on the Light I section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

8. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional course in physics and by students who have completed only the lecture-laboratory course in physics on the Light II section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

9. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional course in physics and by students who have completed only the lecture-laboratory course in physics on the Atomics section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

10. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional lecture-laboratory course in physics and by students who have

completed only the lecture-laboratory course in physics on the Electronics section of the A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

11. There is no significant difference between the gain-scores obtained by students who have completed both the Harvey White course and the traditional lecture-laboratory course in physics and by students who have completed only the lecture-laboratory course in physics on the total A.I.R. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

Conclusions--The Physics Experiment

1. The utilization of the filmed course, Introductory Physics on Film, as described in this experiment did not effectively increase the amount of learning of the facts and principles of physics.

2. The utilization of the filmed course, Introductory Physics on Film, as described in this experiment did not effectively increase problem-solving ability in physics.

3. Schools contemplating the use of Introductory Physics on Film should explore means of utilization other than that described in this experiment.

Findings of the Chemistry Experiment

1. There is a significant difference between the gain-scores obtained by students who have completed both

the John Baxter course and the traditional lecture-laboratory course in chemistry and by students who have completed only the lecture-laboratory course in chemistry on the A.C.S.-N.S.T.A. Test as measured by test-retest at the beginning and at the conclusion of the experiment.

2. The obtained significant difference is in favor of those students who have completed both the John Baxter course and the traditional lecture-laboratory course in chemistry.

Conclusions--The Chemistry Experiment

1. The utilization of the filmed course, Chemistry, An Introductory Course, as described in this experiment effectively increased the amount of learning of the facts and principles of chemistry.

2. Schools contemplating the use of the John Baxter film course should consider using the films in the manner described in this experiment.

Recommendations

Since all prior investigations of the Harvey White course, Introductory Physics on Film, have shown it to be as effective in teaching physics as is the traditional lecture-laboratory course, then its failure to add appreciably to the knowledge of those students enrolled in both it and the regular physics course could be attributed to

its utilization. However, the John Baxter course, Chemistry, An Introductory Course, when used in substantially the same manner, proved to be very effective in increasing the chemistry knowledge of those students taking both it and the regular chemistry course. A possible explanation of this seeming contradition might lie in the degree of similarity between the lecture-laboratory course and the filmed course in each instance. The Harvey White course closely paralleled the traditional lecture-laboratory course in physics while the John Baxter course used a radically different approach to teaching chemistry than that found in the lecture-laboratory course in chemistry. Traditional instruction in chemistry and instruction of the John Baxter film course may be mutually enriching because of the stereoscopic effect of focusing from two different points of view. In light of these observations, it is recommended that future research be undertaken to determine:

1. The relationship between the amount of learning gained from a filmed course in science in addition to a lecture-laboratory course in science and the degree to which that filmed course deviates from the lecture-laboratory course in approach.

2. The most effective method of utilizing filmed courses in science as supplements to traditional lecture-laboratory courses in science.

It is further recommended that any school planning to use filmed courses in science make certain provisions to insure the most effective utilization. Included should be:

1. Adequate steps to assure "readiness" of the students for the films
2. An in-service training program for the teachers on the proper use of educational films
3. Student-evaluation of the films
4. Provision for class discussion of the content of the films immediately after each showing.

Summary of the Physics Experiment

The purpose of the physics experiment was to determine the effectiveness of using a filmed course in physics in addition to the traditional lecture-laboratory course in physics.

It was hypothesized that those students who saw the filmed course in addition to the regular lecture-laboratory course in physics would not have a significantly higher gain in knowledge of the facts and principles of physics or in problem-solving ability in that science than students who had only the regular course in physics.

Control groups and experimental groups were matched pair-by-pair on the basis of two variables, intelligence and prior knowledge of science, as measured by the Otis

Quick-Scoring Test of Mental Ability and the Science section of the Sequential Tests of Educational Progress respectively. The control group had the traditional course in physics and the experimental group had both the Harvey White film course in physics and the lecture-laboratory course.

The American Institute for Research Physics Achievement Test and the Physical Science Study Committee Physics Achievement Test were used to determine the difference in gain in knowledge of the facts and principles of physics and gain in problem-solving ability in physics between the control group and the experimental group.

