THE DEVELOPMENT AND TESTING OF A PROGRAMMED UNIT OF STUDY ON THE TOPIC, "THE PRINCIPLE OF THE WATER CYCLE"

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THE DEVELOPMENT AND TESTING OF A PROGRAMMED UNIT OF STUDY ON THE TOPIC, "THE PRINCIPLE OF THE WATER CYCLE"

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ABSTRACT

The purpose of this study was to develop and test a programmed unit on the topic, "The Principle of the Water Cycle." This was done in response to an educational problem that centers around the fact that children vary individually in their learning capabilities. Prior to and in conjunction with the development of the programmed unit a review of literature and research related to programmed instruction in general was conducted. Also, it was hypothesized that the linear type program when augmented with support materials leads to different achievement and retention over a three week interval than the traditional lecture method of instruction.

The steps followed in writing the programmed unit were described and revisions were made on the basis of criticisms from a teacher, two graduate students, a content specialist, and two grade seven students. Also, the programmed unit was subjected to the Thorndike-Lorge Word List and revisions were made, where necessary, in order to arrive at the grade seven level of reading. After the program was developed it was evaluated by comparing it to the traditional lecture method of instruction in an experimental versus a control group situation.

The limitations and findings of the study were listed and described briefly. Also, suggestions for future research were listed and described. It was concluded that the programmed unit on the topic, "The Principle of the Water Cycle" might be

able to be utilized as a substitute for the teacher in presenting prerequisite material that is necessary for an understanding of the causes of relief rainfall and frontal rainfall. Also, the recommendation was offered that other areas of the social studies in which programmed units could be utilized should be identified and programs developed to cope adequately with them. Furthermore, it was concluded that the findings were not a function of the posttest or retention test.

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This internship is dedicated to my three children

Joanne, Janie, and Jacob.

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Chapter 1

STATEMENT OF THE PROBLEM

In the past, teachers in schools throughout Newfoundland and elsewhere have placed great emphasis on the lecture method of instruction. This method of instruction presupposes the coverage of content at the normal rate of progress for the particular group receiving instruction. The normal rate of progress is determined by the teacher and is usually based on the teacher's limited knowledge of the group of students with whom he is dealing. The lecture method therefore neglects the individual who is unable to keep pace with the normal rate of progress for the group in which he happens to find himself. The student might have to proceed at a slower rate of progress or on the other hand, he might be able to proceed at an accelerated rate.

The individual who is unable to keep pace with the normal rate of progress usually attends special education classes, remedial classes, or just drops out of school. The student who is capable of proceeding at a faster rate is often bored by the repetition and lack of challenge he frequently experiences in the classroom. In order to deal adequately with individual differences among students in Newfoundland schools, especially since the provincial government has curtailed its effort to lower the pupil-teacher ratio, it is felt that educators in the province should seriously look at alternative means of coping with educational problems arising from the fact that students differ individually in their learning capabilities. One aspect of educational endeavour that could be investigated as a possible solution or part of the solution to this problem is programmed instruction. Skinner indicates an awareness of this problem when he states:

> Even in a small classroom the teacher usually knows that he is moving too slowly for some students and too fast for others. Those who could go faster are penalized and those who should go slower are poorly taught and unnecessarily punished by criticism and failure.[1]

Teachers who practise the lecture method of instruction are too preoccupied with teaching classes to give much consideration to individuals in their classes. Teachers through the utilization of the lecture method try to present subject matter step-by-step in logical order and to get students to participate by having them listen and write. Such teachers also attempt to correct students' mistakes and to provide for review. However, these teaching principles are extremely difficult to apply in crowded classrooms.

Traditionally, teachers employing the lecture method have made few arrangements for the student to respond actively to the information presented by thinking of illustrations,

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[1]B. F. Skinner, The Technology of Teaching (New York: Appleton-Century-Crofts, 1968), p. 30.

examining himself, and summarizing. There is usually no indication that the student is assimilating the information presented to him by the lecture method because he is able to remain passive during the presentation of the material. However, in programmed instruction, the student is forced to actively participate because he is required to respond to each frame in the program.

Teachers who employ the lecture method of instruction present considerable amounts of information before giving the student an opportunity to respond. Therefore, no check is made to see if the individual student is following the development of a concept or principle. In programmed instruction a response is required from the student after the presentation of each piece of information. In this way a check is made to see that the student is following the development of the material being presented.

In the construction of a programmed package student reaction to the program is continually and carefully monitored. A programmed package is, therefore, better able to meet individual needs than is the lecture method which is teacher directed and designed with the so-called normal students of the class in mind.

The programmed package developed and tested in this internship was selected from the grade seven social studies program and was of approximately one week in duration. The area within the social studies program that was considered was geography and to further specify, the internship dealt with the development and testing of a programmed unit of study on the water cycle, which is a topic covered in physical geography.

The present course of study in grade seven geography, in part, deals with relief rainfall and frontal rainfall. Teachers in the Bay Roberts, Newfoundland, area have observed that many of their students are unable to cope with this information when it is presented to them. The reason for this is that the students do not understand the concepts of evaporation, condensation, and precipitation, or the principle of the water cycle. These concepts and the accompanying principle are fundamental to an understanding of relief rainfall and frontal rainfall. It is for this reason that the topic "The Principle of the Water Cycle" was selected for this investigation. If individuals do not understand basic concepts it is useless for them to proceed to a principle made up of these concepts. The situation becomes very difficult when the same students are expected to understand what causes relief rainfall and frontal rainfall.

The package or program developed and tested was the linear type program plus augmentation with related materials. This modified program was still linear in format in that each student had to proceed through a series of small steps called frames, respond to each frame, and receive immediate feedback for each response. This type of program was selected because it appeared to be the easiest program for students to follow.

The students had to proceed horizontally rather than vertically through each module in the program. Here, the first frame was presented at the top of the first page. When the student wrote his answer or responded to directions he turned the page and received feedback on the top of page two. At the top of page two he also received the second presentation frame to which he was required to respond. From the top of page two he then proceeded to the top of page three, and so on. This procedure was followed until the student arrived at the midpoint of each of the five modules in the program. Then he was directed back to page one of each module where he read the frame at the bottom of the page and proceeded as before except that the frames were located at the bottom of each page rather than at the top. This procedure was easy to follow because the materials were presented on successive pages.

Confusion might have developed with respect to page turning if the branching type program had been developed, because then the student would not have been required to follow the numerical sequence of pages. Also, it was a first experience with programmed instruction for the students in this study and an experimental versus control group situation was established. Therefore, the writer decided to keep the program as simple and straightforward as possible. Otherwise, complications arising from the program itself might have interfered with the results of the investigation. The programmed unit proved to be as successful as the traditional lecture method of instruction and can be placed in the library for use by all students including those who are unable to keep pace with the normal rate of presentation. Also, it can be used for enrichment purposes by students who are able to proceed faster than the normal rate of presentation.

Chapter 2

A REVIEW OF RELATED LITERATURE AND RESEARCH

INTRODUCTION

This chapter looks briefly at three antecedents of programmed instruction that predate the twentieth century and identifies the main characteristics of such instruction as it exists today. Emphasis is placed on descriptions of the linear and branching type programs, and several modified versions of the linear type program are also presented. Before dealing with research related to programmed instruction some of the arguments for and against programmed learning are briefly discussed. The review of related research deals primarily with studies that evaluated programmed instruction by comparing it to traditional or conventional methods of teaching.

HISTORICAL BACKGROUND

Programmed instruction came into prominence in the twentieth century as a result of the pioneer work of Sidney Pressey[2] in the 1920's and the publication of the works of

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[2]Nicholas A. Fattu, "Training Devices," Encyclopedia of Educational Research, ed. Chester W. Harris (New York: Macmillan, 1960), p. 1529.

B. F. Skinner[3] in the 1950's. However, it would be a mistake to view programmed instruction as having all its origins in the twentieth century. Programmed instruction is a method that has developed from contributions made by educators that date back more than two thousand years.

Lysaught and Williams[4] state that one of the earliest units of programmed instruction was developed by Socrates in the field of geometry. Plato recorded this program in the dialogue Meno. Here Socrates guided his student through the use of conversation from fact to fact and insight to insight. This procedure resembles the use of steps employed in programmed instruction.

Dene Lawson[5] describes a teaching machine called a quintain that was utilized to train knights during the Middle Ages. A quintain was the figure of a swordsman mounted on a pivot. The figure held a shield in one hand and a sword in the other. A knight on horseback had to strike the shield directly in the center or else the quintain would pivot quickly and strike the knight with its sword. Thus, the quintain provided feedback to the knight. In units of programmed instruction

[3]Nicholas A. Fattu, "Training Devices," Encyclopedia of Educational Research, ed. Chester W. Harris (New York: Macmillan, 1960), p. 1580.

[4]J. P. Lysaught and C. M. Williams, A Guide For Programmed Instruction (New York: John Wiley and Sons, Inc., 1963), p. 3.

[5]Dene R. Lawson, "Who Thought of It First," Educational Technology, IX (October, 1969), 95.

students receive feedback, but it is not so violent in nature as that given by the quintain. It consists of permitting the student to see if he has responded correctly or incorrectly at the end of a frame.

Wilbur Schramm[6] points out that five hundred years ago Comenius tried to describe a type of education in which the student would be more active, learn more, and the teacher would teach less. Comenius also suggested that the student proceed from the easier to the more difficult and that his progress not be rushed. Today programmed instruction requires the student to move along a carefully sequenced series of steps, to give an active response at the end of each step, and to proceed at his own pace without assistance from the teacher.

These three examples of teaching techniques have been presented in order to emphasize the fact that many of the ideas incorporated in programmed instruction predate the twentieth-century. It might be concluded that some of the techniques of programmed instruction are as old as teaching and learning.

Although the United States Patent Office recorded devices aimed at aiding teaching as early as 1809, it was not until the 1920's that Sidney Pressey was given credit for having developed

[6]Wilbur Schramm, "Programmed Instruction Today and Tomorrow," Four Case Studies of Programmed Instruction, (New York: Fund for the Advancement of Education, 1964), p. 106.

the first tool labelled a teaching machine.[7] Pressey's device was actually a testing machine because it introduced a series of questions to the student and immediately informed him if his reply were right or wrong. If a student were wrong he was supposed to reread the textbook. In this way Pressey's machine was really a supplement to the textbook and not a replacement for it. At first Pressey's teaching machine was greeted with much enthusiasm and interest. However, the movement towards such teaching machines lost its impetus. Deterline[8] attributes this loss of impetus to the fact that the world was beginning to experience the upset of depression and its impact on education created an unfavourable environment for the employment of expensive teaching machines in schools in the United States. Also, educational psychology had not attained an adequate comprehension of the principles of learning that could be employed in the development of systematic programming of materials to be utilized in Pressey's teaching machines.

Despite this apparent setback the idea of programmed instruction continued to exist. Educators later acquired a renewed interest in programmed instruction when Skinner read his paper entitled "The Science of Learning and the Art of

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[7]Nicholas A. Fattu, "Training Devices," Encyclopedia of Educational Research, ed. Chester W. Harris (New York: Macmillan 1960), p. 1529.

[8]William A. Deterline, An Introduction to Programmed Instruction (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1963), p. 10.

Teaching" in 1954[9]. At the time educators looked upon programmed instruction as if it could provide them with the answer to all their problems. During the late 1950's and early 1960's many programs were developed and tested. Also, research was conducted on many aspects of programmed instruction and the findings were published. Today there are not so many articles dealing directly with programmed instruction being published; however, this is no indication of its present state of health. Rummier[10] suggests that programmed instruction is alive and well and that it is having its greatest impact by providing people with a process that is fundamental to all effective training. For example, the processes of systems, behavioral analysis, instructional design, development, and validation could very well become the processes followed in all training.

Deterline[11] indicates that from programmed instruction educators have acquired the technology that makes possible such things as ungraded schools, flexible scheduling, student-centered instruction, and individualized instruction.

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[9]Jerome P. Lysaught and Clarence M. Williams, A Guide to Programmed Instruction (New York: John Wiley and Sons, Inc., 1966), p. 5.

[10]Geary A. Rummier, "P. I.-Where The Action Is," Educational Technology, X (July 1970), 31.

[11]William A. Deterline, "Programmed Instruction Today," Educational Technology, X (July, 1970), 29.

DEFINITION OF PROGRAMMED INSTRUCTION

In order to clarify the meaning of programmed instruction three selected definitions will be presented. The definitions will then be followed by a list of the characteristics necessary for a teaching method to be called programmed instruction.

The International Encyclopedia of the Social Sciences gives the following definition:

> The term "programmed learning" is used to describe an instructional situation in which materials presented in a controlled sequence require the learner to respond in a way that meets specified criteria of the program objectives. Terms often used synonymously are "programmed instruction," "automated instruction," "automated tutoring," or even "teaching machines".[12]

William Ryan refers to programmed instruction as:

> . . . the use of materials or procedures which incorporate an "auto-instructional" (or self-instructional) program. Such a program commonly attempts to provide conditions under which a student can learn something efficiently with little or no outside help. Current programs typically employ a pre-arranged sequence of material that is presented to the student one small unit at a time (e.g., a sentence or paragraph). Most programs require the student to respond actively at least once for each unit (or 'frame') of material, for example, by composing or selecting an answer to a question. Programs also commonly provide prompt confirmation, as the case may be, for each response the student makes.[13]

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[12] David L. Gills (ed.) International Encyclopedia of the Social Sciences, IX (Washington, D.C.: The MacMillan Company & The Free Press, 1968), 182.

[13] William T. Ryan, A Handbook of Programmed Learning Information (Albany, New York: The State Education Department, 1964), p. 49.

Espich and Williams define programmed instruction as:

> . . . a planned sequence of experiences leading to proficiency, in terms of stimulus-response relationships . . . that have proven to be effective.[14]

In order for a teaching method to be defined as programmed instruction it is essential for it to have the following characteristics.

1. Each student works individually on the program at his own pace.

2. The student is presented with a relatively small unit of information at a time.

3. The information is arranged in a series of carefully sequenced steps, usually from the simple to the complex.

4. The student is required to respond actively to each segment of information.

5. The program gives the student immediate knowledge of results after each response he makes.

6. After the student responds to the presentation and receives feedback concerning his answer, the next unit of information is presented. This cycle of presentation, response, and feedback continues throughout the program.

7. Programs are tested and revised on the basis of student responses to them.

In a programmed unit of instruction each piece of

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[14] James E. Espich and Bill Williams, Developing Programmed Instructional Materials (Palo Alto, California: Fearon Publishers, 1967), p. vi.

information presented is called a frame. Perhaps this is so because when teaching machines are utilized the information appears through a window on the machine. The student is led toward predetermined goals, a little at a time, through a careful sequential arrangement of frames. A series of carefully sequenced frames that lead the student step-by-step toward an objective is called a program.

At present there are two basic types of programs. One is the linear program developed by B. F. Skinner and the other is the intrinsic or branching program developed by Norman A. Crowder. The main difference between these two types of programs lies in the way that each sequences the learning materials. Skinner takes his cue from learning theory and relies heavily on the principle of reinforcement. On the other hand, Crowder takes his cue from communication theory. He sees teaching as a communication system which gets established between the teacher and the students.

Today a variety of modified programs exists alongside the two basic types. These modified versions represent attempts by programmers to develop programs that are able to meet a variety of individual needs.

THE LINEAR PROGRAM

The linear program unit of instruction was developed by Skinner when he attempted to apply to human learning situations the principles of reinforcement learning theory he had found to be successful in animal learning experiments. When Skinner looked to the field of education he found that many practices were contrary to those he believed were essential for efficient learning. He observed that teachers did not speak to one person, but to a whole class and that the student very often listened without understanding. Skinner saw that students were not given many opportunities to respond to the instruction and even when they were a day might elapse before they received feedback concerning the correctness or incorrectness of their response. In order to make learning more efficient Skinner suggested that students be taught individually at their own rates and that they receive immediate feedback concerning their responses. In order to achieve this in the human learning situation Skinner utilized a teaching machine that presented a linear program with the following essentials:

1. The material to be taught was divided into a series of small steps called frames.

2. Each frame placed information before the student and he was required to respond to it. The response was overt and usually written.

3. The information was divided into steps small enough to ensure the correct response from almost all of the students.

4. The student was presented with the correct answer immediately following his response.

The linear programmed unit of instruction relies heavily on the concept of reinforcement. Reinforcement is sometimes referred to as reward. Lewis[15] describes a reinforcer as any object or event that serves to increase or maintain the strength of a response. Primary reinforcers serve innately to increase response and secondary reinforcers are learned through the association with primary reinforcers and these also serve to increase or maintain the strength of response. If learning is to occur, the student must get something he wants and he must be rewarded.

In utilizing the linear programmed unit the student responds to a stimulus. Each frame in the program contains a stimulus. For example, a stimulus might read thusly. "Metals expand when heated. Copper is a metal and will ___response___ when heated." The student is rewarded for the correct response by finding out that he is right, or having the satisfaction of finding out the correct answer after being wrong. The linear programmed unit and student are on a one-to-one basis and the student is rewarded for each response made.

THE BRANCHING PROGRAM

The branching program is sometimes called intrinsic programming and was developed by Norman Crowder. Crowder states:

> The crucial and identifying feature of intrinsically programmed materials is the fact that the material presented to each student is

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[15]Donald J. Lewis, Scientific Principles of Psychology (Englewood Cliffs, New Jersey: Prentice-Hall, 1963), p. 107.

continuously and directly controlled by the student's performance in answering questions.[16]

In the branching program each student is presented a paragraph or more of information in each frame. At the bottom of the frame the student is tested by a multiple-choice question. This question serves primarily a diagnostic function in that it sees whether or not the information in the frame has been successfully communicated to the student. If the student answers the question correctly he is directed to proceed to the next frame in the program. On the other hand, if the student answers the question incorrectly he is directed to a branch frame where he is shown why his response is incorrect. After this the student is referred back to the original frame and given another try at answering correctly the question following it. All students are not expected to pass through the same sequence of frames because the next frame they are exposed to is determined by the answer they gave in the preceding one. Students usually select different answers to a particular multiple-choice question. In the linear type of program all students have to follow the same sequence of frames.

The branching type of programmed unit is based on the pupil-tutor model. This model is characterized by interaction. The student using a branching program responds to the information

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[16]Norman A. Crowder, "The Rationale Of Intrinsic Programming," Human Learning in the School, ed. John P. DeCecco (New York: Holt Rinehart, and Winston, 1963), p. 185.

presented in a frame and the program selects the next frame to be presented on the basis of the student's response.

MODIFIED PROGRAMS

The branching method of programming instruction is an attempt to provide for individual differences. However, the brighter students have to cover all the steps in the main stream of the branching type program. Also, the branching programs have been criticized because the amount of material presented in each frame is too large for some students to handle. Brighter students might be able to proceed through a program by skipping large numbers of frames and, in addition, they tend to require little instruction. Slower students, on the other hand, might require three or four times the amount of instruction in order to cover the same material. Therefore, modified programs such as those that follow have been developed in order to meet a variety of individual needs that appear to have been neglected by both Crowder's branching program and Skinner's linear program.

A program might be constructed so as to include gate frames.[17] Such frames direct the student to different fragments of a linear program. The gate frame might direct the student to jump ahead several frames, or it might send him back to review certain material. The directions that a student receives at a gate frame depend upon the amount of understanding he

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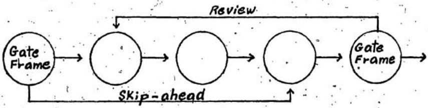
[17] James E. Espich and Bill Williams, Developing Programmed Instructional Materials (Palo Alto, California: Fearon Publishers, 1967), p. 90.

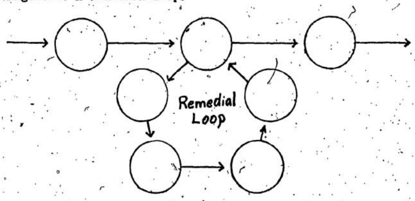
demonstrates concerning the information being presented. Figure 1 illustrates the employment of gate frames.

Figure 1. Gate Frames.



Another technique that might be applied to programmed instruction in order to modify the linear type of program is that of the remedial loop.[18] The remedial loop is a form of branching. This technique takes the student off the main track of the program and guides him through a series of frames that provide him with the information he appears to be lacking at that point in the program. Figure 2 is a pictorial representation of a remedial loop.

Figure 2. A Remedial Loop.



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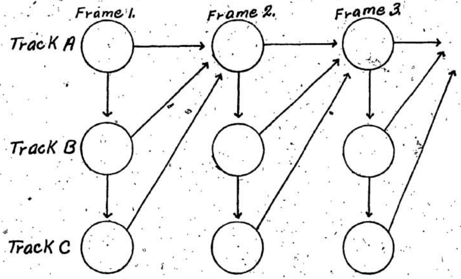
[18] Ibid., p. 91.

Secondary tracks[19] is a third device used in order to modify traditional programmed instruction. In each frame the student is presented with three tracks, Track A, Track B, and Track C. The student first reads the information in Track A. If he does not understand the material he drops down to Track B which is a reproduction of Track A in simpler terms. The student may make a response in Track B and proceed to the next frame, but if he still does not understand the material he may drop down to Track C where he will receive an even more detailed account. The student can proceed through the program using only Track A of each frame or by taking any of many possible track combinations. Figure 3 is a diagrammatical representation of secondary tracks.

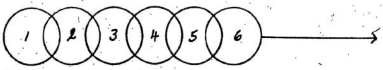
Figure 3. Secondary Tracks.



[19]Ibid., p. 94.

Another paradigm employed in programming is called conversational chaining.[20] In conversational chaining each item is connected to the succeeding item, and the response to the second item becomes a part of the stimulus of the third, and so on throughout the program. Figure 4 is a diagrammatical representation of conversational chaining.

Figure 4. Conversational Chaining.



A final technique used to modify linear programming is the employment of criterion frames.[21] A criterion frame is utilized to determine whether or not a student should proceed through a particular sequence. If the student demonstrates a knowledge of the material to be presented, the criterion frame would show this and the student would be able to skip some of the frames in the main track of the program. Figure 5 illustrates the employment of a criterion frame.

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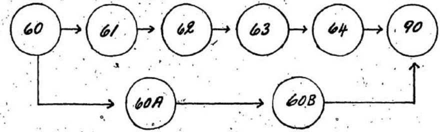
20 J. P. Lysaught and C. M. Williams, A Guide For Programmed Instruction (New York: John Wiley and Sons, Inc., 1963), p. 74.

21 Ibid., p. 80.

Figure 5. A Criterion Frame



Programmed instruction is often presented in programmed textbooks. In the programmed textbook the presentation-answer-feedback cycle of the program is achieved by turning the pages of the text. There are several variations of the programmed text. One way is to present the first frame in the top row of the first page. The student fills in his answer and turns to page two to see if his answer is correct. The answer is presented at the top of page two in the top row. The student then turns to page three and reads the next question. This procedure is followed to the back of the book. Then the student turns to page one and repeats it for row two and continues until the last row on the page is completed. After this the student turns the book over and follows the same procedure except that this time the student is working from the back of the book toward the front.

The scrambled textbook is used in order to present the Crowder or branching program. In using the scrambled textbook the student does not follow the numerical sequence of pages. For example, he may be directed to page six if he chooses one wrong answer or to page ten if he chooses another wrong answer.

If the student chooses the correct answer he is directed to a page containing new information.

SOME PROS AND CONS CONCERNING THE USE OF PROGRAMMED INSTRUCTION

Lindvall and Bolvin[22] in the sixty-sixth yearbook of the National Society for the Study of Education discuss four positive findings from the use of programmed instruction in schools. A summary of these findings is as follows:

1. Programs are able to teach effectively. Educators have found that students who work throughout a series of sequenced frames are able to gain mastery of relatively difficult concepts and principles without any extra help from the teacher.

2. Programmed units of instruction are able to hold the attention of students. Active involvement as well as the opportunity to proceed at his own rate are reasons offered as possible ones for the fact that programs do hold a student's attention.

3. Teachers are able to use programs in a variety of ways. For example, they can be used as substitutes for remedial classes or as opportunities for student enrichment.

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[22]C. M. Lindvall and John C. Bolvin, "Programmed Instruction in the Schools: An Application of Programming Principles in Individually Prescribed Instruction," Programmed Instruction, ed. Phil C. Lange, The Sixty-sixth Yearbook, NSSE, Part II. (Chicago, Illinois: The University of Chicago Press, 1967), pp. 222-24.

4. Programs permit a student to proceed at his own rate and when used they help educators to achieve the goal of individualizing instruction.

Programmed instruction can be criticized from the point of view that it may impede the socialization process because it deprives the student of opportunities to work cooperatively with fellow students. The student interacts with the program, not with the teacher or the other students. Other critics of the programmed instructional approach fear a lock-step curriculum that shows little regard for the individualized nature of growth and development. Other critics state that it would be difficult to develop an appreciation of art and music through the use of programmed instruction. Such criticisms are well founded; however, it should be remembered that programmed instruction should be viewed as only part of the answer to some of these problems.

The National Society for the Study of Education makes the following statement in its sixty-sixth yearbook:

> Schramm in a survey of the research literature in programmed instruction finds little reason to doubt the effectiveness, efficiency, and promise of programmed instruction; and Ofiesh, in a survey of industrial applications, provides further support for the view that the methods are effective and are here to stay[23].

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[23] William A. Deterline, "Practical Problems in Program Production," Programmed Instruction, ed. Phil C. Lange, The Sixty-sixth Yearbook, NSSE Part II (Chicago, Illinois: The University of Chicago Press, 1967), p. 180.

REVIEW OF RELATED RESEARCH

A review of the research pertaining to programmed instruction quickly reveals it to be a method of instruction that has come into use surrounded by a great amount of research activity. The research has dealt with such variables as prompting, confirmation of response, branching, pacing, and step size. Comparative studies have been conducted in which achievement scores of children who used teaching machines have been compared with those of children who used programmed texts and programmed television. Also, a considerable amount of research in the area deals with response modes such as overt versus covert and multiple choice versus constructed responses. Researchers such as Georgelle Thomas[24] in the field of programmed instruction have studied variables such as sex, race, and reading level in order to see if they affect posttest scores. Some experiments have compared the amount of learning from programs with the amount of learning from traditional classroom teaching in the same subject area. Wilbur Schramm[25] tabulated thirty-six reports on such experiments. Sixteen of these experiments were done at the college level, four at the

[24] Georgelle Thomas, "Programmed Instruction For Teaching Anthropology In The Fifth Grade," The Journal of Experimental Education, XXXVI (Summer, 1968), 88-92.

[25] Wilbur Schramm, The Research On Programmed Instruction (Washington: U. S. Government Printing Office, 19640, p. 5.

secondary school level, five at the primary school level, ten with adults and one with retarded children. Eighteen of these thirty-six comparisons showed no significant difference when both groups were measured on the same criterion test. However, seventeen showed a significant superiority for students who worked with the program. One experiment showed a final superiority for the traditional classroom students. Such research appears to produce findings in favour of programmed learning. However, Anatol Pikas[26] demonstrated in 1967 that the degree of similarity between the test items and frames in programmed units are reflected in the differences in performance of the experimental groups. (In the study conducted in this internship the test items were similar to the material presented by the frames as well as the material presented by the lecture method.)

Hough[27] conducted an experiment in order to determine the effectiveness of programmed instruction. His sample consisted of education students. Twenty were placed in the experimental group and twenty-one in the control group. The programmed unit dealt with the topic, "The Contemporary Secondary School". The experimental group was taught by programmed

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[26] Anatol Pikas, "Comparison Between Traditional and Programmed Learning As A Function of the Contents of the Comparison Test," Programmed Learning and Educational Technology, IV (1967), 270-83.

[27] John B. Hough, "Research Vindication For Teaching Machines," Phi Delta Kappan, LXII (1962), 240-42.

instruction and the control group was taught by the lecture-discussion method. An analysis of the pretest and posttest results revealed no significant difference between the two groups.

Jamieson, Janes, Laythan, and Fozen[28] made a comparison between teaching methods at the post-graduate level. They selected one hundred eighty-four post-graduate students and divided them into three groups. One group received instruction by way of a programmed text, another group was taught by the lecture method augmented with audio-visual materials, and the last group was taught by means of straight lectures. Achievement as measured by the posttest revealed the group instructed by the programmed text to be in first place, the group instructed by means of the lecture plus the use of audio-visual materials was in second place, and the group that received instruction by means of the straight lecture came third. Critics might say that the superiority of the group using the programmed text could be attributed to the similarity of the structure of the programmed text and posttest items. However, a retention test that was similar to the posttest was given five months later. It revealed that the programmed group was still superior.

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[28] G. H. Jamieson, Pamela E. Janes, G. W. A. Laythan, and A. H. D. Fozen, "Comparison Between Teaching Methods at the Post-Graduate Level," Programmed Learning and Educational Technology, VI (1969), 243-49.

Norman Smith[29] carried out an investigation in which he studied the effectiveness of the programmed method of instruction and compared it to the effectiveness of the conventional classroom method of instruction. The subject area employed was elementary statistics. The subjects involved in the investigation were one hundred twenty-eight freshmen cadets in the American Air Force. These subjects were divided into an experimental and a control group. From the results of this experiment it was not possible to conclude that either the conventional classroom method of teaching or the programmed method of instruction produced better results. The cadets who were exposed to the programmed method of instruction considered it to be more efficient and felt that they had more opportunity to receive individual assistance from the teacher than under conventional classroom situations.

Jamieson and Marchant[30] compared the effectiveness of the use of the tape/slide, the linear program, and the illustrated booklet as a means of testing the British decimal system to fifty females ranging in age from thirty to sixty

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[29] Norman A. Smith, "The Teaching of Elementary Statistics by the Conventional Classroom Method Versus the Method of Programmed Instruction," Journal of Educational Research, LV (1962), 417-20.

[30] G. H. Jamieson and H. Marchant, "Learning By Tape/Slide, Linear Program, and Illustrated Booklet: A Comparative Study," Programmed Learning and Educational Technology , VIII (1971), 245-49.

years. The results of the experiment revealed that the mean percentage gain score of the group who learned by the linear program was significantly greater than the same score for the groups using the tape/slide and illustrated booklet. Again, this finding could be attributed to the similarity in the structure of the criterion test and the programmed unit.

Burnkrant and Lambert[31] made a comparative study of the effects of various learning procedures upon punctuation and content in free writing situations. The subjects employed in this study were high school students. They were divided into three groups. One group received normal teaching, another instruction from a programmed text, and the third group was exposed to the programmed text and was given help in review work by the teacher. The treatment did not produce significant results in any case. However, it is interesting to note that the teacher approach was not significantly superior so the programmed approach could be used to free the teacher from some of the routine of teaching.

Thomas[32] conducted a study in order to compare the achievement of fifth grade students utilizing programmed

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[31] E. G. Burnkrant and Philip Lambert, "A Comparison of the Effects of Various Learning Procedures Upon Punctuation and Content in the Free Writing Situation," Programmed Learning, II (1964-66), 158-69.

[32] Georgelle Thomas, "Programmed Instruction For Teaching Anthropology in the Fifth Grade," The Journal of Experimental Education, XXXVI (Summer, 1968), 88-92.

instructional materials in anthropology with fifth-grade students being taught anthropology by traditional classroom methods. The subjects consisted of three hundred twenty students in fourteen fifth grades in Georgia. The experimental group used the programmed text and the control group was taught by traditional methods. Traditional methods were defined as instruction involving narrative expository oral and written material with accompanying activities such as art work, role playing, museum trips, and scrapbook compilations.

The posttest scores were examined by analysis of variance. No statistical evidence was obtained to show a difference in performance as measured by the posttests between the experimental and control groups. The subject variable of sex did not significantly affect posttest scores. There was a significant difference between races. An examination of mean scores revealed that the average was in favour of the white students. There was also a significant difference between reading levels. A positive significant relationship was found between reading ability and performance on the posttest. Also, it was found that the interactions of treatment by sex, treatment by race, and treatment by reading levels were nonsignificant.

Shafer[33] described how she prepared a programmed unit

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[33] Susanne M. Shafer, "Teaching Machines and the Social Studies," Social Education, XXV (February, 1961), 85-86.

in social studies. The title of the unit was "How A Bill Becomes Law." The purpose of the unit was to enable learners wishing to fill in gaps in their knowledge of American government to be able to do so at their own pace. After the program was completed it was presented to an eighth grade class whose average I.Q. was recorded as one hundred thirty. Shafer then related how she revised her program in view of the pupils' responses to it. From her particular experiment with programmed instruction she concluded that social studies content in part lends itself to programming. Students who used the program were definitely enthusiastic about it. Shafer made the following statement with respect to programmed instruction and the social studies.

> If we are to be ready to participate in new trends in learning resources such as the broad use of teaching machines in our schools, we must develop programs, test them, and then come up with sound recommendations as to the sphere of the teacher and that of the teaching machine in social studies education.[34]

Barcus and Pottle[35] described how teachers developed and evaluated a programmed unit of instruction on the Constitution of the United States. As part of their evaluation process they used an experiment involving sixty ninth grade classes. Two

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[34] Susanne M. Shafer, "Teaching Machines and the Social Studies," Social Education, XXV (February, 1961), 86.

[35] Delbert Barcus and Jack Pottle, "Programming the Constitution," Social Education, XXIX (January, 1965), 29-31.

experimental groups and two control groups were established in each of fifteen junior high schools in Denver. The experimental groups were instructed to use the programmed booklet as homework whereas the control groups were to study the Constitution in the traditional fashion. The experimental groups were assigned a small number of items from the programmed booklet to be read each night. No written response was required. The students read the material and responded silently. The next day the students were presented with a short quiz on what they had studied and then discussed the content with the teacher.

The control groups and the experimental groups were comparable in number and I.Q. All groups made a substantial gain on the posttest. However, the group using the program made a significant gain in facts over those who were taught the subject in the regular fashion. The posttest was administered again to the students three months after the completion of the experiment and results revealed that although the experimental groups tended to do less well, they maintained a seven percent advantage over the students who learned in the traditional manner.

Wood[36] hypothesized that students learning by a combination of programmed material and teacher-led activities will not differ significantly in their ability to generalize

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[36] Leslie A. Wood, "Programming Textual Material as a Partial Substitute for Teacher-Led Classroom Procedures in Geography," Journal of Educational Research, LVIII (September, 1964), 22-26.

and to make applications from students learning entirely by specified teacher-led activities. Wood also hypothesized that a combination of programmed material and teacher-led activities is more effective in teaching textbook content than the same amount of time spent under the direction of the teacher using specific commonly used methods.

The subjects employed in this experiment were one hundred fifty in six ninth grade geography classes. The classes were divided into two groups according to the recommendations of the three cooperating teachers. Programs were constructed on the topics, "Scandinavia and Finland" and "South Africa and its Neighbours". The programs used a linear, small-step approach with constructed responses.

The results of the experiment showed that the students using programmed materials learned factual material significantly better than those entirely under teacher direction at the 0.05 level. The test was constructed especially for this experiment. Also, there was no significant difference in the pupils' ability to apply factual knowledge either to the geographic area being studied or to new, but similar situations.

Shafer[37] hypothesized that the slow pupil learns more from programmed instruction than he does from reading a textbook and that geographic facts can be taught effectively

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37 Susanne M. Shafer, "Geography Via Programmed Instruction," The Journal of Geography, LXI (February, 1965), 77-81.

by the use of programmed materials. Shafer selected two ninth-grade classes to participate in her experiment and developed a program to teach facts about the geography of Brazil and Argentina. The class made up of slow learners took the program on two successive days. After completing the program during the first half of each period the class discussed the economic development and potential of each country during the second half. One day was devoted to Argentina and the next to Brazil. In the parallel class the pupils were of average ability. Instead of using the program they read the part of their textbook dealing with Argentina and Brazil. The teacher led a discussion identical to that of the experimental group.

The results of the experiment showed that some of the more able students did only slightly better than the weakest members of the class. A most significant finding was that the median score on the test was the same for the class made up of slow learners who took the program as for the average students who read the textbook in order to gain knowledge of the geography of Argentina and Brazil. However, the finding might have been caused by a similarity in the structure of the program and posttest.

Thomas[38] in his experiment utilized a programmed unit on electricity plus a programmed unit on water. Each

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[38]Adrian Thomas, "A Study in the Evaluation of Some Junior School Science Programs," Programmed Learning and Educational Technology, VII (July, 1970), 106-126.

unit contained a sequence of practical experiments that could be worked on by the students in groups. Evaluation of the combined units was effected by comparison with conventional teaching. The experimental group received programmed instruction and the control group received conventional instruction in each of three schools. The subjects employed in this experiment were boys and girls who were about ten years of age. The findings of this experiment demonstrate that programmed instruction saves time and that students using the program achieve equal and sometimes superior gain scores to those receiving conventional instruction. Positive correlation of attainment with I.Q. and reading level occurred for both groups. The hypothesis that the immediate and retention score gains of the control groups would be significantly more highly correlated with I.Q. than the same gains for the experimental groups was rejected. Also, analysis of variance revealed that there were no significant main effects for sex, nor were there any significant interactions involving sex. Students' attitudes toward both the programmed and conventional instruction were generally favourable. However, the boys tended to like programmed science better than the girls.

Noonan[39] conducted a study in order to determine whether a unit of sixth grade social studies, "Latitude and

[39] James LeRoy Noonan, "A Study of Three Methods of Teaching a Unit on Latitude and Climate to Sixth Grade Students," unpublished Doctor's dissertation, University of North Dakota, (1968), pp. 1-77.

Climates," could be learned more effectively through the utilization of: (1) programmed materials only, (2) programmed materials plus teacher assistance, (3) conventional methods of instruction only. Nine classes of sixth grade students were randomly assigned to one of the three treatment groups. A pretest and posttest on the materials was administered. The data from both tests were subjected to the analysis of variance technique in order to test the following null hypotheses:

1. There is no significant difference in the effectiveness of the three methods of instruction as measured by the score on the final examination.

2. There is no significant difference in the amount of time required to complete a unit in social studies using the three methods of instruction.

3. There is no significant difference in the effectiveness of the three methods of instruction as measured by the total score of the final examination with students at different levels of ability.

The study indicated these factors. (1) There was no significant difference on the pretest and posttest by those subjects treated to the three methods of instruction within the same level. (2) The shortest mean time for the completion of the unit was in the conventional method of instruction. (3) There was a significant difference by levels of ability on both the pretest and posttest as related to subsequent methods of instruction.

In this study programmed instruction showed no fundamental superiority to conventional instruction, nor did it prove to be more efficient in the amount of time needed to complete the unit.

The review of literature and related research on programmed instruction revealed it to be an effective and efficient teaching method. However, literature and research that dealt with programmed instruction on the topic, "The Principle of the Water Cycle," could not be found. Therefore, in order to determine if programmed instruction is as effective as the traditional lecture method of instruction in presenting information on the topic, "The Principle of the Water Cycle," the following study was conducted. It proved to be as effective as the traditional lecture method of instruction and it can be employed to impart the knowledge that grade seven students should have before starting a study of the causes of relief rainfall and frontal rainfall.

SUMMARY

The foregoing review of related literature dealt briefly with the antecedents of programmed instruction in order to emphasize the fact that its origins predate the twentieth century. Three such antecedents were selected. Two of these were the ideas of Socrates and Comenius, and the other was the idea of the quintain, a medieval device employed in the training of knights. In reviewing developments in programmed instruction that have occurred during the twentieth century, the works of Pressey, Skinner, and Crowder were described. Pressey is given credit for having developed the first teaching machine in the 1920's. Later, Skinner developed the linear program and Crowder developed the branching program. The branching type of program was really an attempt to meet individual learning needs. Next, spin-offs of the programmed instructional movement such as instructional design, behavioral analysis, process of systems, as well as the contributions it made to ungraded schools, individual instruction, flexible scheduling, and student-centered instruction were briefly stated.

Following the overview of the development of programmed instruction three definitions were presented. On the basis of these definitions the main characteristics of programmed instruction were listed. These were as follows:

1. each student progresses individually and at his own pace,

2. a small unit of information is presented at a time,

3. the information is arranged from the simple to the complex,

4. students respond actively,

5. students receive immediate feedback, and

6. the programs are tested and revised in view of student responses.

In describing the linear type of program developed by

Skinner it was pointed out that the ideas behind it were formulated as a result of experiments conducted with animals. The ideas fundamental to the linear type of program are as follows:

1. the material is divided into a series of small frames,

2. the student gives an overt response to each frame,

3. material is divided into small steps so as to ensure the correct response from all students, and

4. the student is given the correct answer immediately following his response.

The branching type of program differs from the linear program in that the student's response is employed in determining the material to which he will next be exposed. In the linear program all students must proceed through the same series of steps. It is realized that the branching program was developed as an attempt to meet individual learning needs. Other devices employed in order to compensate for the fact that students' learning capabilities differ include the utilization of gate frames, conversational chaining, remedial loops, secondary tracks, and criterion frames.

After presenting the arguments for and against the employment of programmed instruction it was concluded that it is an effective and efficient teaching method and that it is here to stay.

The review of related research dealt briefly with all major aspects of research on programmed learning with special emphasis being placed on studies that evaluated programmed instruction by comparing it to traditional or conventional methods of teaching. In summary, it can be stated on the basis of the research reviewed here that programmed instruction is as effective a means of imparting knowledge as is the traditional method of instruction. Also, it can be stated that the research findings indicate that programmed instruction is just as efficient in the amount of time needed to complete units of instruction as is the traditional method of instruction.

It should be pointed out that an attempt was made to find comparative studies in all subject areas and studies that dealt with all age groups. Toward the end of the review of related research the writer focussed on studies in the area of the social studies and in particular those that dealt with social studies at the elementary school level. The results of these studies are summarised as follows:

(a) Two studies showed no significant difference in the achievement of students who used the programmed methods and those who used the traditional method of instruction.

(b) Two studies demonstrated a significant gain for the students using the programmed units over those using the traditional method of teaching.

(c) One study revealed that students using programmed units on the geography of Argentina and Brazil achieved results equal to those obtained by brighter students who did not use the programmed units.

(d) Another study in which a programmed unit was prepared on the topic, "How a Bill Becomes Law," concluded with the statement that social studies content in part lends itself to programming.

Chapter 3

THE STUDY

INTRODUCTION

This chapter presents the hypotheses tested in the study. Also, the procedures followed in developing the programmed unit as well as a delineation of the procedural steps taken in executing the study are presented.[40] Finally, statements are made concerning the limitations of the study, together with the findings, the conclusions resulting from the study, and suggestions for future research.

HYPOTHESES

1. The linear type of programmed learning leads to significantly different achievement in the topic, "The Principle of the Water Cycle," than does the traditional lecture method of instruction.

2. The linear type of programmed learning leads to significantly different retention in the topic, "The Principle of the Water Cycle," than does the traditional lecture method of instruction over a three week period.

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[40] See Appendix A for a chronological account of the activities and events in the development of the internship.

The following null hypotheses concerning posttest achievement were tested.

1. There is no significant difference in achievement between students taught by the traditional lecture method of instruction and those using the linear type of programmed learning in the topic, "The Principle of the Water Cycle".

2. There is no significant difference in retention as measured over a three week period between students taught by the traditional lecture method of instruction and those using the linear programmed approach in the topic, "The Principle of the Water Cycle".

DEFINITIONS

1. The linear type of programmed learning as it is used here refers to the Skinnerian program that was developed by B. F. Skinner plus augmentation with related materials.

2. Achievement is operationally defined as test scores obtained by students upon completion of units of study by both the control and experimental groups.

3. The traditional lecture method of instruction as it is here used refers to a teaching procedure in which the teacher makes an outline of each module and talks to the class concerning that content. Also, the teacher places diagrams on the chalkboard, uses flash-cards when introducing new words, and dictates important parts of the content in such a manner as to permit students to write these parts in their notebooks.

4. Retention is operationally defined as test scores obtained on the same test administered to measure achievement after a three week interval.

STEPS FOLLOWED IN THE DEVELOPMENT OF THE PROGRAMMED UNIT

The first step taken in writing the programmed unit was to organize the material. The organization of material was similar to a task analysis. This first step consisted of breaking the content into small segments. For purposes of this program the principle of the water cycle was broken into the concepts that make it up and each of these concepts was then divided into the facts that make it up.

After the content material was organized the general objectives for the programmed unit were written and then the specific aims of the unit were stated.[41] In stating these objectives careful attention was paid to the material that had been previously organized in order to ensure that the objectives were based on and indicated the content to be dealt with.

The third step in writing the program consisted of writing three parallel test items for each objective that had been already stated. One item was placed on the pretest,[42]

[41] See Appendix B for a list of the objectives and aims of the programmed unit.

[42] See Appendix D for the copy of the final version of the pretest after modifications were made to it.

another on the posttest,[43] and another on the criterion frames. The items placed on the pretest and posttest were the same, except that the distractors were juggled. The criterion frames are really test frames in the programmed unit.[44] The wording of these criterion frames is not the same as that for the items placed on the pretest or the posttest.

The next step was to arrange the criterion frames into a logical sequence. For example, when a program deals with concept teaching criterion frames should first deal with examples and nonexamples of the concept. Hence, the criterion frames in the programmed unit dealt with a definition of the concept and, finally, with discriminations between examples and nonexamples of the concept.

Having placed the criterion frames in their logical sequence teaching frames were written so as to lead from entry level behavior[45] to the first criterion frame and so to subsequent criterion frames. After all teaching and criterion frames were written, each frame was numbered.

The frames were presented according to the following format:

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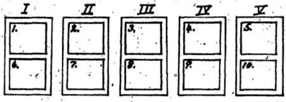
[43] See Appendix F for a copy of the final version of the posttest.

[44] See Appendix E for a copy of the final version of the entire programmed unit after modifications were made to it.

[45] See Appendix C for a copy of the instrument used to determine entry level behavior.



Here the first teaching frame was placed at the top of page one. The correct response to that frame was placed at the top of page two along with the next frame. The same procedure was followed for the first half of the program. Then the frames and answers were written at the bottom of the pages for the last half of the program.

When each set of frames that dealt with each concept in the water cycle as well as the water cycle itself were written each set was given to a teacher to read. The teacher was asked to consider the content covered by each set of frames as well as the way one frame flowed into or followed another. In this particular case the teacher felt that each set of frames was well constructed and that each covered adequately the content it dealt with. In view of this feedback the writer did not feel it necessary to change any frames. Prior to trying the program out on the students it was decided to call each of the five sets of frames a module. The program then consisted of five modules.

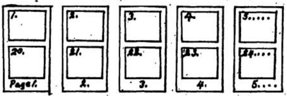
It was further decided that the program should be tried out on two students. In order to select these two students the writer first obtained reading scores as measured by the Gates-

MacGinite Reading Test from the District Office of the Avalon North Integrated School Board. The reading scores were obtained for the grade seven classes in the following schools: Holy Redeemer, Spaniard's Bay; St. Peter's, Upper Island Cove; Bay Roberts Amalgamated, Bay Roberts; St. Mark's, Shearstown; and Coley's Point Elementary, Coley's Point. The mean grade reading level was then calculated for each of these classes. The means obtained were based on the vocabulary and comprehension sections of the Gates-MacGinite Reading Test. It was found that the mean grade reading level of the grade seven class in the Bay Roberts Amalgamated School best matched that of the Coley's Point Elementary School where the experimental situation was to be established. Next, two students were randomly selected from the grade seven class at the Bay Roberts Amalgamated school. This was accomplished by writing the names of the twenty-nine students in that class on pieces of paper and placing them in a hat. The hat was then shaken up and one piece of paper was selected. The student whose name appeared on that piece of paper was selected as one of the two students. The piece of paper was placed back in the hat and the hat was again shaken up. A second piece of paper was then selected from the hat. The student whose name appeared on that piece of paper became the other of the two students. The writer then obtained permission to try the programmed unit on these two students from the principal and staff of the Bay Roberts Amalgamated School.

Before the students received the programmed unit they were told that they could help the writer develop the program by offering their criticisms. Also, the students were told to ask questions whenever they had difficulty and to let the writer know if they made an incorrect response to any of the frames.

As the students worked through each module the writer observed that they were having trouble handling the ninety-five pages that made up the program at that time. This was particularly obvious when the two students had to carry these pages and materials to and from the kits when they were conducting their experiments. In order to correct this situation the writer decided to modify the format of the program. This was accomplished by organizing each module in a manner similar to that in which the entire program was organized. That is, the frames in each module were presented according to the following format:

MODULE I



Here the first teaching frame for each module was placed at the top of page one. The correct response to that frame was placed at the top of page two along with the next frame. The same procedure was followed for the first half of each module in the program. The frames and answers were written at the bottom of the pages for the last half of each module. Also, the modules were separated so that the module the student was to deal with on one day was the only one he need handle.

As a result of the difficulties experienced by the students and in view of their criticisms the frames that were modified or added are as follows:

1. frames 3, 7, and 21 in module one,
2. frames 5, 8, 18, 34, and 35 in module two,
3. frames 13, 16, 22, 26, and 39 in module three,
4. frames 5 and 45 in module four,
5. frame 19 in module five.

Several of the foregoing frames were modified by the addition of formal prompts. Formal prompts provide the student with information about the structure of an acceptable response, but not its meaning. These prompts were added after the students indicated that they had responded incorrectly to a frame. For example, prior to the modification process frame three in module one read as follows;

"Vapor is formed when the smallest particles of a liquid called molecules pass from the liquid into the ____________."

After the addition of the prompt it read thusly;

"Vapor is formed when the smallest particles of a liquid called molecules pass from the liquid into the at ______________."

The students informed the writer that they did not know what duplicating fluid is. This terminology appeared in frame seven, module one. It was therefore necessary to explain what duplicating fluid is. Before the addition of such an explanation the frame read as follows:

"You are able to set up an experiment to prove that liquids change into vapor. The liquid used in this experiment is duplicating fluid instead of water. Duplicating fluid is used because it changes into a vapor faster than water at room temperature and you are able to smell it. Therefore, it is better to use duplicating fluid in this ________________."

After the explanation of duplicating fluid was included the frame read thusly:

"You are able to set up an experiment to prove that liquids change into vapor. The liquid used in this experiment is duplicating fluid instead of water. This fluid is used in machines to make many copies of the same paper. Duplicating fluid is used because it changes into a vapor faster than water at room temperature and you are able to smell it. Therefore, it is better to use duplicating fluid in this ____________."

It was necessary to modify the answers presented for some of the frames. For example, frame five and its answer in module four read as follows:

"List one example of moisture falling to the earth's surface. ________________.

RAIN, FROZEN RAIN, SNOW"

After the modification was made the frame and its answer appeared thusly:

"List one example of moisture falling to the earth's surface. ________

ANY ONE OF THE FOLLOWING IS CORRECT.

RAIN, FROZEN RAIN, SNOW"

After the students had completed module four the writer observed that they had not placed the materials utilized in the experiment in their kits. The writer then inquired why this was so. The students informed him that the module had not instructed them to return the materials to the kit. In order to correct this error frame forty-five was added to module four. That frame reads as follows:

"Now follow these instructions in order to put away the materials you just used in your experiment.

(a) Remove the two-holed stopper from the flask.

(b) Remove the tape from the inside of the beaker.

(c) Now take the flask, pour the water from the flask into the sink.

(d) Take the ice out of the bag and place it in the sink.

(e) Fold up the bag and place the wire around it.

(f) Now take a paper towel and dry off the saucer and beaker.

(g) Good. Now take the bag, roll of tape, saucer, beaker, two-holed stopper, attachments and flask back to the kit.

(h) Place all the materials in the kit and the paper towel in the garbage.

(i) Good, Now you have cleaned up after your experiment."

In summary, the types of changes made in the program as a result of working with the two students were as follows:

(a) the definite division of the programmed unit into five modules,

(b) the addition of formal prompts,

(c) a more specific statement of correct answers,

(d) the use of definitions in order to clarify the meaning of key words,

(e) the addition of an extra frame.

After all five modules were tested on the two students, the content validity of the entire program was checked. The testing instruments used consisted of an entry level test, a pretest, and its parallel posttest. The entry level test consisted of ten items. Each item dealt with information that the student had to acquire before he could use the programmed unit of instruction in a meaningful manner. Both the entry level test and the pretest were submitted to a testing specialist with the Department of Educational Psychology at Memorial University. No major changes were found to be necessary on either of these two tests.

The three tests were devised by the writer. Therefore, a professional geographer on the university faculty at Memorial University plus two graduate students in the field at Memorial University were asked to determine the content validity of each test. Also, the content validity of the programmed unit on the topic, "The Principle of the Water Cycle," was determined in the same manner.

As a result of the feedback received from the three persons engaged for purposes of validating the entire program, modifications were made to the entry level test, pretest, posttest, and programmed unit. On the entry level behavior test items 5, 9, and 10 were modified in order to remove choices that were too obviously incorrect. For example, it was pointed out that magnetism as one of the choices in item nine was too obviously incorrect. Before test item nine was modified it read as follows:

"When the atmosphere is in motion across the earth's surface it is called ....( )
(a) Magnetism (b) Wind (c) Noise (d) Force"

After test item nine was modified it read thusly;

"When the atmosphere is in motion across the earth's surface it is called ....( )
(a) Strength (b) Wind (c) Noise (d) Force"

On the pretest, items 1, 2, 3, 9, 15, 17, 20, 22, 23, 24, 28, 30, and 31 were modified. Again some of the choices in the test items were worded so as to indicate the correct choice. Also, it was suggested that the writer's choice of terminology was inadequate in some of these items. For example, the writer used the term "steam" in test item three and it was pointed out that steam is invisible. It is water droplets that are seen on the cool window pane and not steam. Therefore, it was suggested that water droplets be used in the test item instead of steam. Prior to modification test item three read as follows:

"An example of evaporation is a .... ( )

(a) Pool of water drying up

(b) River flowing to the sea

(c) Kettle of boiling water

(d) Window pane with steam forming on it."

After the substitution was made the item read as follows:

"An example of evaporation is .... ( )

(a) Pool of water drying up

(b) River flowing to the sea

(c) Kettle of boiling water

(d) Window pane with water droplets forming on it."

Also, the writer acted on the recommendation of the professional geographer and added arrows to test item thirty-one in order to show lateral movement of moisture in the atmosphere and water on the earth's surface. The same modifications were made to the parallel items on the posttest.

In checking the content validity of the programmed unit the professional geographer observed that the writer had not introduced the idea of lateral movement in the water cycle. The geographer pointed out that this was an important idea in the water cycle and that provision should be made to accommodate it.

In order to introduce the idea of lateral movement the writer first added three more objectives to the list of objectives for the programmed unit. These additional objectives were as follows:

"(a) Identify the symbol for lateral movement in a diagram of the water cycle,

(b) Tell why there is lateral movement of moisture within the atmosphere,

(c) State how moisture that falls to the earth finds its way from higher levels to lower levels of the earth's surface."

Next three parallel test items were written for each of the foregoing objectives. One item was placed on the pretest, another on the posttest, and another within the programmed unit as a criterion frame. This meant the addition of items 13, 24, and 32 to the pretest and items 15, 18, and 33 to the posttest. Also, for the programmed unit it meant the addition of frame 42 in module two, frame 43 in module four, and frame 18 in module five.

The idea of lateral movement of moisture in the atmosphere was included in the program by placing additional frames between the concepts of warm air rising and condensation. This meant the addition of frames 36, 37, 38, 39, 40, 41, and 42 to module two.[46] Also, the idea of the lateral movement of moisture

[46] See Appendix E, Module II, Frames 36-42.

on the earth's surface was included in the program by placing additional frames after the concept of precipitation. This part of the program was selected because much of the moisture that falls to the earth flows over its surface to lower levels. Therefore, frames 38, 39, 40, 41, 42, and 43 were added to module four.[47] The professional geographer pointed out that inclusion of the notion of the lateral movement of moisture in the water cycle would make it both valid and geographic.

In order to deal adequately with the notion of lateral movement in the water cycle frame 9 was added to module five. Also, frame 16 in the same module was modified.

The professional geographer suggested that the writer's use of terminology was inadequate in some of the frames, and offered solutions to this situation. For example, it was pointed out that particles in the air that act as condensation nucleii may be dust particles, salt crystals from sea spray, soil particles, and chemicals. Therefore, in frame thirty, module four, it was pointed out that it would be more accurate to eliminate the word "dust" before particle. Before modification frame thirty read as follows:

"If a supercooled droplet of water strikes a dust particle in the air it freezes. Also, when it strikes the surface of the earth it ____________."

After the word dust was eliminated it read as follows:

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[47] See Appendix E, Module IV, Frames 38-43.

"If a supercooled droplet of water strikes a particle in the air it freezes. Also, when it strikes the surface of the earth it ________."

By following the suggestions of the professional geographer the writer modified frame 33 in module two, frames 4, 25, and 41 in module three, frames 2, 21, and 30 in module four and frame 31 in module five.

After the writer added frames 36, 37, 38, 39, 40, 41, and 42 to module two and frames 38, 39, 40, 41, 42, and 43 to module four the frames were tried out on the same two students from Bay Roberts Amalgamated school. As a result it was found necessary to add formal prompts to frames thirty-six and forty in module two and frame forty-two in module four. Before the addition of the formal prompts to frame forty-two in module four it read as follows;

"In order for moisture on the earth to find its way to lower levels of the earth's surface it sometimes flows over the ________ of the earth."

After the addition of the formal prompt it read thusly;

"In order for moisture on the earth to find its way to lower levels of the earth's surface it sometimes flows over the s________ of the earth."

The next step in the development of the programmed unit of study was to ensure that the reading level of the material presented was appropriate for the grade seven students. This was accomplished by utilizing the Thorndike and Lorge[48] list of

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[48] Edward L. Thorndike and Irving Lorge, The Teacher's Word Book of 30,000 Words (New York: Bureau of Publications, Teachers College, Columbia University, 1959), pp. 1-208

30,000 words, as contained in a book entitled The Teacher's Word Book of 30,000 Words. Each word in the list is followed by five columns of numbers indicating its frequency of occurrence, namely the Thorndike general count of 1931, the Lorge magazine count, the Thorndike count of 120 juvenile books, the Lorge-Thorndike semantic count, and the general count which is a summary of the other four counts.

If a word is followed by the number one for a particular type of reading matter it means that the word appears at least one time in every million words, but not so many as two times per million. If the letter A follows a word for a particular type of reading matter it means that the word appears at least fifty times per million words, but not so many as 100 per million. If the letters AA follow, it means the word appears one hundred times or over per million.

In order to illustrate the format of the reading list the word "substance" is taken as an example. In the reading list the word appears as follows:

	G	T	L	J	S [49]
substance	A	160	71	471	369

The letter G indicates the general count. The letters T, L, J, and S indicate the Thorndike general count of 1931, the Lorge magazine count, the Thorndike count of 120 juvenile

[49] Edward L. Thorndike and Irving Lorge, The Teacher's Word Book of 30,000 Words (New York: Bureau of Publications, Teachers College, Columbia University, 1959), p. 178.

books, and the Lorge-Thorndike semantic count respectively.

For purposes of checking the reading level of the programmed unit the column for the general set of reading matter was utilized. This column was selected because it is a summary of the other four counts. Also, Thorndike and Lorge have accepted it as being the most important and usually the most decisive. The writer selected words from the program that were thought to be above the grade seven reading level.[50] All words with counts ranging from AA down to six were below the grade seven reading level or equal to it. The frames containing such words were not modified. However, if the count for a word in the general column was six or below the frame containing it was modified. The frame was modified by substituting another word for the one above the grade seven level or by including the pronunciation and sometimes a definition of the word in the frame.

Modifications were made to frames 1, 4, 7, 8, 13, 30, and 36 in module one, frames 16 and 36 in module two, frame 38 in module three, and frame 14 in module four as a result of the writer's utilization of the Thorndike-Lorge word list. For example, the word "molecules" had a count of three in the general column. Therefore, the pronunciation of that word was added to the frame in which it first appeared.

Before the pronunciation was added, frame one in

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[50] See Appendix G for a list of the words selected from the programmed unit and looked up in the Thorndike-Lorge word list.

module one read as follows:

"As a substance changes from a liquid to a vapor and floats in the atmosphere billions of tiny particles of the substance called molecules leave the surface of the liquid and float in the __________ as vapor."

After the pronunciation was added to the frame it read thusly:

"As a substance changes from a liquid to a vapor and floats in the atmosphere billions of tiny particles of the substance called molecules (MOLL-uh-KULS) leave the surface of the liquid and float in the __________ as vapor."

In frame two, module two, the word "considered" was used. However, it was found to have a count of 1 in the word list. Therefore, the frame was modified by substituting the words "used as" for the words "considered to be".

Before the substitution was made the frame read as follows:

"Any situation in which air is warmed and ________ can be considered to be an example of warm air rising."

After the substitution was made the frames read thusly:

"Any situation in which air is warmed and __________ can be used as an example of warm air rising."

The word "materials" had a count of five in the word list. The word "materials" first appears in frame eight, module one. Therefore, frame eight was modified by adding the pronunciation for materials as well as a description of what the materials were in this particular case.

Prior to the modifications frame eight, module one, read as follows:

"In order to set up this experiment you must follow the instructions very carefully and keep them with you at all times.

(a) Go to the kit containing your materials.

(b) Open the kit.

(c) Remove the container marked duplicating fluid.

(d) Now remove the container marked beaker.

(e) Next take the bottle and beaker back to your seat.

(f) Place both on your desk."

After the modifications were made frame eight read thusly:

"In order to set up this experiment you must follow the instructions very carefully and keep them with you at all times.

(a) Go to the kit containing your materials (ma-TER-E-als). Materials are things contained in your kit.

(b) Open the kit.

(c) Remove the bottle marked duplicating fluid.

(d) Now remove the container marked beaker (BEK-er).

(e) Next take the bottle and beaker back to your seat.

(f) Place both on your desk."

The programmed instructional unit developed in this internship was basically the same as the linear type of program except that here the program required the student to set up five experiments in order to demonstrate each of the four concepts in the water cycle as well as the principle of the water cycle itself. In each case the program directed the student toward a kit containing the materials needed to set up the experiment.[51] After the student obtained the required materials from the kit, the program led him through a series of steps to the establishment of the particular experiment. For example, in setting up an experiment to demonstrate the concept of evaporation part of the directions read as follows:

"(a) Go to the kit containing your materials (ma-TER-E-als). Materials are things contained in your kit.

(b) Open the kit.

(c) Remove the bottle marked duplicating fluid.

(d) Now remove the container marked beaker (BEK-er).

(e) Next take the bottle and beaker back to your seat.

(f) Place both on your desk.

Now you should have a bottle marked duplicating fluid and a container marked beaker placed on your desk."

Each student in the experimental group was assigned a kit containing the materials necessary for setting up the five experiments that were included in the program. A complete list of such materials was compiled after the program was written. This was done in order to ensure that each kit contained the materials required. Materials not placed in the kit were

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[51] See Appendix H for a list of the materials contained in each kit.

provided in appropriate locations in the classroom. These materials included ice cubes, paper towels, and hot and cold water.

PROCEDURAL STEPS FOLLOWED DURING THE EXPERIMENTAL PHASE OF THE STUDY

For the experimental phase of the study the writer used an experimental design presented by Kerlinger.[52] This design is referred to as experimental group-control group randomized subjects. A representation of that design is as follows:

$$\boxed{R}\quad \frac{X \qquad Y_a}{\sim X \qquad Y_a} \qquad \begin{matrix}\text{(experimental group)}\\ \text{(control group)}\end{matrix}$$

$\boxed{R}$ indicates that the subjects were randomly assigned.

X indicates an experimental variable that was manipulated.

$\sim X$ indicates an experimental variable that was not manipulated.

Y_a indicates the posttest given to each group.

Prior to the establishment of the experimental and control groups at the Coley's Point Elementary School, the principal and staff of that school agreed to cooperate during the experimental phase of the study. Also, the special assistance of two teachers was obtained. One of these teachers

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[52] Fred N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc., 1973), p. 331.

agreed to teach the control group and the other agreed to supervise the experimental group. Furthermore, the principal and staff were informed of the necessary timetable changes. These changes entailed the cancellation of class sessions in the resource center each afternoon for a period of one week and the use of substitute teachers to fill in for the teacher of the experimental group, the teacher of the control group, and the writer.

Before the groups were randomly selected or assigned to treatments, the entry level test and pretest were administered to the entire grade seven class at the same time and place. The results obtained on the entry level test demonstrated that the students did not have the information necessary to start a meaningful study of the topic, "The Principal of the Water Cycle." The students lacking sufficient entry level behavior were taught the necessary information. Each of the ten items on the entry level test had to be dealt with because each item on it was answered incorrectly by at least four members of the class. The scores obtained on the pretest[53] demonstrated that the students already had some knowledge of the material presented in the programmed unit. However, random assignment to groups ensured theoretically that the experimental group and the control group were equal to each other.

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[53]See Appendix I, Figure 5, for the unadjusted and adjusted scores obtained by the grade seven students on the pretest.

The sample employed in the experimental phase of the study consisted of the grade seven class at the Coley's Point Elementary School. The class consisted of thirty-one students. However, one student was absent during the administration of the entry level test and pretest. Therefore, the results of that student were omitted in the final analysis of the data collected during the experiment.

Next, the names of the thirty students were listed in the order in which they occurred on the class register and were numbered from one to thirty. The thirty students were randomly assigned to two groups by using a table of 4000 random numbers.[54] The numbers were generated by utilizing a CIMS Computing Center routine at the computing center, Courant Institute of Mathematical Sciences, New York University. The 4000 random numbers were organized in forty sets of one hundred each. The table of random numbers covers pages 714, 715, 716, and 717 with each set of numbers arranged in columns that extend the length of pages 714, 716, and 715, 717. The rows of numbers extend across pages 714, 715, and pages 716, 717. The two pages on which to start were selected by the toss of a coin. The book was then opened to pages 714 and 715 and placed on the desk in front of the writer. The writer then closed his eyes and moved a pen in various directions above the two pages. Next, the tip of the pen was placed on the book. The number

[54] Fred N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc., 1973), pp. 714-17.

in the table nearest the tip of the writer's pen was selected as the starting point. The writer then proceeded to follow the rows of numbers across the pages. The names listed opposite the first fifteen numbers that were less than thirty were assigned to group A. The names that were opposite the remaining fifteen numbers were assigned to group B. After the two groups were randomly selected they were assigned to treatments by the toss of a coin.

After assignment to treatments group A was called the experimental group and group B was called the control group. The experimental group received the programmed treatment and the control group received the lecture treatment.

Each student in the grade seven class was then informed of the group into which he or she had been placed. Also, each student was told to select a book from the library to be read if he or she completed the modules before the allotted time expired. The students in the experimental group then went to the resource center where they were to utilize the programmed unit and the students in the control group remained in the classroom where they were to be exposed to the traditional lecture method of instruction. Also, each student in the experimental group was assigned a kit. Each kit, in addition to the science materials and programmed unit of instruction, contained written instructions to students[55] on the use of the

[55] See Appendix J for a copy of the instructions to students.

programmed materials, a short practice module,[56] and the objectives of the unit. The students in the experimental group were told to read the instructions, do the practice module, and then read the objectives before starting work on the programmed unit on the topic, "The Principle of the Water Cycle."

During the experimental phase of the study the parallel group method was employed. The programmed unit was divided into five segments called modules. Also, the material from which the teacher in the control group was to construct his lectures was divided into five parallel modules.[57] During each session the control group and the experimental group covered the same content. This was achieved by having both groups complete module one on the first day, module two on the second day, and so on until module five was completed on the fifth day. This method of exposure helped prevent students in one group from informing the students in the other group of the material they would receive next or of that which they had already received.

During each session the experimental group was supervised by the same teacher. This teacher was employed for

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[56] See Appendix K for a short practice module.

[57] See Appendix L for the five parallel modules given to the teacher in the control group.

purposes of maintaining discipline and did not help students with problems that arose from their working on the program. The teacher employed in the control situation was informed of what to include in his lectures and of the diagrams to draw on the chalkboard while the students took notes.[58] Also, the teacher of the control group was provided with flash-cards and was instructed to use them for the words underlined in the material from which he was to draw his lectures. It seems reasonably safe to assume that the pedagogical idiosyncrasies of the teachers did not influence the results of the investigation because each teacher was told exactly what to do. During each session the writer observed that the teacher in the control group did exactly what he was instructed to do. Also, the writer observed that the teacher of the experimental group did not assist the students. The writer was able to make these observations because both teachers agreed to permit him to move freely from one group to the other.

Immediately following the completion of the programmed unit both the experimental group and the control group received the posttest at the same time and place. Three weeks after the administration of the posttest the retention test was administered to the students in both groups at the same time and place.

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[58]See Appendix M for the procedural instructions given to the teacher in the control group.

During the experimental phase of the study two students missed one day of school each. One of these students was from the experimental group and the other was from the control group. Therefore, the results obtained from these two students were omitted in the final analysis of the data collected during the study. The two students were permitted to continue participating in the experiment and the student not present for the administration of the entry level test and pretest was assigned to the control group. This was necessary because a teacher was not available to supervise these three students during the experimental sessions. Also, a room could not be found where these students could engage in independent study.

ANALYSIS OF THE DATA COLLECTED

The pretest, posttest, and retention test each contain thirty-three multiple choice items. The writer decided to give one point of credit for each correct response and to use the correction-for-chance formula. This formula corrects for omissions rather than for guessing alone. The general formula[59] is usually written

$$S = R - \frac{W}{O-1}$$

In this formula

[59] C. C. Ross and Julian C. Stanley, Measurement In Today's Schools (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962), p. 156.

S is the score corrected for guessing

R is the number of right responses.

W is the number of wrong responses, not counting omitted items.

Q is the number of options presented for each item.

The multiple-choice tests used in this study consist of twenty-eight, four option items and five, five option items. Therefore, the writer had to use the formula $S = R - \frac{1}{3} W$ for twenty-eight of the items and the formula $S = R - \frac{1}{4} W$ for five of the items. The results obtained after the application of these formulae to each student's answers were then added together thereby giving the adjusted result. For example, if a student attempted all questions and answered twenty-five of the twenty-eight items correctly and one of the five items correctly the adjustment procedure was as follows:

$$S = \left(R - \frac{1}{3} W \right) + \left(R - \frac{1}{4} W \right)$$

$$= \left(25 - \frac{1}{3} \times 3 \right) + \left(1 - \frac{1}{4} \times 4 \right)$$

$$= (25 - 1) + (1 - 1)$$

$$= 24 + 0$$

$$= 24$$

In the foregoing example the student's unadjusted score is twenty-six and the adjusted score is twenty-four. It should be noted that in the actual situation a student might have an unadjusted score of twenty-six and not receive an adjusted score of twenty-four because of a different combination of correct and incorrect answers.

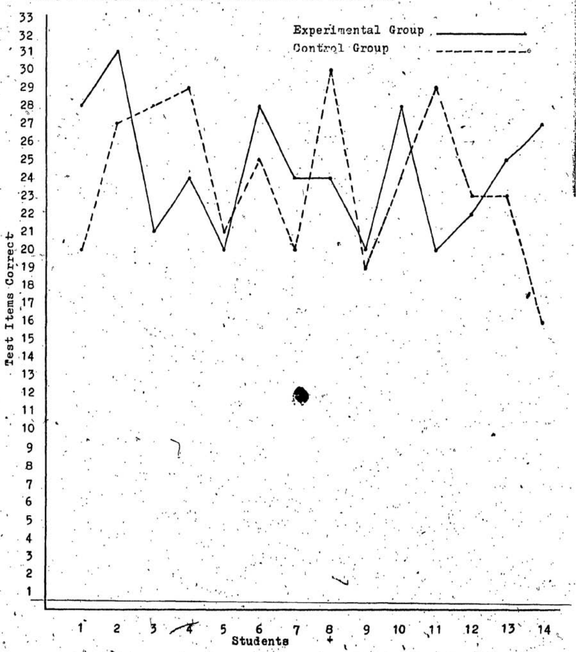
The mean of the experimental group's unadjusted scores on the posttest was 24.43 and that of the control group was 23.86. Table 1 shows the experimental group's and control group's unadjusted scores as obtained on the posttest. To further illustrate, Figure 6 is a graphic representation of the experimental group's and control group's unadjusted scores as obtained on the same test. The median of the experimental group's unadjusted scores on the posttest was 24 and that of the control group was 23.5. The standard deviation for the experimental group was 3.44 and for the control group was 4.086.

Table 1. The Experimental Group's and Control Group's Unadjusted and Adjusted Scores as Obtained on the Posttest

Students[a]	Experimental Group		Control Group	
	Unadjusted Scores	Adjusted Scores	Unadjusted Scores	Adjusted Scores
1	28	27	20	16
2	31	30	27	26
3	21	17	28	26
4	24	21	29	28
5	20	16	21	17
6	28	27	25	23
7	24	20	20	17
8	24	21	30	29
9	20	16	19	16
10	28	26	24	21
11	20	16	29	28
12	22	19	23	20
13	25	23	23	20
14	27	25	16	11

[a]Students assigned to groups according to the table of random numbers.

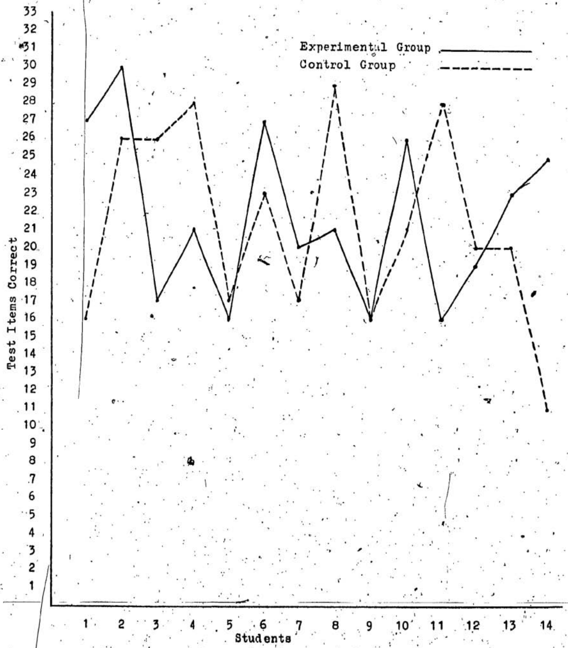
Figure 6. A Graph Showing the Experimental Group's and Control Group's Unadjusted Scores Obtained on the Posttest.



Also, the standard error of the mean for the experimental group's unadjusted scores on the posttest was 0.9194 and for the control group it was 1.092. A difference in the unadjusted achievement scores for the experimental and control groups did occur. In order to determine if the difference obtained by measuring the means of the two groups was a chance or a true one a t test was employed. The difference obtained proved to be non-significant at the .05 level.

The mean of the experimental group's adjusted scores on the posttest was 21.71 and that of the control group was 21.29. Table 1 presents the experimental group's and control group's adjusted scores as obtained on the posttest. To further illustrate, Figure 7 is a graphic representation of the experimental group's and control group's adjusted scores as obtained on the same test. The median of the experimental group's adjusted scores on the posttest was 21 and that of the control group was 20.5. The standard deviation for the experimental group was 4.526 and for the control group it was 5.337. The standard error of the mean for the experimental group was 1.21 and for the control group it was 1.426. A difference in the adjusted achievement scores for the experimental and control groups occurred, also. In order to determine if the difference obtained by measuring the means of the two groups was a chance one or a true one a t test was again employed. The difference obtained proved to be non-significant

Figure 7. A Graph Presenting the Experimental Group's and Control Group's Adjusted Scores as Obtained on the Posttest.



at the .05 level. Therefore, the following null hypothesis was accepted:

$$Ho : M_{exp.} = M_{cont.}$$

Table 2 summarizes the foregoing data related to the experimental group's and control group's performance on the posttest.

Table 2. A Comparison of the Mean, Median, Standard Deviation and Standard Error of the Mean for the Unadjusted and Adjusted Scores of the Experimental Group and Control Group as Obtained on the Posttest.

	Experimental Group		Control Group	
	Unadjusted Scores	Adjusted Scores	Unadjusted Scores	Adjusted Scores
Mean	24.43	21.71	23.86	21.29
Median	24	21	23.5	20.5
Standard Deviation	3.44	4.526	4.086	5.337
Standard Error of The Mean	0.9194	1.21	1.092	1.426

The results of the t test on both the unadjusted and adjusted posttest means proved to be non-significant at the .05 level. However, the unadjusted mean gain score for the experimental group was 8.93 on the posttest over the pretest and the unadjusted mean gain score for the control group was 7.57 on the posttest over the pretest. Also, the adjusted mean gain score for the experimental group was 11.57 on the posttest over the pretest and the adjusted mean gain score for the control group was 10.14. This demonstrates that the students in the experimental group who were exposed to the programmed unit of instruction gained more information on the topic, "The Principle of the Water Cycle," than did the students in the control group who were exposed to the traditional lecture method of instruction.

The mean of the experimental group's unadjusted scores on the retention test was 21.57 and that of the control group was 21.29. Table 3 presents the control group's and experimental group's unadjusted scores as obtained on the retention test. To further illustrate, Figure 8 is a graphic representation of the experimental group's and control group's unadjusted scores as obtained on the same test. The median of the experimental group's unadjusted scores on the retention test was 20.5 and that of the control group was 21.5. The standard deviation for the experimental group was 4.117 and for the control group it was 4.367. The standard error of the mean for the experimental group was 1.100 and for the control group it was 1.166. A difference did occur in the unadjusted scores as obtained by the experimental and control groups on the retention test. In order to determine if the difference obtained by measuring the means of the two groups was a chance one or a true one a t test was utilized. The difference obtained proved to be non-significant at the .05 level.

Table 3. The Experimental Group's and Control Group's Unadjusted and Adjusted Scores as Obtained on the Retention Test.

Students[a]	Experimental Group		Control Group	
	Unadjusted Scores	Adjusted Scores	Unadjusted Scores	Adjusted Scores
1	27	26	16	12
2	31	30	23	20
3	19	15	27	25
4	21	17	26	24
5	19	15	18	16
6	24	21	22	19
7	20	16	18	13
8	19	15	29	28
9	16	11	21	17
10	24	22	22	19
11	18	14	26	24
12	21	19	19	17
13	17	12	17	12
14	26	24	14	8

[a]Students assigned to groups according to the table of random numbers.

The mean of the experimental group's adjusted scores on the retention test was 18.36 and that of the control group was 18.14. Table 3 presents the control group's and experimental group's adjusted scores as obtained on the retention test. To further illustrate, Figure 9 is a graphic representation of the adjusted scores received by both groups on the same test. The median of the experimental group's adjusted scores on the retention test was 16.5 and that of the control group was 18.0. The standard deviation for the experimental group was 5.35 and for the control group it was 5.54. The standard error of the

Figure 8. A Graph Illustrating the Experimental Group's and Control Group's Unadjusted Scores as Obtained on the Retention Test.

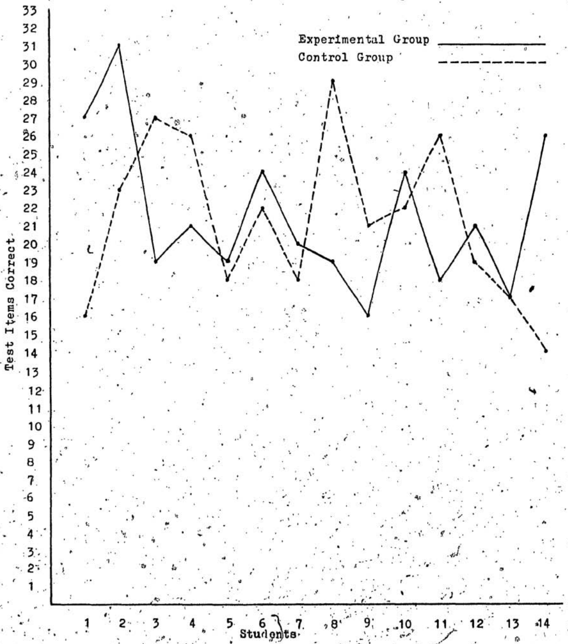
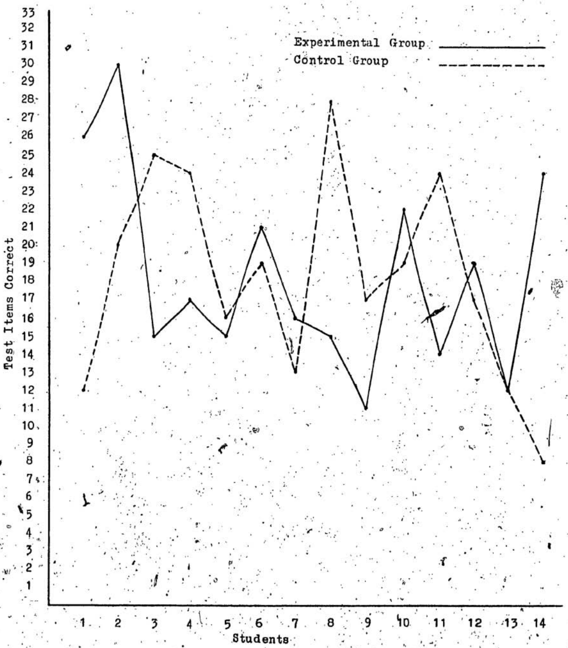


Figure 9. A Graph Showing the Experimental Group's and Control Group's Adjusted Scores As Obtained on the Retention Test.



mean for the experimental group was 1.430 and for the control group it was 1.481. A difference in the means of the experimental group and control group did occur. In order to determine if the difference obtained by measuring the means of the two groups was a chance one or a true one a t test was employed. The difference obtained proved to be non-significant at the .05 level. Therefore, the following null hypothesis was accepted:

$$Ho:\ M_{exp.} = M_{cont.}$$

Table 4 summarizes the foregoing data related to the experimental group's and control group's performance on the retention test.

Table 4. A Comparison of the Mean, Median, Standard Deviation, and Standard Error of the Mean for the Unadjusted and Adjusted Scores of the Experimental Group and Control Group as Obtained on the Retention Test.

	Experimental Group		Control Group	
	Unadjusted Scores	Adjusted Scores	Unadjusted Scores	Adjusted Scores
Mean	21.57	18.36	21.29	18.14
Median	20.5	16.5	21.5	18.0
Standard Deviation	4.117	5.35	4.365	5.54
Standard Error of the Mean	1.100	1.430	1.166	1.481

Graphs[60] were constructed showing the following:

(i) Figure 10, a comparison of the experimental group's unadjusted scores as obtained on the pretest, posttest, and retention test,

(ii) Figure 11, a comparison of the experimental group's adjusted scores as obtained on the pretest, posttest, and retention test,

(iii) Figure 12, a comparison of the control group's unadjusted scores as obtained on the pretest, posttest, and retention test,

(iv) Figure 13, a comparison of the control group's adjusted scores as obtained on the pretest, posttest, and retention test.

In viewing these graphs it becomes apparent that students in the experimental group and the control group scored higher on the posttest than they did on the pretest. However, student number nine in the control group was an exception in that he received the same score on both the pretest and posttest. Also, the scores received by the students in both groups on the retention test fell between, or were equal to, the pretest scores and posttest scores with one exception. Again student number nine in the control group was the exception in that he obtained a higher score on the retention test than he did on the pretest and posttest. This

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[60]See Appendix N, Figures 10, 11, 12, and 13.

is true for both his unadjusted and adjusted scores. This situation might have occurred because it took this student a longer time to assimilate the information he had received. Also, during the three week interval that elapsed between the administration of the posttest and the administration of the retention test he might have been exposed to information pertaining to the water cycle.

From the graphs in Appendix N it can be seen that the unadjusted and adjusted scores obtained on the retention test by the experimental and control groups are generally high in relation to the results obtained on the posttest. One possible explanation for this is that some of the material to which the students in both groups were exposed had been introduced to them in grade five geography and in science courses in grades six and seven. Therefore, the students in studying the topic, "The Principle of the Water Cycle," were actually reviewing parts of material to which they had already been exposed, but which they had forgotten to some extent. When the students were exposed to this material again they tended to retain more of it at the end of a three week interval. Also, the results obtained by the students on the pretest supports the idea that the students had some knowledge of the materials before the experimental and control groups were established.

LIMITATIONS

The teacher employed in teaching the control group was given specific instructions as to the amount of material he was to impart each day. Also, he was told how often to repeat or review the material he covered. The control group situation involved some interaction between children and the teacher and it was impossible to control the children's and the teacher's personalities, both of which might have either facilitated or impeded the amount of learning that took place.

The study originally employed thirty-one grade seven students. It is possible that a larger sample would have added strength to the study with respect to internal validity. However, because several small elementary schools exist in the Bay Roberts area it was impossible to obtain a larger class without destroying the principle of randomization.

The findings of the study are not able to be generalized beyond the sample of twenty-eight grade seven students because the subjects were not selected at random from the total grade seven population.

The students in the control group learned mainly through the auditory channel whereas those in the experimental group used primarily the senses of sight and touch. These different means of receiving information might have either expedited or obstructed learning.

The students in the control group learned about a topic in a situation that they had become familiar with whereas the experimental group learned about the topic by utilizing a method of instruction that was new to them. This might have facilitated or impeded the amount of learning taking place thereby giving one group an advantage over the other.

The experimental group might have perceived that they were being treated differently because they went to the resource center, used the programmed unit of instruction, and read the objectives they were to achieve. This might have caused them to become more interested in the topic. On the other hand the control group learned by a method to which they had become accustomed.

The students in the control group had the information presented to them in a more abstract manner than did the students in the experimental group. The students in the experimental group were able to manipulate the equipment and set up experiments whereas those in the control group were not. This might have given the students in the experimental group an advantage over the students in the control group.

FINDINGS

The linear programmed unit proved to be equally as effective as the traditional lecture method in presenting information on the topic, "The Principle of the Water Cycle," to grade seven students. The difference obtained between the mean scores received on the posttest by the experimental group and the control group proved to be non-significant at the .05 level.

The linear type of programmed learning did not lead to significantly different retention in the topic, "The Principle of the Water Cycle," than did the traditional lecture method of instruction over a three week interval. The difference obtained between the mean scores received on the retention test by the experimental group and the control group proved to be non-significant at the .05 level.

CONCLUSIONS

Programmed instruction proved to be as effective as the traditional lecture method of instruction in presenting material pertaining to the topic, "The Principle of the Water Cycle," to a class of grade seven students. This indicates that programmed instruction might be able to be employed as a substitute for the teacher in presenting the prerequisite material that is necessary for an understanding of relief rainfall and frontal rainfall. This would free teachers from review and remedial work in this area. Each student would be able to use programmed instruction and thereby be permitted to proceed at his own rate within the specified class sessions in order to obtain this necessary information.

At least one area of the social studies lends itself to programming and a review of the related research revealed that there are others. Additional areas could be identified and programs developed to cope adequately with them.

The findings are not a function of the posttest or retention test because the content covered by the lecture method of instruction was identical to that covered by the programmed unit.

SUGGESTIONS FOR FUTURE RESEARCH

Ten grade seven classes could be matched on several variables such as intelligence, achievement, and reading level. Then the classes could be randomly assigned to treatments, five to the control group and five to the experimental group. The results of such a study would be stronger with respect to external validity than the one conducted by the writer.

An investigation could be conducted to see if underachievers benefit more from programmed instruction on the topic, "The Principle of the Water Cycle." This could be accomplished by randomly selecting one group of underachievers and exposing them to programmed instruction. Another group of underachievers could be selected and exposed to the traditional lecture method of instruction. Then a t test could be employed in order to determine if the difference obtained between the means of the group is a true one or due to chance.

An experiment could be carried out in which three groups are established. The first group could follow the traditional lecture method of instruction, the second group could utilize the programmed unit of instruction, and the third group could use the programmed unit and receive input from a teacher. The results obtained on the posttest could then be analyzed in order to determine the method of exposure that is the most effective and efficient in imparting knowledge of the "Principle of the Water Cycle."

Several parallel programs on the topic, "The Principle of the Water Cycle," could be developed for different reading levels. Then the students in the experimental group could be assigned programs more in keeping with their individual reading levels. Again the results could be analyzed in order to determine if the traditional lecture method of instruction would lead to greater achievement on the posttest.

A study could be conducted in order to determine if students at the grade seven level express more favourable attitudes towards the programmed unit of instruction on the topic, "The Principle of the Water Cycle," than toward the traditional lecture method of instruction on the same topic.

An investigation, very similar to the one presented in this internship, could be conducted. However, in this suggested study the experimental group could be given several practice sessions with other programmed instructional materials in order to become accustomed to them before the actual experiment begins.

Research could be conducted in order to determine if there is a positive or negative correlation between variables such as sex, achievement, intelligence, and socio-economic background and achievement as a result of being exposed to the programmed unit on the topic, "The Principle of the Water Cycle." In this particular situation there would be no need for an experimental and control group. A large group of approximately five hundred students could be randomly selected from the entire grade seven population in Newfoundland. Then they could be exposed to the programmed unit and the results obtained on the posttest analyzed as already indicated.

SUMMARY

It was hypothesized that the linear type of programmed learning would lead to different achievement in the topic, "The Principle of the Water Cycle," than would the traditional lecture method of instruction. Also, it was hypothesized that the linear programmed learning approach would lead to greater retention in the topic, "The Principle of the Water Cycle," than would the traditional lecture method of instruction over a three week period.

The steps that were followed in the development of the programmed unit are as follows:

1. organization of materials,
2. the writing of general and specific objectives,
3. writing three parallel test items for each objective,
4. utilizing the test items in the pretest, posttest, and criterion frames,
5. arranging the criterion frames into a logical sequence,
6. writing the teaching frames to lead from entry level to the first criterion frame and so on to subsequent criterion frames.

After the program was written it was read by a teacher, two grade seven students, content specialists, and it was subjected to the Thorndike-Lorge Word List. Revisions were made in the program according to criticisms and as the results of subjecting words used in the program to the Thorndike-Lorge Word List. Also, examples of the revisions made were presented. Following this the program was compared with the traditional lecture method of instruction as a means of imparting information, and of leading to greater retention over a three week period. Through the process of random assignment an experimental and control group occurred. In order to determine if the difference obtained by measuring the means of the two groups was a chance one or a true one, a t test was used to test the null hypothesis at the .05 level of significance. The same procedure was followed for the retention test that was administered after a three week interval.

The study as conducted appeared to have the following limitations.

1. The control group situation involved some interaction between children and the teacher and it was impossible to control the teacher's personality which might have either facilitated or impeded the amount of learning taking place.

2. The study originally employed thirty-one grade seven students. It is possible that a larger sample might have added strength to the study with respect to internal validity.

3. The findings are not able to be generalized beyond the sample of thirty-one grade seven students because the subjects were not selected at random from the grade seven population.

4. Students in the control group learned mainly

through the auditory channel whereas those in the experimental group used the senses of sight and touch. This may have given one group an advantage over the other.

5. The students in the control group learned by a teaching method with which they were familiar whereas the students in the experimental group utilized a method of instruction that was new to them. This may have given the control group an advantage over the experimental group.

6. The experimental group might have perceived that they were being treated differently in that they went to the resource center for classes and used the new method of instruction. This might have given the experimental group an advantage over the control group.

7. The students in the control group had the information presented to them in a more abstract manner than did the students in the experimental group. This might have placed the students in the control group at a disadvantage.

The study proved that the linear type programmed unit was just as effective as the traditional lecture method in presenting information on the topic, "The Principle of the Water Cycle," to grade seven students. Also, the linear type of programmed learning did not lead to significantly different retention in the topic, "The Principle of the Water Cycle," than did the traditional lecture method of instruction over a three week interval.

It was concluded that the programmed unit on the topic, "The Principle of the Water Cycle," might be able to be employed as a substitute for the teacher in presenting the pre-requisite material that is necessary for an understanding of the causes of relief rainfall and frontal rainfall. This would free teachers from review and remedial work in this area. Also, other areas of the social studies, that is, the content which lends itself to programming, could be identified and programs developed to cope adequately with them. Furthermore, it was concluded that the findings were not a function of the posttest or retention test.

Seven suggestions for future research were presented. Each suggestion centered around the idea of such research being conducted on the programmed unit developed in this internship. These suggestions included the utilization of larger experimental and control groups, the employment of students of varying abilities, the need for a correlational study and the idea of testing the unit with another teaching method, other than the traditional lecture method of instruction. The suggestions for future research were made in view of some of the limitations found in this study.

Chapter 4

SUMMARY OF THE ENTIRE STUDY

In chapter one the problem dealt with in the study was described. The problem centers around the fact that children vary individually in their learning capabilities. This problem is compounded when educators attempt to solve it by a continual use of the traditional lecture method of instruction. It was suggested that programmed instruction as an alternative to the constant use of the lecture method might provide part of the answer to this problem. In order to become more specific and to investigate the possible usefulness of programmed instruction, it was suggested that the topic, "The Principle of the Water Cycle," be selected. A programmed unit on this topic was constructed and compared with the traditional lecture method of instruction in an experimental versus a control group situation.

Chapter two presented a review of literature and research related to programmed instruction. The contributions made by Socrates, Comenius, Pressey, and Skinner to programmed instruction were discussed briefly. Also, the main characteristics of programmed instruction as it exists today were identified. Emphasis was placed on descriptions of the two main types of programmed instruction, namely, the linear program and the branching program. Several techniques employed in programmed instruction in order to compensate for the fact that individuals differ in their learning capabilities were mentioned. The review of related research dealt primarily with studies that evaluated programmed instruction by comparing it to traditional or conventional methods of instruction. This review revealed that programmed instruction is just as efficient and effective as the traditional methods of instruction. However, it was deemed necessary to conduct this study in order to determine if programmed instruction is as effective as the traditional lecture method of instruction in presenting information on the topic, "The Principle of the Water Cycle," because literature and research that dealt with that topic could not be found.

Chapter three presented a detailed description of the study. It was hypothesized that the linear type of program when augmented with support materials leads to different achievement and retention over a three week interval than does the traditional lecture method of instruction.

The steps followed in writing the programmed unit were described and revisions were made on the basis of criticisms from a teacher, two graduate students, a content specialist, and two grade seven students. The types of revisions made were described and examples were given. Also, the programmed unit was subjected to the Thorndike-Lorge Word List and revisions were made, where necessary, in order to arrive at the grade seven level of reading. After the program was developed it was evaluated by comparing it to the traditional lecture method of instruction in an experimental versus a control group situation.

The limitations of the study were described briefly. The statement was made that it was impossible to control the teacher's personality, which might have either facilitated or impeded the amount of learning taking place in the control group situation. It was indicated that the small sample might have weakened the internal validity of the study. Also, the findings are not able to be generalized beyond the sample of thirty-one grade seven students engaged in the experimental phase of the study.

The findings were that the programmed unit of instruction proved to be as effective as the traditional lecture method of instruction in imparting information on the topic, "The Principle of the Water Cycle." Also, the linear programmed learning approach did not lead to significantly different retention in the topic, "The Principle of the Water Cycle," than did the traditional lecture method of instruction.

It was concluded that the programmed unit on the topic, "The Principle of the Water Cycle," might be able to be utilized as a substitute for the teacher in presenting the prerequisite material that is necessary for an understanding of the causes of relief rainfall and frontal rainfall. Also, other areas of the social studies in which programmed units could be utilized should be identified and programs developed to cope adequately with them. Furthermore, it was concluded that the findings were not a function of the posttest or retention test.

Several suggestions for future research were described briefly. These suggestions centered around the idea of such research being conducted on the programmed unit developed in this internship. These suggestions included the employment of larger experimental and control groups, the utilization of students of varying abilities, the need for a correlational study, and the idea of testing the unit with another teaching method, other than the traditional lecture method of instruction.

BIBLIOGRAPHY

BIBLIOGRAPHY

Barcus, Delbert, and Jack Pottle, "Programming the Constitution," Social Education, XXIX (January, 1965), 29-31.

Burnkrant, E. G., and Philip Lambert, "A Comparison of the Effects of Various Learning Procedures Upon Punctuation and Content in the Free Writing Situation," Programmed Learning, I-III (1964-66), 158-69.

DeCecco, John P. (ed.) Human Learning in the School. New York: Holt, Rinehart and Winston, 1963.

Deterline, William A. An Introduction to Programmed Instruction. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1962.

Espich, Jane E. and Bill Williams. Developing Programmed Instructional Materials. Palo Alto, California: Fearon Publishers, 1967.

Gills, David L. (ed.) International Encyclopedia of the Social Sciences. Washington: Macmillan Company, 1968.

Harris, Chester. (ed.) Encyclopedia of Educational Research. Third Edition, New York: Macmillan Co., 1960.

Hough, John B. "Research Vindication For Teaching Machines," Phi Delta Kappan, XLII (1962), 240-42.

Jamieson, G. H. and H. Marchant. "Learning By Tape/Slide, Linear Program and Illustrated Booklet: A Comparative Study," Programmed Learning and Educational Technology, VIII (1971), 245-49.

Jamieson, G. H., Pamela E. Janes, G. W. A. Laythan, and A. H. Fozen. "Comparison Between Teaching Methods at the Post-Graduate Level," Programmed Learning and Educational Technology, VI (1969), 243-49.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart and Winston, Inc., 1973.

Lange, Phil C. (ed.) Programmed Instruction. Sixty-sixth Yearbook, Part II. Chicago, Illinois: The University of Chicago Press, 1967.

Lawson, Dene R. "Who Thought of it First," Educational Technology, IX (October, 1969), 93-96.

Lewis, Donald J. Scientific Principles of Psychology. London: Longman, Green and Co. Ltd., 1967.

Lysaught, Jerome P. and Clarence M. Williams. A Guide to Programmed Instruction. New York: John Wiley and Sons, Inc., 1966.

Noonan, James LeRoy, "A Study of Three Methods of Teaching a Unit of Latitude and Climate to Sixth Grade Students." Unpublished Doctor's dissertation, University of North Dakota, 1968.

Pikas, Anatol. "Comparison Between Traditional and Programmed Learning As A Function of the Contents of the Comparison Test," Programmed Learning and Educational Technology, IV (1967), 270-83.

Ross, C. C. Measurement in Today's Schools. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.

Rummier, Geary A. "P. I.-Where The Action Is," Educational Technology, X (July, 1970), 31.

Ryan, William T. A Handbook of Programmed Learning Information. Albany, New York: The State Education Department, 1964.

Schramm, Wilbur. "Programmed Instruction Today and Tomorrow," Four Case Studies of Programmed Instruction. New York: Fund for the Advancement of Education, 1964.

Schramm, Wilbur. The Research On Programmed Instruction. Washington: U. S. Government Printing Office, 1964.

Shafer, Susanne M. "Geography Via Programmed Instruction," The Journal of Geography, LXI (February, 1965), 77-81.

Shafer, Susanne M. "Teaching Machines and the Social Studies," Social Education, XXV (February, 1961), 85-86.

Skinner, B. F. The Technology of Teaching. New York: Appleton-Century-Crofts, 1968.

Smith, Norman A. "The Teaching of Elementary Statistics by the Conventional Classroom Method Versus the Method of Programmed Instruction," Journal of Educational Research, LV (1962), 417-20.

Thomas, Adrian. "A Study in the Evaluation of Some Junior School Science Programs," Programmed Learning and Educational Technology VII (July, 1970), 106-126.

Thomas, Georgelle. "Programmed Instruction for Teaching Anthropology in the Fifth Grade," The Journal of Experimental Education, XXXVI (Summer, 1968), 88-92.

Thorndike, Edward L. and Irving Lorge. The Teacher's Word Book of 30,000 Words. New York: Bureau of Publications Teacher's College, Columbia University, 1959.

Wood, Leslie A. "Programmed Textual Material as a Partial Substitute for Teacher-Led Classroom Procedures in Geography," The Journal of Educational Research, LVIII (September, 1964), 22-26.

SUPPLEMENTAL BIBLIOGRAPHY

SUPPLEMENTAL BIBLIOGRAPHY

Campbell, Donald T., and Julian C. Stanley. Experimental And Quasi-Experimental Designs For Research. Chicago: Rand McNally and Company, 1970.

Canadian Education Association. Programmed Instruction In Canadian Schools. Toronto, Ontario: Research and Information Division, Canadian Education Association, 1965.

Davis, Ira C., John Burnett, E. Wayne Gross. Science: Observation and Experiment I. New York: Holt Rinehart and Winston, Inc., 1962.

Davis, Ivor K. The Management of Learning. London: McGraw-Hill, 1971.

DeCecco, John P. (ed.) Readings In Programmed Instruction. New York: Holt, Rinehart and Winston, 1964.

Division of Audiovisual Instructional Service. Selection And Use of Programmed Materials: A Handbook For Teachers. Washington, D.C. National Education Association, 1964.

Edwards, Allen L. Statistical Analysis. New York: Holt, Rinehart and Winston, Inc., 1969.

Evans, James L. Principles of Programmed Learning. Teaching Machines, Inc., 1962.

Gagne, Robert M. The Conditions of Learning. New York: Holt, Rinehart and Winston, Inc., 1965.

Glass, Gene V. and Julian C. Stanley. Statistical Methods in Education and Psychology. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970.

Grazia, Alfred de and David A. Sohn (eds.) Programs, Teachers, and Machines. New York: Bantam Books, 1964.

Green, Edward J. The Learning Process and Programmed Instruction. New York: Holt, Rinehart and Winston, Inc., 1963.

Gronlund, Norman E. Stating Behavioral Objectives For Classroom Instruction. London: Butterworth and Co. Ltd., 1972.

Guenther, William C. Concepts of Statistical Inference. Toronto: McGraw-Hill Book Company, 1965.

Herman, Wayne L., Jr. Current Research in Elementary School Social Studies. London: Collier-Macmillan Limited, 1969.

Herron, W. B., and N. P. Palmer. Matter, Life, and Energy. Chicago: Lyons and Carnahan, 1965.

Hughes, J. L. Programmed Instruction For Schools and Industry. Chicago: Science Research Associates, Inc., 1962.

Jacobs, Paul I., Milton H. Maier, and Lawrence M. Stolurow. A Guide To Evaluating Self-Evaluation Programs. New York: Holt, Rinehart and Winston, Inc., 1966.

Kemp, Jerrold E. Instructional Design: A Plan For Unit and Course Development. Belmont, California: Fearon Publishers, 1971.

Leedham, John and Derrick Unwin. Programmed Learning in the Schools. London: Longman, Green and Co. Ltd., 1967.

Lumsdaine, A. A. and Robert Glaser (eds.) Teaching Machines and Programmed Learning. Washington, D. C.: National Education Association, 1966.

Mager, Robert F. Preparing Instructional Objectives. Belmont, California: Fearon Publishers, Inc., 1962.

Mann, A. P. and C. P. Brunstrom (eds.) Aspects of Educational Technology. Vol. III. London: Sir Isaac Pittman and Sons Limited, 1969.

Markle, Susan Meyer. Good Frames and Bad. New York: John Wiley and Sons, Inc., 1966.

Mendenhall, William. Introduction to Statistics. Belmont, California: Wadsworth Publishing Company, Inc., 1964.

Mills, Annice L. Programmed Learning and the Educational Process. Stanford, California: Thomas Alva Edison Foundation, Inc., 1961.

O'Day, Edward F., et. al. Programmed Instruction. New York: Appleton-Century-Crofts, 1971.

Popham, W. James and Eva L. Baker. Systematic Instruction. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970.

Ramsey, William L. and Raymond A. Burckley. Modern Earth Science. New York: Holt, Rinehart and Winston, Inc., 1961.

Strahler, Arthur N. Introduction to Physical Geography. New York: John Wiley and Sons, Inc., 1965.

Stolurow, Lawrence M. Teaching by Machine. Washington: U. S. Government Printing Office, 1963.

Taba, Hilda. Curriculum Development Theory and Practice. New York: Harcourt, Brace, and World, Inc., 1962.

Wiley, John. A Guide For Wiley Authors. New York: John Wiley and Sons, Inc., 1963.

APPENDIX A

Log of the Development of the Internship

LOG OF THE DEVELOPMENT OF THE INTERNSHIP

The Germination of the Idea

The idea to develop a programmed unit of study on the topic, "The Principle of the Water Cycle," originated during the summer of 1975. That summer the writer was taking a course in instructional development at Memorial University. The students enrolled in the course were given an assignment. The assignment was to identify an educational problem and to suggest a possible solution to that problem.

The writer decided that his educational problem would be the difficulty that grade seven students were having in understanding the causes of frontal rainfall and relief rainfall. This problem became apparent to the writer because of his own experience in teaching that section of grade seven geography and in view of comments he had heard the previous winter from other grade seven teachers in the Bay Roberts area. The writer suggested that a possible solution to this problem would be to present a unit on the topic,"The Principle of the Water Cycle," to the students before the section concerning the causes of frontal rainfall and relief rainfall is introduced to them.

The instructor of the course that summer suggested that many of the assignments submitted to him could be used as the basis for an internship. When the writer consulted the instructor concerning the possibilities of using his assignment as the basis for an internship the instructor indicated that it certainly had potential.

Following classes that summer the writer contacted his advisor, Mr. Brewster, and indicated he would like to develop and test a programmed unit on the topic, "The Principle of the Water Cycle," for his internship. The writer told Mr. Brewster that he would not be ready to start his internship until January, 1976. The writer received encouraging remarks from his advisor and was informed that he would have to present a written proposal.

During the Christmas Recess 1975-76 the writer drew up an outline of an internship proposal and presented it to Mr. Brewster around the middle of January, 1976. Mr. Brewster read the outline and indicated that it would be an acceptable study for an internship. Mr. Brewster then suggested that the writer conduct a review of literature and research pertaining to programmed instruction. He further suggested that Dr. Boehnker, Assistant Professor in the Division of Learning Resources, might consent to act as programmed unit consultant and Mr. McPartland, Professor of Geography in the Faculty of Arts, would possibly act as content specialist during the development of the programmed unit. Also, it was suggested that Dr. Connelly, Professor of Mathematical Education, be requested to act as consultant in the selection of the experimental design for the study and in the analysis of the data collected from the study.

ACTIVITIES AND EVENTS

1976	
February 2-13	Writer collected information on programmed instruction from books, journals, and microfilms at the Education Library, Memorial University. Also, information on the water cycle was collected and analyzed.
February 14-March 2	Emphasis placed on writing the programmed unit. Some time was spent on writing the internship proposal.
March 3	Presented programmed unit to Dr. Boehnker.
March 4	Emphasis placed on writing internship proposal.
March 5	Received program back from Dr. Boehnker with suggestions for major revisions. Presented internship proposal to Mr. Brewster who read it and made suggestions for revisions.
March 6-18	Emphasis placed on revising the program and the internship proposal.

March 19	Presented internship proposal to Mr. Brewster. He read it and suggested further revisions. Presented revised program to Dr. Boehnker.
March 20-24	Emphasis placed on making revisions in the internship proposal.
March 25	Borrowed science equipment for kits from Mr. Mews at the Department of Chemistry.
March 26	Presented the revised internship proposal to Mr. Brewster. He read it and accepted it. Received the programmed unit back from Dr. Boehnker who said that the next step was to try it out on two students.
March 27	The writer visited the District Office of Avalon North Integrated School Board and received the records of scores obtained on the Gates-MacGinite Reading test by grade seven students in the following schools: Holy Redeemer, Spaniards Bay; Bay Roberts Amalgamated, Bay Roberts; St. Marks, Shearstown; St. Peter's, Upper Island Cove; and

Coley's Point Elementary, Coley's Point. The writer also received verbal permission to use any of the board's schools in the Bay Roberts area for purposes of developing his program.

March 29 — Analysis of reading scores. It was found that the mean score of the students at Bay Roberts Amalgamated matched that of the students at the Coley's Point Elementary School very closely.

March 30 — Mr. Wilbur Sparkes, Principal of Bay Roberts Amalgamated, gave permission to use any two grade seven students in his school.

March 31 — At the regular monthly meeting of the staff of the Coley's Point Elementary School, the teachers agreed to cooperate fully during the experimental phase of the internship.

April 2 — Picked up five zeroxed copies of the programmed unit at Memorial University and met with advisor, Mr. Brewster.

April 3 — Kits were made up.

April 4	Randomly selected the names of two students from the grade seven class at Bay Roberts Amalgamated School.
April 5	First day of trying out the programmed unit. (i) The writer was introduced to two students by the principal. (ii) The writer explained to the students what he was doing and asked if they were willing to participate. Each student agreed to cooperate. (iii) Administered entry level test. (iv) Did some teaching to raise entry level behavior. (v) Administered pretest. (vi) The students then worked through Module I.
April 6	Students worked through Module II.
April 7	Students worked through Module III.
April 8	Students worked through Module IV.
April 9	Students worked through Module V and were given the posttest. The writer then motored to St. John's and received

drawings from Mr. McLoughlan at the College of Trades and Technology. The writer also visited the home of Mr. MacPartland in order to give him a copy of the programmed unit.

April 10-11	Prepared for seminar and modified the program in view of difficulties experienced by both students at Bay Roberts Amalgamated School.
April 12	Presented internship proposal before a seminar at Memorial University.
April 14	Met with Mr. MacPartland in order to discuss program modifications.
April 15-16	Revised the program in view of suggestions made by Mr. MacPartland, the content specialist.
April 17	Tried out additional frames on the two students from Bay Roberts Amalgamated School.
April 18-19	Applied the Thorndike-Lorge word list to the program and made the necessary modifications.
April 20	Passed in revised programmed unit for

zeroxing at Memorial University.

April 23	Picked up zeroxed copies of the programmed unit at Memorial University.
April 24	Mr. Claude Barrett agreed to teach the control group and Mrs. Carol French agreed to supervise the experimental group.
April 26	Staff at Coley's Point Elementary were informed of the timetable to be followed during the experiment. This involved substitutions for the teachers in the control and experimental groups and cancellation of classes in the resource centre.
April 27-29	Prepared for the experimental phase of the internship and wrote up some revisions made to the program.
April 30	Implemented the experimental phase; administered the entry level test. Students lacking the necessary information were taught it. Administered the pretest.

May 1	Marked pretest and randomly assigned students to groups and then groups to treatments.
May 3	Students were told to which groups they had been assigned. The control group remained in the classroom and the experimental group went to the resource centre. Both groups completed Module I.
May 4	Both groups completed Module II.
May 5	Both groups completed Module III.
May 6	Both groups completed Module IV.
May 7	Both groups completed Module V plus the posttest.
May 8	Marked the posttest and disassembled the kits.
May 10	Tabulated results of pretest and posttest and then recorded them.
May 11-12	Completed writing up revisions made to the program.
May 13	Consulted Dr. Connelly concerning statistical analysis of data collected.

May 13-27	Statistical analysis of data.
May 28	Further consultation with Dr. Connelly concerning the statistical analysis of the data collected.
May 29-July 3	Wrote up the findings of the study and finished writing up the internship report.
July 3	Submitted entire internship report to Mr. Brewster for the first time.

APPENDIX B

General Objectives and Specific Aims of the Programmed Unit.

OBJECTIVES

Students should be able to achieve these objectives at the 70% level of accuracy on a multiple-choice objective test consisting of thirty-three items. Also, students should complete the test in a period of thirty minutes.

Students will demonstrate that they understand the principle of the water cycle by:

(i) naming each step in the water cycle in its order of occurrence;

(ii) labelling the steps in a diagram of the water cycle;

(iii) identifying an experiment showing the principle of the water cycle;

(iv) identifying an example of the water cycle as it occurs in nature;

(v) identifying the symbol for lateral movement in a diagram of the water cycle.

SPECIFIC INSTRUCTIONAL AIMS

A. Evaporation

1. Name three things that influence the rate of evaporation.
2. Tell why evaporation is a cooling process.
3. Distinguish between evaporation and boiling.
4. Identify the correct definition of evaporation.
5. Identify an experiment showing evaporation.
6. Identify an example of evaporation as it occurs in the world around you.

B. Warm air rising

1. Tell what happens when air is heated.
2. Tell why warm air rises above cool air.
3. Recall what happens to warm air when it rises.
4. Identify an experiment showing warm air rising.
5. Identify an example of warm air rising.
6. Tell why there is lateral movement of moisture within the atmosphere.

C. Surface water of the earth

1. List three sources of evaporated water on the earth's surface.
2. Tell why some precipitation might not fall to the earth's surface.
3. State how moisture that falls to the earth finds its way from higher levels to lower levels of the earth's surface.

D. Cycle

1. Identify the correct definition of the word cycle.
2. State one example of a cycle.

E. Condensation

1. State the name given to water molecules that are invisible and float in the air.
2. Distinguish between condensation and evaporation.
3. Distinguish between water vapor and water droplets.
4. Identify an experiment showing condensation.

5. Identify an example of condensation.
6. Tell why clouds often form high above the earth.

F. Precipitation

1. Tell why clouds are able to float high in the air.
2. State why large droplets of water fall to the earth's surface.
3. Identify the correct definition of precipitation.
4. Tell why snow falls.
5. Tell why rain falls.
6. Recall how frozen rain is formed.
7. Identify an experiment showing precipitation.
8. Identify an example of precipitation as it is found in nature.

APPENDIX C

Entry Level Behavior

ENTRY LEVEL BEHAVIOR

NAME ______________

You should read the instructions carefully. Answers must be filled in on this sheet. This examination must be completed in ten minutes.

From the four given items select the one that makes the statement correct and place the letter of that item in the brackets at the right.

Sample: The line about which the earth is spinning is called its .... (c)
(a) Latitude (b) Longitude (c) Axis (d) Equator

1. The smallest particle of a substance that retains all the properties of the substance is called a .... ( )
(a) Proton (b) Molecule (c) Neutron (d) Metalloid

2. How many forms can water occur in? .... ( )
(a) Five (b) Two (c) Six (d) Three

3. The energy an object has because of its motion is called .... ( )
(a) Kinetic energy (b) Solar energy (c) Potential energy (d) Electrical energy

4. The changing of a liquid into a gas is called ...... ( )
(a) Vaporization (b) Oxidation (c) Filtration (d) Combustion

5. We call the mixture of many gases that surround the earth to a height of many miles the .... ( )
(a) Space (b) Vapor (c) Vacuum (d) Atmosphere

6. The name given to a trial or test to find out something which is unknown is an .... ( )
(a) Approach (b) Investigation (c) Experiment (d) Observation

7. For a given temperature there is a limit to the amount of moisture that the air can hold. This limit is known as the ....( )

(a) Saturation Point (b) Boiling Point
(c) Kindling Temperature (d) Melting Point

8. The mixture of gases that surround the earth contains billions of ....( )

(a) Elements (b) Nova (c) Nucleii (d) Particles

9. When the atmosphere is in motion across the earth's surface it is called ....( )

(a) Strength (b) Wind (c) Noises (d) Force

10. Animals, lakes, soil, vegetation, oceans, and rivers all contain a substance which is called ....( )

(a) Blood (b) Alcohol (c) Moisture (d) Algae

APPENDIX D

Pretest

PRETEST

NAME ____________

You should read the instructions carefully. Answers must be filled in on this sheet. This examination must be completed in thirty minutes.

From the four or five given items select the one that makes the statement correct and place the letter of that item in the brackets at the right.

Sample: The capital of the Soviet Union is ....(a)
(a) Moscow (b) Leningrad (c) Paris (d) London

1. Each of the following factors influence the rate of evaporation except .... ( )
(a) Surface Area (b) Temperature (c) Depth (d) Wind

2. In evaporation, energetic molecules escape from a liquid, thereby lowering its .... ( )
(a) Saturation Point (b) Density (c) Temperature (d) Boiling Point

3. An example of evaporation is a ....( )
(a) Pool of water drying up
(b) River flowing to the sea
(c) Kettle of boiling water
(d) Window pane with water droplets forming on it.

4. The changing of a liquid into a vapor at the liquid's surface is called .... ( )
(a) Combustion (b) Precipitation (c) Oxidation (d) Evaporation

5. Five experiments have been set up on tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the process of evaporation .... ( )
(a) Experiment A
(b) Experiment B
(c) Experiment C
(d) Experiment D
(e) Experiment E

6. When air is heated it .... ( )

(a) Contracts (b) Falls (c) Expands (d) Settles

7. Warm air rises above cold air because warm air is .. ( )

(a) Heavier than cold air
(b) Lighter than cold air
(c) Drier than cold air
(d) Denser than cold air

8. When warm air rises it becomes .... ( )

(a) Cooler (b) Drier (c) Thicker (d) Lighter

9. An example of warm air rising is .... ( )

(a) Air escaping from an automobile tire
(b) Wind making the trees move
(c) Smoke rising from a fire
(d) An aircraft rising from a runway

10. Five experiments have been set up on tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that proves warm air rises. ( )

(a) Experiment A
(b) Experiment B
(c) Experiment C
(d) Experiment D
(e) Experiment E

11. Water molecules that are invisible and float in the air are called .... ( )

(a) Particles (b) Atoms (c) Water vapor (d) Water droplets

12. When condensation occurs water vapor becomes ...... ( )

(a) Water droplets (b) Gas (c) Rain (d) Solid

13. There is lateral atmospheric movement of moisture because .... ( )

(a) The moisture remains in one place in the atmosphere and it is the earth that moves.
(b) Tiny droplets of moisture propel themselves across the sky.
(c) Moisture in the atmosphere has a tendency to escape into space.
(d) Currents in the atmosphere carry moisture from one area to another.

14. An example of condensation is .... (   )

    (a) The formation of clouds
    (b) The changing of a liquid to a gas
    (c) A rainstorm
    (d) A lake freezing over.

15. Five experiments have been set up on the tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the process of condensation .... (   )

    (a) Experiment A
    (b) Experiment B
    (c) Experiment C
    (d) Experiment D
    (e) Experiment E

16. Some of the moisture that starts falling towards the earth's surface does not reach it. The reason for this is that it .... (   )

    (a) Evaporates (b) Goes into space (c) Burns up (d) Contracts

17. A series of events that repeatedly follow each other in the same order is called a .... (   )

    (a) Circle (b) Sequence (c) Cycle (d) Rotation

18. Water is able to leave the surface of animals, lakes, soil, vegetation, oceans, and rivers and pass into the earth's atmosphere by the process of .... (   )

    (a) Condensation (b) Evaporation (c) Precipitation (d) Oxidation

19. An example of a cycle is .... (   )

    (a) A series of events
    (b) A waterfall
    (c) The seasons of the year
    (d) The pages in a book

20. Clouds are made up of tiny water droplets that are able to float in the air because .... (   )

    (a) Evaporation keeps them up there
    (b) The sun and moon attract them
    (c) They tend to fly away into space
    (d) The air supports them

21. Large droplets of water fall toward the earth's surface because .... (   )

    (a) They are too heavy for the air to support.
    (b) The air around them is very light.
    (c) The low temperature forces them to fall.
    (d) Strong winds blow them towards the earth.

22. The process whereby moisture falls from the air to the earth's surface is called .... (   )

    (a) Condensation (b) Precipitation (c) Oxidation (d) Combustion

23. Precipitation falls as snow when the temperature of the layer of air next to the earth's surface is .... (   )

    (a) Continually changing (b) 15° Celsius (c) Below 0° Celsius (d) 30° Celsius

24. Some of the moisture that falls to the earth finds its way to lower levels of the earth's surface by ....(   )

    (a) The process of evaporation
    (b) Evaporating into the atmosphere
    (c) Being absorbed into the vegetation
    (d) Flowing over the land.

25. When supercooled droplets of water come into contact with the earth's surface they freeze. This type of precipitation is called ....( )

    (a) Rain (b) Frozen Rain (c) Snow (d) Dew

26. If the temperature of the layer of air next to the earth is above 0° Celsius and moisture falls to the earth's surface it falls as .... (   )

    (a) Rain (b) Snow (c) Frozen Rain (d) Dew

27. An example of precipitation is .... (   )

    (a) A frozen rain storm
    (b) The evaporation of precipitation
    (c) Water evaporating from a lake
    (d) Water falling over a dam.

28. Five experiments have been set up on the tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the process of precipitation .... (   )

    (a) Experiment A
    (b) Experiment B
    (c) Experiment C
    (d) Experiment D
    (e) Experiment E

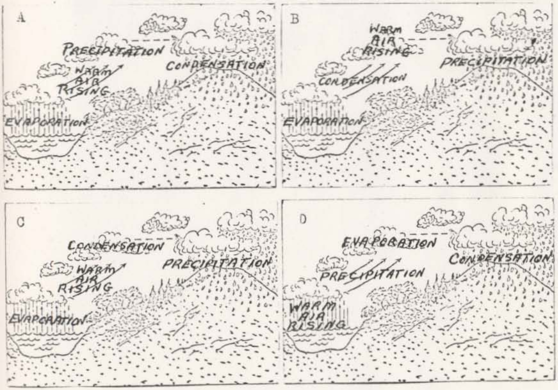
29. The principle of the water cycle is made up of a series of steps that repeatedly follow each other and always in the same order. Identify the correct order ...... ( )

(a) Precipitation, Condensation, Evaporation, Warm air rising
(b) Condensation, Evaporation, Warm air rising, Precipitation
(c) Warm air rising, Evaporation, Precipitation, Condensation
(d) Evaporation, Warm air rising, Condensation, Precipitation

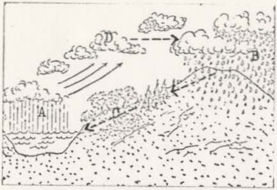
30. Five experiments have been set up on the table at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the water cycle .... ( )

(a) Experiment A
(b) Experiment B
(c) