THE RELATIVE EFFECTIVENESS OF TECHNIQUES OF USING SOUND FILMS FOR INSTRUCTION

by

HAROLD ROBERT CALLAHAN

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INTRODUCTION

The most effective use of motion pictures in education is a problem which affords ample opportunity for study. In the development of the motion picture as an educational adjunct, undue enthusiasm has greatly impeded progress. The film having been transported in its entirety from the theatrical world to the classroom was unpedagogical in arrangement and content. Despite the indifferent selection of films and the poor technique of showing them as aids in teaching, each year finds more films being used in schools. As educators realize the superiority of the film lesson in certain phases of instruction, and as producers make better films and projection equipment, the motion picture will assume a more prominent place in education.

The need for professional training in the use of visual aids is reflected in the lack of information of and interest by many teachers and too much enthusiasm from others. As with anything of comparatively recent origin, there is a wide difference of opinion among educators upon the value of motion pictures. Much of the increased interest in motion pictures for classroom use is due to the introduction of the sound or talking picture.

The original cost and maintenance of sound equipment

is far in excess of silent equipment, but due to the advantages of the former, sound pictures are gradually supplanting the silent films.

At the present time approximately 160 Kansas high schools make use of motion pictures as teaching aids. Of this number about 25 per cent own sound projectors. Since no school in Kansas has a film library, all films are rented - the length of the rental periods being one day in most cases. The rental rates for sound films are twice as much as those for silent films, and the cost of projection equipment is about four times as much for sound films as for silent ones.

An important question is whether or not sound film is sufficiently superior to the silent film to warrant the additional expense. This question can only be answered when both types of films are being used at their maximum efficiency. Effective techniques and teaching aids have been developed for using silent films, but information concerning the proper use of sound films is meager. This study is concerned with developing an improved classroom procedure for using sound films.

SURVEY OF THE LITERATURE

As recent as 1934 the International Congress of the Teaching and Educational Film (4) adopted the following resolutions:

> As to the methods to be used for school films, the Congress states,
>
> 1. That the use of the cinema should not interfere with the educational influence of the teacher, nor with the effect of his words. It is he who should put the questions, explain, comment, inspire, and direct the activity and the response of the pupils.
>
> 2. That consequently the teaching film should not be sound or talking, but a silent film in which the commentary is made by the teacher except where the sound or talking film may usefully complete and strengthen the visual impression.

It is of course true that more information can be acquired through two senses than through one. In addition, sound is an integral part of many films such as those used in learning to speak a foreign language or those used in music appreciation.

During the past eight years many studies have been made to determine the relative values of sound and silent pictures, also to ascertain the effectiveness of sound pictures with different age and school level groups. There are but meagre studies on the technique of presenting a film lesson, and those studies which have been made are

mostly by-products of some other problem. The efficiency of the sound film as a teaching medium has been attested by investigations. The Middlesex experiment (13) in 1930 was the first major study with educational talking pictures and while the results were inconclusive, it served as a stimulus for producers. The chief and about the only merit of the spectacular Fox Film experiment (7) conducted in 1931 was to draw the attention of teachers to the fact that educational talking pictures were being produced.

Clark (3) studied the relative effectiveness of sound pictures, silent motion pictures, and classroom lecture demonstrations. Conclusions drawn from this well conducted experiment were:

> 1. Educational sound films of the type in which the sound is a vital and realistic part of the picture are as effective as are identical lecture demonstrations in conveying specific information to mature students.
>
> 2. Silent films similar to those used in this investigation appear to be less effective in teaching junior college students than are classroom demonstrations. The gains of the students having the demonstration, however, are not sufficient to justify final conclusions or general applications.
>
> 3. The results of the topical tests show that the two sound and the two silent films used and their corresponding lecture demonstrations are equally effective as media for teaching junior college students to think more clearly and to reason more logically.

The most comprehensive experiment to measure the effectiveness of the sound film was conducted by Arnspiger (1) in 1933. Sound films in natural science and music were used in the experiment. The natural science units were studied in the second half of the fifth grades; the music units in the second half of the seventh grades. Results of the experiment showed that pupils using sound films in natural science learned 26 per cent more, and those using music films 27 per cent more than the students taught by the ordinary classroom methods.

One criticism might be made of this otherwise excellent study. The control group was taught by fifth grade teachers who were not specialists in science and had only a bibliography upon which to build their units. Accordingly the units of the control group were disorganized and poorly taught when one considers the time and effort which went into the construction of the films for the experimental group. In making the films which were used by the experimental group, subject-matter specialists and a special educational research staff working with experienced film technicians supervised the production. Here one lone teacher with but a few hours preparation was competing against a staff of specialists working for weeks on the same unit. The same may apply to a somewhat lesser degree

to the music units.

Rulon (16) evaluated the effectiveness of the use of educational sound films in the teaching of science in the ninth grade. The results of the investigation revealed that on a test following the experimental teaching groups studying with the aid of the sound film a superiority of 20.5 per cent over the groups studying without such aid; on a test given several months later, the sound film groups showed a superiority of 38.5 per cent over the non-film groups. Gatto (6) found as did Rulon that in a delayed test administered five weeks after the instructional period the mean score of the film group increased 11 per cent while the mean score of the non-film group decreased 11 per cent in relation to scores on immediate tests. Rulon made a short preliminary investigation to determine the number of film projections the students considered optimum, and on the basis of pupil opinion selected three projections.

In a controlled experiment in elementary physical science to determine whether the use of sound films had any demonstrable effect, it was found that there was a significant difference in the average scores in favor of the students who had seen the sound films (6, p. 4).

The results of investigations by Einbecker (5), Weber (18), and Westfall (19) agreed that oral commentary on film is more effective than presentation of a film without oral commentary or with written titles.

There is an inconsistency of results in experiments in which the sound and silent films were compared. Einbecker's (5) data indicated that the silent picture accompanied by teacher's comments was superior to talking pictures in the learning of new technical words or unfamiliar words, but that both were equally effective in other respects as measured by factual information. Westfall (19), on the other hand, interpreted his results as indicating that a mechanically produced lecture was significantly superior to any of the other forms of verbal accompaniment used in his experiment. Clark (3) found that silent and sound films were equally effective as instructional methods when results were measured in terms of factual information. Sumstine (17), on the other hand, found that verbal accompaniment was positively detrimental in film instruction. Hansen (8) reported no reliable difference between teacher and film commentary when the verbalization was identical. Hoban (9) in reviewing research in instructional films concludes:

From the data available on the problem of verbal

> commentary on film presentation it may be concluded (a) that some verbal accompaniment is necessary to films when learning is measured by verbal tests of factual information, (b) the superiority of sound films or silent films accompanied by teacher comment depends on the type of material and the type of comment, (c) verbal discussion after film presentation is more effective than film presentation after verbal discussion, and (d) oral comment is superior to written comment because the former eliminates the factor of pupil reading difficulties.

In regard to the frequency of projection, there have not been any conclusive results. Although Poland (15) touched upon the problem, he did not study it deeply. Rulon (16) made a short preliminary survey, and, on the basis of pupil opinion, selected three projections as a method in his experiment on values of sound films in general science teaching. Knowlton and Tilton (12) investigated the problem of use of films in relation to the size of the instructional group. In this investigation, average sized class groups were shown historical photoplays in the classroom in addition to the regular verbal instructions, and groups of over 200 pupils were shown the same films in the school auditorium. In the auditorium instruction other visual aids were generally used to fill in the class period before or after the film presentation. It was found that the results on factual tests were consistently higher for the groups who had seen the films in the classroom.

Because a school auditorium is generally used for assemblies, entertainments, and the like, and as such produces a different "mental set" in the minds of the pupils than does a classroom which is the normal situation for instruction, the above results are quite normal.

Excellent examples of the techniques of using educational sound films are published from time to time. Although these opinions are subjective, nevertheless they are valuable. McCarthy (14) suggests that the whole film be used the first day and on succeeding days but small sections of the film studied. Hotchkiss (10) provided the students with questions on the picture to be studied during the unit together with charts and graphs based on the information in the film. As a general practice the class watched the sound film with no discussion. At the conclusion of the picture there was a class discussion. Especially was this true for the first few pictures, in order to offset the impression that movies are intended for recreation. Hotchkiss suggests the following details of management:

1. Use two reels of film for a 40-minute class period.

2. Films can be shown effectively in an average classroom with ordinary window shades drawn.

3. The classroom is the best place to use for showing films.

4. The teacher must be familiar with the film in order to present it properly.

5. Sound films do not require as much follow-up discussion as do silent films.

6. Titles and advertising matter do not give sufficient information as to the content of the film.

Brunstetter (2) has drawn several conclusions based on the results of 18 experimental studies which were set up in representative cities throughout the United States to determine the most effective use of sound films as a medium of instruction. From this study it was concluded that repeated showings of films used as a means of direct teaching are worthwhile when they are made to function as a direct answer to important new problems arising from discussions following the previous showing of the film, whereas one showing of the film may be considered sufficient when the picture is only indirectly related to the topic which is being studied.

The motion picture is not intended as a substitute for the teacher. The maximum benefits can be realized only by the skillful teacher who introduces the film with a definite purpose in mind and assists in the interpreting of the new ideas presented in order that they may be integrated with the subject matter which they are studying

in their classes. Pupils should be held responsible for the information presented in the film and a test may be given following the showing.

In order to emphasize certain points covered in the film, the teacher may wish to interrupt the showing to permit the introduction of questions and answers. When films are shown for purposes of review and summarization, it has sometimes been found advisable to supplement the picture with both pupil and teacher comment.

THE PROBLEM

The primary purpose of this problem was to determine by experimentation the relative effectiveness of various techniques for the presentation of sound films to ninth grade students in the field of natural science. To verify conclusions drawn from experiments conducted under dissimilar conditions was a secondary consideration.

The scope of the study was limited in respect to the number participating but fairly general in regard to the amount and variety of material studied. The experimental control technique was employed, utilizing equated groups, all of which were under the direction of the same instructor. Not unmindful of the limitations of this technique the experiment was prepared to control, as well as possible, the variable factors except the one being measured. Hoban (9) points out several neglected factors of experimental procedure isolated in 61 studies.

Of these the first is the typicalness of classroom procedure. In many studies comparisons are made of educational practices which have long since been abandoned or never extensively practiced in American education. In this study the regular classroom procedure making use of all teaching aids was followed. Demonstrations, maps,

slides and exercises were used for all groups. To make sure that each group received the normal amount of instruction, standardized tests were given at the end of several units and comparison with established norms demonstrated that the quality of instruction was adequate for all groups.

A second factor of experimental procedure which has been widely neglected in investigations is that of comparability of methods of instruction. Whereas the motion picture always produces the material in the same sequence, and the structure is identical in all cases, classroom instruction is highly diversified. This objection was partially overcome by using the same instructor for all groups and the presentation of the subject matter similar to the content of the film and in the same order.

By use of pre-tests and final tests the amount of factual information gained was measured fairly accurately, and those units were selected for study where the results of the pre-tests showed that pupils knew very little or nothing of the subject. Where a large amount of initial knowledge is present, the opportunity for gain in knowledge is diminished, and the treatment of data in terms of gains obtained may not be a true index to the effectiveness of instructional method.

Another neglected factor in experimental procedure is grade classification. By using all pupils from the same grade this factor was kept fairly constant.

SELECTION OF EQUATED GROUPS

Three classes of ninth grade students were selected to take part in this experiment. These students were regularly enrolled in an elementary course covering the entire field of science, and, since this subject was elective, it was presumed that all had an active interest. City and rural, white and colored students made up these classes. Range in age was from 13 to 17 years with an average of 14 and one-half years. Thirty-two students were enrolled in each class, and from this number 25 were selected from each group to participate in the experiment. In selecting the three groups, care was taken to equate the classes and to eliminate students with poor attendance records, extremely poor readers, and those having other abnormalities which might unduly influence the results.

In order to equate the classes the Henmon-Nelson Intelligence Tests were administered. All classes met in the same classroom for hour length class periods under the direction of a specialized teacher.

Unavoidable absences of pupils, variation of ability to read and interpret both textbook material and tests, and disturbing factors in school life such as shortened periods and inter-scholastic contests were several

Table 1. Selection of pupils; characteristics of students participating in experiment.

Students	Class I	Class II	Class III
Number participating	25	25	25
Number of boys	16	15	18
Number of girls	9	10	7
Intelligence quotients:			
Highest	132	124	126
Lowest	74	83	75
Mean	100.64	99.88	100.20
Number of students above 110	8	6	4
Number of students below 90	4	3	5
Number of students between 90 and 110	9	16	16

variables which could not be controlled but which materially affected the accuracy of the results.

After the classes had been equated on the basis of equivalent intelligence quotients and age groups, several units were taught using the same techniques for three classes. Units on physiology, weather, and erosion were taught using the conventional classroom procedure. The units on transportation and electricity were taught using sound films as teaching aids in addition to ordinary classroom procedure. The unit on sound was taught by means of the film lesson using the best technique developed by this study. Table 2 shows the resulting group gains in response to identical teaching procedures. From this table it will be readily seen that equivalent intelligence quotients and age groups are not sufficiently valid criteria upon which to equate classes accurately.

Considering a critical ratio of four to be of statistical significance, class I was superior to class II in only the physiology unit. However, it will be noted that the mean gains of class I were consistently above those of class II although not enough to be of statistical significance. Between class I and class III there was but a slight difference, and this difference was well within the limits of probable error. The superiority of class III

Table 2. Comparison of group gains in response to identical teaching procedures.

Unit	Superiority of Class I Compared to Class II			Superiority of Class I Compared to Class III			Superiority of Class III Compared to Class II		
	Diff. mean gains	P.E. of diff. of means	Critical ratio	Diff. mean gains	P.E. of diff. of means	Critical ratio	Diff. mean gains	P.E. of diff. of means	Critical ratio
Conventional Classroom Procedure									
Physiology	11.76	1.99	5.9	2.99	1.97	1.5	8.77	1.84	4.8
Weather	4.64	2.25	2.1	.4	2.17	- .2	5.04	2.22	2.3
Erosion	3.00	1.59	1.8	3.80	1.45	2.6	6.80	1.63	4.1
Conventional Classroom Procedure with Film as Teaching Aid									
Electricity	5.32	2.16	2.5	1.07	2.30	.5	4.26	1.94	2.2
Transportation	2.88	2.11	1.3	-1.12	1.74	- .6	4.00	2.10	1.9
Film Lesson									
Sound	.14	.26	.5	.44	.26	1.7	- .32	.28	-1.1
Total	27.74	10.36	2.7	6.88	9.89	.7	28.55	10.01	2.8

over class II was approximately the same as the superiority of class I over class II.

The greatest difference of group gains occurred with the conventional type of teaching. On the sound film lesson there was no weakness of class II, and there was a much smaller difference of the mean gains among the three classes.

It may be concluded that while there was undoubtedly a difference in the abilities of the three classes using ordinary classroom procedure, this difference was so small when the material was based upon sound films alone that the classes may be said to have been fairly well equated. Since this study was concerned primarily with film lesson techniques, the three classes were sufficiently equated for experimental purposes.

Differences in study habits, home environment, associations, and fatigue all influence the quality of work. Class II met just before lunch intermission.

Each class acted as the control group at various times. Thus greater sensitivity to different techniques resulted. Slightly different experimental procedures were tried on the two experimental classes. When a technique was developed whereby maximum results were obtained,

confirmation was secured by means of repetition on several units. The length of the units varied from 360 minutes to 120 minutes.

TESTS

For measuring the amount of factual information resulting from instruction, objective tests were used. Most of these were standardized tests in two forms, A and B, for which norms were established and which were based upon the material in the textbook. The remainder of the tests were constructed by the instructor with approximately the same number and type of questions as contained in the standardized tests. Tests consisted of 80 to 100 items and included essay completion, one word completion, multiple choice, two choice, and true-false items. In all cases two tests were given each pupil, and in some units a third test was administered at a later date.

The initial tests were given to determine the beginning point, the final tests to determine the gain, and the recall tests to determine the amount of retention of factual information. The material in the initial tests and final tests was identical.

On all the standardized tests no coefficient of reliability was calculated. The norms for each form were given in deciles, and by plotting a curve using the information given in the norms the scores of Form B could be corrected to be the equivalent of Form A.

The following are the reliability coefficients on tests made by the instructor:

Molecular Theory of Matter	.82
Plant Growth and Seed Dispersal	.76
Body Defenses against Disease	.72
Transformation of Energy	.85
Sound Waves and Their Sources	.90
Light Waves and Their Uses	.84

EXPERIMENTAL UNITS

Astronomy Unit

Time of teaching period: 300 minutes.

Titles of films shown: The Earth in Motion.
The Moon and Its Phases.

The teaching procedure was identical for the three classes except that the time consumed in viewing the sound motion pictures was used for other activities in the respective classes.

Class I. (Experimental) The pictures were shown on the last day of the unit. Each film was projected twice but no discussion was permitted.

Class II. (Control) No picture was shown to this class but the time was consumed in reviewing the unit.

Class III. (Experimental) The pictures were shown at the beginning of the unit and again at the end. Reference was made to the film material from time to time during the discussion but no exercises or recitations were based upon the film material. The films were projected twice at each showing.

It will be observed from table 4 that there is a

Table 3. Astronomy unit informational gains; scores of final minus initial test.

	Class I	Class II	Class III
Initial test mean	34.4*	26.9	35.4
Final test mean	78.1	56.8	74.5
Mean gain	43.7	29.9	39.1
Standard deviation of gain	9.4	10.15	11.45
Probable error of mean gain	1.27	1.37	1.54

*Median of norm 70.

Table 4. Astronomy unit comparative class gains; scores of final minus initial test.

Classes Compared		Difference of means	P.E. difference of means	Per cent difference	Critical ratio
Superior class	Inferior class				
Class I	Class II	13.8	1.87	46.0	7.4
Class I	Class III	4.6	1.99	11.8	2.3
Class III	Class II	9.2	2.06	32.8	4.4

significant statistical difference between the gains of classes I and III that saw the picture and class II that did not. Thus it may be concluded that the sound pictures make a definite contribution and are a valuable teaching aid. It will also be observed that class III to whom the pictures were shown on two days, once at the beginning of the unit and again at the end, did not exceed class I to whom the pictures were shown only once, at the end of the unit. The rental of films for two separate occasions is not justified from the data as shown in table 4.

On recall tests given 12 weeks later to the same three groups the data shown in table 5 were obtained. In the light of these data class I, to whom the pictures were shown once as a review at the end of the unit, suffered the greatest loss of information, and their superiority over the other two classes was wiped out. Class III to whom the film was shown on two different occasions was then superior. The treatment of data in terms of gains obtained is not a true index to the effectiveness of the instructional method where there is considerable difference in the amount of previous information held by the respective groups. Where there is a large amount of initial information, the opportunity for gain of knowledge is diminished. While the value of the additional showing of the pictures

Table 5. Astronomy unit informational gains; scores of recall minus initial test.

	Class I	Class II	Class III
Initial test mean	34.4*	26.9	35.4
Recall test mean	66.6	59.3	73.3
Mean gain	32.2	32.4	37.9
Standard deviation of gain	8.88	11.5	111.5
Probable error of mean gain	1.19	1.55	1.55
Difference $Final_m$ - $Recall_m$	-11.5	2.5	-1.2
Probable error of means $Final_m$ - $Recall_m$	1.7	2.1	2.2
Per cent of loss or gain	26.3 loss	7.0 gain	3.1 loss
Critical ratio	6.8	1.2	.6

*Median of norm 70.

to class III was not evident on the final test, the value was evident in the amount of information retained. It is interesting to note that the mean of the recall test for class was still above the median of the norm for final tests.

Changes in teaching procedure which suggested themselves as a result of the astronomy unit are the following:

(a) The technique whereby pictures were shown on different days should be abandoned. Even though some values resulted, this procedure would be impractical because it would double the cost of a visual program.

(b) Information imparted by pictures should be impressed by class discussion at the conclusion of the picture. It was found that students did not recognize the significance of the experiments and had many vocabulary difficulties.

(c) For units of considerable length a larger number of films would make visual aids a more potent factor in the determination of the amount of learning.

(d) Experimental units should be selected for study where the initial information as shown by the pre-test is equal. It would be more desirable if subjects were selected for experimental purposes on matters about which the pupils knew nothing.

Erosion-Vulcanism Unit

Time of teaching unit: 300 minutes.

Titles of films shown: The Work of the Atmosphere.
The Earth's Rocky Crust.
The Work of Rivers.
Volcanoes in Action.

Identical methods of classroom procedure including a considerable number of film slides were used for the three classes. Two final tests were administered, one before the sound pictures were shown and one after. In this manner the differences in technique could be more accurately measured. Recall tests were administered 12 weeks later.

Class I. (Experimental) After the final test the four pictures were shown twice. There was no class discussion.

Class II. (Experimental) The four pictures were shown once. Discussion of the materials in the picture followed the projection of each film.

Class III. (Control) No pictures were shown this group. A short field trip and review exercises were substituted for the pictures.

The data of table 7 show that no statistically

Table 6. Vulcanism-Erosion unit informational gains without sound pictures.

	Class I	Class II	Class III
Initial test mean	30.5*	30.6	33.3
Final test (Final 1) mean	59.1	56.8	66.3
Mean gain	29.2	26.2	33.0
Standard deviation of gain	7.31	9.19	7.86
Probable error of mean gain	.99	1.24	1.06

*Median of norm 57.

Table 7. Vulcanism-Erosion unit informational gains with sound pictures.

	Class I	Class II	Class III
Initial test mean	30.5	30.6	33.3
Final test (Final 2) mean	61.6	60.5	65.3
Mean gain	31.1	29.9	32.0
Standard deviation of gain	9.63	8.93	9.94
Probable error of mean gain	1.30	1.20	1.34
Final 1 (before picture) - Final 2 (after picture)	1.9 gain	3.6 gain	1.0 loss
Probable error of difference of means (Final 1 - Final 2)	1.5	1.7	1.7
Percentage gain or loss	6.4 gain	13.8 gain	0.3 loss
Critical ratio	1.3	2.1	0.0

Table 8. Vulcanism-Erosion unit informational gains, recall minus pre-test.

	Class I	Class II	Class III
Initial test mean	30.5	30.6	33.3
Recall test mean	57.7	63.9	63.2
Mean gain	27.2	33.3	29.9
Standard deviation of gain	8.99	8.93	6.91
Probable error of mean gain	1.21	1.20	.93
Difference of means Final 2 - Recall	-3.9	3.5	-2.1
Percentage of gain or loss	12.5 loss	11.6 gain	6.3 loss
Probable error of difference of means (Final 2 - Recall)	1.71	1.69	1.63
Critical ratio	2.3	2.1	1.3

significant informational gains were made by using the pictures or as a result of the review and the field trip. Note that the gain resulting from discussion and pictures was twice as great as that resulting from pictures alone. Since the mean score of the final test before the showing of pictures was near the median of the norm, it could hardly be expected that the pictures would make a significant contribution because the opportunity for gain was small.

The results of the recall tests in this unit confirm other experiments in which unusual results were obtained. Table 8 shows that the weak class II gained information during the 12 weeks, while the expected loss occurred for the other two classes. The mean of the recall test for class II is highest for the three classes, and, considering that class II is the weak class, it is quite probable that the showing of pictures and the explanations were more effective than the other procedures.

The information obtained from this unit warranted the following changes in technique:

(a) More time should be spent on discussion of the materials in the sound films. The instructor should make sure the students know when actual photography is being

used and when animated drawings are being shown. He should correct false impressions resulting from animated sketches. Molecules are frequently represented by black and white discs to show diffusion, pressure, and the like, and students are led to believe that molecules are small circular discs of different colors. It is desirable to explain such technical points as time lapse, photography, and micro-photography before the films are shown.

(b) The instructor should not attempt to show more than one film during an hour.

(c) Since only vitally interested students took part in a discussion, it would be well to give an exercise to every student and base the exercise upon the film subject.

Physiology Unit

Time of teaching unit: 360 minutes.

Titles of films shown: The Mechanics of Breathing.
The Heart and Circulation.

The same classroom procedure was used for the three classes, and a standardized test was given at the close of the unit. Charts, film slides, and one silent motion picture on digestion were visual aids employed. After the final tests had been given, two hours were devoted to film

lessons based upon the two pictures, The Mechanics of Breathing, and The Heart and Circulation. These film lessons were conducted with the following variations:

Class I. (Experimental) To this class the pictures were shown twice, once each day. On the first day following the picture, a short discussion was permitted and an exercise was assigned. On the second day the pictures were repeated at the beginning of class, and, after a short work period, the exercise which had been assigned on the previous day was checked by exchanging papers, and the scores on the exercise were recorded.

Class II. (Experimental) During the first 50 minutes of the class period on the first day the pictures were shown twice. The same exercise was assigned to this class as was assigned to class I, and the few minutes remaining were devoted to a discussion of the picture. At the beginning of class on the following day the exercise was checked by the exchange of papers, and the scores were recorded. The remainder of the period was devoted to a discussion of the pictures.

Class III. (Experimental) To this class the pictures were shown three times, two projections of the picture on the first day and the final projection on the second day.

At the close of the hour on the first day, the same exercise which had been given to the other classes was assigned. At the beginning of class the second day the pictures were shown for a third time. The remainder of the period was devoted to completing and checking the exercise and to a short discussion.

The data found in tables 9 and 10 show that the film lessons contributed considerably more information to classes I and II than to class III. Since class III ranked highest before the pictures were shown, the opportunity for gain was diminished. The opposite was true for class II.

The median of the norm of the standardized tests used for this unit was 62. Before the pictures were shown, the mean score of classes I and III had exceeded this median. The gains from the pictures and exercises are more significant because of this fact.

The differences of technique in presenting the physiology film lesson are insignificant, all factors being considered. It was observed that the third showing of the film to class III resulted in boredom and inattention. In comparing the gains resulting from pictures for the vulcanism-erosion unit and the physiology unit, it is evident that an exercise in addition to discussion is remarkably effective. In the former unit there were no

Table 9. Physiology unit information gains without sound pictures.

	Class I	Class II	Class III
Initial test mean	32.74	35.27	41.44
Final test mean without pictures (Final 1)	52.64	53.41	57.35
Mean gain	29.90	18.14	26.91
Standard deviation of gain	11.08	9.72	7.54
Probable error of mean gain	1.49	1.31	1.29

Table 10. Physiology unit informational gains with sound pictures.

	Class I	Class II	Class III
Initial test mean	32.74	35.27	41.44
Final test mean with pictures (Final 2)	71.62	54.45	73.90
Mean gain	38.88	29.18	32.46
Standard deviation of gain	11.72	12.36	7.28
Probable error of mean gain	1.52	1.67	.98
Difference of means (Final 1 - Final 2)	8.98	11.04	5.55
Probable error of difference of means (Final 1 - Final 2)	2.1	2.1	1.6
Percentage of gain or loss due to films	39.3 gain	60.9 gain	20.6 gain
Critical ratio	4.3	5.2	3.6

significant gains, while in the latter the gain was significant in all cases in spite of the fact that the median of the norm had been exceeded in two classes before the film lessons. The same time was devoted to the film lessons in both units, and only half the number of films was shown in the latter unit. While there are many variable factors which cannot be controlled, the use of the exercise in addition to the discussion and the projection of pictures is an important factor.

The writer found that the introduction of the exercise eliminated many problems previously encountered. The attitude of the class was improved, and the "show" atmosphere disappeared. Between reels, while the machine was being threaded or the film re-wound, students had something to keep them occupied and were anxious to get the task completed within the hour if possible. During discussion pupils were more attentive and found difficulties in the exercise which they had given but little thought previously. Students with an ordinarily passive attitude were spurred to greater activity because the exercises were checked, and the teacher had material evidence that each student made some effort. The exercise also gave every student a means of expression and assurance that he knew the subject matter. The checking of the exercise stimulated discussion

which might have been neglected and in which all would have been interested.

The most important fact discovered by the writer in this experiment was the value of discussion and exercises in the film lesson.

IMPROVED TECHNIQUE

In the following four units the classes were divided into experimental and control groups, and these groups rotated. In the experimental groups the following technique of instruction was used: At the beginning of the class period a mimeographed copy of the exercise which had been assigned was distributed to each student. Then followed the projection of the picture without interruption. Discussion of the picture for a limited time after the projection with an opportunity to ask questions insured a more adequate understanding of the film content during the second projection. After a short work period the second projection projection of the film took place. On the following day the exercises were completed and then checked by exchanging papers among the students. During the checking, discussion was permitted, and many points were clarified. At the beginning of the following class period the final test was administered. In the control group the exercise was omitted, but the time was used for the conventional oral recitation. The pictures were projected twice, with discussion intervening. The single variable in the last four units was the exercise. The experimental groups were obliged to work this exercise during class time, while the control groups were not.

Plant Growth and Seed Dispersal

Time of unit: 120 minutes.

Titles of films shown: Plant Growth

Seed Dispersal.

Experimental groups: Classes I and II.

Control group: Class III.

Table 11. Comparative informational gains made by experimental and control groups on the unit Plant Growth and Seed Dispersal.

	Experimental Groups Class I	Class II	Control Group Class III
Initial test mean	33.56	35.67	36.20
Final test mean	54.82	55.31	50.53
Mean gain	21.26	19.54	14.38
Standard deviation	8.78	8.54	7.50
Probable error	1.18	1.11	1.01
Difference of the means Experimental - Control	6.88	5.16	
Probable error of difference of the means	1.55	1.50	
Per cent superiority	47.90	35.80	
Critical ratio	4.44	3.44	

Body Defenses against Disease

Time of unit: 120 minutes.

Title of film shown: Body Defenses against Disease.

Experimental groups: Classes II and III.

Control group: Class I.

Table 12. Comparative informational gains made by experimental and control groups on the unit Body Defenses against Disease.

	Experimental Groups		Control Group
	Class II	Class III	Class I
Initial test mean	34.46	31.20	36.84
Final test mean	57.08	56.56	54.90
Mean gain	22.22	25.36	18.06
Standard deviation	6.64	4.28	2.30
Probable error	.90	.58	.31
Difference of the means Experimental - Control	4.16	7.30	
Probable error of difference of the means	1.16	1.33	
Per cent superiority	47.90	35.80	
Critical ratio	3.58	5.41	

Light Waves and Their Uses

Time of unit: 120 minutes.

Title of film shown: Light Waves and Their Uses.

Experimental groups: Classes I and III.

Control group: Class II.

Table 13. Comparative informational gains made by experimental and control groups on the unit Light Waves and Their Uses.

	Experimental Groups Class I	Class III	Control Group Class II
Initial test mean	33.93	34.67	32.45
Final test mean	59.51	66.41	56.27
Mean gain	25.58	31.74	23.82
Standard deviation	7.68	8.59	7.28
Probable error	.94	1.16	.88
Difference of the means Experimental - Control	1.76	7.92	
Probable error of difference of the means	1.32	1.45	
Per cent superiority	7.40	33.30	
Critical ratio	1.33	5.46	

The Molecular Theory of Matter

Time of unit: 120 minutes.

Title of film shown: The Molecular Theory of Matter.

Experimental groups: Classes I and III.

Control group: Class II

Table 14. Comparative informational gains made by experimental and control groups on the unit The Molecular Theory of Matter.

	Experimental Groups Class I	Class III	Control Group Class II
Initial test mean	30.00	30.00	30.00
Final test mean	59.30	57.26	48.38
Mean gain	29.30	27.26	18.38
Standard deviation	8.88	10.66	8.12
Probable error	1.20	1.34	1.10
Difference of the means Experimental - Control	10.92	8.88	
Probable error of difference of the means	1.62	1.73	
Per cent superiority	59.30	48.30	
Critical ratio	6.12	5.13	

The findings resulting from this study as compared with previous investigations were found to be in agreement but less pronounced. The data of this experiment verify the conclusions of Rulon (16) and Gatto (6) that students to whom pictures are shown retain a larger amount of information than do those who do not observe the pictures.

Greater care in equating the groups, the rotation of the experimental and control groups, and the better quality of instruction for the control group are factors which reduce the apparent superiority of the film group. The foregoing factors were neglected to some extent in studies by Arnspiger (1) and Rulon (16).

Variations resulting from different techniques of administration of film lessons were greater than those for film and non-film groups. It may be concluded that the manner of showing the films is of as much importance as the film itself. The development of the most efficient technique was another neglected factor in previous studies.

Film producers and distributors could render an additional service by furnishing schools with exercises and standardized tests to accompany each film. These exercises and tests should be designed for different age level groups. Because of the extremely short period for which the film is available to the teacher, it is difficult to prepare supplementary material.

CONSTRUCTION OF THE EXERCISE

In constructing the exercise to accompany the film presentation the teacher should bear in mind the difficulties which beset the student. The exercise should be a means of correcting misconceptions, integrating facts, and furnishing the student a means of self expression.

The difficulties which are most frequently encountered in a film lesson are (a) vocabulary difficulties, (b) inability of students to distinguish animation from actual photography, (c) special camera techniques, (d) misinformation obtained from analogies, and (e) failure to recognize the object of various experiments. In preparing the exercise each of the above difficulties should be carefully taken into account.

Vocabulary difficulties will vary with different age groups. The exercise should contain a number of definitions of key words which are used in the lecture accompanying the picture. A simple word such as "sever" offers real difficulty to a ninth grade student.

The exercise should contain questions to make sure that students are able to distinguish animation from actual photography and that there is a complete understanding of special camera techniques.

In the film sequence many experiments are performed to demonstrate physical laws. Although the object of these experiments is quite obvious to the instructor, nevertheless the exercise should contain problems as to the object of every experiment performed. Students fail to grasp the important facts in the mass of detail.

The most important function of the exercise is to correct misconceptions which are obtained from viewing the film. Frequently, by means of animated drawings, dynamic processes are shown where electrons, light rays, sound waves, atoms, molecules, and bacteria are represented by various symbols. Questions in the exercise as to the actual nature of the processes or materials symbolized will correct the misconceptions.

CONCLUSIONS

By making statistical comparisons of 75 students enrolled in three classes in general science in the ninth grade using the experimental-control group technique, the following conclusions were obtained:

1. Sound films are an effective teaching aid regardless of the time or manner of showing, and they create a more lasting impression upon the pupil than does ordinary classroom procedure.

2. The rental of the same film for two occasions is not justified by the increased informational gains of those classes seeing films on two different occasions.

3. Discussion after the film projection is more beneficial than repeated projections of the films. Repeated projections of films without a definite purpose are of no value.

4. Two projections of films are ample if there is discussion of the film material after the first projection.

5. Students in secondary schools have difficulty in distinguishing animation from actual photography and understanding special camera techniques.

6. In the film lecture there are many words not included in the vocabulary of the students.

7. One 400-foot sound film contains sufficient material to occupy students for the ordinary classroom period.

8. A small number of film lessons well taught is more effective than a large number of films shown in a haphazard manner.

9. The introduction of the written exercise based upon the film lesson adds materially to the informational gains resulting from the film showing.

10. The exercise to accompany a film must be constructed to correct any misconceptions likely to occur from analogies presented, to anticipate vocabulary difficulties, and to make sure that the students are aware of the significance of the demonstrations included in the film lesson.

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APPENDIX

TESTS ON EVERYDAY PROBLEMS IN SCIENCE—REVISED

By C. J. PIEPER AND W. L. BEAUCHAMP

UNIT I: HOW IS THE EARTH RELATED TO THE OTHER BODIES IN THE UNIVERSE?—FORM A

Name..... Period..... Score.....

School..... Grade..... Date.....

Directions. Each of the incomplete statements below is followed by a number of parts which might be used to complete the statement. You are to place a plus sign (+) in the parentheses opposite each part which correctly completes the statement, and a zero (0) opposite each part which does not correctly complete the statement. Remember that from none to all of the parts may be correct. Mark all parts. The sample below will show you how to mark the test.

The earth
- is round ..... (+)
- is flat ..... (0)
- is a planet ..... (+)
- does not move ..... (0)

The earth on which we live
- is visible because it reflects the light of the sun ..... 1 (.....)
- has a liquid interior ..... 2 (.....)

The force of gravity
- affects every body in the universe ..... 3 (.....)
- of bodies varies with their mass ..... 4 (.....)
- of the sun is less than that of the earth ..... 5 (.....)
- is fully understood by scientists ..... 6 (.....)

The rotation of the earth
- is a very irregular motion ..... 7 (.....)
- is the same as the revolution of the earth ..... 8 (.....)
- is a motion like that of an object attached to a string and whirled around ..... 9 (.....)
- requires one year for one complete rotation ..... 10 (.....)

The revolution of the earth
- requires 24 hours ..... 11 (.....)
- requires 365¼ days ..... 12 (.....)
- is completed in less time than that of any other planet ..... 13 (.....)
- is the movement of the earth in its orbit around the sun ..... 14 (.....)

The sun
- is always the same distance from the earth ..... 15 (.....)
- exerts little gravitational force on the planets ..... 16 (.....)
- sends to the earth practically all of the heat and light which the earth receives ..... 17 (.....)
- is large when compared to other stars ..... 18 (.....)
- is composed of white hot solid materials ..... 19 (.....)

The distance from the earth to the sun
- is less than the distance from the earth to other stars. . . . . 20 (.....)
- is small when compared to the distance from the sun to other stars. . . . . 21 (.....)
- is more than one hundred million miles. . . . . 22 (.....)
- is greater than the distance from the moon to the sun during an eclipse of the moon. . . . . 23 (.....)

The solar system
- is composed of the sun and the bodies which revolve around it. . . . . 24 (.....)
- is held together by the force of gravity. . . . . 25 (.....)
- consists of bodies which are all incandescent. . . . . 26 (.....)
- includes the entire universe. . . . . 27 (.....)

The nine planets of the solar system
- revolve around the sun in the same direction. . . . . 28 (.....)
- revolve around the sun at the same speed. . . . . 29 (.....)
- receive the same amount of energy from the sun. . . . . 30 (.....)
- are all covered with water and an atmosphere. . . . . 31 (.....)

The moon appears to change its shape because
- its actual shape varies during each month. . . . . 32 (.....)
- only one-half of the moon can be lighted by the sun at one time. . . . . 33 (.....)
- it moves back and forth across the earth's orbit. . . . . 34 (.....)
- the moon rises at different hours from day to day. . . . . 35 (.....)

An eclipse
- is the shadow of one heavenly body on another. . . . . 36 (.....)
- of the sun occurs when the shadow of the earth strikes the moon. . . . . 37 (.....)
- of the moon occurs when the shadow of the earth strikes the moon. . . . . 38 (.....)
- of the moon occurs when the moon gets directly between the earth and the sun. . . . . 39 (.....)

The stars in the universe
- appear very small because they are so near together. . . . . 40 (.....)
- are bodies similar to our sun. . . . . 41 (.....)
- are visible because they reflect light from the sun. . . . . 42 (.....)
- are grouped together in galaxies. . . . . 43 (.....)

The constellations
- visible to us revolve around a point near the star Polaris. . . . . 44 (.....)
- change their positions in the sky from month to month. . . . . 45 (.....)
- are the same as galaxies. . . . . 46 (.....)

The galaxy to which the earth belongs
- is one of a few hundred such star groups. . . . . 47 (.....)
- makes up the universe. . . . . 48 (.....)
- is constantly changing in shape. . . . . 49 (.....)

Standard time
- in one time belt is always one hour more or less than standard time in the adjacent belt. . 50 (.....)
- at Greenwich is five hours ahead of standard time in Philadelphia, which is on the 75th meridian, west. . . . . 51 (.....)
- requires that one set his watch forward one hour when crossing the line between two time belts in going from east to west. . . . . 52 (.....)
- in the United States is indicated by five time belts. . . . . 53 (.....)

Days and nights

are of unequal length at different seasons of the year. . . . . 54 (.....)
are of equal length because the earth rotates at constant speed. . . . . 55 (.....)
are of unequal length because the axis of the earth is inclined to the plane of revolution. . 56 (.....)
would be of equal length if the earth rotated in the same plane as its plane of revolution. 57 (.....)

Seasons change

in such a way that one hemisphere has summer while the other has winter. . . . . 58 (.....)
because the angle of the sun's rays varies at different times of the year. . . . . 59 (.....)
because the earth is farther from the sun in winter than in summer. . . . . 60 (.....)

The change in the angle at which the sun's rays strike the earth at different times of the year

causes different temperatures on the earth's surface. . . . . 61 (.....)
is caused by a change in the speed of the rotation of the earth. . . . . 62 (.....)
is caused by the inclined axis of the earth. . . . . 63 (.....)
results in different lengths of days and nights. . . . . 64 (.....)

Tides

rise and fall once in about 25 hours. . . . . 65 (.....)
are caused by the gravitational pull of the sun and the moon on the earth. . . . . 66 (.....)
are low on the sides of the earth most nearly on a line with the moon. . . . . 67 (.....)

Directions. Complete each sentence or answer each question with a single word, if possible. There are some, but not many, which will require two or more words for an answer. Use figures to answer the questions that call for numbers or fractions. In the case of the sentences or questions which contain words in *italic* type, use one of the *italicized* words or groups of words for your answer. The samples below will help you.

Is the earth *stationary* or does it *move* in the universe? . . . .*move*.....
The diameter of the earth is about ..... miles. . . . .*8000*.....
Neptune is larger than Mars. (*True* or *False*) . . . .*True*.....
The early men who studied the stars in order to predict human affairs were called . . . .*astrologers*.....

No life could exist on the earth without the energy received from the. . . . . 68 .....

The movement of the earth on its axis is called. . . . . 69 .....

A moving body will continue to move in a ..... line unless interfered with by some outside force. . . . . 70 .....

The angle of the sun's rays is the *same* *different* at various places on the earth's surface. . . . . 71 .....

The rate at which the earth is moving through space is far beyond our ordinary experience. (*True* or *False*) . . . . . 72 .....

Bodies like the earth which revolve about the sun are called. . . . . 73 .....

Does the rotation of the earth cause the earth to *bulge out* or to *draw in* at the equator? . . . . . 74 .....

The attraction of the earth for all objects is called. . . . . 75 .....

An eclipse of the ..... results when the moon comes between the sun and the earth so as to cast a shadow on the earth. . . . . 76 .....

..... is the planet with the beautiful rings. ..... 77 .....

Meteors are stars. (*True* or *False*) ..... 78 .....

The fraction of the earth lighted by the sun at any given time is ..... 79 .....

The smallest planet is ..... 80 .....

The study of the heavenly bodies is called ..... 81 .....

Does the moon rise *earlier* or *later* on successive nights? ..... 82 .....

The season during which the earth's axis is inclined toward the sun is ..... 83 .....

Does the gravitational attraction of one body for another grow *less* or *greater* as the distance between them increases? ..... 84 .....

The sun is composed of or consists of ..... 85 .....

Greater *less* area is covered when the sun's rays are direct. ..... 86 .....

The ..... of the earth is used to keep correct time. ..... 87 .....

The groups of stars visible to us are commonly called ..... 88 .....

In the United States the sun rises south of east during the ..... season. .. 89 .....

The telescope has revealed the fact that stars are grouped into systems, or .. 90 .....

Bodies other than planets which circle about the sun are ..... 91 .....

If it is 4:00 A.M. in Philadelphia, longitude 75° W., what time is it in Los Angeles, longitude 120° W.? ..... 92 .....

The planet ..... was discovered by Galle when he was following directions sent him by Leverrier. ..... 93 .....

The gravitational pull of a body is dependent upon its ..... 94 .....

The time which elapses between successive crossings of the sun on a meridian is one ..... 95 .....

The speed of light is ..... miles per second ..... 96 .....

The large star which is 27,000,000 times the volume of our sun is called ..... 97 .....

Is our sun a *small*, *medium-sized*, or *large* star? ..... 98 .....

The starting-point in the United States for determining standard time is the ..... meridian. ..... 99 .....

A body which is twice as far from a source of light as another body will receive ..... as much light. ..... 100 .....

Sample of Tests Made by the Instructor

Test: Molecular Theory of Matter

Name_____Period_____Score_____

Each of the statements below is either true or false. Place a plus sign ( ) in the parentheses opposite each true statement, and a zero (0) opposite each statement that is false. Mark all parts.

1. If a few drops of ink are placed in a beaker of clear water, the ink will gradually color the entire beaker of water because of molecular motion.....( )
2. The three states of matter differ chiefly in the compactness of the molecules. .....( )
3. Evidence of molecular motion is lacking in modern science. .....( )
4. The fact that hydrogen diffuses through unglazed earthenware is evidence of molecular action.....( )
5. If a block of gold is placed on top of a block of lead and allowed to remain that way for a long while, no diffusion will be observed.....( )
6. Cohesion is a result of molecular repulsion.....( )
7. In a solid the molecules wander from one end to the other.....( )
8. The motion of gas molecules is less than that of solid molecules.....( )
9. Molecules of liquid water move more than do molecules of steam.....( )
10. Matter always occupies space.....( )
11. Some scientists think that matter is a form of energy.....( )
12. Air currents are solely responsible for the distribution of illuminating gas that escapes from a gas jet into a room.....( )
13. The velocities of vapor particles leaving the surface of boiling liquid are due to currents within the liquid.....( )
14. Small raindrops assume a spherical shape because of the adhesion of water particles.....( )
15. Molecules can be seen with a very high-powered microscope.....( )

16. It is difficult to prevent the diffusion of hydrogen from balloons.....( )
17. When compressed air in an automobile tire is allowed to escape from the valve, the air near the valve becomes warmer.....( )
18. Carbon dioxide is much heavier than air and is therefore always found only near the floor of a room.....( )
19. Molecules in a gas are always equidistant from each other.....( )
20. As a general rule gases can be compressed a great deal more than can liquids.....( )
21. At absolute zero it is thought that all molecular motion ceases.....( )
22. Gas molecules are always at rest.....( )
23. The amount of motion of liquid molecules is measured by a barometer.....( )
24. The barometer measures the intensity of bombardment of molecules of air on the mercury container at the bottom.....( )
25. There are no air molecules above the mercury in a barometer.....( )
26. The vessel containing the mercury at the bottom of a barometer is sealed air tight.....( )
27. Diffusion of gas is responsible for the spread of odors.....( )
28. Rise in temperatures means that the molecules are moving slower.....( )
29. In cooling air the motion of the molecules is decreased.....( )
30. A molecule is always round.....( )
31. All molecules are alike.....( )
32. All matter is composed of molecules.....( )
33. Gases have no weight.....( )
34. We do not know what a molecule looks like.....( )
35. A theory is better established than a hypothesis....( )
36. Molecules attract each other more when close together than when far apart.....( )
37. If a gas is cooled sufficiently, it becomes a liquid.....( )
38. Air can be cooled until it becomes a liquid.....( )
39. Liquids can be cooled until they become solids.....( )
40. All matter has weight.....( )
41. In a crystal there is an orderly arrangement of molecules.....( )

42. Diffusion is much more rapid in gases than in liquids.....( )
43. Evaporation takes place more rapidly at a high temperature than at a low temperature.....( )
44. Gases are materials which have weight but occupy no space.....( )
45. There is no molecular motion in solids.....( )
46. The colder a solid becomes the farther apart the molecules are.....( )
47. It would be possible to count the number of molecules of water in a teaspoonful in a day's time.....( )
48. Bromine diffuses more rapidly in a vacuum than it does in air.....( )
49. Pressure is caused by molecules striking the walls of a container.....( )
50. Pressure can be increased by putting fewer molecules into the same sized container.....( )
51. Pressure can be increased by cooling the molecules of air within a sealed container.....( )
52. In an inflated automobile tire there are more molecules bombarding the outside of the tire than there are bombarding the inside.....( )
53. Temperature is a measurement of the kinetic energy of molecules.....( )
54. A thermometer measures the air pressure.....( )
55. Molecules of air are in motion even though there is no wind.....( )
56. Crystals do not have any definite shape.....( )
57. Most materials crystallize from solutions which are being heated.....( )
58. There is greater molecular motion in solids than there is in liquids.....( )

Complete each of the following statements by writing the proper word or letter in the space provided at the right hand margin.

59. The state of matter in which there is the greatest amount of molecular movement is (a. solid, b. liquid, c. gas)....._____
60. The best synonym for kinetic is (a. moving, b. stationary, c. difficult)....._____
61. Bromine gas is (a. heavier, b. lighter, c. the same as) air....._____
62. Light molecules diffuse (a. more rapidly, b. the same as, c. slower than) heavy molecules....._____

63. At what temperature is there no molecular motion?..... ....._____
64. When a given quantity of air is cooled, the volume.... ....._____
65. A (a. supposition, b. hypothesis, c. theory) has the greatest amount of experimental evidence to substantiate it....._____
66. All material has two properties; it has weight and occupies....._____
67. A physical law is a concise statement of a._____
68. Air is a (a. material, b. form of wave motion, c. imaginary substance)....._____
69. All matter is composed of....._____
70. The molecules of a gas are (a. the same distance as, b. farther apart than, c. nearer together than) the molecules of a liquid....._____
71. The attraction between the molecules of a solid is (a. greater than, b. less than, c. the same as) that of liquids and gases....._____
72. The pressure which a given gas exerts upon the sides of a containing vessel depends upon (a. the size of the molecules, b. the shape of the molecules, c. the number of blows struck per second)....._____
73. The property of matter by which a substance resists being torn apart is....._____
74. Attraction between molecules of like kind is called (a. adhesion, b. cohesion, c. tenacity)...._____
75. When the velocity of the molecules of an enclosed gas is increased, the (a. density, b. pressure, c. mass) is increased....._____
76. The kinetic theory of gases states that molecules are (a. in motion, b. at rest, c. expanding)..._____
77. A falling drop of water becomes spherical in shape because of (a. adhesion, b. cohesion, c. mobility).... ....._____
78. Upon cooling most solids (a. expand, b. contract, c. undergo no change)....._____
79. At absolute zero all matter would be in a (a. gaseous, b. liquid, c. solid) form....._____
80. When ether evaporates from your hand (a. it takes a long time, b. your hand becomes warm, c. your hand becomes cool)....._____
81. Is everything made of molecules?....._____
82. Is your body made of molecules?....._____

Sample of Exercise Constructed by Instructor

Exercise to Accompany the Film: Molecular Theory of Matter

Name_____Period_____Score_____

1. Define:
   1. Theory
   2. Hypothesis
   3. Molecule
   4. Obstruct
   5. Diffuse
   6. Mutual
   7. Evaporation
   8. Equilibrium
   9. Kinetic
   10. Oscillation
   11. Cohesion
   12. Adhesion
2. What was the object of the experiment showing the diffusion of bromine in air and in a vacuum?
   Has anyone ever seen individual molecules?
   How were the molecules of air represented in the picture?
   How were the molecules of bromine represented in the picture?
   Explain stop motion photography.
3. What comparison was made in regard to the number of molecules in a cubic centimeter of air?
4. The effect of firing bullets from a machine gun at a target is similar to the bombardment of the walls of a container by molecules of air.
   The target corresponds to the _____.
   The bullets correspond to the _____.
   The speed of the bullets corresponds to the _____.
   The number of bullets fired per second corresponds to _____.
   The instrument which we use to record the molecular bombardment as the gauge does the bullet bombardment is a _____.
   If the bullets were fired less frequently, the gauge reading would be _____.
5. In the experiment of rolling a steel ball past a magnet, the steel ball represented a _____, and the magnet represented the _____force.
6. By means of a sketch show the evaporation of water in a partial vacuum, and also evaporation at ordinary pressure. Explain why warm water evaporates more rapidly than cold water.
7. In the Brownian movement can you see molecules moving? Is the Brownian movement shown in the picture an animated diagram or an actual photograph?