The obtained differences were examined using Fisher's small sample technique for determining the significance of a difference between the means of related groups. No significant differences were obtained, and it was concluded that utilization of the Harvey White film course was not effective in increasing the gain in knowledge of physics or in problem-solving ability in physics.

Summary of the Chemistry Experiment

The purpose of the chemistry experiment was to determine the effectiveness of using a filmed chemistry course in addition to the traditional lecture-laboratory course in chemistry.

It was hypothesized that students who had the film course in chemistry in addition to the regular course in chemistry would not have a significantly higher gain in knowledge of the facts and principles of chemistry than did students who had only the traditional course in chemistry.

Control groups and experimental groups were matched pair-by-pair on the basis of two variables, intelligence and prior knowledge of science. The control group had the traditional course in chemistry and the experimental group had both the John Baxter film course and the traditional lecture-laboratory course in chemistry.

The American Chemical Society-National Science Teachers Association High School Chemistry Test was used to determine the difference in gain in knowledge of the facts and principles of chemistry between the control group and the experimental group.

The obtained difference was examined using Fisher's small sample technique for determining the significance of a difference between the means of related groups. A difference significant at better than the .001 level of confidence was found.

It was concluded that utilization of the John Baxter film course in chemistry in addition to the lecture-laboratory course in chemistry is an effective method of increasing gain in the knowledge of the facts and principles of chemistry.

APPENDIX I

TABLES XIII-XVI

TABLE XIII

PHYSICS FILMS--SEQUENCE AND TITLES

Session Number	Film Title
1	Physics, an Exact Science
2	Optical Illusion
3	Units of Measurements
4	Measurement of Distances and Angles
5	Slide Rule
6	Algebra and Powers of Ten
7	Trigonometry
8	Speed and Velocity-Lecture
9	Speed and Velocity-Laboratory
10	Accelerated Motion-Lecture
11	Accelerated Motion-Laboratory
12	Composition of Velocities
13	Resolution of Velocities
14	Falling Bodies-Lecture
15	Falling Bodies-Laboratory

TABLE XIII--Continued

Session Number	Film Title
16	Newton's First Law of Motion
17	Projectiles-Lecture
18	Projectiles-Laboratory
19	Newton's Second Law of Motion
20	The Force Equation-Laboratory
21	Newton's Law of Gravitation and Third Law of Motion
22	Balanced and Unbalanced Forces
23	Concurrent Forces-Laboratory
24	Resolution of Forces
25	Resolution of Forces-Laboratory
26	Rotational Equilibrium
27	Parallel Forces-Laboratory
28	Center of Mass and Center of Gravity
29	The Simple Crane-Laboratory
30	Equilibrium of Rigid Bodies
31	Friction
32	Coefficient of Friction-Laboratory
33	Streamlining
34	Work and Energy
35	Center of Gravity-Laboratory

TABLE XIII--Continued

Session Number	Film Title
36	Energy and Power
37	Horsepower-Laboratory
38	Conservation of Energy
39	Conservation of Momentum
40	Energy and Momentum-Laboratory
41	Levers
42	Levers-Laboratory
43	Anatomical Mechanics
44	Machines
45	Ballistics-Laboratory
46	Circular Motion
47	Centripetal Force-Laboratory
48	Dynamics of Rotation
49	Conservation of Angular Momentum
50	Moment of Inertia-Laboratory
51	Atomic Theory of Matter
52	Electricity
53	Hooke's Law-Laboratory
54	Bending, Twisting, and Bouncing
55	Pressure in a Liquid

TABLE XIII--Continued

Session Number	Film Title
56	Pressure in Liquids-Laboratory
57	Archimedes' Principle
58	Density and Weight Density-Laboratory
59	Surface Tension
60	The Atmosphere
61	Weighing the Air-Laboratory
62	Fluids in Motion
63	Fluid Friction
64	Bernoulli's Principle
65	Vibrations and Waves
66	The Pendulum-Laboratory
67	Temperature and Expansion
68	Thermal Expansion-Laboratory
69	Heat Capacity and Change of State
70	Heat Transfer
71	Specific Heat-Laboratory
72	Radiant Heat
73	Latent Heat of Fusion-Laboratory
74	Change of State
75	Refrigeration and Geysers

