

PUPIL DISCOVERY VERSUS DIRECT INSTRUCTION: AN EVALUATION OF KNOWLEDGE RETENTION
BY STUDENTS IN EIGHTH GRADE SCIENCE CLASS AT GLENDIVE, MONTANA

by

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ABSTRACT

The purpose of this study was to determine the difference, if any, in the retention of knowledge of eighth grade science material initially learned by the pupil discovery method as opposed to direct and detailed instruction.

An examination of literature concerning the retention of knowledge revealed conflicting studies and opinions as to what methods or techniques would increase the retention of knowledge. However, no studies could be found by the writer in which meaningless material could be remembered better than meaningful materials.

To test the retention of knowledge using meaningful subject matter material, a control and an experimental group of eighth grade science classes were set up. The control group consisted of two randomly selected classes and were taught by direct and detailed instruction. The experimental group consisted of two randomly selected classes and were taught by the pupil discovery method. In order that all classes used in the experiment had approximately an equal science background, the science portion of the Stanford Achievements Test for each participant was evaluated and proper adjustments were made. At the end of a specific unit of study, all classes were given a chapter test. Twenty-four hours later one class from the control and experimental group was given the identical test again. Two weeks later the other class from the control and experimental group was given the identical test. Later in the year the same testing procedure was followed for a different unit of study, only the time variable was extended to two weeks and four weeks. A one and two tailed t test was used to statistically compare the retention of knowledge by evaluating the total error scores obtained by each class. There did not seem to be any significant difference in the retention of knowledge between classes taught by the pupil discovery method as opposed to the classes taught by direct and detailed instruction in either unit of study.

The experiment seemed to offer evidence, although not conclusive, that regardless which method was used if the teacher was enthusiastic and did the best job possible the students would progress somewhat equally in regard to the retention of knowledge initially learned.

CHAPTER I

INTRODUCTION

Educators have, for some time, been concerned with efficient methods of teaching in the various content areas. Research has uncovered many new methods which will often, when used as suggested, improve instruction. However, not all of the useful materials which have been uncovered through research has undergone experimentation on the local level. Therefore, much valuable material which might improve the curriculum is often passed over.

It is generally agreed among educators that although different teachers use different methods of instruction, some learning will take place. The goal of the individual teacher is to increase the amount of subject material learned and understood by his pupils. Over a period of time, the individual teacher has perfected a technique and method of instruction most suited to him in order to achieve this goal.

When new ideas, techniques, or methods become publicized teachers often skim over them lightly and do not analyze or thoroughly understand them. They often resist any change in their technique or method of instruction even though research supports potential improvements towards this same goal.

In order to test the effectiveness of the technique and method used by the teacher, emphasis is placed on the retention of knowledge. To what extent is material learned during a day, week, month, or year remembered? At the present time, actual classroom tests are the most prevalent device used in measuring retention of knowledge by teachers.

Now it follows that results of these tests are compared many times with other faculty members throughout a school year. Proponents of any given method of instruction are often eager to demonstrate the superiority of their method to others. Many schools of thought have sprung up within our schools today. Each of them expounds on the excellent results and advantages his philosophy or method has to offer. The children, on the other hand, are exposed to a wide variety of methods as they progress through school. Surprisingly, they continue to master the material!

The two methods of instruction predominately used in schools that are departmentalized according to this writer are: (1) direct and detailed instruction, and (2) pupil discovery. The retention of knowledge was examined by comparing these two widely used methods of instruction in this study. A brief look at these methods is in order so the reader can more fully understand the problem.

Many teachers instruct their pupils by the use of direct and detailed instruction. This method is sometimes characterized as the shortest road to the specific goal of efficient learning. By this method, the subject material being considered is presented to the pupils in great detail. The teacher poses problems and proceeds directly to the task of solving these problems without allowing much opportunity for the pupils to discover methods of solution or principles involved in their solution.

The subject material can be presented in various ways. However, the teacher is always in command. He guides the discussion, answers the questions, and presents the materials. The teacher may lecture after a reading assignment is completed or give explanatory and supplementary information during oral reading. Sometimes, lessons are centered around demonstra-

tions presented to the class by the teacher. Class demonstrations can take place in which an exchange of ideas, problems, or thoughts are channeled toward answering specific questions raised by the demonstration. At times the teacher may simply explain the demonstration as he goes and lecture on the principles involved.

The direct and detailed method of instruction, although primarily teacher dominated, must take into account good teaching practices. Individual needs and differences, such as the various reading levels, attention span, recognition, participation, and so forth should be accounted for. The lessons should be planned in a logical manner so that a sequential step by step pattern can be easily recognized and understood by the pupils. Great attention is placed on explaining the facts, principles, and details. The teacher should be enthusiastic, pleasant, and concerned about motivation. Time should be allowed for classroom activities such as reports, bulletin boards, research, drill, discussions, and so forth.

The method used in presenting subject material can vary just as the degree of student involvement in the lesson can vary. Realistically, however, the teacher is the focal point for information. The direct and detailed method of instruction for purposes of this study shall be called Method A. It also represents the control group in the study.

The second method of instruction which I will call Method B, and represents the experimental group, could be characterized as a method of pupil discovery. By this method the pupil is called upon to be active, carefully study illustrative material on his own, and contemplate leading questions asked by the teacher. The pupils must discover principles and make generalizations of their own, for very few positive statements of fact, principles, or generalizations are given orally by the teacher. The

teacher, again, must take into account good teaching practices as mentioned in Method A. However, the difference lies in the approach to the lesson.

In the pupil discovery method the teacher is not the immediate focal point for information, nor does he present the initial demonstrations. The pupils are actively involved in the lesson and have to do much of their work, either on their own or with the group. Much emphasis is placed on problem solving in this method. So much, in fact, the pupil discovery method is often called the problem solving method of teaching.

This study is not to investigate which method of teaching is superior or to imply one method should be used by everyone, but only to measure in some small way the retention of knowledge initially learned by comparing these two widely used methods of instruction.

A review of related literature shows that imperical evidence does not support any one consistent set of hypotheses with regard to the relative efficiency of pupil discovery versus teacher dominated instruction (1, 2, 4, 5, 9, 11).

STATEMENT OF PROBLEM

The purpose of this study was to provide additional experimental and applied research evidence as to the relative effect of pupil discovery upon initial learning and retention of knowledge as compared to direct and detailed instruction.

The major hypothesis held was that there is no difference between groups taught by Method A (direct and detailed instruction) or Method B (pupil discovery) in retention of knowledge twenty-four hours, two weeks, or four weeks after instruction.

THE PROCEDURES

The first procedure was to review literature to determine if research supported an increase in the retention of knowledge by using a particular method of instruction. The second procedure was to establish an experimental and control group of students in which the retention of knowledge could be evaluated by comparing the results of two different methods of instruction used in eighth grade science.

LIMITATIONS OF THE STUDY

The review of literature contained in this study was made in the library at Montana State University. The experiment was conducted with four eighth grade classes of approximately 21 students each, or a total of 84 students. The experiment was conducted locally using various classes in the Glendive, Montana, school system as experimental and control groups. One teacher taught both methods and tested with teacher made tests.

The review of literature contained in Chapter 2 presents findings pertaining to retention of knowledge.

CHAPTER II

BACKGROUND OF PROBLEM

A review of related literature points out some of the conflicting studies, thoughts, and opinions as to retention of knowledge and the methods used to facilitate knowledge retention.

The typical subject matter material used in a classroom is meaningful. The students can read it and hopefully understand it. What do research investigators say about retention of knowledge using meaningful material?

Nobel (14) constructed three 12-item serial lists using his scaled dissyllables. The items in one list had a mean value of 1.28 (low meaningfulness), those in another, 4.42, and those in the third, 7.85 (high meaningfulness). The subjects were college students selected at random and divided into three equal groups of 30. Each group learned a different list and then practiced on the two other lists. Serial anticipation learning was used with a 2-second presentation rate. Learning was carried to one perfect trial. The relationship between the three levels of meaningfulness and mean number of trials was compared. The list consisting of items of low meaningfulness required over twice as many trials to learn as did the list of high meaningfulness.

Davis (5) employed six subjects who learned a total of 40 serial lists over a period of 60 days. Of the 40 lists, 20 were serial lists of 12 syllables, each having a value of 20 per cent or less. The other 20 lists were made up of 12 three-letter words. On one day, the subject would learn one list of a given kind, on the next day a list of the other kind, and so

on, so that practice effects should be distributed equally over both kinds of lists. Learning was carried to one perfect trial, i.e., until the subject correctly anticipated all items on a single trial. On the average, the syllables required 9.8 trials; the words, 3.7 trials.

Sauer (16) employed 20 subjects who learned a total of 40 serial lists over a period of 30 days. Of the 40 lists, 20 were serial lists of 12 syllables. The other 20 lists were made up of 12 three-letter words. Practice or exposure time to the different lists was greatly reduced in contrast to Davis' subjects. The results showed that the mean number of trials to learn the syllables was 14.05 and to learn words, 5.67.

The ratio between these two studies was nearly the same when meaningful material was compared to non-meaningful material, even though the learning and practice time was greatly reduced. It simply took more trials to complete the task.

No studies could be found that supported meaningless materials and as Klausmeier (10) summarized: (1) "The evidence is now clear that meaningful material is retained better than meaningless; (2) material acquired with purpose is retained better than material learned incidentally; and (3) having knowledge enables one to retain new knowledge better."

Since subject matter material is meaningful, it would seem, then, that retention would be greater with subject matter material than with nonsense material. Could this meaningful material be presented to the students in any fashion? Are there ways to aid the retention of knowledge?

Klausmeier (9) thought so, for he stated: "For facilitating retention, then, the teacher (1) fosters intent to learn well and remember; (2) makes the initial learning meaningful; (3) arranges for satisfying conse-

quences of correct response; (4) distributes practice and review; (5) avoids interference between learning situations; (6) emphasizes general concepts and abilities; and (7) provides for sequential cumulative learning."

To facilitate retention, then, the method of teaching used by the instructor apparently doesn't really matter as long as the above sound principles are incorporated into his method.

Yuker (20) disagrees, for he thinks the method of teaching used is very important. In his opinion: "A more pleasant, cooperative atmosphere under a democratic leader with the emphasis on pupil discovery facilitates the recall of factual information more than a competitive atmosphere under authoritarian leadership."

Bugelski (4) countered, "While progressive educators condemn lectures, there is no unequivocal evidence that this process is a bad one or even a poor one. In fact, it may be the most effective available for some kinds of learning situations."

Bugelski (4) further pointed out that: "While some educators condemn lectures, they endorse certain audio-visual aids that are similar to lectures, i.e., phonograph records, radio, tape recordings, and some movies."

Otto (15) tried to settle the argument by saying, "Some approaches to teaching, such as the discovery method, have generally shown no superiority in immediate learning or recall outcomes."

Another aspect to the retention of knowledge deals with time. How long can a person remember meaningful subject matter material? What percent of the material initially learned can be retained? Is there a steady loss in the amount of material initially learned due to the principle of

disuse and the passage of time? Although there is some disagreement among research investigators, an interesting conflict that deals with this study was found.

Brooks (3) found in a study on retention of knowledge in a seventh grade American history class that a steady decline of knowledge initially learned occurred over a period of two months. He used sixty-four students and gave them a post test at different times throughout the two-month period. Brooks pointed out that, although the decline was steady, the students still retained sixty-nine per cent of the material initially learned. He explained that the high percentage of recall was aided by the tests.

Ballard (2) on the other hand did not find a steady decline of knowledge retention in a literature class. He found an increase! Ballard found in a study using 5,192 students that under certain conditions, recall may be more efficient after two or three days than it is immediately after learning. He had the students learn long selections of poetry under time limits insufficient for mastery. Recall tests were given immediately, without advance notice, one, two, three, four, five, six, and seven days later. Incomplete recall of the "Ancient Mariner" was shown to be six to nine per cent better after two or three days than it was immediately after learning.

The various studies and opinions pertaining to the retention of knowledge is voluminous. It is not the purpose of the background study to review all of the literature available on the subject, but rather to point out some of the conflicting thoughts, studies, and opinions on the subject. No studies were found that opposed or debated the importance of meaningful material in knowledge retention. Conflicting views were found on the me-

thod of teaching meaningful material in order to facilitate initial learning and retention. Conflicting views were found on the percentage of meaningful material retained over a period of time.

Since there are conflicting studies and opinions on retention of knowledge, and since no studies could be found relating to eighth-grade science, I would propose the following hypothesis. There is no difference in retention of material initially learned as measured twenty-four hours, two weeks, or four weeks after instruction between groups taught by pupil discovery or direct and detailed instruction.

CHAPTER III

METHODS

This study was conducted for the purpose of determining possible differences in the retention of knowledge between groups of students taught by direct and detailed instruction (Method A) and pupil discovery (Method B) in eighth grade general science.

This chapter is organized to include discussions of the population used, teaching procedures employed, methods of testing, methods used in the collection of data, and methods of data analysis used in the conduct of the investigation.

POPULATION

At the outset of this study, the principal of the Glendive Junior High School was contacted and the author's idea of forming two groups was explained. Each group would be made up of two classes, and one group would be taught throughout the school year by a direct and detailed method of instruction. This group would be used as the control group. (Method A) The other would act as the experimental group and would be taught the same units by the pupil discovery method. (Method B) Through the principal and the assistance of fellow faculty members, four classes were made up and all of their records were made available to this investigator.

The principal arranged four of six eighth grade classes by random selection. The method used for selecting students to participate was by alphabetical order of last names. The boys whose last names began with A through K were placed in one class. Girls whose last names began with K

through Z were placed in the same class. In the second class, the girls whose last names began with A through K and the boys whose last names began with K through Z were placed together. The third and fourth classes were similarly arranged. The principal also attempted to put 15 boys and 15 girls in each class. He was successful in two classes, while in the other two there were 16 girls and 14 boys.

The faculty cooperated by agreeing to accept into their homerooms any new eighth grade students throughout the school year, so as not to disrupt the experiment. In every respect the random selection of participants seemed to be satisfied.

The science portion of the Stanford Achievement Test of each participating student was then evaluated. The purpose of this evaluation was to determine the approximate background of science knowledge of each class.

Each student's science portion of the achievement test was listed from the highest to lowest score and the class median score was computed. At this point, it was discovered that the class median scores were vastly different. This, of course, posed a very serious problem, for the results of this study could be questioned on the basis of this difference. Adjustments were then made by eliminating certain students from the experiment. They, of course, remained in their respective class and participated in the experiment, but their results were not used.

Even after these adjustments were made it was found that all four classes could not have the same median score and approximate deviations without skewing some classes. Therefore, a plan was devised whereby each class would be compared to another class with an identical median score with approximately the same deviations. The results were that two classes had a

TABLE 1

RAW DATA FOR THE STANFORD ACHIEVEMENT SCIENCE TEST SCORES IN THE
EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

METHOD A			METHOD B		
8-5's		8-2's	8-6's		8-1's
1.	11.5	1. 11.0	1.	11.2	1. 10.6
2.	11.4	2. 10.4	2.	10.8	2. 10.6
3.	11.0	3. 10.2	3.	10.4	3. 10.4
4.	11.0	4. 10.2	4.	10.2	4. 10.4
5.	10.4	5. 10.0	5.	10.2	5. 10.2
6.	10.2	6. 10.0	6.	10.0	6. 10.0
7.	10.0	7. 9.8	7.	9.2	7. 10.0
8.	9.3	8. 9.8	8.	9.2	8. 9.8
9.	9.0	9. 9.6	9.	9.0	9. 9.6
10.	8.9	10. 9.6	10.	8.9	10. 9.2
11.	8.7**	11. 9.2**	11.	8.7**	11. 9.2**
12.	8.0	12. 9.2	12.	8.7	12. 9.2
13.	7.7	13. 9.0	13.	8.5	13. 9.0
14.	7.5	14. 9.0	14.	8.2	14. 8.8
15.	7.2	15. 8.8	15.	8.0	15. 8.6
16.	7.2	16. 8.5	16.	7.5	16. 8.4
17.	6.8	17. 8.2	17.	7.1	17. 8.0
18.	6.7	18. 8.0	18.	6.7	18. 8.0
19.	6.5	19. 7.6	19.	6.7	19. 7.9
20.	6.5	20. 7.4	20.	6.7	20. 7.8
21.	6.4	21. 7.4	21.	6.5	21. 7.8

**Median Score

median score of 8.7, and the remaining two classes had a median score of 9.2.

The group that was taught by Method A was composed of two classes, one of which had a median score of 8.7 and the other 9.2. Both classes had twenty-one participants.

The group that was taught by Method B was composed of two classes, one of which had a median score of 8.7 and the other 9.2. Both classes had twenty-one participants.

The regular homeroom class number was used to identify each class. The group taught by Method A was composed of both the 8-5's and 8-2's, while the group taught by Method B was composed of both the 8-6's and 8-1's. The four classes are listed with their Stanford Achievement Science Test scores in Table 1.

The period of instruction for all classes was 45 minutes per day, five days per week. The time of instruction is given in Figure 1:

METHOD A		METHOD B	
8-5	10:30 A.M. - 11:15 A.M.	8-6	1:00 - 1:45 P.M.
8-2	2:30 P.M. - 3:15 P.M.	8-1	9:00 A.M. - 9:45 A.M.

Figure 1: Time schedule of classes to be used in the "Pupil Discovery vs. Direct and Detailed Instruction" experiment.

METHODS OF TEACHING

Method A: Direct and Detailed Instruction.

A great deal of preparation was put into each lesson with specific objectives in mind. Basic science principles, theories, or laws was the theme of most lessons. The Scott-Foresman eighth-grade science textbook was used throughout the experiment. Other textbooks, library books, and supplemental material were used so that every student had materials that he could read with success and understand about the particular science unit covered. The science text, however, for the most part, was the main source of written information. The teacher's guide was carefully followed. Some of the aspects of direct and detailed instruction are as follows:

1. Lectures were given singly before, during, or after a portion of the textbook was covered. Period lectures were sometimes given to introduce a new unit or at the close of the unit.
2. Demonstrations. All of the demonstrations were given by the instructor. The discussions, problems, thoughts, and exchange of ideas were channeled towards answering specific questions raised by the demonstration.
3. Guided reading. Much oral reading was done in class and supplemental or informative information was integrated at various times.
4. Field Trips. Field trips were planned ahead of time by the instructor. Specific objectives were planned and outlined to the class. The instructor pointed out many of the items to be observed. Questions and answers occurred both during and after the field trips.
5. Audio-Visual Aids. A wide variety of audio-visual aids was employed throughout every unit taught. Many times they were used for supple-

mental or supporting information found in the textbook. In all cases they added to or offered specific answers to questions raised by either the textbook or instructor.

6. Class projects. Class projects were employed again to answer specific questions raised by the textbook or instructor. The students often offered suggestions as to how to go about getting the desired information. Through these suggestions, committees were set up or individuals volunteered to give reports. Some students offered to keep the bulletin board organized and up to date.

7. Drill. The use of drill was often used by the instructor to go over materials that were to be memorized. The drill was organized so that a sequential step by step pattern could be recognized by the pupils.

8. Assignments. Three basic types of daily assignments were employed by the instructor.

- a. The students were to read a certain portion and be prepared to discuss it.
- b. A specific written assignment.
- c. Outside reading.

All three types of assignments had specific objectives in mind.

9. Tests. Periodically, tests were administered over very specific areas covered in class. The tests for the most part were fact oriented.

This method of teaching and presenting subject material can vary just as the degree of student involvement in the lesson can vary. Realistically, however, the teacher and the textbook are the focal point for information.

Method B: Pupil Discovery.

In the pupil discovery method much emphasis was placed on problem solving. Although behavior from problem to problem and from individual to individual was remarkably different, there are certain basic aspects of the problem-solving process that have been determined and seem to be fairly common. The following sequence of steps was generally used throughout the experiment.

1. Identifying the problem and feeling the need to pursue it.
2. Seeking to clarify the problem and understand its nature, scope, and subproblems.
3. Collecting data and information related to the problem.
4. Selecting and organizing the data which apply most pertinently to the problem.
5. Determining the various possible solutions in view of the assembled data and knowledge of the problem.
6. Evaluating the solutions and selecting the best one for the situations.
7. Putting the solution into action.
8. Evaluating the problem-solving process employed.

A very democratic, cooperative atmosphere is essential in order to allow the students to function properly in this method.

Problems may arise from the textbook, teacher, or the class itself. It is very important to explain, reevaluate, and repeat the problem until everyone in the class completely understands it. Possible solutions are presented by the pupils. None were rejected by the teacher. Only the pupils could reject possible solutions through their oral discussion at

this point. The students were then divided into groups and each group selected a potential solution to investigate. Then the hypothesis had to be established within the group. This hypothesis was always written out in a clear statement.

Some groups did research either in the classroom or the library. Other groups were allowed to set up an experiment to test their hypothesis. One member of the group was responsible to report to the class what his group discovered. The hypothesis was either accepted or rejected by the class after all groups had reported. If the hypothesis was rejected, the class had by now probably discovered solutions to the problem, and a new hypothesis was developed and investigated. However, if the hypothesis was accepted, certain generalizations were made by the class at this point and tested, if possible. Science principles were then established through oral discussions.

The teacher must take great pain in not getting directly involved in solving the problem. Patience must be exercised when some groups slow down or wander off the track. However, common sense must be involved by the teacher, for he must surely guide the pupils occasionally and assist them in some experiments. It is only after certain science principles are discovered that the teacher lectures and adds any supplementary information that is important.

The major differences between this method and Method A is not only in the approach to the lesson by factors guiding the progress of the unit. For example, in Method B the textbook is used for general and sometimes supplementary information. It is also used as a guideline, for it is written in a sequential pattern. However, more outside reading was done,

and many of the assignments were given in this area. The experiments and demonstrations were set up by the students. During these demonstrations the teacher often posed specific questions which generally required more research or further experimentation to answer them. Problems and/or specific items to be evaluated on field trips were established by both the students and teacher beforehand. During the field trip students making discoveries were quick to point them out. Discussions were often held on the spot, and answers to questions were evaluated. There was generally less time for class projects or drill, for most of the class period was used up in group work. This included research both in the room library and central library, setting up demonstrations, discussions, reporting, and evaluating.

The students became actively involved in the learning process, and the teacher was but a guide. However, subtle as it may sound the planning of such lessons places a heavy burden on the teacher. Realistically, then, it is probably more accurate to refer to this method as directed pupil discovery.

METHOD OF TESTING AND COLLECTING DATA

In order to test the retention of knowledge initially learned by either Method A or Method B, a planned sequence of tests was devised.

It should be pointed out that throughout the year the classes did not finish a given unit on the same day. However, a concerted effort was exercised by this instructor so that all classes finished the units of study for this experiment on the same day. This was done in order to prevent possible contamination of data.

Upon completion of a designated unit of study (Ecology) a teacher-made final test was administered and grades taken. A copy of the test is exhibited in Appendix A. No discussion of the test was held during or after the test. Therefore, with no prior knowledge of a second identical test, one was given twenty-four hours later to one class taught by Method A (8-5) and one class taught by Method B (8-6). Two weeks later the remaining two classes (8-2 and 8-1) were given the same test in the same manner, even though they were well into another unrelated unit of study.

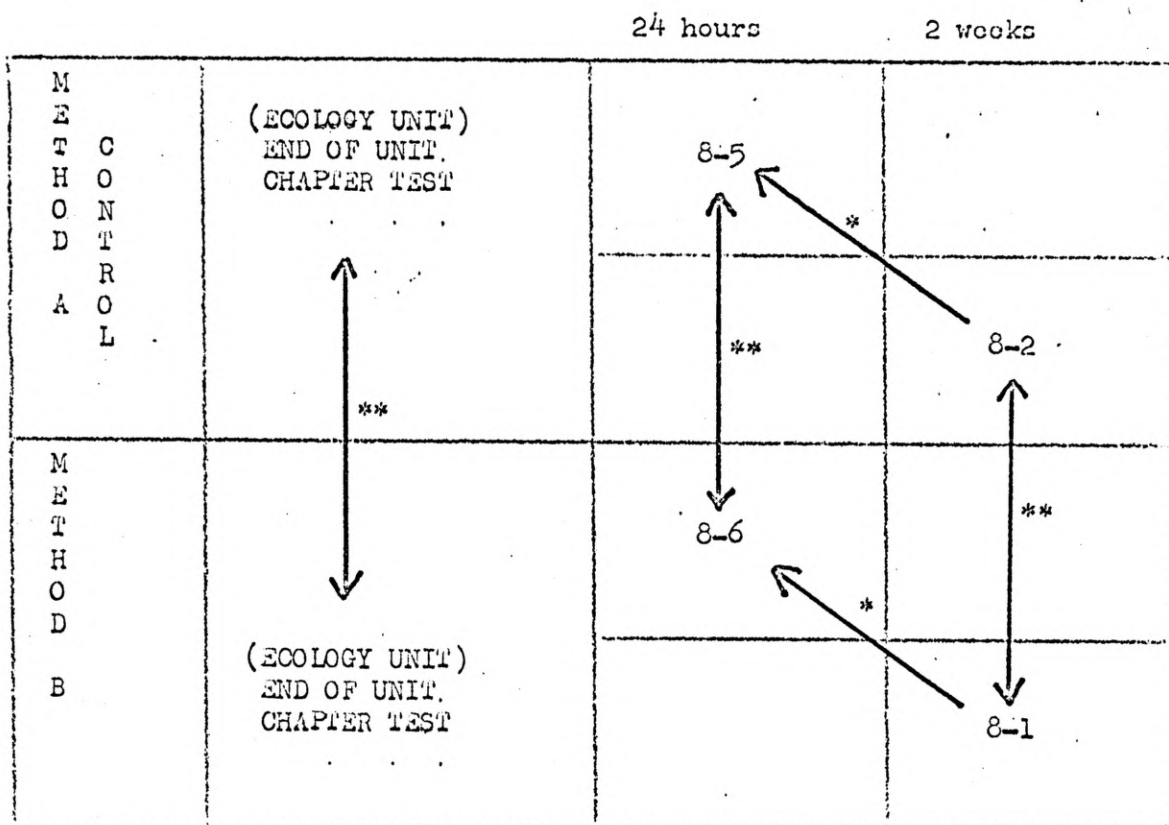
Later in the school year, another unit of study (Electricity) was tested in this experiment. The testing was the same as before, but the time variables were extended. Upon completion of this unit of study, a teacher-made final test was administered and grades taken. A copy of the test is exhibited in Appendix B. Two weeks later one class taught by Method A (8-5) and one class taught by Method B (8-6) was given an identical test. The remaining two classes (8-2 and 8-1) were given an identical test four weeks later.

ANALYSIS OF DATA

A "t" test was used to determine if there was a significant difference between the groups under investigation. The level of significance (alpha level) was set at .05. A two tailed "t" test was used in comparison of the initial chapter error scores. Two tailed "t" tests were also used in the comparison of groups: 8-5 to 8-6 and 8-2 to 8-1 for both the twenty-four hour—two week testing situation.

A one tailed "t" test was used for the comparison of groups: 8-2 to 8-5 and 8-1 to 8-6 for both the twenty-four hour—two week and the two week-

four week testing situation. Refer to figures 2 and 3 for a diagram of comparisons.



* one tailed t test

** two tailed t test

FIGURE 2 Diagram of testing scheme for retention of knowledge in "Pupil Discovery vs. Direct and Detailed Instruction."

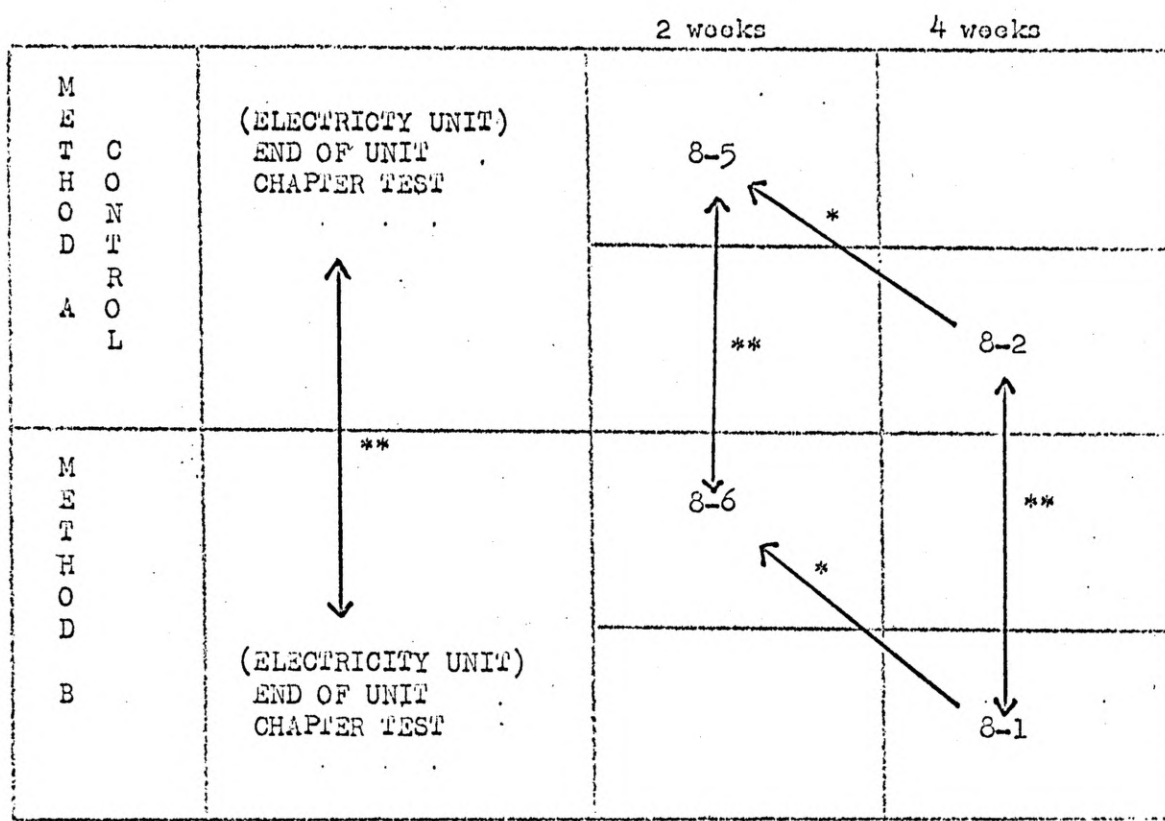


FIGURE 3 Diagram of testing scheme for retention of knowledge in "Pupil Discovery vs. Direct and Detailed Instruction."

CHAPTER IV

RESULTS

Upon completion of the ecology chapter test, each student's paper was evaluated for number of errors. It was found that there were no significant differences between the control group taught by Method A (8-5 and 8-2) and those taught by Method B (8-1 and 8-6). Refer to Table 2 for raw data.

For the two week testing situation no significant differences were found between groups 8-2 (Method A) and 8-1 (Method B). Refer to Table 4 for raw data.

In the comparisons of the two groups taught by Method A for the science unit of ecology in which the 8-5's were tested 24 hours after the initial chapter test, there were no significant differences found. Refer to Table 5 for raw data.

In the comparisons of the two groups taught by Method B for the science unit of ecology, there appeared to be a difference between groups 8-6 tested after 24 hours and 8-1 tested after 2 weeks, by looking at the raw data. However, after computation no significant difference was found. Refer to Table 6.

Upon completion of the electricity chapter test, each student's paper was evaluated for the number of errors. It was found that there is no significant difference between the two groups taught by Method A (8-5 and 8-2) and Method B (8-6 and 8-1). Refer to Table 7 for raw data.

For the two week testing situation no significant difference was found between the groups taught by Method A (8-5) and Method B (8-6). Refer to

Table 9 for raw data.

In the comparison of the two groups taught by Method A for the science unit of electricity in which the 8-5's were tested two weeks and the 8-2's were tested four weeks after the initial chapter testing, no significant difference was found. Refer to Table 10 for raw data.

In the comparison of the two groups taught by Method B for the science unit of electricity in which the 8-6's were tested two weeks and the 8-1's were tested four weeks after the initial chapter testing, no significant difference was found. Refer to Table 11 for raw data.

A total summary of t scores for mean differences between all groups used in this study is presented in Table 12.

No comparisons were made between the two units of study (Ecology-Electricity) because of the vast differences of subject material, possible student interest differences and time factors. The second unit (Electricity) was used only in order to extend the time variable. It was felt there would be too much contamination of data if only one unit was used because of test repetition.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study has been concerned with the retention of knowledge in eighth grade science. It has been suggested by this writer that teaching science by using the pupil discovery method will not increase the retention of knowledge as compared with the traditional direct and detailed method of instruction.

SUMMARY

This writer, after reviewing the literature available on the retention of knowledge, conducted an experiment using two widely used methods of instruction—the pupil discovery method and the direct and detailed method. Each method was used on two eighth grade science classes that were randomly selected and evaluated for approximate equal science background as scored on the science portion of the Stanford Achievement Tests.

The error scores between the classes taught by direct and detailed instruction (METHOD A) and pupil discovery (METHOD B) was statically evaluated on two unrelated science chapters (units). There was no significant differences found. The error scores between classes taught by Method A and Method B were then statistically evaluated in post tests taken 24 hours, 2 weeks, and 4 weeks after initial instruction. No significant difference was found. Error scores were also statistically evaluated between classes taught by Method A in which there was a difference in the time variable. This was done also to classes taught by Method B. In

both cases no significant difference was found.

The one tailed and two tailed t test was used for the statistical evaluation in all cases.

This writer is of the opinion that the results obtained by the pupil, discovery method may have been different if a test could be devised to measure the retention of knowledge. The teacher made tests were somewhat fact oriented, and the true understanding of science principles was not measured.

It was interesting to note that both groups scored less errors twenty-four hours after the initial chapter test was administered and grades taken. This writer noticed two factors that may account for this: 1) Many students checked their textbook or notes immediately after turning in their tests and, 2) There seemed to be a more relaxed atmosphere when the students were taking the second exam. These factors would make an excellent study for some future graduate student.

CONCLUSIONS

It is difficult, if not impossible, to measure the influence of the teachers' interest in presenting the two methods of instruction. To say that there was no difference in enthusiasm and presentation would not be accurate. There is little chance in saying whether or not there was a great deal of difference in the teacher's attitudes in presenting the two methods. However, it should be kept in mind that there were, no doubt, as many variables as there were students combined with the lone teacher.

It was concluded that: 1) The experiment seems to offer evidence, although not conclusive, that students taught by either method of instruc-

tion retain approximately the same amount of knowledge as evaluated on teacher made tests. 2) It would appear that as long as the teacher made an honest effort to do the best job possible, his students will progress somewhat equally no matter which method of instruction is used. 3) The retention of knowledge is for the most part an unmeasured variable. It all depends on what you want to measure. In this case it was facts, not ideas, or true understanding of science principles, theories, or laws.

RECOMMENDATIONS FOR FURTHER STUDY

The results of this investigation suggests the following questions would be worthy of future study:

1. What are the results of a study of this type when a larger sampling is used?
2. What are the results of a study of this type when more teachers have used the pupil discovery method for a number of years?
3. What are the results of a study of this type when different grade levels are experimented with?
4. What are the results of a study of this type when students must take a more complete comprehensive examination which includes essay questions?

TABLE 2

RAW DATA FOR THE INITIAL CHAPTER TEST IN THE EVALUATION "PUPIL
DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

ECOLOGY CHAPTER TEST						ECOLOGY CHAPTER TEST											
8-5			METHOD. A			8-2			8-1			METHOD. B			8-6		
1.	X	X ²	1.	X	X ²	1.	X	X ²	1.	X	X ²	1.	X	X ²			
2.	2	4	2.	2	4	2.	4	16	2.	4	16	2.	2	4			
3.	3	9	3.	3	9	3.	5	25	3.	5	25	3.	4	16			
4.	4	16	3.	4	16	3.	5	25	3.	5	25	3.	4	16			
5.	6	36	4.	5	25	4.	5	25	4.	5	25	4.	5	25			
6.	6	36	5.	5	25	5.	6	36	5.	6	36	5.	5	25			
7.	7	49	6.	7	49	6.	6	36	6.	6	36	6.	6	36			
8.	8	64	7.	8	64	7.	8	64	7.	8	64	7.	7	49			
9.	9	81	8.	10	100	8.	9	81	8.	9	81	8.	7	49			
10.	9	81	9.	10	100	9.	10	100	9.	10	100	9.	9	81			
11.	9	81	10.	10	100	10.	10	100	10.	10	100	10.	9	81			
12.	10	100	11.	11	121	11.	11	121	11.	10	100	11.	10	100			
13.	10	100	12.	12	144	12.	12	144	12.	11	121	12.	10	100			
14.	13	169	13.	12	144	13.	12	144	13.	11	121	13.	10	100			
15.	13	169	14.	12	144	14.	12	144	14.	12	144	14.	11	121			
16.	13	169	15.	12	144	15.	12	144	15.	12	144	15.	13	169			
17.	14	196	16.	13	169	16.	13	169	16.	15	225	16.	14	196			
18.	14	196	17.	13	169	17.	13	169	17.	15	225	17.	14	196			
19.	15	225	18.	13	169	18.	13	169	18.	15	225	18.	14	196			
20.	15	225	19.	14	196	19.	14	196	19.	17	289	19.	16	256			
21.	17	289	20.	15	225	20.	15	225	20.	19	361	20.	16	256			
			21.	15	225	21.	15	225	21.	22	484	21.	26	676			
ΣX (ΣX ²)			ΣX (ΣX ²)			ΣX (ΣX ²)			ΣX (ΣX ²)								
206 2376			206 2342			227 2947			212 2743								
(ΣX) ² X̄			(ΣX) ² X̄			(ΣX) ² X̄			(ΣX) ² X̄								
42,436 9.8			42,436 9.8			51,529 10.8			44,944 10.1								

TABLE 2 (continued)

ECOLOGY CHAPTER TEST.	METHOD B	METHOD A
	$\bar{X}$ 10.5 $(\sum X)^2$ 192,621 $\sum X^2$ 5,695	$\bar{X}$ 9.8 $(\sum X)^2$ 169,744 $\sum X^2$ 4,718

TABLE 3

RAW DATA FOR THE TWENTY-FOUR HOUR TESTING SITUATION BETWEEN 8-5 (METHOD A) AND 8-6 (METHOD B) IN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION."

UNIT: ECOLOGY			UNIT: ECOLOGY		
8-5 (METHOD A)			8-6 (METHOD B)		
	X	X ²		X	X ²
1.	2	4	1.	2	4
2.	2	4	2.	3	9
3.	4	16	3.	4	16
4.	7	49	4.	6	36
5.	6	36	5.	6	36
6.	5	25	6.	6	36
7.	7	49	7.	6	36
8.	12	144	8.	6	36
9.	10	100	9.	9	81
10.	8	64	10.	8	64
11.	7	49	11.	12	144
12.	9	81	12.	14	196
13.	9	81	13.	8	64
14.	11	121	14.	10	100
15.	14	196	15.	10	100
16.	8	64	16.	14	196
17.	16	256	17.	15	225
18.	18	324	18.	13	169
19.	16	256	19.	14	196
20.	13	169	20.	16	256
21.	15	225	21.	20	400
ΣX (ΣX^2)			ΣX (ΣX^2)		
199 2313			202 2400		
$(\Sigma X)^2$ $\bar{X}$			$(\Sigma X)^2$ $\bar{X}$		
39,601 9.5			40,804 9.6		

TABLE 4

RAW DATA FOR THE TWO WEEK TESTING SITUATION BETWEEN 8-2 (METHOD B)
IN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ECOLOGY			UNIT: ECOLOGY		
8-2 (METHOD A)			8-1 (METHOD B)		
	$\bar{X}$	$\bar{X}^2$		$\bar{X}$	$\bar{X}^2$
1.	7	49	1.	5	25
2.	4	16	2.	5	25
3.	4	16	3.	6	36
4.	7	49	4.	6	36
5.	9	81	5.	6	36
6.	9	81	6.	7	49
7.	8	64	7.	7	49
8.	14	196	8.	10	100
9.	13	169	9.	12	144
10.	13	169	10.	12	144
11.	13	169	11.	11	121
12.	12	144	12.	11	121
13.	10	100	13.	13	169
14.	7	49	14.	13	169
15.	12	144	15.	13	169
16.	18	324	16.	16	256
17.	19	361	17.	15	225
18.	21	441	18.	16	256
19.	17	289	19.	18	324
20.	20	400	20.	22	484
21.	18	324	21.	22	484
ΣX			ΣX		
255			246		
$(\Sigma X)^2$			$(\Sigma X)^2$		
65,025			60,516		
(ΣX^2)			(ΣX^2)		
3635			3422		
$\bar{X}$			$\bar{X}$		
12.1			11.7		

TABLE 5

RAW DATA OF THE COMPARISON OF CLASSES TAUGHT BY METHOD A (8-2 and 8-5)
IN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ECOLOGY			
METHOD A	8-2	8-5	t Score
$\bar{X}$	12.1	9.5	
$(\sum X)^2$	65,025	59,601	.40
$\sum X^2$	3,635	2,313	

TABLE 6

RAW DATA FOR COMPARISON OF CLASSES TAUGHT BY METHOD B (8-6 and 8-1)
IN EVALUATION OF PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ECOLOGY			
METHOD B 24 hr.-2 week	8-1	8-6	t Score
$\bar{X}$	11.7	9.6	
$(\sum X)^2$	60,516	40,804	1.31
$\sum X^2$	3,422	2,400	

TABLE 7

RAW DATA FOR THE INITIAL CHAPTER TESTING IN THE EVALUATION OF "PUPIL
DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

ELECTRICITY CHAPTER TEST					ELECTRICITY CHAPTER TEST				
8-5		METHOD A		8-2	8-1		METHOD B		8-6
	X	X ²	X	X ²		X	X ²	X	X ²
1.	2	4	0	0	1.	0	0	1	1
2.	4	16	1	1	2.	1	1	1	1
3.	5	25	1	1	3.	2	4	2	4
4.	5	25	2	4	4.	2	4	3	9
5.	5	25	3	9	5.	4	16	3	9
6.	6	36	4	16	6.	5	25	5	25
7.	6	36	5	25	7.	5	25	5	25
8.	7	49	6	36	8.	5	25	6	36
9.	8	64	6	36	9.	6	36	8	64
10.	10	100	8	64	10.	6	36	9	81
11.	10	100	12	144	11.	7	49	10	100
12.	10	100	12	144	12.	8	64	10	100
13.	10	100	12	144	13.	10	100	13	169
14.	11	121	12	144	14.	11	121	13	169
15.	11	121	12	144	15.	13	169	14	196
16.	12	144	12	144	16.	14	196	15	225
17.	12	144	13	169	17.	16	256	17	289
18.	12	144	14	196	18.	19	361	18	324
19.	18	324	17	289	19.	20	400	19	361
20.	20	400	17	289	20.	21	441	19	361
21.	20	400	19	361	21.	22	484	20	400
ΣX		(ΣX^2)	ΣX	(ΣX^2)	ΣX		(ΣX^2)	ΣX	(ΣX^2)
204		2478	188	2360	197		2813	211	2949
$(\Sigma X)^2$		$\bar{X}$	$(\Sigma X)^2$	$\bar{X}$	$(\Sigma X)^2$		$\bar{X}$	$(\Sigma X)^2$	$\bar{X}$
41,616		9.7	35,384	8.9	38,809		9.4	44,521	10.048

TABLE 7 (continued)

ELECTRICITY CHAPTER TEST.		METHOD B	METHOD A
	$\bar{x}$ $(\sum x)^2$ $\sum x^2$	9.7 166,464 5762	9.3 143,664 4338

TABLE 8

RAW DATA FOR THE TWO WEEK TESTING SITUATION BETWEEN 8-5 (METHOD A) AND 8-6 (METHOD B) IN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ELECTRICITY			UNIT: ELECTRICITY		
8-5 (METHOD A)			8-6 (METHOD B)		
	X	X ²		X	X ²
1.	0	0	1.	0	0
2.	7	49	2.	1	1
3.	5	25	3.	2	4
4.	12	144	4.	4	16
5.	11	121	5.	3	9
6.	7	49	6.	6	36
7.	10	100	7.	7	49
8.	13	169	8.	5	25
9.	11	121	9.	9	81
10.	14	196	10.	9	81
11.	12	144	11.	10	100
12.	14	196	12.	12	144
13.	15	225	13.	14	196
14.	12	144	14.	15	225
15.	10	100	15.	15	225
16.	12	144	16.	17	289
17.	16	256	17.	14	196
18.	18	324	18.	20	400
19.	18	324	19.	22	484
20.	18	324	20.	20	400
21.	20	400	21.	19	361
	ΣX	(ΣX^2)		ΣX	(ΣX^2)
	255	3555		224	3522
	$(\Sigma X)^2$	$\bar{X}$		$(\Sigma X)^2$	$\bar{X}$
	65,025	12.1		50,176	10.7

TABLE 9

RAW DATA FOR THE FOUR WEEK TESTING SITUATION BETWEEN 8-2 (METHOD A) AND 8-1 (METHOD B) IN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ELECTRICITY			UNIT: ELECTRICITY		
8-2 (METHOD A)			8-1 (METHOD B)		
	X	X ²		X	X ²
1.	2	4	1.	1	1
2.	3	9	2.	2	4
3.	2	4	3.	4	16
4.	4	16	4.	3	9
5.	3	9	5.	5	25
6.	8	64	6.	3	9
7.	12	144	7.	7	49
8.	10	100	8.	6	36
9.	9	81	9.	9	81
10.	11	121	10.	6	36
11.	12	144	11.	10	100
12.	14	196	12.	14	196
13.	10	100	13.	13	169
14.	15	225	14.	12	144
15.	15	225	15.	14	196
16.	18	324	16.	16	256
17.	18	324	17.	24	576
18.	20	400	18.	19	361
19.	24	576	19.	18	324
20.	25	625	20.	25	625
21.	26	676	21.	22	484
ΣX			ΣX		
251			234		
(ΣX^2)			(ΣX^2)		
4367			3682		
$(\Sigma X)^2$			$(\Sigma X)^2$		
63,001			54,756		
$\bar{X}$			$\bar{X}$		
11.9			11.2		

TABLE 10

RAW DATA OF THE COMPARISON OF CLASSES TAUGHT BY METHOD A (8-2 and 8-5)
IN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ELECTRICITY			
METHOD A 2 weeks-4 weeks	8-2	8-5	t Score
$\bar{X}$ $(\sum X)^2$ $\sum X^2$	11.9 63,001 4367	12.1 65,025 3555	.95

TABLE 11

RAW DATA OF THE COMPARISON OF CLASSES TAUGHT BY METHOD B (8-6 and 8-1)
IN THE EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

UNIT: ELECTRICITY			
METHOD B 2 weeks-4 weeks	8-1	8-6	t Score
$\bar{X}$ $(\sum X)^2$ $\sum X^2$	11.2 54,736 3682	10.7 50,176 3322	.32

TABLE 12

T SCORES (ONE AND TWO TAILED) FOR MEAN DIFFERENCES BETWEEN GROUPS IN AN EVALUATION OF "PUPIL DISCOVERY VS. DIRECT AND DETAILED INSTRUCTION"

GROUPS -		DF .	T	P	SIGNIFICANT DIFFERENCE.
24 hour- 2 weeks	8.2-8.5	20	.40	1.72*	NONE
	8.6-8.5	20	.048	2.09**	NONE
	8.2-8.1	20	.25	2.09**	NONE
	8.1-8.6	20	1.31	1.72*	NONE
2 weeks- 4 weeks	8.5-8.2	20	.95	1.72*	NONE
	8.2-8.1	20	.29	2.09**	NONE
	8.1-8.6	20	.32	1.72 *	NONE
	8.5-8.6	20	.78	2.09**	NONE
Ecology	B - A	41	.70	2.02**	NONE
Electricity	B - A	41	.29	2.02**	NONE

* level .05

* one tailed t test

** two tailed t test

t scores (one and two-tailed) for mean differences between groups in an evaluation of "Pupil Discovery vs. Direct Instruction"

DF--Degrees of Freedom

T--T test

P--Probability

S--Significance

APPENDICES

Circle the correct answer

NAME _____

- T F The epidermis cells on a plant leaf are green in color.
- T F Chlorophyll is usually contained in special particles located in the cytoplasm of food making cells.
- T F Chlorophyll acts as a catalyst for a chemical change that produces a special nitrogen compound known as ATP.
- T F Photosynthesis is an energy storing process.
- T F Some kinds of plants get their food from dead things or from materials that have come from living things. These plants are called saprophytes.
- T F The tap root soaks up water and dissolved minerals from the soil.
- T F Mushroom, molds, and moss belong to a group of plants known as funji.
- T F Carbon, Hydrogen, and Oxygen are the three elements that make up carbohydrates.
- T F Photosynthesis means put together by light.
- T F Every established colony of living things must have at least three groups: carnivorous animals, herbivorous animals, and saprophytes.

MATCHING

- | | |
|------------------------------|--|
| _____ SYMBIOTIC RELATIONSHIP | A. ant "cows" |
| _____ PREDATORS | B. A living thing that must live off a host without benefit to the host. |
| _____ INDEPENDENT PLANTS | C. Animals that eat other animals |
| _____ EPIPHYTE | D. Gets food from air. |
| _____ APHIDS | E. Gets food from dead things. |
| _____ HABITAT | F. Small openings under leaf. |
| _____ CONSERVATION | G. Place where organism lives. |
| _____ ROOT HAIRS | H. Makes plants green |
| _____ PARASITE | I. Very small insects |
| _____ CHLOROPLASTS | J. Green plants |
| | K. Small particles containing chlorophyll |
| | L. Using things wisely |
| | M. Takes in H ₂ O and dissolved minerals. |
| | N. Two organisms living together for mutual benefit |
| | O. Mushrooms |
| | P. Outer layer of cells on leaf |
| | Q. Not using things. |

SCIENCE 8

MULTIPLE CHOICE

NAME _____

Plants that return nitrogen compounds to the soil are called (epiphytes)
(nitrogen giving plants)(legumes)

Animals that live and work together for the good of the whole group are called
(bees) (social animals) (termites)

(Man) (Carnivorous animals) (Herbivorous animals) is/are responsible for
upsetting the balance of numbers more than anything else.

There are (2) (3) (4) main steps in photosynthesis.

(Nature) (Biology) (Ecology) is the study of an organism in relation to its
environment.

Carbon Dioxide gets into the leaf through the (guard cells) (epidermis cells)
(stomates)

Water and dissolved minerals get into the plant and to the leaves through
(capillary action) (root hairs) (tap or fibrous roots)

Conservation of (animals) (plants) (the soil) is the most important.

A good example of a parasitic animal is the (termite) (maggot) (tapeworm)

A good example of a parasitic plant is the (bacteria) (dodder) (mushroom)

COMPLETION

Plants transport H_2O to the leaves by a process known as _____

Light + $6CO_2$ + $6H_2O$ — _____ + _____

Give an example of a plant or animal that has a symbiotic relationship. _____

Name the two main roots found in plants _____

Name five food values we get from eating green plants. _____

SCIENCE 8

NAME _____

(True or False - mark + for TRUE and 0 for FALSE)

1. _____ Ohms is the resistance of volts.
2. _____ The lack of electrons causes an object to be positively charged while the surplus of protons causes an object to be negatively charged.
3. _____ A switch or fuse is always connected in series with the appliance.
4. _____ Electric current flows from the positive to the negative pole.
5. _____ The force that moves electrons along a path is called amperage while the resistance to the electrons is called ohms.
6. _____ Electrically charged atoms are called ions.
7. _____ Three things could cause the resistance in a wire: its length, its diameter, and the kind of material it is made of.
8. _____ If you double the resistance and the voltage stays the same you will cut the current in half.
9. _____ If you cut the resistance in half and the amperage stays the same you will double the voltage.
10. _____ The current in ampers equals the electromotive force in volts divided by the resistance in ohms.

MATCHING

- | | |
|--------------------------|---------------------------|
| 1. _____ Ohms | A. Negative charge |
| 2. _____ Rubber | B. Positive charge |
| 3. _____ Open Circuit | C. Incomplete path |
| 4. _____ Volts | D. Insulator |
| 5. _____ Conductor | E. Copper |
| 6. _____ Watts | F. Dry Cell |
| 7. _____ Direct current | G. Complete Path |
| 8. _____ Amperes | H. Kilowatts |
| 9. _____ Electrons | I. Amount of current |
| 10. _____ Closed circuit | J. Electrical pressure |
| | K. Alternating current |
| | L. Resistance |
| | M. Electrical energy used |
| | N. Atoms |
| | O. Ions |
| | P. Condensers |
| | Q. Non-conductor |
| | $I = \frac{E}{R}$ |

SCIENCE 8

NAME _____

(Multiple Choice - Circle the correct answer)

1. There are (100) (1,000) (10,000) watt hours in one kilowatt hour.
2. In measuring the size of wire, the larger the number the (larger) (smaller) (More it costs for) the wire.
3. The force that moves electrons along a path is called (amps) (electrical force) (electromotive force)
4. Two or more chemical cells connected together will form (a battery) (a circuit) (electrical energy)
5. The instrument used to find out whether or not a current is flowing is called a/an (ammeter) (voltmeter) (galvanometer)
6. If you connect two or more batteries together in series you will increase the (ohms) (amps) (volts)
7. If you connect two or more batteries together in parallel you will increase the (ohms) (amps) (volts)
8. (Revolutions) (Alternations) (Cycles) are the number of times the electrons change direction per second in an alternating current.
9. Electrons will move better from where there is a greater surplus of them to where there is (a smaller surplus) (no surplus) (a shortage)
10. Friction produces (alternating current) (static electricity) (direct current)

PROBLEMS TO SOLVE

1. What is the wattage of 115 volts with a 3 amp current?
2. What must the voltage be at a 60 watt bulb to force a current of $\frac{1}{2}$ ampere to flow through it?
3. If the current is supplied at 120 volts, how many 80 watt bulbs can be connected in a 30 ampere branch circuit before the fuse blows?
4. If a 1200 watt iron was used 18 hours during a given month and the electric company charged 5¢ a kilowatt hour, how much was the bill?
5. How many amps in a 1210 watt iron with a 110 volt circuit?
6. How many watt hours are used in a 60 watt bulb left on for 36 hours?
7. How many watts does a mixer use on a 120 volt circuit with 5 amperes?
8. At 5¢ a kilowatt hour how much will it cost to run the mixer in problem 7 for one hour?

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