A COMPARATIVE STUDY OF THE EFFECTIVENESS OF USING A FULL FILM AND SHORT FORMAT FILMS TO TEACH CHEMISTRY

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This is to certify that the

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ABSTRACT

A COMPARATIVE STUDY OF THE EFFECTIVENESS OF USING A FULL FILM AND SHORT FORMAT FILMS TO TEACH CHEMISTRY

by Lloyd A. Trinklein

The abstract consists of three parts: a summary of the design and findings of the study, conclusions, and recommendations.

Summary

The major purpose of this study was to investigate certain modes of instruction, involving single concept films, in comparison with the use of a full length film. Specifically, this study compared the relative effectiveness of a full film with combinations of excerpts from that film to teach factual information to CHEM Study students.

The sample for this study consisted of 382 students from sixteen school systems throughout the lower half of Michigan. Eighteen teachers from the eighty-nine school systems that had purchased classroom quantities of CHEM Study materials in 1964-65 were selected to participate in the study. The sample contained 231 boys and 151 girls. On

the Otis Quick-Scoring Mental Ability Test the students ranged in IQ from 64 to 135. Small and large schools were involved as well as public and parochial.

The media which were utilized were various combinations of the film BROMINE-ELEMENT FROM THE SEA and excerpts from that film. The film is one of twenty-six prepared for use in the CHEM Study curriculum.

The content which was measured by the objective tests was the concepts, descriptive material, and principles that were given in the film excerpts.

The test materials used in the study consisted of the Otis Quick-Scoring Mental Ability Test, Gamma Test, Form Fm, and an objective pretest and a post-test which were prepared and validated by the experimenter.

Each class was assigned to one of three treatment groups. These three treatments are: (1) film only, (2) excerpts only, and (3) a combination of the film and the excerpts. The filmed treatment was applied during the teaching of chapter nineteen of the CHEM Study text. Each teacher was unrestricted in his teaching of the chapter, except for the showing of one of the filmed sequences at specific points in the chapter as assigned by the experimenter. To equalize the exposure of the students to the subject matter to be tested, each class saw the filmed material twice.

The null hypothesis that was tested was: There is no significant difference among the means of achievement gains of three groups of students who have been taught factual information by a film, excerpts from that film, or a combination of the film and excerpts from that film.

The data which were analyzed to test this hypothesis were the differences between each student's pretest score and his post-test score--his achievement gain. Since significant variance was found among the three groups on IQ, analysis of covariance was used to analyze the data, controlling for IQ. An F ratio of 63.893 was computed for this analysis. Since an F ratio of greater than 3.07 was necessary for rejection of the null hypothesis with 2 and 378 degrees of freedom and with a .05 level of significance, the null hypothesis was rejected; Scheffé comparisons were computed to determine directional relationships between the adjusted means of the three groups. The result of these comparisons showed the adjusted mean of the combination treatment to be significantly greater than the adjusted means of either the film or excerpts treatments, and the adjusted mean of the film treatment was significantly greater than the adjusted mean of the excerpts treatment.

A student questionnaire also was analyzed to determine student preferences on the filmed sequences.

Conclusion

A combination of a full film and excerpts from that film is more effective for teaching factual information to CHEM Study chemistry students than either the film or the excerpts alone. The results on the questionnaire indicated that the students were most satisfied with the combination treatment.

Recommendations

Four general recommendations are made by the author:

1. More emphasis be placed on instrument writing for future studies.
2. Single concept films should be made easily available to teachers.
3. Packages of single concept films and longer films should be prepared for instructional use.
4. Short format films should be used in programed learning situations.

Five suggestions for further study are recommended by the author:

1. A replication or replications of the present study should be done in another subject matter area and at different grade levels.
2. A study should be conducted to determine the effectiveness of whole film-short film combination for purposes other than the transmission of factual information.
3. A determination study for the most effective placement of the full film in the combination should be carried out.
4. A study of retention should be done.
5. A comparison of individual use of short films with classroom use in the combination would be profitable.

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Lloyd A. Trinklein

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CHAPTER I

INTRODUCTION TO THE PROBLEM

Introduction

Recently public education has received increased attention. Because of the application of pressures from many groups outside of education and because of the recognized need for more effective methods of instruction by individuals from within the field, many teachers searched for solutions for the dilemma.

Many devices have been developed which could help to solve some of the problems of education, but few of them have been thoroughly investigated.

Such a device is available today: the single concept film. These films have many names: film loops, short format films, film bits, etc. But the short filmed sequence covering the one basic idea is not new. "In the Twenties, for example, Bray produced about 500 of the 1-6 minute films in 35mm, most of them in the field of science--forerunners of the single-concept film of today."[1]

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[1]Robert W. Wagner, "The Educational Film in Transition," Audiovisual Instruction, IX (March, 1964), p. 174.

With the rejuvenation of single concept films, research must seek out their correct use. In 1965 one investigator studied the effect of single concept films by comparing the discovery and expository methods of teaching concepts.[2]

This study is an outgrowth of a research project which has been in operation at Michigan State University since July, 1964. The United States Office of Education (USOE) Single Concept Film Clip Project has identified over one thousand excerpts from existing educational films which, in the opinion of the project members, are usable as single concept films. Although the feasibility of excerpting educational films has been established, the project did not contract to experiment in the use of these films. In the spring of 1965, another project employee and the author of this study conducted a pilot use study at Detroit Denby High School, using excerpts which had already been identified. Although this pilot study was not a carefully controlled study, the results showed that further research in this field was warranted.[3]

Thus, the proposal is not to discover if short films can teach. The principle has been established by previous

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[2]Castelle Gentry, "Relative Effectiveness of Discovery and Expository Methods of Teaching Concepts Through the Single-Concept Film" (unpublished doctoral dissertation, Michigan State University, 1965).

[3]Elwood E. Miller _et al_., "Film Clip Project: Half Way Point," _Audiovisual Instruction_, XI (January, 1966), pp. 34-35.

research. This study investigates certain modes of instruction, involving single concept films, to compare their use with full length films.

The Problem

Since the early part of this century, many investigations have involved the testing of the teaching effectiveness of motion picture films. An exhaustive compilation of these research reports is found in a technical report by Hoban and van Ormer for the Department of the Army and Navy.[4] As early as 1932 the Thirty-First Yearbook of the National Society for the Study of Education showed that several studies used films in science classes.[5] Wood and Freeman conducted a study in 1929 using 3300 students and 100 teachers to test the effectiveness of films on general science classes.[6] The investigators in that study found that the experimental group (with films) achieved results considerably better on all the tests than the control group

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[4]Charles F. Hoban and E. B. van Ormer, Instructional Film Research, 1918-1950 (Rapid Mass Learning), Report on The Pennsylvania State College Project Jointly Sponsored by the Department of the Army and the Department of the Navy (U.S. Navy Special Devices Center, Port Washington, Long Island, New York: 1951).

[5]A Program for Teaching Science, Thirty-first Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1932), passim.

[6]Ben D. Wood and Frank N. Freeman, Motion Pictures in the Classroom (Boston: Houghton Mifflin Company, 1929).

(without films). Because of the evidence accumulated in these studies and in the numerous ones since that time, educators no longer are concerned with whether or not films can be used to teach. However, the correct method of usage of films has not been investigated fully.

As educators have increased the functional use of films, they have found an increasing need for short film sequences which illustrate single concepts or phenomena. Also, they felt a need for showing these sequences more than once. During World War II, Pennsylvania State College did many research projects using closed-loop films. The closed-loop films filled the need for quick repetition of short sequences. Several devices were invented for the projection of these film-loops, but none of them proved effective enough to bring about wide-spread use.

In 1961 the Technicolor Corporation brought the closed-loop idea to the attention of the public again. Their projector used a cartridge to enclose approximately four minutes of 8mm film. The ease with which this projector could be operated caused renewed interest by educators. Since the cost of individual cartridged films and the projector is relatively low, more schools could afford to place these projectors and films in individual rooms or departments for easy access.

At present, approximately 3000 single concept films are commercially available.[7] But many schools seem to be using them without giving any thought as to their proper usage.

The major purpose of the study was to investigate the use of different modes of instruction, involving short format films, in high school chemistry classes, and to test the effectiveness of such films with the classes. Specifically, could three different uses of the same film produce differences in achievement among Chemical Education Materials Study (CHEM Study) chemistry students as measured by an objective test which was prepared and validated by the experimenter?

In addition, the study sought answers to other questions involving the effectiveness of each type of treatment. The following questions are exemplars:

1. Are excerpts from a film more effective than the total film?

2. Is a combination of excerpts and the total film more effective than the film alone?

3. Is the combination of excerpts and film more effective than the excerpts alone?

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[7] Source Directory, Educational Single-Concept Films, (Costa Mesa, California: Technicolor Corporation, March, 1966).

Rationale for the Model

General research of the effectiveness of audiovisual devices has been reported extensively.[8] Much of this research has been concerned with whether or not motion picture films can be used to teach subject matter; many studies have successfully proved that films can be used to teach many things. This study builds on previous research by investigating modes of instruction using single concept films. In his book on the conditions of learning Gagné has defined a "mode of instruction" as the particular arrangement of resources; and has stated that, to insure optimum learning, the selection of the particular mode was most important, and that the correct application of resources will secure the greatest instructional efficiency.

> As has often been said, instructional media constitute the valuable "resources for learning" that an educational system has to draw on. When these resources are put to use, they are usually placed in some particular arrangement called a mode of instruction. Some of these, like the lecture, are very widely and frequently used, but others, like the tutoring session, are employed rather infrequently (at least in this country). The various modes of instruction are employed for the purpose of getting the greatest instructional usefulness from media and combinations of media. Thus the choice of modes is also a matter of aiming for optimal functioning in generating the proper conditions for learning.[9]

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[8] Hoban and van Ormer.

[9] Robert M. Gagné, The Conditions of Learning (New York: Holt, Rinehart, and Winston, 1965), pp. 28-29.

The modes of instruction with which this study is concerned involve several different media and different combinations of media: a whole film, excerpts from the film, and a combination of a whole film and excerpts from the film. Combined with each of these media is discussion of the subject matter within the filmed sequences. The purpose of the study was to determine which was the best mode of instruction for presenting the principles, concepts, and descriptive material within the short films.

A study by Faison, Ross and Podell (1955) reported the difference in effectiveness of a single showing of a 20-minute film compared to a single showing with rest breaks interspersed. The results of the experiment showed that the insertion of three very short (30 second) rest pauses in the 20-minute film led to a reliable increase on an index of audience attentiveness. Also, "the introduction of the rest breaks led in turn to reliably greater learning as measured by a postfilm test than did a continuous showing of the same film."[10]

Travers, in his interim report, reports some research in the area of blocking which is directly related to this study. In citing work by Woodworth and Schlosberg

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[10] N. L. Gage (ed.), Handbook of Research on Teaching (Chicago: Rand McNally and Company, 1960), p. 646.

(1954),[11] Bills (1931-35),[12] and Martinson (1938),[13] he states that research indicates that the design of educational media must change. "To insert rest periods, or discussion periods throughout the presentation of a film, if the film is of more than a few minutes duration, might increase attention during the film and decrease wandering or blocking of attention."[14] This length factor suggested the investigation of the instructional value of short films compared to the use of long films in teaching, as well as the combination of short films with a whole film in different modes of instruction.

Hypotheses

Three different techniques for film utilization were investigated for possible differences in achievement among the students viewing the films:

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[11]R. S. Woodworth and H. Schlosberg, Attention (New York: Henry Holt and Company, 1954).

[12]A. G. Bills, "Blocking: A New Principle of Mental Fatigue," American Journal of Psychology, XLIII (October, 1931), pp. 230-245.

[13]Betty Martinson, "A Study of Brain Potential During Mental Blocking," Journal of Experimental Psychology, XXIV (1939), pp. 143-157.

[14]Robert W. Travers (ed.), Research and Theory Related to Audiovisual Information Transmission, An Interim Report to U.S. Department of Health, Education, and Welfare, Office of Education Contract No. 3-20-003 (July, 1964).

A. Film only
B. Excerpts only
C. Combination of film and excerpts

The null hypothesis to be tested was:

H_o: A = B = C

Possible alternative hypotheses are:

H_1: A $\neq$ B $\neq$ C
H_2: A = B $\neq$ C
H_3: A = C $\neq$ B
H_4: A $\neq$ B = C

Procedures

The classroom phase of the study involved three treatments for the use of the film, BROMINE - ELEMENT FROM THE SEA: (1) film only; (2) excerpts only; (3) combination of the film and the excerpts. Each treatment consisted of two parts: (1) showing a filmed sequence; and (2) discussion of the filmed portion. In the "film only" treatment, the film was first shown following the teaching of section 2.2 in chapter nineteen of the CHEM Study text. Following the showing of the film, the teacher discussed the film content with the students following a set of questions prescribed by the experimenter. The film was again shown as a review at the end of chapter nineteen with no discussion.

In the "excerpts only" technique, the teacher showed the excerpts twice. Following the teaching of the section of chapter nineteen to which the excerpt applied, the excerpt was shown once; its content was discussed using those questions from the list prescribed by the experimenter which applied to that excerpt. Immediately following the discussion, the excerpt was shown again, but without discussion.

In the "combination" treatment, the teacher followed the same pattern as the teacher using only the excerpts, except they did not show the excerpt the second time. They also used the total film at the end of the chapter as a review, but without subsequent discussion.

The procedural steps which were used in the collection of the data are as follows:

1. The Otis Quick-Scoring Mental Ability Test (New Edition) Gamma Test, Form Fm was administered to each student to obtain a measure of general ability.
2. An objective pretest was given to each student. This test and its construction are described in a later section.
3. The treatments were applied by the teachers during the teaching of chapter nineteen of the CHEM Study text.
4. On completion of chapter nineteen each student was given an objective post-test. This test is described later.
5. The data which were analyzed were the means of the differences between each student's pretest score and

post-test score. The null hypothesis that was tested, using an F test, was $H_0: A = B = C$, that the three treatments are equal.

The population from which the sample for this study was taken was the schools within one hundred twenty-five miles of East Lansing that use CHEM Study chemistry materials. The list of schools was acquired from CHEM Study headquarters at The University of California, Berkeley. Included were all the schools in the Southern Peninsula of Michigan that purchased classroom quantities of CHEM Study materials during the school year, 1964-65; presumably each of these schools had been using this curriculum for at least one year. All of the schools that fit this category were asked if they would cooperate in the study. Sixteen of the responding schools were selected to participate.

The schools are located in the southern two-thirds of the Southern Peninsula of Michigan. Industrial areas as well as farming communities were selected. The enrollment of the schools varied from the very large schools of Detroit to small schools of only a few hundred students. Parochial, as well as public, schools were used, since approximately one-third of the schools in Michigan using CHEM Study materials are parochial schools. One chemistry class of each of the participating teachers was selected for use in the study.

The instruments which were used in this study were:

1. The Otis Quick-Scoring Mental Ability Test (Gamma Test, Form Fm)
2. An objective pretest
3. An objective post-test

The reliability and validity of the Otis have been well established. In the test manual, the split-half reliability coefficient for the Gamma Test is given as .88. The validity of each item was established by finding the bi-serial coefficient of correlation between the item and the total score. The median value of these coefficients was +.61.

The original test was prepared for the pilot study at Detroit Denby High School. The items on the objective tests were prepared by the experimenter. The items on the test were made by listing all of the specific concepts, descriptive matter, and principles that were given in the film excerpts; and true or false items based upon this content were then prepared. Many of the items are recall items, but some test the student's ability to apply the material in a different situation.

The validity and reliability of this test was established by the following procedures. The answers on the original test were analyzed to get an item analysis of the test. On the basis of this analysis and with the help of

Dr. Robert Ebel (a former Vice President of Educational Testing Service) a revised form of the test was written.

A second pilot study was done at Detroit Denby High School in January, 1966 to field test the revised instrument. The students' answers on the revised form were subjected to an item analysis, and the test was again rewritten. This is the form of the test that was used as the post-test during the major phase of the study. The pretest was simply the final revision of the post-test with the items in different order.

The raw data that were available for analysis were:

1. Intelligence scores based on the Otis Quick-Scoring Mental Ability Test
2. Pretest scores by individuals and classes
3. Post-test scores by individuals and classes
4. Personal information from the students

The achievement score data that were analyzed were the means of the differences between the individual student's pretest score and his post-test score. These means were then analyzed by use of analysis of variance, F test, to test the hypothesis: H_o: A = B = C. A .05 level of significance was used.

Definition of Terms

CHEM Study materials: Special materials developed through the Chemical Education Materials Study Project, a study supported by a grant from the Course Content Improvement Section of the National Science Foundation. The materials include: a textbook, a teacher's manual, a student laboratory manual, a set of twenty-eight films, a teacher's guide to the films, and a set of tests.

Total film: In this study refers to a specific film, twenty-two minutes in length, prepared for the CHEM Study curriculum. The film, BROMINE - ELEMENT FROM THE SEA, contains five major divisions: (1) correct handling of bromine; (2) reactivity of bromine and solubility of bromine compounds; (3) preparation of aqueous bromine; (4) laboratory extraction of bromine from sea water; and (5) commercial extraction of bromine compared to laboratory method of extraction.

Excerpt: A section of film, covering one of the major divisions above, which can be used as a meaningful segment. Each excerpt contains many concepts.

Content of film: Concepts, descriptive information, and application of previously learned principles used to broaden each student's understanding of halogen chemistry.

Achievement: Measured gain in knowledge of concepts, descriptive information, and ability to apply principles through the use of film and excerpts.

Mode of instruction: Combinations of teaching, discussion, and different types of filmed media.

Overview of the Study

The general plan of this study was as follows: chapter two consists of a review of the literature and its implications for the study. The first section of the review covers the history of film use in general and the use of films in science teaching. After a short discussion on mental blocking and vigilance, the literature on single concept films is reviewed. In the next section, the literature on the use of films in different modes of instruction is reviewed; and finally, a section on film use in programing.

Chapter three details the procedures which were followed for the collection of the data for the study and the manner in which it was prepared for analysis. A detailed description of the procedures which were used to prepare a reasonably valid and reliable post-test is described in chapter three, and the hypotheses are stated.

In chapter four, the data which applies to each of the hypotheses are presented and analysis is made.

Chapter five states conclusions and implications based on the analysis presented in chapter four, and recommendations for further study are presented.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter reviews the literature on film usage and film research and shows its implications for this study. The first section reviews film research with particular emphasis on the transmission of factual knowledge. The next section discusses the literature about filmed science courses. The research and writings on single concept films make up a third section. Although all three sections have direct bearing on this study, additional information is included for background. The last two sections review modes of instruction involving films and film use in programing.

Although many teachers have used films for little more than a source of entertainment for their students, audiovisual specialists have suggested several steps that will optimize learning from film utilization. These steps are: (1) preparation of the students before the showing of the film; (2) viewing of the film; (3) discussion of the content of the film; and (4) a second showing of the film. Many research reports substantiate the effectiveness of these methods.

Various reasons for using films have been suggested. David Ridgway, writing about the production and use of CHEM Study films, suggests that films be used to do what films can do best and to leave the rest of the teaching to the text, laboratory, or the teacher.[1] Students cannot watch the actual growth of a plant, but time lapse photography can compress many days' growth into a few seconds and show students how growth does occur. Many other such instances can be cited. George Frasier advises in his book on educational methods, "Remember these four methods of teaching: (1) Use actual material if possible. (2) Or use good moving pictures. (3) If neither of these is feasible, use diagrams. (4) Depend entirely on written or spoken words only in dire necessity."[2] Mark Slade agrees with Fraiser and states that if ideas are to come alive to students great care must go into the communicating of those ideas. He also states that films can be used in certain circumstances to "liberate complex ideas from a printed page."[3]

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[1]David W. Ridgway, "CHEM Study Films: Project for Curriculum Improvement," Educational Screen and Audiovisual Guide, XLI (December, 1962), p. 715.

[2]George W. Frasier, An Introduction to the Study of Education (New York: Harper and Brothers, 1956), p. 317.

[3]Mark Slade, "Liberating a Complex Idea," Educational Screen and Audiovisual Guide, XLIII (May, 1964), p. 251.

General Film Research

Lumsdaine's chapter in the Handbook of Research on Teaching on instruments and media of instruction gives several major compilations of research on instructional films. Hoban and von Ormer summarized the research on instructional films from 1918 to 1950 under a Navy-sponsored research program at The Pennsylvania State University.[4] A series of studies conducted in the Information and Education Branch of the Office of the Chief of Staff of the War Department have been reported by Hovland, Lumsdaine, and Sheffield in 1949.[5] In their book, Learning from Films, May and Lumsdaine report a series of studies at Yale University from 1946 to 1949.[6] Still another major compilation of research on films was done at The Pennsylvania State University under the direction of C. R. Carpenter. Mimeographed reports of these studies were issued by the U.S. Naval Training Devices Center and are available from the Office of Technical Services, U.S. Department of Commerce.

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[4]Charles F. Hoban and E. B. van Ormer, Instructional Film Research 1918-1950 (Rapid Mass Learning), A Report on The Pennsylvania State College Project Jointly Sponsored by the Department of the Army and the Department of the Navy (Port Washington, New York: 1950).

[5]Carl I. Hovland, Arthur A. Lumsdaine, and Fred D. Sheffield, Experiments on Mass Communication (Princeton, N.J.: Princeton University Press, 1949).

[6]Mark A. May and Arthur A. Lumsdaine, Learning from Films (New Haven, Connecticut: Yale University Press, 1958), passim.

Many research studies have established that knowledge of facts can be transmitted by films.

> The evidence during the past decade supported Hoban and van Ormer's conclusion that films can teach factual information effectively over a wide range of subject matter content, age, abilities, and conditions of use. This factual learning, however, tends to be rather specific to the information actually communicated by the film, there apparently being nothing in the film presentation, per se, that would assure better learning.[7]

Factual knowledge of the background of World War II, the German war strategy, and the events of the Battle of Britain was increased using films in several studies reported in Hovland, Lumsdaine, and Sheffield.[8] Meierhenry used groups of Nebraska high school classes also to prove that factual knowledge can be transmitted by films. By devoting one-sixth of the classes' instructional time to enrichment programs with motion pictures, the students attained significantly better scores than nonfilm classes on informational tests which were directly related to the content of the films. Each of the student groups achieved comparable scores on national standardized tests.

Other studies have been done in many different subject matter areas. Barry and Smith used the Iowa Reading Films to test their effectiveness in teaching reading to

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[7]William H. Allen, "Audio-Visual Materials," Review of Educational Research, XXVI, No. 2 (April, 1956), pp. 125-126.

[8]Hovland, Lumsdaine, and Sheffield, passim.

ninth grade students. All of the different treatments resulted in gains in achievement, but the experimenters could not find any significant increase by the film groups over the other experimental methods.[9]

The studies cited show that factual knowledge can be taught in many subject matter areas through the use of films. The present study extends the studies cited above since none of those studies used single concept films as a medium for transmitting the factual information.

Many science films have always been available to teachers. This abundance of science films is undoubtedly a result of the nature of science itself. Even though the present emphasis in science education is to teach the structure of a subject, many processes and individual bits of information must still be taught. Large amounts of money are available to science curriculum projects from the National Science Foundation and other organizations, such as the American Chemical Society. With the availability of large sums of money for film development, excellent science films have been made an integral part of all the major curriculum improvement studies in science.

With many films readily accessible, research involving science films is extensively reported. For the

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[9]Robert F. Barry and Paul E. Smith, "An Experiment in Ninth-Grade Reading Improvement," Journal of Educational Psychology, XLV (November, 1954), pp. 407-414.

purposes of this review, the literature on instructional science films is divided into two major sections: research on entire filmed courses in the sciences, and research on intermittent use of science films. The latter is discussed in the section on modes of instruction.

Filmed Science Courses

A crucial educational problem was brought to the public's attention during the late 1950's; education in the United States was not keeping pace in the scientific fields. Several attempts were made to deal with this problem; one was the utilization of mass media instructional materials in the form of completely filmed courses in the high school sciences. Two of these series were produced in the decade from 1950 to 1960: a series of 162 lectures and demonstrations by Professor Harvey White in high school physics in 1956-57, and a series of 160 lectures and demonstrations by Professor John Baxter in high school chemistry in 1957-58. The Fund for the Advancement of Education financed both projects, and the films are distributed by Encyclopaedia Britannica Films, Incorporated.

Four major studies show the effectiveness of the filmed physics courses in high school classes. Only two reports were found which utilized the chemistry film series.

The University of Wisconsin conducted an evaluation of the first semester of the physics series in the first semester of the academic year 1957-58. Thirty experimental schools and thirty control schools tested the effectiveness of the first half of the 162 films. Just before the close of the experiment, fifty-two schools, known as control-control schools, were added to control for the Hawthorne effect. The students in the control-control schools were tested only at the end of the experimental period. Thus, they were not aware that they were included in the study.

Although the control schools realized that they were part of the study, the teachers taught physics in the conventional way. The experimental schools had one film per day (thirty minutes in length) with specially prepared lesson outlines, but the teacher was allowed to use the remaining time in whatever way seemed appropriate.

The results reported which are pertinent to this study are:

1. Comparing the achievement of control groups and experimental groups, no significant difference was found.
2. When the achievement of the control groups, experimental groups, and control-control groups were compared, the control groups exhibited significant superiority over both the other groups. (The addition of the control-control groups introduced a degree of precision, which resulted in the significant difference.)

3. The experimental group achieved significantly greater when all groups were tested on the information that was included in the films.

Since only half the series was used in this study, it is difficult to judge the effectiveness of the entire series; but the students were asked to comment on the experiment upon its completion. Some of these comments have relevance for film use in science classes.

Some positive reactions are:

1. The students had never seen such excellent laboratory equipment or had so many demonstrations.
2. Experiments always worked; no loss of time to failures.
3. Excellent graphic materials were used.

A few of the more prominent negative comments were:

1. The films set too fast a pace.
2. They couldn't take notes and watch film.
3. Laboratory films were too long and drawn out.
4. There was no chance to ask questions during the film, and the problem was often forgotten by the end of the film.
5. The film left no time to practice what was learned.[10]

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[10]Milton O. Pella _et al_., "The Use of the White Films in the Teaching of Physics," _Science Education_, XLVI (February, 1962), pp. 6-21.

A full year study was conducted in Utah on funds that were appropriated by the Fund for the Advancement of Education. Ten experimental and ten control schools constituted the sample which ranged in size from large schools to quite small schools.

Because of the large interschool variations in mathematics and physics knowledge, intelligence, and interests, inferential statistical techniques could not be used. Since adjustments for initial differences were not employed, it is difficult to interpret the results of the research.[11]

Beginning in February of 1957 a study was conducted showing the physics films over television in Chicago schools. The film group saw five telecasts each week; and the control group had seven periods each week, including two double laboratory periods.

In the first analysis, 692 television viewers were compared with 906 control students. The mean Otis IQs of the television group was 115.6 and, for the control group, 108.9. Because of the great difference in mean IQ, no statistical significance could be established.

In an attempt to establish a correlation between ability and method of presentation, a sample of 584 students

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[11] Matthew F. Noall and Lerue Winget, "Staff Utilization Studies Help Utah Educators - The Physics Film Project," National Association of Secondary School Principals Bulletin, XLIII (January, 1959), pp. 183-195.

was matched on IQ. For each ability group the non-television students scored significantly higher than the television group. The largest differences occurred in the highest and lowest ability groups. This suggests a relationship between mode of instruction and ability with the students of average ability tending to respond to the televised films more favorably than either of the extreme groups.[12]

Another year-long study utilizing 149 of the Harvey White physics films was conducted by Anderson and Montgomery in Kansas during 1958-59. Two schools were used; one with two instructors and 225 students and the other with two instructors and 176 students. The group of 225 students saw one film each day except when tests were given. Each week the other group had two class periods of lecture, discussion, or demonstrations, two class periods for laboratory work, and one period for tests.

The authors concluded that the film method produced greater variability in achievement than the conventional method; and that in the proportion that this greater variability in achievement was true, the film method was superior.[13]

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[12] Max D. Engelhart, E. C. Schwactgen, and Mary M. Nee, "Chicago Public Schools Television Experiment in High School Physics," American Journal of Physics, XXVI (October, 1958), pp. 347-349.

[13] Kenneth E. Anderson and Fred S. Montgomery, "An Evaluation of the Introductory Physics Course on Films," Science Education, XLIII (December, 1959), pp. 386-394.

Commenting on this study in the Handbook of Research on Teaching, Fletcher Watson states:

> We must question the authors' conclusion that the increased variance in four of the experimental classes showed "that the film method produced somewhat superior results . . . " (italics in original) (p. 390). At least there was agreement that 149 films were too many to use in one year.[14]

In an article in Science Education, Kenneth Anderson reports that he and a group of other researchers carried out three companion studies using the Encyclopaedia Britannica Film Course on Chemistry. About 600 students and thirty-three classes were involved over a period of one year. The design of the experiment was the typical film vs. non-film groups, and he states that most of the data were in favor of the non-film group. No other report of these studies could be found; so no inferences can be drawn.[15]

Popham and Sadnavitch also conducted a carefully controlled experiment in Kansas to test the effectiveness of both the Baxter chemistry series and the White physics series. Forty schools were originally considered for inclusion in the study with a final sample of twelve matched schools. The twelve schools were divided into two groups: six were experimental schools for chemistry and control schools for

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[14] Fletcher G. Watson, "Research on Science Teaching," Handbook of Research on Teaching, ed. N. L. Gage (Chicago: Rand McNally and Company, 1963), Part IV, p. 1049.

[15] Kenneth E. Anderson, "Audio-Visual Research," Science Education, XLV (December, 1961), pp. 430-436.

physics, and the other six were experimental schools for physics and control schools for chemistry. Of the 312 physics students involved, 155 were taught by films; and of the 475 chemistry students, 234 were taught by film.

A total of 149 physics films and 132 chemistry films were employed in the study. For physics, the teachers agreed to show four films every other week with five films alternate weeks. For the chemistry series, only four films were shown each week. The remaining time was utilized for laboratory sessions and testing.

The results on achievement of the chemistry study are summarized as follows:

1. No significant difference in achievement between the experimental and control groups was found.
2. There was no significant interaction between teaching method and level of intelligence.

Following is a summary of the achievement results for physics:

1. The achievement of the control group was significantly better than the experimental (film) group.
2. No significant interaction between method of teaching and student intelligence was found.

The author's conclusion summarizes all of the studies on the filmed courses in science.

> In conclusion, the results of the major analyses for both physics and chemistry seem to create doubts concerning the value of teaching science courses via

> film, particularly in the case of the physics series. While the limitations cited at the outset of this discussion suggest that the findings of this experiment are far from conclusive, research of this type should make it incumbent upon proponents of the filmed science courses to supply empirical evidence that the filmed technique produced educational gains which are at least comparable to those yielded by ordinary instructional methods. With a view to sound fiscal policies in the secondary school, the considerable cost associated with their purchase should dictate that more evidence must be presented before a favorable judgment regarding their educational usefulness can be reached.[16]

The studies cited above seem to indicate that using filmed sequences as the sole source of information in a science class is questionable, but many researchers have found that interspersed films can increase achievement in knowledge of factual information. Studies of this type are discussed in the section on modes of instruction.

Mental Blocking and Vigilance

Although the research on the filmed science courses has shown that films have no advantage over conventional methods for teaching physics and chemistry, the research reports have given some other information which applies to the present study. Almost all of the studies above used questionnaires to determine the students' and teachers' reactions to

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[16] W. James Popham and Joseph M. Sadnavitch, The Effectiveness of Filmed Science Courses in Public Secondary Schools, A Report Prepared under a Research Grant from the U.S. Office of Education, Department of Health, Education, and Welfare (Kansas State College of Pittsburg: August, 1960), p. 50.

the filmed courses. Almost unanimously, the summary of reactions show that the students got bored with so much film, and thus their achievement decreased.

Another reason for low achievement from the filmed science courses can be found in Travers's interim report. One whole chapter is devoted to the theories of attention and to related empirical studies on this subject. Since the review is very comprehensive and only two sections have relevance to the present study, only the conclusions on mental blocking and vigilance are given here.

Travers defines blocking as "momentary lapses in performance which occur with periodicity throughout a mental task."[17] The results of the studies seemed to indicate that blocks were rest breaks which were enforced by the body, and that blocks were most frequent and longer in more homogeneous tasks. One of the researchers hypothesized that if the number and length of blocks did not increase in both competitive and homogeneous tasks that mental fatigue would increase and achievement would decline severely.

Although the studies which Travers reports on vigilance are not directly connected to watching moving pictures, he feels that the data are sufficient to allow him to

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[17]Robert W. Travers, Research and Theory Related to Audiovisual Information Transmission, Interim Report for the U.S. Department of Health, Education and Welfare, USOE Contract No. 3-20-003 (Bureau of Education Research: University of Utah, 1964), p. 8.48.

generalize enough to suggest that when the perceptual system receives information from particular sources there is a declining ability to receive information from any particular source which is a function of time. He also states the same point differently:

> . . . when the nervous system is set to take in information by a particular channel, that it becomes steadily less capable of handling information through the same channel. While the data are derived from a situation involving a low information input, common observation suggests that a similar phenomenon probably occurs when the density of information is greater but that the decrement is probably less.[18]

Travers sums up his findings on blocking by suggesting that in using educational media it would be advantageous to insert artificial, externally enforced rest periods to increase the number of responses in mental tasks and to decrease the number of mental blocks. He also proposes that if types of tasks are varied the attention span will increase and that, since frequency and length of blocks increase in proportion to the number of conflicting elements with any material, competitive information should not be given within the same film.

Single Concept Films

Since single concept films cover only one major idea and are only a few minutes long, perhaps short films can resolve some of the problems which Travers finds in educational

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[18] Travers, p. 8.67.

media. Also, the teachers who used the Baxter chemistry series and the White physics series felt that they had been relegated to a more minor position before the class, because the films were the primary source of information. And, since a film which took most of a class period had to be shown almost every day, the teacher's creativity was severely limited. So, single concept films could serve a multiplicity of purposes in an educational setting.

> Many learning theorists and methodologists felt that here at last was an instructional device long overdue in educational institutions, a device which could be used for explaining and exploring areas of knowledge and research by meting out "small doses" of information at any given time - visual instruction that could be repeated as often as necessary until the facts presented were completely assimilated by the viewer. Each piece of knowledge thus provided was but a small unit within the structure of a series of films encompassing a broader area of curriculum development . . . [19]

This excerpt from a recent article by Frederick E. Strauss, written for UNESCO, indicates that single concept films could have a function in education. Although the technology is only recently available to make the use of these films more convenient, the theory of single concept films has been established for many years.

A continuous loop of film is not the only way to make short films convenient for projection. As early as the

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[19] Frederick E. Strauss, 8mm Silent Capsule Films (Monograph prepared for The Director, Office of Science Teaching, Department of Natural Sciences, UNESCO: 1964), p. 2.

1920's, single frames of movies were installed in discs which could then be used by educators who wanted easy-to-use motion pictures. "In the Spirograph system, instead of recording sequential images on a ribbon of film, frames were arranged in a spiral on a disc. Starting at the outside edge, the projector aperture and optics tracked, like a phonograph arm on a record, toward the center of a revolving disk."[20]

In 1924 H. Y. McClusky determined by a careful analysis of the content of one hundred teaching films that about only one-half of each film was composed of shots that had moving subjects, and that the rest was made of subtitles and still photographs which could be more conveniently presented by wall charts, textbooks, or slides.[21] F. Dean McClusky did one of the first comparative studies on media for his doctoral dissertation. When he discovered an educational film that contained too much irrelevant material, he excerpted the film to get motion pictures which were equivalent to other types of visual materials. He found that, in order to obtain a film to compare with other visualized materials that was chiefly a picture of motion, he had to excerpt a portion from an existing film.[22]

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[20]Joseph L. Anderson, "Looking Back for the Single-Concept Film," Journal of the University Film Producers Association, XVII, No. 2 (1965), p. 31.

[21]Joseph L. Anderson, p. 28.

[22]Joseph L. Anderson, p. 28.

In the past, educational films have not only contained much irrelevant material; but they were often packed with too much information for easy assimilation. Because films have not been readily available to teachers and because they often came at an inopportune time, films were seldom used correctly. Often the students received no preparation for the film, and no discussion followed the film. Under these conditions even an excellent film would probably increase the student's knowledge of the subject of the film very little.

What can be done about the low level of achievement acquired through the customary use of films? Many investigations on proper film usage have established that multiple showings of a film will increase the achievement over one showing. But, how many teachers have the time necessary to rewind a film after the first showing and project it the second time or to show it during another class period? If the film were packaged in a way that made multiple viewings of a film convenient, teachers could easily overcome this disadvantage of conventional films. Cartridge films have the unique quality of reducing the technological handicaps present in ordinary film use.

If a teacher had a series of short filmed sequences readily available to him, two other disadvantages of longer films could be overcome. First, the teacher could use the films in any of several ways. He could vicariously demonstrate something which was impossible to do within his classroom. He could use the film bit to stimulate discussion. The creative teacher would find many applications. Secondly, the teacher would once again be in complete control of his classroom. This does not mean that single concept films will replace the longer educational films. Rather, it will mean that each will have specific purposes. When a specific principle or concept is to be taught, a short film could be utilized. But if interest, review, or preview was the purpose for the film, a longer, more general film would be effective.

> The single-concept film . . . is a reflection of Skinnerian psychology and information theory . . . Many teachers feel that short, specific films could mean classroom libraries of reference films for immediate use in automatic projectors or for incorporation in larger systems such as the Edex programer where they may become part of a multi-media presentation over which the teacher has control.[23]

Skinner states that the whole process of becoming competent in any field must be divided into a large series of very small increments, and reinforcement must be given immediately upon the completion of each step.[24] If the subject matter of a film was presented in small amounts, followed by or preceded by discussion, the students would

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[23]Robert W. Wagner, "The Educational Film in Transition," Audiovisual Instruction, IX (March, 1964), p. 172.

[24]B. F. Skinner, Harvard Education Review, XXIV (1954), pp. 86-97.

receive immediate reinforcement. This is exactly what Skinner suggests in his shaping theory.

> Thorndike's fish had to complete the total act of swimming through the hole before he was reinforced by escape. Skinner's pigeon, on the other hand, was reinforced at first for the merest approximation of the final act of turning around to the left. And this is the heart of Skinner's strategy for teaching, the process of shaping.[25]

So, by using short segments of films we are able to reinforce each successive step in the building of a whole idea; but in using only longer films, reinforcement is delayed if it is ever given.

Very few research studies have used film loops or single concept films as one of the treatment variables. But several studies at The Pennsylvania State College for the Instructional Film Research Program under the direction of C. R. Carpenter utilized film loops as a teaching medium for motor skill training, and recently three studies used loops to teach factual information.

In the Instructional Film Research Program, a study conducted by S. F. Harby on 100 men found that film demonstrations projected by means of film loops in daylight proved as effective as a live instructor's demonstration for

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[25]Daniel C. Neale, "A Matter of Shaping," Phi Delta Kappan, XLVII (March, 1966), p. 376.

teaching tumbling skills to college students.[26] A second similar study by Murnin, Hayes, and Harby substantiated the fact that film-taught groups learned skills without an experienced instructor; that live instruction was superior to film instruction (the advantage being attributed to coaching); and, using film loops, an instructor with a minimum of training can teach skills effectively.[27]

S. F. Harby conducted another project using film loops. In his report he stated that students can learn a physical skill simply by watching a motion picture and by mentally going through the motions of the skill as they see it demonstrated on the screen. The sample included 250 men from the physical education department of The Pennsylvania State College, and the skill involved was the underhand basketball free-throw.[28]

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[26] S. F. Harby, Evaluation of a Procedure for Using Daylight Projection of Film Loops in Teaching Skills, A Report Prepared by the Instructional Film Research Program, The Pennsylvania State College, Human Engineering Report SDC 269-7-25 (Special Devices Center, Port Washington, Long Island, New York: May, 1952).

[27] J. A. Murnin, W. Hayes, and S. F. Harby, Daylight Projection of Film Loops as the Teaching Medium in Perceptual-Motor Skill Training, A Report Prepared by the Instructional Film Research Program, The Pennsylvania State College, Human Engineering Report SDC 269-7-26 (Special Devices Center, Port Washington, Long Island, New York: May, 1952).

[28] S. F. Harby, Comparison of Mental Practice and Physical Practice in the Learning of Physical Skills, A Report Prepared by the Instructional Film Research Program, The Pennsylvania State College, Human Engineering Report SDC 269-7-27 (Special Devices Center, Port Washington, Long Island, New York: June, 1952).

A final study from the Instructional Film Research Program, written by McIntyre and Sherk, tested whether repeated showings of the same film loop were more effective for teaching knot tying than an equivalent number of different filmed demonstrations of the same technique. The results showed that more learning occurred when the single demonstration was repeated than by modifying the film.

All of these studies have demonstrated that film loops are an effective means of teaching physical skills, and recommendations from each of the studies emphasized that this method should be used more often.

Recently, a variety of projects has investigated if single concept films can be effective tools in the teaching of factual information. A pilot study was conducted during 1965 to test if repetitive 8mm film loops would be instrumental in helping underachievers in reading. These films were adapted from 16mm black and white films which had been used over a six-year period in Delmar, New York. The school was located in an area where the income was low, and the people had few cultural advantages. Since the school officials felt that little could be done in reading for these retarded children even if the teacher had only ten or twelve students, a system was devised which employed repetitive film loops on an individual basis. Every member of the class was kept meaningfully occupied saying sentences after a model voice with picture clues to meanings and then having them reappear without the clues. The lesson could be repeated as often as necessary for the individual child to master the subject matter.

> Even with the slowest beginner some real progress can be achieved by means of the repetitive loop film lesson . . . Recently an unskilled worker of twenty-two who had heard of the progress of these retarded youngsters presented himself as a pupil and has learned to read and write by means of these lessons. A retarded sixteen-year old sister of one of the children had voluntarily read her first sentence from the screen.[29]

Castelle Gentry, project assistant for the Single Concept Film Clip Project during the academic year 1964-65, utilized single concept films in the research for his doctoral dissertation. The general purpose of the study was to provide guidelines for the programing and use of single concept films. Specifically, he compared the expository and discovery methods of film clip use for teaching the concept, "adaptation." With a sample of 280 junior high students from eighth grade science classes, he tested three independent variables: sequence of concept instances, intelligence level, and teaching method. His technique was unique in that the teacher was completely removed, and the films were the sole source of information. The students responded to three criterion tasks: generation of new instances of the concept, application of the principle to problem

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[29] Ruth M. Riddick and Ceferina Estacio, "The Use of the Repetitive 8mm Loop with Underachievers in Reading," Audiovisual Instruction, X (April, 1965), p. 308.

situations, and recognition of new instances of the concept. No significant differences were found for the hypotheses, but:

> . . . a trend . . . indicated that bright students learned best when taught by single-concept films programed for the expository method, while less bright learned best when the programing followed the discovery method. This trend reoccurred during three regroupings of the data. In one of the regroupings (i.e., subjects separated by sex) significant differences were found favoring the trend.[30]

Employing groups of driver education students, Fletcher tested four different teaching methods, including some involving loop films: group I was the control group and had no instruction; group II only saw the films; group III had live demonstrations; and group IV saw the films and had live demonstrations also. On a knowledge test as to the procedures needed to develop the skill, group II, III, and IV scored about equally well. These same groups also scored equally well on the first effort at performing the skill and in the number of practice trials needed to perform the driving skill correctly. Fletcher also listed three advantages of using loop films over live demonstrations:

1. There is a saving of instructor's demonstration time.
2. The film demonstration never overlooks an explanation or skips a step.

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[30]Castelle G. Gentry, "Relative Effectiveness of Discovery and Expository Methods of Teaching Concepts Through the Single Concept Film" (unpublished doctoral dissertation, Michigan State University, East Lansing, Michigan: 1965), p. 4 (of abstract).

3. The instructor can spend more time with the students in actual driving sessions.[31]

Many educators are convinced of the capability of single concept films. Thousands of short science films are already on the market, and the other curricular areas are considering the usefulness of film loops in planning new curricula.

> The answer has come for those communications specialists who have urged the utilization of only those portions of projected materials which serve a specific purpose. The means is now provided for the implementation of the conceptual approach to teaching and learning as conceived by the researchers in social studies curriculum . . . The focus of these single concept films will be upon the ability of the student to extract the presented facts, and to develop both insight and critical judgment.[32]

Modes of Instruction

Research cited above has shown that the value of entirely filmed courses is questionable; but long science films have been used effectively with many different modes of instruction.

At the Instructional Film Research Program, VanderMeer compared three modes of instruction for general science: films exclusively, films plus study guides, and

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[31] Harry D. Fletcher, "Loop-film, Tool for Driver Education Classes," Education Screen and Audiovisual Guide, XLIV (November, 1965), pp. 20-21.

[32] Leonard W. Ingraham, "Innovation in the Social Studies: The 8mm Single Concept Film," Social Education, XXX (February, 1966), p. 91.

standard lecture methods. In the "films exclusively" treatment, the students only viewed selected films. Specially prepared study guides on the films accompanied the films in the "films plus study guide" treatment. The standard lecture method used no films. The researcher reports that the three methods were equally effective, but that the films plus study guides method was slightly more effective for teaching factual material.[33]

Anderson, Montgomery, and Ridgway conducted a study using eighteen films to test the effectiveness of four different modes of instruction for high school biology. The methods involved various combinations of traditional textbook methods, laboratory work, and film utilization. As measured by the Minnesota State Board Examination in Biology, the students in the combined film and laboratory groups achieved significantly more factual information than the other three groups.[34]

In 1956, Anderson and other associates report a yearlong study in biology classes which compared different

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[33]Abram W. VanderMeer, Relative Effectiveness of Instruction by: Films Exclusively, Films Plus Study Guides, and Standard Lecture Methods, A Report Prepared by the Instructional Film Research Program, The Pennsylvania State College, Human Engineering Report SDC 269-7-13 (Special Devices Center, Port Washington, Long Island, New York: July, 1950).

[34]Kenneth E. Anderson, Fred S. Montgomery, and Robert W. Ridgway, "A Pilot Study of Various Methods of Teaching Biology, Science Education, XXXV (December, 1951), pp. 295-298.

methods of employing sound motion pictures. Three modes of instruction were compared: control group--no films shown or films of the teacher's choice; experimental group--films shown at intervals throughout the year with teachers making their own preparations for the films; another experimental group--same films used as the other experimental group, but the films were reinforced by emphasizing the principles covered or stressed by the films. The results of the experiment showed that there was no difference in achievement if intelligence scores and pretest scores were kept constant; but, "There is some evidence that the Films-with-Principles-Stressed Method yielded results somewhat superior to Film Method, and the Film Method yielded results somewhat superior to Control Method."[35]

Two high school chemistry classes were used as the sample for an experiment which integrated two films into a unit on sulfur. Controlling for total grade point average in courses common to the two groups, intelligence scores, and scores previously accumulated on chemistry tests, the researcher found an $F_{1,34} = 10.53$. Although he does not state what level of significance was used, it is significant at $p < .01$ in favor of the film groups.[36]

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[35]Kenneth E. Anderson et al., "Toward A More Effective Use of Sound Motion Pictures in High School Biology," Science Education, XL (February, 1956), p. 54.

[36]Courtney W. Nelson, "Effectiveness of Sound Motion Pictures in Teaching a Unit on Sulfur in High School Chemistry," School Science and Mathematics, LII (January, 1952), pp. 8-10.

Besides using films as a technique for transmitting factual information, the present study also required student participation by having the students discuss the filmed sequences after they had viewed them for the first time.

> Different investigators account for the superiority of participation technics in various ways. Hoban and van Ormer consider it to be one of several "audience involvement" factors, the others being identification, familiarity, subjective cameras, anticipation, and Sheffield suggests that the factors of "direct rehearsal," "motivation," and "practice under stimulus conditions of the response subsequently to be performed" are the determining ones. Michael concludes that the main factor in responding to discrete items of factual information is "practice"; but that where principles or methods are practiced there is "transfer" to phenomena rather than in motivational terms. Roshal supports the "Practice of the response to be learned" position. Gibson supports the principle of "overt response with reinforcement of right and wrong response."[37]

Since so many studies involving student participation have been carried out, only those studies most pertinent to the present study are reviewed. These experiments all have some type of verbalization of response.

As early as 1936 researchers recognized the need of pupil participation in the process of learning. Hall used three geology films in a general science class to test three different methods: (1) test announced followed by a film and then a test, (2) no test announced or given, and (3) test announcement followed by a film during which slides

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[37]William H. Allen, "Research on Film Use: Student Participation," Audiovisual Communication Review, IV-V (Spring, 1957), p. 424.

containing the test questions were projected below the film throughout the showing, with the students instructed to write their answer as soon as they could. The same test was used as a pretest for all the students two days before showing the film. The results showed that the use of the test during or immediately after the film produced significantly greater achievement when they were retested two weeks later.[38]

In a project done for the Air Force at the Human Resources Research Laboratories, Michael investigated the relative effectiveness of several conditions of participation. Although the researcher employed several different techniques, only two methods apply to this study. Michael used 640 high school students as his sample to test the film "PATTERN FOR SURVIVAL" which was stopped periodically to permit the audience to answer questions on the factual knowledge within the film. Half of the eight experimental groups wrote the answers to the questions, and the other half "thought" the answers. Half of the test questions following the film was on material from the participation technique, and the other half was on material not previously practiced. The difference in achievement of 7.3% in favor of the participation groups over the non-participation groups was

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[38]W. J. Hall, "A Study of Three Methods of Teaching Science with Classroom Films," School Science and Mathematics, XXXVI (December, 1936), pp. 968-970.

significant at the 2% level. But the superiority of the participation techniques held only for the specific items that had been practiced.[39]

Social studies films and filmstrips were used by Slattery to compare three modes of instruction: sound motion pictures, filmstrips with participation, and filmstrips without participation. The results on a test of factual information and concepts within both the films and filmstrips showed the two filmstrip methods were significantly superior to the film method. The filmstrip with participation method was superior to the non-participation method, but not significantly so.[40]

Kendler, Cook, and Kendler tested the effectiveness of overt audience participation on increasing the learning from repetition of review sections in a film. A military film was the experimental film with one, two, or three consecutive presentations of a review added. Twenty-eight high school classes were divided into seven groups of four classes each. Three of the groups participated by calling out the names of objects as they identified them, and three received no instructions. The groups saw either one, two, or three

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[39]Donald N. Michael, <u>Some Factors Influencing the Effects of Audience Participation on Learning from a Factual Film</u>, Reported in the article by Allen above, pp. 427-428.

[40]Sister M. Jamesetta Slattery, <u>An Appraisal of the Effectiveness of Selected Instructional Motion Pictures and Silent Filmstrips in Elementary School Instruction</u>, Reported in the Allen article above, p. 429.

reviews. All the students were tested immediately after seeing the film. The overt audience participation increased the learning on all the reviews, but the increase was statistically significant for the first review only.[41]

One final study on modes of instruction employing films is one which was done to provide comparisons for short films produced to teach factual information necessary for accomplishing certain procedures for constructing clothing. The four methods of film presentation were: (1) continuous showing of the film with no comments or questions, (2) breaking the film into several parts to give the audience rest pauses, (3) incorporation into the film of written questions and statements which allowed "passive participation," and (4) participation of the audience by stopping the film and allowing the audience to question the instructor or answer questions posed by the instructor and the audience writing notes dictated by the instructor. The subjects were eight classes (185 girls) in seventh grade sewing, and each group saw four films (eight to ten minutes) about various phases of clothing construction.

The results showed that active participation of the audience, as class discussion and note-taking, produced

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[41] Tracy S. Kendler, John O. Cook, and Howard H. Kendler, "An Investigation of the Interacting Effects of Repetition and Audience Participation on Learning from Training Films," (Abstract), <u>The American Psychologist</u>, VIII (August, 1953), pp. 378-379.

significantly more learning than any of the other methods.[42]

Thus, student participation has been found to be a significant factor in learning from modes of instruction involving films. When instruction via films is purposeful and planned in terms of the objectives to be reached and when the students are aware of these objectives, positive increments in learning occur.

In the present study, student participation was an important part of the methods used. After the viewing of a filmed sequence, the teacher stimulated discussion of the major principles in the film by a series of questions designed by the experimenter to emphasize those principles.

Simulation

Earlier in this report, it was stated that the theory of the single concept film is based upon Skinnerian psychology, and these principles are the basis of programed instruction. In one sense the CHEM Study films are programed into the curriculum since it is definitely specified at what point in the text the film is to be viewed. In designing this experiment, the excerpts and the discussion of them was

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[42]Philip C. Minter, Fritz A. Albert, and Richard D. Powers, "Does Presentation Method Influence Film Learning?" Audiovisual Communication Review, IX (July-August, 1961), pp. 195-200.

programed very specifically into the teaching of chapter nineteen of the text materials.

Research on programed instruction has been reported in many different sources. In reviewing the research for a report for a study at Palo Alto, Peggie Campeau compiled a most complete list. Searching through this compilation, the author was able to find only one project which utilized films. But several studies have used films in programing simulation studies.[43]

Recently, a pilot study at the Teaching Research Laboratory of the Oregon State System of Higher Education created a procedure for using simulation in teacher education. The project was carried out in two stages. During the first stage a simulation facility was built, and techniques were developed for simulating classroom situations. The situations are created through the media of sound motion pictures and printed materials. To create realistic effects, multiple projection techniques were employed. The simulation technique was designed to provide teachers with a different opportunity for gaining classroom experience. The printed materials were: a set of cumulative records for the hypothetical students, and a description of the school and

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[43]Leslie J. Briggs, et al., Instructional Media: A Procedure for the Design of Multi-Media Instruction, A Critical Review of Research, and Suggestions for Future Research. A Final Report for the Department of Health, Education, and Welfare, Office of Education, Contract No. OE-5-16-011, Under Title VII, Part B of the National Defense Education Act of 1958 (October, 1965).

community. The main portion of the materials was sixty problem sequences on film; each with alternative feedback sequences which were designed to show the student teacher the possible consequences of the way he handled the problem. Each sequence of filmed problems was used repeatedly until the student teacher reached a pre-established level of performance or until the total number of repetitions was ten, whichever occurred sooner. After each presentation of a problem and feedback sequence, the experimenter discussed the experience with the student teacher.

In the experimental phase of the project, forty student teachers were assigned to four experimental groups. All the groups received the same instruction, but the realism of the projection techniques varied from life-size sound motion pictures to still pictures greatly reduced in size. Analysis of variance showed a significant difference ($p < .05$) in favor of the smaller, less realistic projection. An analysis of the self-reports of the subjects showed that the reactions to the instructional medium were favorable with only two exceptions. The experimenter reports that the negative effect to the realistic presentation could have been a reaction to the orientation period which was carried on in the more realistic motion picture projection.[44]

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[44]Bert Y. Kersh, Classroom Simulation: A New Dimension in Teacher Education, The Final Report, Title VII, Project No. 886, National Defense Education Act of 1958 (June, 1963).

Utsey, Wallin, and Belden also applied simulation to teacher education. They used films and printed materials in the education of reading teachers. The technique that was developed programed printed materials and films in such a way that the students learned the essential elements of administering an informal reading inventory. The authors report good results in the achievement of the students in administering the reading inventory, but the carry-over learning has not been completely evaluated.[45]

At the present time the Learning Systems Institute in the College of Education at Michigan State University is preparing other simulation materials for use in teacher education. This project should be in operation in the near future.

Summary of Review of the Literature

In this chapter, the literature which is pertinent to the present study has been reviewed. Since this study tested the effectiveness of combinations of single concept films and a whole film for communicating factual information, the first section of the chapter reviewed general film research with special emphasis on studies testing for facts.

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[45] Jordan Utsey, Carl Wallen, and H. O. Belden, "Simulation: A Breakthrough in the Education of Reading Teachers," *Phi Delta Kappan*, XLVII (June, 1966), pp. 572-574.

Because of the pressure of public opinion for improvement of science teaching, vicarious teachers, in the form of filmed science courses, were tried. The second section of the review covers the research on these attempts at improvement of instruction. The results from these studies showed no significant advantage of the filmed classes over conventional methods.

If large amounts of film were not the answer, perhaps short segments of film which could be utilized as desired by a teacher would hold promise. So the next section reviewed the studies done with film loops and single concept films. These studies showed that the short films on one major idea could teach physical skills and factual information.

But since this study employed discussion of the content of the single concept films, a review of studies on pupil participation with emphasis on research which included student discussion as a variable was done. The conclusions from all the studies was definitely in favor of the groups using discussion methods.

Finally, because the present study programed excerpts and films into a specific chapter of the CHEM Study text, a short section was devoted to a few studies which used films in simulation techniques--a form of programing.

Although the literature was scarce in certain phases, the research reported in this chapter builds a framework around which this study has been formed.

CHAPTER III

THE EXPERIMENTAL DESIGN

The Population

The population for this study consisted of eighty-nine school systems in the Southern Peninsula of Michigan that had acquired classroom quantities of CHEM Study materials during the school year 1964-65; presumably all of these schools had used the materials for at least one year. The CHEM Study headquarters at The University of California, Berkeley furnished the above list. All the schools were contacted and asked to participate in the study. This population includes students who range along the entire continuum of socio-economic status and are from schools which vary in size from the very large schools of Detroit to much smaller schools. The members of this population also includes several races. Parochial, as well as public schools were included in the population.

The Sample

The sample consisted of eighteen classes from the eighty-nine school systems and included 412 students. Because of the need to prepare a valid and reliable instrument, the time during which the study was conducted was near the end of the school year. The content which was covered in the study is listed as optional material by the CHEM Study curriculum, so many of the original population were eliminated because this section of the text was not studied. Finally, eighteen of the remaining teachers were selected to participate. One school had more than one teacher cooperating in the study, the Henry Ford High School in Detroit, which had three teachers involved. Each of the eighteen teachers collected data from one of their chemistry classes.

Because of illness and other reasons, 30 students did not take all three of the tests and thus were eliminated from the study, leaving a total of 382 students. Of this number, 231 were boys and 151 were girls. Their ages ranged from 14 years 7 months to 18 years 2 months. On the Otis Quick-Scoring Mental Ability Test the students ranged in IQ from 64 to 135.

Instrumentation

This section describes the media, the content, and the testing materials which were used in this study.

Media. The media which were utilized were various combinations of the film BROMINE - ELEMENT FROM THE SEA and excerpts from that film. This film is one of the twenty-six prepared for and integrated into the CHEM Study curriculum.

The filmed sequences were all 16mm sound and color motion pictures and were projected for the students on standard 16mm sound projectors. The excerpts from the film had been identified previously by the Single Concept Film Clip Project at Michigan State University as segments which presented one phase of the chemistry of the element bromine.

The visual portion of the film showed demonstrations and descriptive material on bromine chemistry. The sound track of the film presented factual information describing the visual materials.

Content. The specific content which was tested consisted of the concepts, descriptive material, and principles that were given in the film excerpts.

The subject matter which is presented in the film is not presented elsewhere in the CHEM Study curriculum; and thus, the film is an integral part of the curriculum, and the procedures and time for its use were designated specifically by the curriculum makers.

The film content is described in the film guide with the following summary.

> The high chemical reactivity of bromine plus the high solubilities of bromine compounds result in most of the world's bromine being in the oceans. For this reason the chemistry of an aqueous solution of bromine is explored. The process of recovering elemental bromine from sea water is then developed on a laboratory scale. The essential steps are: (1) oxidation of bromide ion with chlorine, (2) concentration by reduction with sulfur dioxide to hydrogen bromide, and (3) reoxidation followed by separation

of the bromine by steam distillation. The same steps are then shown in an industrial bromine plant.[1]

The content of the excerpts can be simply described by listing the titles of the five segments lifted from the whole film: (1) correct handling of bromine, (2) reactivity of bromine and solubility of bromine compounds, (3) preparation of aqueous bromine, (4) laboratory extraction of bromine from sea water, and (5) commercial extraction of bromine compared to the laboratory method.

Test materials. Three tests were used in this study: (1) the Otis Quick-Scoring Mental Ability Test, Gamma Test, Form Fm, (2) an objective pretest, and (3) an objective post-test.

The Otis Test gave a measure of general ability of the students. Its validity has been established by the publishers of the test. In the test manual, the split-half reliability of the test is given as .88. The validity of the individual items was established by deriving the bi-serial coefficient of correlation between each item and the total score on the test. The publishers give the median value of these coefficients as +.61.[2]

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[1] Teacher's Guide to the CHEM Study Chemistry Films (Berkeley, California: Chemical Education Materials Study, The University of California, 1964), p. 1 (description of film #4169).

[2] Otis Quick-Scoring Mental Ability Tests, Gamma Test, Form Fm: Harcourt, Brace, and World, Inc., New York.

The objective pretest and post-test were essentially the same test, but the order of the items was reversed. The individual items were prepared by the experimenter by listing the concepts, descriptive material, and principles which were included in the excerpts from the film; and true and false items were written based upon this content. Since all of the students were exposed to the subject matter included within the excerpts twice, only this content was used as the basis of the test items.

True-false items were used on the objective tests in this study, because the factual information in the excerpts was most conveniently handled by this method. This type of test item was quite popular in the early days of objective testing, but students and teachers alike tend to regard these items as the least acceptable form for objective test construction. In his book on testing, Dr. Robert Ebel lists the following objections which are often given to true-false items: triviality, ambiguity, encouragement of rote learning, susceptibility to guessing, and the exposing of students to error instead of truth. Dr. Ebel agrees that a true-false test could have all of the shortcomings listed above; but he contends that if the items are constructed correctly, they are efficient, convenient, and can provide direct tests of a student's command of knowledge.

> Acquisition of command of knowledge is . . . the central purpose of education. All knowledge is knowledge of propositions. One essential purpose of

> experimental science is to test the truth or falsity of hypothetical propositions. The essential purpose of logical reasoning is to test the truth or falsity of deductive propositions. Propositions are expressed in sentences. These sentences may be true or false. This is the stuff of which human knowledge (and true-false tests) are made.[3]

Details of the procedures used to produce a valid and reliable criterion performance are given below.

The original post-test was written for the first pilot study at Detroit Denby High School. An item analysis was done on the results of the first test, and those items which had a very high index of difficulty or a low index of discrimination were rewritten. The major criterion which was used to judge if an item should be rewritten was the index of discrimination, since no item which is much too difficult or much too easy could discriminate when the Upper-Lower-Difference Index is used.

The revised test was then used in a second pilot study which was also run at Detroit Denby High School. The results of this second pilot study were again item analyzed. Since the reliability of the test was not very good, Dr. Robert Ebel of the College of Education at Michigan State University suggested that the reliability of the test could be increased by increasing the number of items on the test. Both of the pilot forms of the test contained only forty items. At his suggestion, the experimenter rewrote the test

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[3]Robert L. Ebel, Measuring Educational Achievement (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), p. 126.

again but increased the number of items to seventy-five. This increase was accomplished by taking each concept, descriptive fact, or principle and writing both a true and a false item whenever possible. Most of the items from the previous tests which had shown good discrimination were included in the second revision.

This second revision then became the post-test for the major phase of this study. The pretest was made by reversing the order of the items on the post-test.

The data which were analyzed were the means of the differences between each student's pretest score and his post-test score.

Assignment of Classes and Treatments

After the selection of the eighteen teachers who were to participate, their classes were assigned to the three treatments in the following way.

The experimenter arbitrarily assigned the first CHEM Study class of the day for each teacher as the experimental class. To accomodate as many teachers as possible with the materials available, the three teachers from Henry Ford High School were all assigned to the same treatment. The other fifteen classes were randomly assigned to one of the three treatments.

Each teacher was unrestricted in his teaching of chapter nineteen of the CHEM Study text except for the addition of one of the three film treatments. These three treatments are: (1) film only, (2) excerpts only, and (3) a combination of the film and the excerpts. To equalize the exposure of the students to the subject matter to be tested, each class saw the filmed material twice.

Three procedures were used to control the teacher variable. First, the subject matter in the films is not expressly taught elsewhere in the curriculum. Secondly, the experimenter wrote a summary for the film and for each excerpt which was used by the teachers as the only introduction to the film or excerpt. Thirdly, a series of questions based upon the fundamental principles in the excerpts was used as the only basis of discussion for both the film and excerpts. These questions are found in the appendix.

In the film only treatment, the teacher taught in his usual method until he had taught section 2.2 of the chapter. Then he read the introduction to the film and showed it to the class. Immediately following the viewing of the film, the content was discussed following the prescribed questions. After teaching the rest of the chapter, the teacher used the whole film as a review of the chapter but with no discussion.

In the excerpts only technique the teacher showed the excerpts twice. When the teacher reached a place in the chapter which had been arbitrarily assigned by the experimenter as the time for viewing one of the excerpts, he proceeded as follows. After reading the summary of the excerpt as an introduction, he showed the filmed sequence. Next he discussed the content of the excerpt following the questions prescribed by the experimenter, and finally showed the single concept film again with no subsequent discussion.

In the combination treatment, the teacher followed the same pattern as the teacher using only the excerpts, except he did not show the excerpt the second time. Each of these teachers also showed the whole film as a review of the chapter, but without discussion.

Hypotheses

The following hypotheses were investigated to compare the effectiveness of teaching factual knowledge by a film, by excerpts from that film, or by a combination of the film with excerpts from the film.

The legend for the hypotheses is:

A = film only treatment

B = excerpts only treatment

C = combination treatment

M_A = mean of film only treatment

M_B = mean of excerpts only treatment

M_C = mean of combination treatment

Null hypothesis. There is no significant difference among the means of the achievement gains of three groups of students who have been taught factual information by means of a film, excerpts from that film, or a combination of the film and excerpts from that film.

Symbolically stated, the null hypothesis is:

$$H_o: M_A = M_B = M_C$$

Alternative hypothesis. The alternative hypothesis is:

There is a significant difference among the means of achievement gains of three groups of students who have been taught factual information by a film, excerpts from that film, or a combination of the film and excerpts from that film.

Symbolically stated, the alternative hypothesis is:

$$H_1: M_A \neq M_B \neq M_C$$

With the rejection of the null hypothesis at the .05 level of significance and with acceptance of the alternative hypothesis, Scheffé's method of comparisons was used to establish a directional relationship between the means of the treatment groups. This directional relationship is shown in chapter four.

Analysis of Data

The data which were analyzed were the achievement gains of the students. These achievement gains were computed by finding the difference between each student's pre-test score and his post-test score.

The CDC 3600 program, UNEQ1 for analysis of variance, was used to test the null hypothesis of no difference among the means of the three treatment groups. The same program was also used to test for homogeneity within the treatment groups.

When significant variance was found within treatment groups, the program BMDO4V, for analysis of covariance with multiple covariates, was used to test the null hypothesis while controlling for IQ.

Chronological Procedures of Study

In May, 1965 the first pilot study was run at Detroit Denby High School. The purpose of the study was to field-test the procedures of the treatments and the criterion performance (the post-test).

In July, 1965 the list of eighty-nine school systems was received from the CHEM Study headquarters. In October, 1965 letters were written to all of the schools above, asking for cooperation in the study. Also during October, the results of the first post-test were item analyzed; and the first revision was written. Final preparations for the second pilot study were completed.

The second pilot study was run during December, 1965 and January, 1966 at Detroit Denby High School. The post-test was again item analyzed, and the second revision of the post-test was written. This form contains seventy-five items.

During February and March, 1966 the final selection of the eighteen teachers that participated in the major study was made. Also, all of the materials that were necessary for the study were ordered or prepared.

Early in May, 1966 the teachers were supplied with the films, tests, and directions for administering the classroom phase of the study.

Since all of the teachers did not cover chapter nineteen of the CHEM Study text at the same time, the actual application of the treatments to the teaching of the chapter varied from teacher to teacher; but all followed the same general procedures. The general ability test and the pre-test were administered to all students before the teacher began teaching chapter nineteen. The chapter was then taught in the teacher's normal pattern, except for applying the film treatment which had been assigned. Following the teaching of chapter nineteen, the post-test was given immediately. This phase of the study was completed by June 17, 1966.

As the answer sheets were received, they were prepared to be sent through the scoring machine. When the results were received from the scoring office, the experimenter prepared them in a way suitable for the existing programs of the CDC 3600 at the Computer Center for analysis. This phase was completed by July 20, 1966.

CHAPTER IV

ANALYSIS OF DATA

This chapter first discusses the reliability and validity of the objective tests prepared by the experimenter--the criterion measures. The remainder of the chapter is devoted to the methods which were used to test the null hypothesis. Finally, a conclusion is stated based upon the statistical analysis of the data. An optional questionnaire was given to the students following the post-test. The results of this questionnaire are given in the last portion of this chapter, and a short discussion of the significance of the findings is included.

Validity and Reliability of Criterion Measures

Two of the primary criteria for judging the validity of any study must be the reliability and validity of the instruments which are used as criterion measures. The tests which were constructed for this study were field-tested and revised twice in an attempt to produce a reliable instrument. The result of these revisions was to increase the reliability from .56 on the first test to .70 for the post-test and .82 for the pretest of the major study. These reliability coefficients compare favorably with many of the reliability coefficients listed for standardized tests.

The statistics which were computed for the pretest of the major study are:

Mean item difficulty	47
Mean item discrimination	30
Kuder Richardson Reliability #20	.8214

The statistics for the post-test are:

Mean item difficulty	30
Mean item discrimination	21
Kuder Richardson Reliability #20	.7018

The validity of the tests for this study was established as content validity. Borg defines content validity as, " . . . the degree to which the sample of test items represents the content that the test is designed to measure."[1] The content which the tests for this study was designed to measure was the concepts, descriptive material, and principles which were included in the excerpts from the film. Since the true-false items of the tests were based directly upon a list of all of the individual pieces of factual information within the excerpts, the test should be reasonably valid.

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[1]Walter R. Borg, Educational Research: An Introduction (New York: David McCay Company, Inc., 1963), p. 80.

Test of the Hypothesis

The data which were available for analysis to test the null hypothesis were student scores on: the Otis Quick-Scoring Mental Ability Test, the objective pretest, and the objective post-test. The scores on the Otis Test were changed to IQs by using the conversion table which was furnished by the publishers. The data which were actually analyzed were the differences between each student's pre-test score and his post-test score--his achievement gain.

The null hypothesis was stated in chapter three as:

> There is no significant difference among the means of the achievement gains of three groups of students who have been taught factual information by means of a film, excerpts from that film, or a combination of a film and excerpts from that film.
>
> Stated symbolically this hypothesis is:
>
> H_o: $M_A = M_B = M_C$
>
> The legend for these symbols are:
>
> A = film only treatment
>
> B = excerpts only treatment
>
> C = combination treatment
>
> M_A = mean of the film only treatment
>
> M_B = mean of the excerpts only treatment
>
> M_C = mean of the combination treatment

The alternative hypothesis was stated in chapter three in the following manner.

> There is a significant difference among the means of the achievement gains of three groups of students who have been taught factual information by a film, excerpts from that film, or a combination of a film and excerpts from that film. Stated symbolically the alternative hypothesis is:
>
> H_1: $M_A \neq M_B \neq M_C$

One-way analysis of variance with unequal number of replications within the groups was used first to test the null hypothesis. The independent variable used in this analysis was the treatment. The dependent variables were IQ and the difference score or achievement gain for each student. Using the program for the CDC 3600 called UNEQ1, the following analysis of variance table was computed for difference scores and treatment.

Table 1. Analysis of variance table for difference scores.

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic
Between Treatments	9316.6109	2	4658.3055	63.63972
Within Treatments	27742.0723	379	73.1981	
Total	37058.6832	381		

Using the degrees of freedom given above, an F ratio of greater than 3.07 is significant at the .05 level of significance. The computer gave the approximate significance probability as being less than .005. This shows that there was significant variance among the three groups when the treatment groups were analyzed with the difference scores alone.

An analysis of variance table was also computed for treatment and IQ. This table follows:

Table 2. Analysis of variance table for IQ.

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic
Between Treatments	6600.7215	2	3300.3607	29.60498
Within Treatments	42250.8938	379	111.4799	
Total	48851.6153	381		

From the table of F values, an F ratio greater than 3.07 is again required for significance at the .05 level. This statistic is significant at less than .005 level. Thus, there was significant variance among the treatments on IQ also.

Because of the significant variance among treatments on IQ, the experimenter analyzed the data again, but this time used analysis of covariance to control for IQ. This was done using the program for the CDC 3600 called BMC04V for analysis of covariance with unequal replications within the groups. The covariates in this analysis were IQ and treatment, and the dependent variable was difference scores. The following analysis of covariance (Table 3) was computed.

With 2 and 378 degrees of freedom an F value of greater than 3.07 is required for rejection of the null hypothesis at the .05 level of significance. Thus, with a computed F ratio of 63.893, the null hypothesis of no significant difference among the means of the three treatment groups can be rejected.

The alternative hypothesis--H_1: $M_A \neq M_B \neq M_C$--can be accepted, showing a significant difference among the means of the three treatment groups.

Since the null hypothesis of no significant difference among the means can be rejected, Scheffé's method of multiple comparisons was used to determine the directional relationship among the means.[2] "Indeed, a significant F test can be interpreted as evidence that at least one true comparison value among all those possible is not zero."[3]

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[2]William C. Guenther, Analysis of Variance (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964), pp. 57-58.

[3]William L. Hays, Statistics for Psychologists (New York, N.Y.: Holt, Rinehart and Winston, Inc., 1964), p. 485.

Table 3. Analysis of covariance table.

Source of Variance	Degrees of Freedom	YY	Sum of Squares (Due)	Sum of Squares (About)	Degrees of Freedom	Mean Square
Treatment (between)	2	9316.6109				
Error (within)	379	27742.0723	595.6059	27146.4664	378	71.8160
Treatment Error (total)	381	37058.6832	735.1241	36323.5591	380	
Difference for Testing Adjusted Treatment Means				9177.0927	2	4588.5464

$F(2,378) = 63.893$.

To calculate the confidence interval for Scheffé comparisons, the following table of differences of group means was necessary.

Table 4. Differences of adjusted means.

	Mean	B	C
Mean Treatment		7.4770	19.2511
A	11.7396	-4.2626	7.5115
B	7.4770		11.7741
C	19.2511		

Using the method outlined in Guenther, a 95 percent confidence interval for each comparison was calculated. This confidence interval was:

$$\hat{L} - 2.65 = L = \hat{L} + 2.65$$

For this confidence interval to be significant for any of the comparisons between the adjusted means of the treatment groups, the difference between the means would have to be greater than an absolute value of 2.65. From Table 4, the difference between the adjusted means of treatment A and treatment B is -4.2626. Since the absolute value of this is greater than 2.65, there is significant difference between

M_A and M_B. The difference between the adjusted mean of treatment A and the adjusted mean of treatment C is 7.5115. Since the absolute value of this difference is greater than 2.65, there is a significant difference between M_A and M_C. The adjusted mean difference between treatment B and treatment C is 11.7741. This difference is also significant. Thus, we can say that all of the differences contribute to the over-all significance of F.

This significance by Scheffé comparisons between all of the adjusted means of the three treatment groups allows the directional relationship to be established. The adjusted mean for treatment C was 19.2511; for treatment A, the adjusted mean was 11.7396; and for treatment B, the adjusted mean was 7.4770. Thus:

$$M_C > M_A > M_B$$

Conclusion

The analysis of covariance established that there was a significant difference among the means of the difference scores of the three treatment groups when IQ is controlled. Comparing the differences between the means of the treatments by the Scheffé method produced the conclusion that the achievement gain by the combination film and excerpt treatment was significantly greater than the achievement gain by either of the other treatments. Also, the achievement gain by the film treatment was significantly greater than the achievement gain by the excerpt treatment.

Student Questionnaires

Reproduced in the following pages are three questionnaires (one for each treatment group) which the students were asked to complete, following the administration of the post-test.

After each response is a number which represents the frequency of that response. Also, below the last response for each question, a chi-square value for that question is given. With two degrees of freedom and with a .05 significance level, a chi-square of greater than 5.99 is necessary for significance. Thus, a chi-square value of greater than 5.99 indicates that the distribution of answers for that question is not a normal distribution.

Following the reproduction of each questionnaire is a short discussion of the significance of the questionnaire findings.

Student Questionnaire - Film Only

101. How much more did you learn from two showings of the film than you normally do from one showing?

1.	Much more	56
2.	A little more	65
3.	No more	2

Chi-square = 52.62 $p < .005$

102. If you could see a film only once, at what part of the chapter would you like to see it?

1.	First	48
2.	Middle	37
3.	End	37

Chi-square = 2.04 Not significant

103. How important do you think it is that the film be shown when you are studying the same material in the text?

1.	Very important	108
2.	Somewhat important	13
3.	Not important	2

Chi-square = 169.92 $p < .005$

104. In general, do you think chemistry movies are interesting?

1.	Very interesting	24
2.	Quite interesting	76
3.	Uninteresting	22

Chi-square = 46.90 $p < .005$

105. Do you feel that too much material is presented in the standard half-hour chemistry films for you to understand all of it?

1.	Often	20
2.	Sometimes	75
3.	Seldom	26

Chi-square = 30.52 $p < .005$

All of the chi-square values for the student questionnaire on film only are significant except for the question about the placement of a film during the teaching of a chapter. Apparently these students had no preference for the appropriate time for showing a film.

The students realized that they were capable of absorbing more of the information within the film with an additional viewing. Research has shown that a second showing of a film does increase the achievement in information.[4]

The question on the importance of showing a film when it can be correlated with the subject matter being taught shows that apparently these students do not always see the films at the appropriate times, and that timing is important to them.

The last two questions can give some direction to educational film producers. Although many films are interesting to the students, many other films lack this interest. The last question definitely points out that if we are going to use films as a mode of presenting information, we should reduce the quantity of bits of information within any single film. Single concept films accomplish this by including only one major idea within the film.

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[4]Hoban and van Ormer, passim.

Student Questionnaire - Excerpts Only

101. Did the clips present a complete thought or idea?

1.	All were complete	54
2.	Some complete	63
3.	None complete	4

Chi-square = 50.52 $p < .005$

102. Were the clips difficult to understand?

1.	All difficult	3
2.	Some difficult	63
3.	None difficult	54

Chi-square = 50.52 $p < .005$

103. How helpful were the clips in explaining the concepts or ideas in this chapter?

1.	Very helpful	37
2.	Somewhat	62
3.	Not helpful	22

Chi-square = 20.42 $p < .005$

104. Did you think the clips were interesting?

1.	Very interesting	29
2.	Somewhat	72
3.	Not interesting	21

Chi-square = 37.64 $p < .005$

105. Did the clips introduce new ideas?

1.	Many ideas	32
2.	Several	78
3.	None	10

Chi-square = 60.20 $p < .005$

106. Was the material in the clips presented in a clear manner?

1.	Very clear	62
2.	Mixed	51
3.	Not clear	8

Chi-square = 40.72 $p < .005$

107. Did the clips seem to have a main theme or topic?

1.	Most did	77
2.	Some did	34
3.	None did	9

Chi-square = 59.14 $p < .005$

108. Did you think these clips were easier to understand than the full length chemistry movies you have seen?

1.	Much easier	68
2.	Same	30
3.	Not as easy	22

Chi-square = 30.20 $p < .005$

109. The clips you saw were of various lengths, some quite short, others longer. If you had your choice, what length of clip would you choose?

1.	Long	46
2.	Medium	51
3.	Short	23

Chi-square = 8.64 $p < .025$

110. Would you use such clips, on an individual basis, if they were available to you?

1.	Often	49
2.	Seldom	54
3.	Never	16

Chi-square = 16.82 $p < .005$

All of the chi-square values for the questions on the student questionnaire for excerpts only were significant at the .05 level of significance. Most of the results are obvious from the frequency of the different responses, but the results for three of the questions are quite significant.

On question number 107 almost all of the students were able to recognize that at least some of the excerpts had a major theme. Once the students have identified the major idea within a teaching situation, the absorption of that principle is simplified.

In question number 108, the comparison of the ease of understanding the subject matter within the clips with the subject matter presented by longer films, over half of the students agreed that it was easier to absorb the factual information in smaller quantities over a period of time than it was to absorb the subject matter from a longer film. Thus, if the purpose of filmed sequences is to transmit subject matter, students would rather have it presented in shorter sequences.

The last question asked the students to identify how often they would use single concept films if they were made available in an individual study situation. Only sixteen of the total replied that they would never make use of them under these conditions. Apparently, these students felt that an individual study situation with single concept films could have value for them.

Student Questionnaire - Combination

101. Were the clips helpful in explaining the ideas which you then saw in the film?

1.	Very helpful	73
2.	Somewhat helpful	54
3.	Not helpful	5

Chi-square = 78.24 $p < .005$

102. If you had your choice for viewing this material, which would you choose?

1.	Clips only	5
2.	Film plus clips	114
3.	Film only	11

Chi-square = 208.54 $p < .005$

103. Would you use the clips on an individual basis if they were made available to you?

1.	Often	72
2.	Seldom	49
3.	Never	10

Chi-square = 50.12 $p < .005$

104. Do you feel that too much material is presented in the standard half-hour chemistry films for you to understand all of it?

1.	Often	52
2.	Sometimes	56
3.	Seldom	23

Chi-square = 8.22 $p < .025$

105. Did the clips present a complete thought or idea?

1.	All were complete	73
2.	Some complete	56
3.	None complete	2

Chi-square = 64.22 $p < .005$

106. In general, do you think chemistry movies are interesting?

1.	Very interesting	44
2.	Quite interesting	65
3.	Uninteresting	21

Chi-square = 25.04 $p < .005$

107. How did the clips compare in interest with the total film?

1.	More interesting	36
2.	Same	55
3.	Less interesting	40

Chi-square = 6.22 $p < .05$

108. In using the total film with the clips, where would you prefer to see the film?

1.	Before clips	38
2.	Between	4
3.	After clips	89

Chi-square = 92.52 $p < .005$

109. Were the clips easier to understand than the full-length movie?

1.	Much easier	61
2.	Same	47
3.	Not as easy	23

Chi-square = 19.46 $p < .005$

110. Were important ideas, shown in the film, left out of the clips?

1.	Many left out	10
2.	Few left out	70
3.	None left out	49

Chi-square = 47.02 $p < .005$

The chi-square values for all the results on the student questionnaire for the film and excerpts combination were significant at the .05 level of significance also. It is important to note that the responses on almost all of the items on this questionnaire are more favorable than the responses on the other two instruments. Two examples of this trend are on the questions on individual use of excerpts and on the question concerning the completeness of a thought within each concept.

On the question concerning the individual use of clips, only 49 students from the excerpts only treatment responded that they would use the clips often on an individual basis, but 72 students from the combination treatment responded that they would use them often under these conditions.

On the completeness of thought within each excerpt, the excerpt only students responded 54 times that all the excerpts contained a complete idea; 73 students from the combination treatment responded similarly. These two examples illustrate the positive nature of the responses of the students from the combination treatment.

In question number 102, only 16 responses out of 130 total were in favor of using other than the combination of film and excerpts treatment for viewing the material in the filmed sequences. Apparently, students were satisfied with this mode of presentation.

The responses to the question about the placement of the film within the combination are very much in favor of using the film as a review. These responses could be explained by the fact that this was the method used for these students, but it is rather indicative that almost all the students thought that the film should be used as either an introduction or a review.

Conclusion. The results on the questionnaires indicate that the students were most satisfied with the combination treatment.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This chapter is divided into two major sections. The first part of the chapter is concerned with the conclusions which can be made as a result of the analysis of the data collected during the study. In the second part of the chapter recommendations which are pertinent to the use of single concept films are made.

Conclusions

At least one major conclusion can be drawn as a result of the present study: With CHEM Study chemistry students a combination of a full film and excerpts from that film produces greater achievement gains in the factual knowledge contained in the film than either the whole film or the excerpts alone.

The adjusted mean achievement gain for the combination treatment was significant over the other two treatments beyond the .005 significance level. By separating the film into meaningful segments and by using the whole film as a way of drawing together all of these individual ideas into a complete entity, significant learning took place. Also, the results of the questionnaires showed that the combination treatment students were the most satisfied with the mode of presentation which they had experienced. On almost every question, their responses were more favorable than either of the other treatment groups.

Although the achievement gain of the whole film group was found significantly higher than the achievement gain of the excerpts group, the author does not feel that it is possible to conclude that it is better to use a whole film than excerpts from that film for the transmission of factual information. The major reason for this negative reaction to one of the findings of the present study is due to the design of the experiment. In the excerpts only treatment the students were shown the filmed sequences during the teaching of the entire chapter of the text, and no filmed material was shown to them as a review. Thus the students saw some of the single concept films more than a week before they took the post-test. In the film only treatment the students saw the full film, as a review of the chapter, only one day before taking the post-test. Thus, the students in the film only treatment might retain more information because of the time factor.

It is the conclusion of the author of this study that the results found in chapter four are applicable to a wider population than that included in the study. Several reasons can be given for this broadened generalizability.

The first reason is that the population in this study was quite similar to the general population of students found in many high schools. The students in this study were from all types of high schools, including public and parochial schools, large schools, and very small schools, and schools in Detroit and in much smaller communities. Although chemistry students as a group are usually a more select group, the students in this study ranged in IQ from very low (64) to very high (135). The students also came from homes along the continuum of socio-economic status from vice-president of a bank to production factory workers. Thus, the population of this study was fairly representative of the high school population of the State of Michigan.

Another reason for generalizing beyond the present population is that the content of the film used in this study is typical of much of the factual information which is taught in all schools. The results of this study cannot be generalized beyond the transmission of factual information, since no attempt was made to test anything except the achievement gain in specific concepts, descriptive subject matter, and principles included in the film excerpts. However, all of the subject matter areas do teach factual knowledge to some extent. So, if films are available in other subject areas for the transmission of factual information, the combination of a longer film and single concept films should be a profitable method of presentation of these ideas.

Recommendations

The recommendations from this study fall into two categories: general recommendations and recommendations for further study.

General Recommendations. One of the primary requirements for any study is an instrument which will give reliable results. The author of this study is convinced that one of the reasons a significant difference among the means of the treatment groups was found was because a reliable and valid instrument had been prepared. Thus, the first recommendation arising from this study is that, in future studies as in this study, emphasis be placed on preparing an instrument which will truly measure what the experimenter is attempting to answer. Expert help should be sought in preparing the instrument; and at least one field test, followed by revision of the instrument, should be carried out.

The rest of the general recommendations have to do with the preparation and use of single concept films.

Although the single concept film treatment in this study was found to be the least desirable of the three treatments, a significant amount of learning took place in the treatment which included the use of these filmed sequences.

In addition both the film only treatment students and those in the combination treatment responded that they felt that many times longer chemistry films contained too much subject matter for them to absorb all of it. The students also responded that they felt that the excerpts were easy to understand. Thus, if the subject matter had been broken into smaller amounts in shorter films, perhaps it could have been more easily assimilated. Therefore, a second recommendation is that single concept films be made available to teachers for use in their classrooms. Several thousand of these short films are already available commercially, many more are being prepared, and over a thousand excerpts from existing films have been identified by the Single Concept Film Clip Project at Michigan State University. These short films can be used to show things within the classroom that could not be seen otherwise. Dangerous experiments can be seen with no danger to students. Because of their short length and ease of use, a creative teacher could find many uses for single concept films within the context of any curriculum.

A third recommendation is intended specifically for producers of educational films. Since the major finding of this study is that greater achievement gain is possible through a combination of a long film and short films illustrating specific concepts and principles within the longer film, and since the results of the questionnaire to the combination treatment students showed them to be overwhelmingly in favor of the combination treatment over either the film or the excerpts separately, the author recommends that producers of educational films consider preparing a package of films. The package should include single concept films to teach specific principles within a major idea and a longer film which would serve as a means of summarizing the specific ideas in the shorter films. The idea of preparing film packages of the type described above has already been tried in England by Eothen Films. They have prepared several film packages for use in both the public schools of England and in specialized schools, such as nursing schools. Now that convenient methods of handling short, cartridged films are available, these film "coordinates" are a reasonable possibility.

Another recommendation also concerns the use of single concept films. Until the present time, almost all programing has been done by some form of verbalization. Since the technology is available for convenient use of single concept films, short filmed sequences could be utilized in many ways in programed instruction. When motion is required to present an idea in its correct perspective, a motion picture film should be utilized. Modern technology would provide the machines if some innovator presented the idea.

A further recommendation can be made on the basis of the findings of the questionnaires. The students seemed to feel that films were not as interesting as they should be and that films were not utilized within the classroom to their potential. The author recommends that both teachers and educational film producers reexamine film utilization and the content of educational films with the aim of improving the educational potential of films.

Recommendations for Further Study

Five suggestions for possible further study of the use of single concept films have come from the present study. Perhaps two or more of them could be combined into a single study; but in the opinion of the author of this study, all of the suggested studies should be done to give a more complete knowledge of the uses for and combinations of short format films.

The first suggestion for further study is that the present study should be replicated in different subject matter areas and at different grade levels. Although the results of this study are quite conclusive for the population that was involved, replications could serve to substantiate the findings and to broaden their generalizability.

Further study should be done to investigate the use of short format films in combination with full films to teach other than factual information, such as the formation of concepts and the changing of attitudes. The present study has shown that the combination of a film with excerpts from that film can be effective for the transmission of factual knowledge, but much of a teacher's time is spent helping children form concepts and develop attitudes. If the filmed combination is an efficient method for other than teaching facts, much more of a teacher's time could be spent doing things that films cannot do.

The present study used the full film as a review after the teaching of the entire chapter. This was found to be effective, and the results of the questionnaire showed that over half of the students thought that the film should be placed after the viewing of the excerpts. This finding could be partially explained by the manner in which the films had been presented to them. The author believes that it is significant that only a very small proportion of the students thought that the long film should be used between viewings of the single concept films. Almost all of them thought that it should be used as a review or as an introduction. Thus, an investigation should be made into the placement of the film in the combination. Perhaps the combination would be even more effective if the film were used as an introduction or if the film were placed somewhere between the beginning and the end.

No attempt was made to determine the achievement retention of the students in this study. Even if we are concerned only with factual information, the acquisition of that knowledge is useless unless it is retained. Thus, a replication of this study with the capability of testing the retention of the students would be most profitable.

Another suggestion for further study involves the use of single concept films in individual study situations and the use of a whole film for integrating all of the short films into a unified whole. The students in both the excerpts only treatment and the combination treatment indicated that they would use single concept films in an individual study situation if it was available to them. The combination treatment students were much more favorable to the idea, but very few of the excerpts-only students indicated that they would not use them. The author is convinced that one of the major ways that short films will be used in the future is for individual study. All students do not learn at the same rate; if the short films were put into study carrels where the students could view them as often as necessary on some type of automatic projector, even greater learning might take place. If the whole film were then used in class as a summary device, perhaps even greater achievement gain would be found. So the suggestion is that a study be done to compare the effectiveness of classroom use of the short format films from the combination with the individual use of the same single concept films with both groups viewing the whole film in the classroom.

Summary

One major conclusion can be drawn from the results of this study. A combination of a full film and excerpts from that film is more effective for teaching factual information to CHEM Study chemistry students than either the film or the excerpts alone. The results on the questionnaires indicates that the students were most satisfied with the combination treatment.

Four general recommendations are made by the author:

1. More emphasis be placed on instrument writing for future studies.
2. Single concept films should be made easily available to teachers.
3. Packages of single concept films and longer films should be prepared for instructional use.
4. Short format films could be used in programed learning situations.

Five suggestions for further study are recommended by the author:

1. A replication or replications of the present study should be done in another subject matter area and at different grade levels.

2. A study should be conducted to determine the effectiveness of other uses of whole film-short film combination for purposes other than the transmission of factual information.
3. A determination of the most effective placement of the full film in the combination should be carried out.
4. Study of retention should be done.
5. A comparison of individual use of short films with classroom use in the combination would be profitable.

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APPENDICES

APPENDIX A

DIRECTIONS TO TEACHERS PARTICIPATING IN THE COMPARISON STUDY OF DIFFERENT FILM FORMATS.

During this study it is essential that you adhere to the following guide quite closely. This guide is not intended to tell you how to teach chapter nineteen of the CHEM Study text. Teach this material in your normal manner, with the exception of the insertion of the film or excerpts at the proper time. You do not have to use the excerpts sequentially. When you reach a place in the text which is designated as a spot for the insertion of a film or excerpt, then follow the attached film guide.

The steps that you will follow in this study are:

1. Administer the Otis Quick-Scoring Mental Ability Test. Have the students place their answers on the IBM answer sheets. (If your students have not used this type of answer sheet before, spend a few minutes on the proper use of the answer sheet.)

2. Administer the objective pre-test. Have students place answers on the furnished scoring sheets.

3. Teach chapter nineteen in the text, inserting the film or excerpts at the designated times.

4. Administer the objective post-test. Place answers on scoring sheets.

5. Place all scoring sheets in specially marked envelopes and return to experimenter.

The tests which will be administered during the study will not measure your teaching of the chapter, but the tests will measure how much the students have learned from the filmed sequences.

Throughout the entire project try to maintain as normal classroom atmosphere as possible. This will help to reduce the tendency of people participating in a research project to do better than they would under normal conditions.

Film Only Treatment

A. The first showing of the film is following the teaching of 19-2.2 in the text.

B. Before showing the film, read the following summary to the students.

SUMMARY: The high chemical reactivity of bromine plus the high solubilities of bromine compounds result in most of the world's bromine being in the oceans. For this reason the chemistry of an aqueous solution of bromine is explored. The process for recovering elemental bromine from sea water is then developed on a laboratory scale. The essential steps are (1) oxidation of bromide ion with chlorine, (2) concentration by reduction with sulfur dioxide to hydrogen bromide, and (3) reoxidation followed by separation of the bromine by steam distillation. The same steps are then shown in an industrial bromine plant.

C. After first showing of film, use the following questions as a basis for discussion.

1. What is meant by the term "high vapor pressure?"

2. What is the difference between an irritating gas and a toxic gas?

3. The hydrogen continues to burn in the gaseous bromine. What is the difference between burning and supporting combustion?

4. The aluminum did not react immediately with the bromine. What does this suggest as possible uses for aluminum?

5. Discuss the self-oxidation which occurs in the bromine-in-water equilibrium:

$$Br_2 + 2OH^- = H^+ + Br^- + HOBr$$

Note: bromine is both oxidized and reduced. Reaction proceeds as written if made basic, since this reduces hydrogen ion concentration and converts HOBr to OBr^-.

6. Why was it necessary to convert bromine to hydrogen bromide and then once more to bromine?

7. Discuss why chlorine, and not oxygen or some other oxidizing agent, is most suitable for oxidizing bromide to bromine.

8. Why was sulfur dioxide chosen for the reducing agent?

9. Why is sea water not concentrated in the industrial production of bromine?

D. The time for the second showing is after the completion of the teaching of the chapter. No discussion is to follow.

Excerpts Only Treatment

#196-2-I Physical Properties of Bromine

A. This excerpt should be shown following the teaching of 19-1.0.

B. Before the first showing of the excerpt, read the following summary to the students.

SUMMARY: By a demonstration this clip shows the physical properties of bromine. It is the only non-metallic element that is a liquid at room temperature. Because of its high vapor pressure, it readily changes to a colored gas at room temperature. Because it is a toxic, irritating gas, it must be handled with rubber gloves and near some kind of exhaust system. It is also shown to have a density greater than air.

C. Following the first showing, discuss the content by use of the following questions.

What is meant by the term "high vapor pressure?"

What is the difference between an irritating gas and a toxic gas?

D. Show the excerpt a second time with no subsequent discussion.

#196-2-II & III Reaction of Bromine with Phosphorus, Hydrogen, and Aluminum, and Solubility of Bromides

A. This excerpt will be used after section 19-1.1 in the chapter.

B. Before showing the excerpt, read the following summary.

SUMMARY: The reactions of bromine with phosphorus, hydrogen, and aluminum are shown in demonstration. Bromine and red phosphorus react violently to give phosphorus tri-bromide which fumes at the reaction temperature. Hydrogen continues to burn in gaseous bromine and produces hydrogen bromide. Finally, aluminum is dropped into bromine liquid. After the oxide coating on the pellet has been penetrated, a vigorous combination of the elements forms aluminum bromide. The solubility of aluminum bromide, phosphorus tribromide, and hydrogen bromide are demonstrated. A vigorous reaction occurs in each case.

C. Following the first showing of the excerpt, discuss the content by use of the following question.

The hydrogen continues to burn in the gaseous bromine. What is the difference between burning and supporting combustion?

D. Show the excerpt a second time with no discussion.

#196-2-IV Properties of Bromine in Aqueous Solution

A. This excerpt should be used following section 19-2.3 in the chapter.

B. Before showing the excerpt for the first time read the following summary.

SUMMARY: Liquid bromine is put into solution in water by vigorous and prolonged action of a magnetic stirrer. The saturated solution is divided into two parts. Adding sulfuric acid to one part does not change the color. Sodium hydroxide is added to the second part and the color changes as bromide and hypobromite ions are formed. This reaction is easily reversed when the hydroxide ion concentration is reduced by adding acid. Bromine exists in aqueous solution in various forms which are in rapid, reversible equilibrium.

C. Following the first showing, discuss the excerpt by the use of the following question.

Discuss the self-oxidation which occurs in the bromine-in-water equilibrium:

$$Br_2 + H_2O = H^+ + Br^- + HOBr$$

Note: Bromine is both oxidized and reduced. Reaction proceeds as written if made basic, since this reduces hydrogen ion concentration and converts HOBr to OBr^-.

D. Following the discussion, show the excerpt a second time with no subsequent discussion.

#196-2-V Laboratory Extraction of Bromine from Sea Water

A. This excerpt should be used following the teaching of section 19-2.5 in the chapter.

B. Before showing for the first time, read the following summary.

SUMMARY: Concentrated sea water is acidified to reduce the hydroxide ion concentration. Chlorine gas oxidizes the bromide ions to elemental bromine with its characteristic brown color. The gas is blown from the sea water by compressed air, but the attempt to recollect it in water fails because of low solubility. A solubility table shows that hydrogen bromide is very soluble in water. The oxidation state of the bromine in this compound is minus one. An economical reducing agent, sulfur dioxide, is used to reduce elemental bromine to the bromide ion, which in water, forms HBr. The E^{o} values for the total reaction are given, and the experiment is done successfully. Chlorine gas again oxidizes the bromide ions in the HBr solution to bromine gas which is distilled with steam. Less than one gram of pure bromine is collected from a large volume of sea water.

C. Discuss the excerpt, following its first showing, with the following questions.

Why was it necessary to convert bromine to hydrogen bromide and then once more to bromine?

Discuss why chlorine, and not oxygen or some other oxidizing agent, is most suitable for oxidizing bromide to bromine.

D. After the discussion, show the excerpt a second time with no discussion.

#196-2-VI Commercial Production of Bromine Compared to Laboratory Preparation

A. This excerpt should be used following section 19-2.4 in the chapter.

B. Before the first showing, read the following summary.

SUMMARY: The commercial production of bromine is followed step by step through an industrial plant in Texas. The sea water is screened for debris, acidified with sulfuric acid in a large green pipe, and, at the top, treated with chlorine gas to oxidize the bromine. As the water falls over a brick tower, air forced in at the bottom blows out the bromine. A large green pipe removes the air and bromine. A white pipe introduces sulfur dioxide to reduce the bromine vapor. The hydrogen bromide formed is concentrated by dissolving it in a falling spray of water in a large tank. Chlorine is added in a high tower to reoxidize the bromine. Steam distills the bromine gas from the solution. This is condensed to a liquid and stored. The same steps are followed in the laboratory using concentrated and already acidified sea water.

C. Following the first showing discuss the content by using the following questions.

Why was sulfur dioxide chosen for the reducing agent? Why is sea water not concentrated in the industrial production of bromine?

D. Following the discussion, show the excerpt the second time with no discussion.

Combination Treatment

In this method, you will use the full film "BROMINE - ELEMENT FROM THE SEA" and excerpts from that film. Although you do not have to teach chapter nineteen in any order (teach it the way you usually do), please insert either the film or the separate excerpts according to the following schedule:

Excerpt no.	Use following section no.
196-2-I	19-1.0
196-2-II & III	19-1.1
196-2-IV	19-2.3
196-2-V	19-2.5
196-2-VI	19-2.4

Also show the full film following the completion of the teaching of chapter nineteen as a review, but with no discussion to follow.

#196-2-I Physical Properties of Bromine

A. This excerpt should be shown following the teaching of 19-1.0.

B. Before showing of the excerpt, read the following summary to the students.

SUMMARY: By a demonstration this clip shows the physical properties of bromine. It is the only non-metallic element that is a liquid at room temperature. Because of its high vapor pressure, it readily changes to a colored gas at room temperature. Because it is a toxic, irritating gas, it must be handled with rubber gloves and near some kind of exhaust system. It is also shown to have a density greater than air.

C. Following showing, discuss the content by use of the following questions.

What is meant by the term "high vapor pressure?"

What is the difference between an irritating gas and a toxic gas?

#196-2-II & III Reaction of Bromine with Phosphorus, Hydrogen, and Aluminum, and Solubility of Bromides

A. This excerpt will be used after section 19-1.1 in the chapter.

B. Before showing the excerpt, read the following summary.

SUMMARY: The reactions of bromine with phosphorus, hydrogen, and aluminum are shown in demonstration. Bromine and red phosphorus react violently to give phosphorus tri-bromide which fumes at the reaction temperature. Hydrogen continues to burn in gaseous bromine and produces hydrogen bromide. Finally, aluminum is dropped into bromine liquid. After the oxide coating on the pellet has been penetrated, a vigorous combination of the elements forms aluminum bromide. The solubility of aluminum bromide, phosphorus tribromide, and hydrogen bromide are demonstrated. A vigorous reaction occurs in each case.

C. Following showing of the excerpt, discuss the content by use of the following question.

The hydrogen continues to burn in the gaseous bromine. What is the difference between burning and supporting combustion?

#196-2-IV Properties of Bromine in Aqueous Solution

A. This excerpt should be used following section 19-2.3 in the chapter.

B. Before showing the excerpt read the following summary.

SUMMARY: Liquid bromine is put into solution in water by vigorous and prolonged action of a magnetic stirrer. The saturated solution is divided into two parts. Adding sulfuric acid to one part does not change the color. Sodium hydroxide is added to the second part and the color changes as bromide and hypobromite ions are formed. This reaction is easily reversed when the hydroxide ion concentration is reduced by adding acid. Bromine exists in aqueous solution in various forms which are in rapid, reversible equilibrium.

C. Following showing, discuss the excerpt by the use of the following question.

Discuss the self-oxidation which occurs in the bromine-in-water equilibrium:

$$Br_2 + H_2O = H^+ + Br^- + HOBr$$

Note: Bromine is both oxidized and reduced. Reaction proceeds as written if made basic, since this reduces hydrogen ion concentration and converts HOBr to OBr^-.

#196-2-V Laboratory Extraction of Bromine from Sea Water

A. This excerpt should be used following the teaching of section 19-2.5 in the chapter.

B. Before showing read the following summary.

SUMMARY: Concentrated sea water is acidified to reduce the hydroxide ion concentration. Chlorine gas oxidizes the bromide ions to elemental bromine with its characteristic brown color. The gas is blown from the sea water by compressed air, but the attempt to recollect it in water fails because of low solubility. A solubility table shows that hydrogen bromide is very soluble in water. The oxidation state of the bromine in this compound is minus one. An economical reducing agent, sulfur dioxide, is used to reduce elemental bromine to the bromide ion, which in water, forms HBr. The E^o values for the total reaction are given, and the experiment is done successfully. Chlorine gas again oxidizes the bromide ions in the HBr solution to bromine gas which is distilled with steam. Less than one gram of pure bromine is collected from a large volume of sea water.

C. Discuss the excerpt, following its showing, with the following questions.

Why was it necessary to convert bromine to hydrogen bromide and then once more to bromine?

Discuss why chlorine, and not oxygen or some other oxidizing agent, is most suitable for oxidizing bromide to bromine.

#196-2-VI Commercial Production of Bromine Compared to Laboratory Preparation

A. This excerpt should be used following section 19-2.4 in the chapter.

B. Before the showing, read the following summary.

SUMMARY: The commercial production of bromine is followed step by step through an industrial plant in Texas. The sea water is screened for debris, acidified with sulfuric acid in a large greem pipe, and, at the top, treated with chlorine gas to oxidize the bromine. As the water falls over a brick tower, air forced in at the bottom blows out the bromine. A large green pipe removes the air and bromine. A white pipe introduces sulfur dioxide to reduce the bromine vapor. The hydrogen bromide formed is concentrated by dissolving it in a falling spray of water in a large tank. Chlorine is added in a high tower to reoxidize the bromine. Steam distills the bromine gas from the solution. This is condensed to a liquid and stored. The same steps are followed in the laboratory using concentrated and already acidified sea water.

C. Following the showing discuss the content by using the following questions.

Why was sulfur dioxide chosen for the reducing agent?

Why is sea water not concentrated in the industrial production of bromine?

APPENDIX B

OBJECTIVE TESTS PREPARED BY THE EXPERIMENTER

First Pilot Test

DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO

The film Clip Project at Michigan State University is interested in determining if the form and timing in which audio-visual materials are presented make a difference in how well students understand the ideas shown.

The following questions were designed to test your understanding of the concepts presented in both the complete film about bromine, and the clips taken from this film. Analyzing the results of this test for all the Chemistry II students at Denby High will hopefully, be one step in finding the best use for audio-visual materials.

Your teacher will not be able to answer any questions, or even explain the test to you.

You will have 20 minutes to complete the forty questions. Read each statement carefully and mark it true or false. Do not spend so much time on one item that you do not get through. Wild guesses are not much good, but a reasoned opinion is often right. DO THE BEST YOU CAN.

1. Bromine liquid must be stored at temperatures near freezing and pressures above normal to keep it a liquid.

2. Bromine is the only non-metallic element which is a liquid.

3. The high vapor pressure of bromine results in rapid formation of the gas at room temperature.

4. If bromine gas had escaped into a room, the safest place would be close to the floor.

5. Bromine liquid is more harmful to the skin than bromine gas.

6. Bromine gas is toxic if inhaled.

7. Bromine liquid is toxic if it comes in contact with the skin.

8. High vapor pressure means that the gas formed exerts a higher than normal pressure on the container.

9. A violent reaction occurs when phosphorus tribromide is forming.

10. Phosphorus tribromide once formed is stable at the reaction temperature.

11. Phosphorus tribromide is a liquid.

12. Phosphorus tribromide reacts so rapidly with water that bubbles of steam are formed.

13. Burning hydrogen gas supports combustion in a container of bromine gas.

14. Hydrogen gas, burning in bromine, will give the gas HOBr as the product.

15. Both combustion and burning requires that oxygen be present.

16. The oxide coating on aluminum speeds the reaction with bromine.

17. Aluminum bromide is a white solid which is very soluble in water.

18. Water, entering at the bottom of a closed container of a soluble gas, will rise to the top.

19. As the gas dissolves in the water, a partial vacuum forms which allows the water to enter.

20. If an equal amount of water is added to a container of bromine liquid, the two will form a uniformly colored solution.

21. The bromide ion is colorless, although bromine is brownish.

22. The addition of hydrogen ions to a bromine solution increases the number of bromide ions formed.

23. The bromide ions readily form hydrogen bromide when combined with hydrogen ions.

24. The various ions present in an aqueous bromine solution are in a state of equilibrium which can be changed by adding hydroxide ions.

25. The comparison of densities of bromine water is difficult because bromine is soluble in water.

26. The acidification of sea water is a necessary first step in the extraction of bromine from it.

27. Bromide ions are precipitated when chlorine is passed into the acidified sea water.

28. Compressed oxygen is used to remove the bromine from its solution.

29. Bromine is highly soluble in water.

30. Hydrogen bromide is less soluble in water than bromine liquid.

31. Sulfur dioxide is used as a reducing agent, because it is easily available and cheap.

32. The gaseous bromine blown out of the sea water can be concentrated easily as liquid bromine.

33. Bromide ions can be oxidized by chlorine to form elemental bromine.

34. To separate the bromine from the hydrogen bromide solution, live steam is blown through the solution.

35. Air would be just as effective in removing bromine from hydrogen bromide solution.

36. The plant pictured was one of the largest plants on the Great Lakes.

37. Screens are used to remove debris and sea life from the sea water before the chemical processes begin.

38. Sulfur dioxide was used as the oxidizing agent in the commercial production of bromine.

39. The laboratory and commercial production of bromine follow the same step by step procedure.

40. It isn't necessary to concentrate sea water in the commercial process; because of the formation of the hydrogen bromide solution.

Second Pilot Test

DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO

This test was designed to test your understanding of the concepts presented in both the complete film and in the excerpts from that film.

Your teacher will not be able to answer any questions, or even explain the test to you.

You will have twenty minutes to complete the forty questions. Read each statement carefully and mark it true or false on the answer sheet in the following manner. Following the number for each question, you will find five pairs of lines. For each statement that is **TRUE**, blacken the space between the first pair of lines. For each **FALSE** statement, blacken the space under the number 2.

Do not spend so much time on any one question that you do not finish the test. Wild guesses are not much good, but a reasoned opinion is often right.

1. Liquid bromine must be stored at pressures higher than normal to keep it a liquid.

2. Bromine is the only non-metallic element which is a liquid.

3. At 30°C, the equation $Br_2(l) \rightleftharpoons Br_2(g)$ would tend to go toward the right.

4. If bromine gas had escaped into a room, the safest place would be close to the floor.

5. Bromine liquid is more harmful to the skin than bromine gas.

6. A mouse would die in an atmosphere made up of 20% oxygen and 80% bromine.

7. Bromine liquid is toxic if it comes in contact with the skin.

8. High vapor pressure means that the gas formed exerts a higher than normal pressure on the container.

9. A violent reaction occurs when phosphorus tribromide is forming.

10. Phosphorus tribromide fumes at the temperature at which it is formed.

11. Phosphorus tribromide is a liquid at ordinary room temperatures.

12. Phosphorus tribromide is vaporized as it reacts violently with water.

13. A hydrogen flame is reduced in size when placed in a container of gaseous bromine.

14. Hydrogen gas, burning in bromine, will give the gas HOBr as the product.

15. As the term is used in chemistry, oxidation requires that oxygen be present.

16. The oxide coating on aluminum speeds up the reaction with bromine.

17. Aluminum bromide is a white solid which is very soluble in water.

18. Water, entering at the bottom of a closed container of a soluble gas, will rise in the container.

19. As the gas dissolves in the water, a partial vacuum forms which allows the water to enter.

20. If an equal amount of water is added to a quantity of liquid bromine, the two will form a uniformly colored solution.

21. From the examples that were used in the film, we could conclude that the bromide ion is colorless.

22. The addition of hydrogen ions to a bromine solution increases the number of bromide ions formed.

23. A solution containing Br^- and H^+ would also contain large amounts of HBr.

24. The various ions present in an aqueous bromine solution are in a state of equilibrium which can be changed by adding hydroxide ions.

25. The comparison of densities of bromine and water is difficult because bromine is soluble in water.

26. The acidification of sea water is a necessary first step in the extraction of bromine from it.

27. Bromide ions are precipitated when chlorine is passed into the acidified sea water.

28. In the laboratory extraction of bromine from sea water, a blast of oxygen is used to remove the molecules of bromine.

29. Bromine is highly soluble in water.

30. Hydrogen bromide is less soluble in water than bromine liquid.

31. In the commercial extraction of bromine from sea water, hydrogen bromide is formed to make the extraction more successful.

32. In the process of extracting bromine by either the commercial or laboratory method, the bromine is collected directly as a liquid.

33. Since chlorine is more active than bromine, chlorine will oxidize bromide ions to elemental bromine.

34. To separate the bromine from the hydrogen bromide solution, live steam is blown through the solution.

35. A blast of air is effective in removing bromine from a hydrogen bromide solution.

36. The plant pictured was one of the largest plants on the Great Lakes.

37. Screens are used to remove debris and sea life from the sea water before the chemical processes begin.

38. Sulfur dioxide was used as the oxidizing agent in the commercial production of bromine.

39. The laboratory and commercial production of bromine follow the same step by step procedure.

40. In the laboratory method of the production of bromine, the sea water must be concentrated.

Post-test of Major Study. (The pretest was the same in reverse order.)

DO NOT TURN THE PAGE UNTIL DIRECTED TO DO SO

This test was designed to test your understanding of the concepts presented in the films which you saw.

Your teacher will not be able to answer any questions, or even explain the test to you.

You will have thirty-five minutes to complete the seventy-five questions. Read each statement carefully and mark it true or false on the answer sheet in the following manner. Following the number for each question, you will find five pairs of lines. For each statement that is TRUE, blacken the space between the first pair of lines. For each FALSE statement, blacken the space behind the number 2.

Do not spend so much time on any one question that you do not finish the test. Wild guesses are not much good, but a reasoned opinion is often right.

1. Since the acidification of sea water produces no brownish colors, we know that bromine could not be produced this way.

2. The following equation correctly shows the reaction between bromine and burning hydrogen: $Br_2 + H_2 \longrightarrow 2\ HBr$.

3. Aluminum bromide is a colorless liquid.

4. A solution containing Br^- and H^+ would cause large quantities of molecular HBr to be precipitated.

5. In the process of oxidation electrons are exchanged.

6. Aluminum bromide is very soluble in water.

7. Hydrogen gas, burning in bromine, will give the product HOBr.

8. A hydrogen flame is reduced in size when placed in a container of gaseous bromine.

9. The various ions present in an aqueous bromine solution are in a state of equilibrium which can be changed by adding hydroxide ions.

10. Ocean water from the Atlantic Ocean could be used just as it comes from the sea without any filtering process.

11. If you wanted to choose between bromine and chlorine as a suitable oxidizing agent, bromine would be the more efficient.

12. The characteristic amber color of bromine in water solution can be obtained by vigorously stirring the mixture.

13. The Dow plant in Texas produces large quantities of bromine for commercial use.

14. As water enters at the bottom of a tube of soluble gas, the pressure above the water will be increased.

15. The gaseous bromine blown out of sea water can be concentrated easily as elemental bromine.

16. At pressures above normal, the equation $Br_2\ (g) \rightleftharpoons Br_2\ (l)$ would tend to go toward the left.

17. At ordinary temperatures, a quantity of phosphorus tribromide would have a definite shape.

18. At room temperature, bromine has a low vapor pressure.

19. In the laboratory process, the acidification of sea water is a necessary first step in the extraction of bromine from it.

20. In removing bromine from a solution of hydrogen bromide, the live steam reacts with the hydrogen bromide forming elemental bromine.

21. Elemental bromine may be removed from acidified sea water using chlorine as the oxidizing agent.

22. In the laboratory process, the bromine was removed from the solution with a blast of air.

23. To separate bromine from a hydrogen bromide solution, live steam is blown through the solution.

24. Oxygen was not used as the oxidizing agent because it reacted too violently with the solution.

25. The water displacement method is used for collecting soluble gases.

26. If an equal amount of water is added to a quantity of liquid bromine, the two will form a uniformly colored solution.

27. Sulfur dioxide is used as the reducing agent, because it is easily available and cheap.

28. If bromine gas had escaped into a room, the safest place would be close to the floor.

29. Hydrogen bromide was selected as an intermediate compound because it is readily soluble in water.

30. The film emphasizes the need between laboratory methods and commercial methods.

31. As the term is used in chemistry, oxidation requires that oxygen be present.

32. Since bromine is brownish, we can assume that compounds of bromine are brownish also.

33. Hydrogen bromide is less soluble in water than liquid bromine.

34. The plant pictured in the movie is one of the largest plants of its kind on the Great Lakes.

35. Bromine gas is more harmful to the skin than liquid bromine.

36. Phosphorus tribromide reacts readily with water.

37. Sulfur dioxide was the most efficient reducing agent.

38. Bromine and phosphorus combine without any visible signs of reaction.

39. A mouse could not live in an atmosphere of bromine and oxygen.

40. The acidification of sea water is not necessary in the commercial production of bromine from sea water.

41. The oxide coating on aluminum speeds the reaction with bromine.

42. Liquid bromine in the eyes could cause blindness.

43. By shaking a mixture of liquid bromine and water, the bromine may be spread throughout the water as fine particles of bromine.

44. The addition of hydrogen ions to a bromine solution increases the number of bromide ions formed.

45. The comparison of the densities of bromine and water is difficult because bromine is quite soluble in water.

46. The bromide ion is colorless, although bromine is brownish.

47. When handling liquid bromine, rubber gloves should be worn to protect your hands.

48. Bromide ions can be oxidized by chlorine to form elemental bromine.

49. After the oxide coating is removed from aluminum, the aluminum combines easily with gaseous bromine.

50. At high temperatures, bromine would remain a liquid.

51. Screens are used to remove debris and sea life from the sea water before it enters the plant.

52. Oxygen is the cheapest oxidizing agent which could be used in this process.

53. Bromine is the only non-metallic element which is a liquid.

54. Bromide ions are precipitated when chlorine is passed into acidified sea water.

55. In a solution containing H^+ and Br^-, any HBr formed would dissociate almost immediately.

56. The sample of sea water was tested and found to be acidic.

57. Water, entering at the bottom of a container of a soluble gas, will rise in the container.

58. A man's lungs would not be seriously damaged by breathing small amounts of bromine in the air.

59. Once phosphorus tribromide is formed, it is stable at the reaction temperature.

60. Burning hydrogen readily reacts with gaseous bromine.

61. Liquid bromine must be stored at pressures higher than normal to keep it liquid.

62. When working with gaseous bromine, it is not necessary to wear eye protection.

63. So much heat is formed when hydrogen bromide reacts with water, that some of the hydrogen bromide vaporizes.

64. Since bromine is not very volatile, it cannot easily be removed from a solution by a blast of a gas.

65. A violent reaction occurs when phosphorus tribromide is forming.

66. If bromine is removed from a solution by a blast of a gas, the bromine is difficult to concentrate because it is spread throughout large amounts of the gas.

67. Phosphorus tribromide is a liquid at ordinary room temperatures.

68. Phosphorus tribromide fumes at the temperature at which it is formed.

69. At 30°C, the equation $Br_2\ (l) \rightleftarrows Br_2\ (g)$ would tend to go toward the right.

70. The laboratory and commercial production of bromine follow the same step by step procedure.

71. In the laboratory preparation of bromine, the sea water must be concentrated.

72. Chlorine is a liquid at ordinary temperatures.

73. As a gas dissolves in water, a partial vacuum forms which allows more water to enter.

74. High vapor pressure means that the gas formed exerts a higher than normal pressure on its container.

75. Bromine gas is more dense than air.

APPENDIX C

Personal Information Form

Name of Teacher________________________________

Student Questionnaire

Name____

Father's Occupation____

Grade__________________________Age_____________________________

Sex____________________________

Name of School____

Location of School (City)_______________________Michigan

Type of School:

Public______________________

Parochial___________________

Private_____________________

Size of School:

Class A_____________________

Class B_____________________

Class C_____________________

Class D_____________________