TABLE XIII--Continued

Session Number	Film Title
76	Newton's Law of Cooling-Laboratory
77	Heat Energy and Gas Laws
78	Mechanical Equivalent of Heat-Laboratory
79	Liquid Air
80	Heat Engines
81	Boyle's Law-Laboratory
82	Sound Waves
83	Frequency of Tuning Fork-Laboratory
84	Resonance, Beats and Doppler Effect
85	Vibrating Strings and Air Columns
86	Vibrating Strings-Laboratory
87	Wind and Percussion Instruments
88	Reasonating Air Columns-Laboratory
89	Sound Energy and Hearing
90	The Science of the Musical Scale

TABLE XIII--Continued

Session Number	Film Title
91	Speed of Sound-Laboratory
92	The Quality of Musical Sounds
93	The Nature of Light
94	Light Sources and Illumination
95	Photometry-Laboratory
96	Reflection from Plane Surfaces
97	Reflection from Plane Surfaces-Laboratory
98	Reflection from Curved Surfaces
99	Refraction of Light
100	Index of Refraction-Laboratory
101	Lenses
102	Study of Lenses-Laboratory
103	Dispersion
104	Color
105	Magnifying Power of a Lens-Laboratory
106	The Eye and Optical Instruments
107	Principles of the Microscope-Laboratory

TABLE XIII--Continued

Session Number	Film Title
108	Diffraction and Interference
109	Polarization of Light
110	Rainbow, Blue Skies and Red Sunsets
111	Electricity at Rest
112	Coulomb's Law-Electronics
113	Electricity in Motion
114	Electromotive Force of a Battery Cell-Laboratory
115	Ohm's Law
116	Series Circuits-Laboratory
117	Parallel Circuits
118	The Electric Field and Potential
119	Parallel Resistances-Laboratory
120	Capacitance
121	The Potential Divider-Laboratory
122	Magnetism
123	Magnetic Fields
124	Wheatstone Bridge-Laboratory
125	Effect of Electric Currents

TABLE XIII --Continued

Session Number	Film Title
126	Electrical Equivalent of Heat-Laboratory
127	Electric Motors
128	Magnetic Induction
129	A Study of Motors-Laboratory
130	Induced Electric Currents
131	Coulomb's Law-Magnetism-Laboratory
132	Transformers
133	Alternating Current Theory
134	Transformers
135	Discovery of the Electron
136	Electronic Charge and Mass
137	The Elements and Their Isotopes
138	Electronic Charge to Mass Ratio-Laboratory
139	Light Sources and Their Spectra
140	Wave Lengths of Spectrum Lines-Laboratory
141	X-Rays
142	Radioactivity
143	Radioactivity Measurements-Laboratory

TABLE XIII--Continued

Session Number	Film Title
144	Electromagnetic Waves
145	Vacuum Tubes
146	Characteristics of Vacuum Tubes-Laboratory
147	Oscillators, Amplifiers, and Radio
148	The Photoelectric Effect
149	Electromagnetic Waves-Laboratory
150	Radar and TV
151	Geiger-Mueller and Scintillation Counters-Laboratory
152	The Bohr Atom
153	Electron Shell Structure
154	Photon Collisions and Atomic Waves
155	Electron Optics
156	Nuclear Disintegration
157	Cosmic Rays
158	Atomic Accelerators
159	Radiation Measurements-Laboratory
160	Transmutation

TABLE XIV

CHEMISTRY FILMS--SEQUENCE AND TITLES

Session Number	Film Title
1	Introduction
2	Planning a Career
3	Chemists at Work I
4	Chemists at Work II
5	Laboratory Techniques and Apparatus I
6	Laboratory Techniques and Apparatus II
7	Classifying Matter-The Need
8	The Physical States of Matter
9	Classifying Matter-A Method
10	Atoms and Molecules
11	A Chemical Reaction and Its Equation
12	Combustion-Molecules in Action
13	Atoms and Their Weights
14	Oxygen: The Earth's Most Abundant Element
15	Molecules and Their Weights
16	Weighing-The Analytical Balance
17	The Mole Concept
18	Using the Mole Concept

TABLE XIV--Continued

Session Number	Film Title
19	The Empirical Formula of a Compound-An Experimental Determination
20	First Look at Hydrogen
21	Mole and Weight Relationships in Chemical Reactions
22	Laws of Stoichiometry and the Atomic Theory
23	Introduction to Gas Behavior
24	Gas Pressure: Origin and Measurement
25	Partial Pressures-Boyle's Law
26	The "Gas" Temperature Scale: Absolute Zero
27	Gas Law Calculations-How Errors Arise in Experiments
28	Speeds of Molecules-Gaseous Diffusion
29	Standard Temperature and Pressure-Gas Density and Molar Volume
30	Determination of Molecular Weights of Gases

TABLE XIV--Continued

Session Number	Film Title
31	Formulas-Empirical and Molecular
32	Determination of Molecular Weights of Liquids and Solids
33	Volume Relationships
34	A First Look at Atomic Structure
35	The Nucleus and the Neutral Atom
36	Electronic Arrangements
37	The Formation of Ionic Compounds
38	Ionic Compounds and Ionic Binding
39	Covalent Binding
40	Ionic and Covalent Binding Contrasted
41	Water-Its Structure
42	Water-Some of Its Properties
43	Water-Its Peculiar Properties
44	Ionic Compounds and Electrical Conductivity
45	Ionic Compounds Continued-Precipitation

TABLE XIV--Continued

Session Number	Film Title
46	How Salts Dissolve in Water
47	Hydrogen Chloride-Preparation and Properties
48	Acid and Bases
49	Developing an Acid-Base Theory
50	A Typical Acid-Base Reaction
51	Relative Strengths of Acids and Bases
52	Construction of an Acid-Base Table
53	Using an Acid-Base Table
54	Making Solutions of Known Concentration
55	An Acid-Base Titration
56	Titration of a Weak Acid-Calculations
57	Dynamic Equilibrium
58	Chemical Equilibrium
59	A Summary of Equilibrium Principles
60	The Le Chatelier Principle
61	Applications of the Le Chatelier Principle

TABLE XIV--Continued

Session Number	Film Title
62	The pH Scale
63	Buffer Solutions
64	Thermochemistry-Temperature and Reaction Extents
65	Rates of Chemical Reactions
66	Temperature-Reaction Rates and Reaction Extents
67	Covalent Binding-Its Geometry
68	Carbon
69	Multiplicity of Carbon Compounds
70	Geometry of Carbon Compounds
71	Alkanes-The Saturated Hydrocarbons
72	Petroleum
73	Gasoline and Motor Fuels
74	Alkenes and Alkynes-The unsaturated Hydrocarbons
75	Alcohols
76	Compounds Containing the Carbonyl Group
77	Organic Compounds Containing Nitrogen

TABLE XIV--Continued

Session Number	Film Title
78	Dyes-Some Principles of Organic Synthesis
79	Synthetic Polymers I
80	Synthetic Polymers II
81	Natural Polymers-Carbohydrates and Proteins
82	Biochemistry-A General View
83	Carbohydrates and Fats
84	Proteins-Enzymes
85	Chemical Reactions in Higher Plants
86	Chemical Reactions in the Animal Body
87	Some Typical Biochemical Laboratory Tests
88	Structural Properties of Simple Ions
89	Reactivities of Atoms and The Periodic Table
90	A Family of Elements-The Alkali Metals
91	The Alkali Metals
92	The Alkaline Earth Metals

TABLE XIV--Continued

Session Number	Film Title
93	Groups IA and IIA Compared
94	Soluble and Insoluble Salts
95	Precipitation Reactions
96	Equilibrium in Saturated Solutions of Salts
97	The Chemistry of Lime
98	Hard Water-Its Formation
99	Hard Water-Its Treatment
100	Precipitation and Inorganic Synthesis
101	Washing Soda, Soap, and Synthetic Detergents
102	The Chemistry of Sodium Bicarbonate
103	The Ammonia Soda Process
104	Experiments with Acidic Cations
105	Introduction to Ion Hydration
106	Colors of Aquo Complex Ions
107	Relating Structural and Chemical Properties
108	Gelatinous Hydroxides
109	The Transition Metals

TABLE XIV--Continued

Session Number	Film Title
110	Experiments with Some Typical Transition Metal Ions
111	Some Complex Ions of the Transition Metals
112	Some Applications of Complexing Reactions
113	Some Aspects of Complex Ion Theory
114	A Review of Valence Concepts
115	Oxidation Number and the Naming of Compounds
116	An Introduction to Oxidation and Reduction
117	Building of an Oxidation-Reduction Table
118	A Typical Electric Cell
119	Electric Cells and the Faraday Laws
120	Equivalent Weights of Metals
121	The Lead Storage Battery
122	Some Chemical Experiments with a Daniel Cell
123	Oxidation-Reduction Equations

TABLE XIV--Continued

Session Number	Film Title
124	The Copper-Silver Ion Reaction
125	Electrolysis I
126	Electrolysis II
127	Types of Reactions
128	The Halogens
129	Chlorine
130	Fluorine, Bromine, and Iodine
131	Halogen Chemistry
132	Laboratory Experiments with Halide Ions
133	The Sulfur Family
134	Hydrogen Sulfide
135	Sulfur Oxides
136	Nitrogen, Ammonia, and Nitric Acid
137	Phosphorus and Its Compounds
138	Silicon, Silica, and Silicates
139	Some Applications of Silicate Chemistry
140	Metals and Metallurgy I
141	Metals and Metallurgy II
142	Metals and Metallurgy III

TABLE XIV--Continued

Session Number	Film Title
143	Iron
144	Steel-Alloys
145	Iron-Solution Chemistry I
146	Iron-Solution Chemistry II
147	Iron-Corrosion
148	The Packing of Spheres
149	Measuring the Size of a Molecule
150	Units, Significant Figures
151	Determining Structures
152	Radioactivity and Radiochemistry I
153	Radioactivity and Radiochemistry II
154	The Chemistry of Photography
155	Colloids
156	Qualitative Analysis I
157	Qualitative Analysis II
158	Qualitative Analysis III
159	Qualitative Analysis IV
160	Summary-What of the Future?

TABLE XV

DATA USED IN MATCHING CONTROL AND EXPERIMENTAL GROUPS IN PHYSICS

Control			Experimental		
Subject	Otis	S.T.E.P.	Subject	Otis*	S.T.E.P.**
A	137	48	A'	135	51
B	133	47	B'	132	47
C	128	35	C'	126	35
D	125	33	D'	124	33
E	124	45	E'	124	44
F	124	39	F'	124	40
G	123	48	G'	124	45
H	122	39	H'	120	41
I	121	42	I'	119	39
J	121	37	J'	120	38
K	121	37	K'	120	37
L	118	40	L'	118	41
M	118	28	M'	119	28
N	113	35	N'	115	34
O	109	41	O'	110	44
Mean	122.4	39.6		121.4	39.2
S.D.	6.8	5.6		5.5	5.8

*Otis Quick-Scoring Test of Mental Ability

**Sequential Tests of Educational Progress-Science

TABLE XVI

DATA USED IN MATCHING CONTROL AND EXPERIMENTAL GROUPS IN CHEMISTRY

Control			Experimental		
Subject	Otis	S.T.E.P.	Subject	Otis*	S.T.E.P.**
A	135	42	A'	133	41
B	129	46	B'	127	45
C	129	34	C'	129	35
D	129	28	D'	129	29
E	128	36	E'	129	38
F	127	41	F'	125	40
G	126	38	G'	124	36
H	125	43	H'	123	41
I	125	40	I'	126	38
J	124	38	J'	125	38
K	123	45	K'	123	44
L	123	28	L'	124	29
M	122	39	M'	124	39
N	122	38	N'	122	38
O	122	37	O'	121	36
P	120	34	P'	121	34
Q	120	29	Q'	118	29
R	118	31	R'	118	29
S	118	29	S'	119	31
T	117	34	T'	117	35
U	117	30	U'	115	29
V	116	33	V'	114	34
W	116	24	W'	115	26
X	115	34	X'	114	34
Y	115	31	Y'	115	31
Z	114	32	Z'	115	30
AA	114	32	AA'	116	30

TABLE XVI--Continued

Control			Experimental		
Subject	Otis	S.T.E.P.	Subject	Otis*	S.T.E.P.**
BB	113	25	BB'	112	26
CC	113	25	CC'	113	25
DD	112	27	DD'	112	29
EE	112	26	EE'	112	27
FF	111	34	FF'	110	33
GG	111	32	GG'	112	32
HH	111	24	HH'	111	24
II	110	27	II'	109	26
JJ	109	28	JJ'	109	26
KK	106	31	KK'	104	29
LL	106	30	LL'	106	30
MM	106	26	MM'	106	27
NN	103	31	NN'	102	31
OO	101	30	OO'	101	30
PP	91	14	PP'	89	12
Mean	116.7	32.2		116.4	32.4
S.D.	8.4	6.3		8.8	6.2

*Otis Quick-Scoring Test of Mental Ability

**Sequential Tests of Educational Progress-Science

APPENDIX II

DESCRIPTION OF THE MEASURING INSTRUMENTS

A. The Otis Quick-Scoring Test of Mental Ability, Gamma, Fm.--This is a group intelligence test consisting of eighty items, including word meaning, verbal analogies, scrambled sentences, interpretations of proverbs, logical reasoning, number series, arithmetic reasoning, and design analogies. Actual testing time is thirty minutes. Split-half reliability coefficients of .91, .92, and .91 are reported for this test in grades 10, 11, and 12 respectively. This test has been shown to have a high correlation with many of the better tests of intelligence (2, pp. 496-299).

B. The Sequential Tests of Educational Progress, Science, 2B.--This is a standardized test of general achievement in science. It consists of eighty questions designed to measure skill in identifying scientific problems, ability to interpret data, ability to suggest hypotheses, and ability to reason quantitatively and symbolically. This test has content validity as the items on the test were prepared by selected groups of teachers in the science field. The publisher of this test indicates in the technical report concerning S.T.E.P.-Science that

he expects to make empirical checks of validity, but none have been forthcoming to this date (3, p. 9). One study has been made which has some bearing on this matter. A correlation of .67 was found by one investigator when he compared S.T.E.P.-Science scores and school grades in science (4, p. 26). Internal consistency of the test has been determined by use of the Kuder-Richardson Formula Twenty. An application of this formula produced a reliability coefficient of .87 (3, p. 10).

C. The American Chemical Society-National Science Teachers Association-High School Chemistry Test-Form 1959.--This is an eighty-minute, 100 item standardized test of chemistry achievement. The test was prepared by the Examinations Committee of the Division of Chemical Education of the American Chemical Society. This form of the test is too recent for reviews to have been made in the literature, however this form is a revision of the 1958 version which proved a reliable and valid measure of chemistry achievement (2, p. 279).

D. The Physical Science Study Committee Physics Achievement Test.--This is a standardized test of physics achievement. The two parts used in this study each consist of thirty-five multiple choice questions built around six or seven physical situations. The questions are so designed as to measure problem solving ability as well as

knowledge of facts and principles. Very few questions can be answered from mere recall of statements made in the text (5, p. 4). While there have as yet been no studies made to determine the empirical validity of these tests, the ability of the committee which designed the tests seems to assure content validity. Included in this committee were Frederick Ferris and Frank Fornoff of Educational Testing Service and Henry Chauncey of the College Entrance Examination Board (5, p. 3). The reliability of these tests has not been reported.

E. The American Institute for Research Physics Achievement Test.--This test was designed for the American Institute for Research by Educational Testing Service. It is still in an experimental state, but the directors of the American Institute for Research released it for use in this study. The test consists of a series of six thirty-minute, forty-item, multiple choice tests designed to measure the specific content covered in the Harvey White film course in physics. The six tests are Electricity I, Electricity II, Light I, Light II, Atomics, and Electronics. No validity data have been established for these tests. Using the Kuder-Richardson Formula Twenty, the following reliability coefficients have been obtained: Electricity I--.77, Electricity II--.62, Light I--.79, and Light II--.77 (1). No reliability information has been

reported for either the Atomics test or the Electronics test.

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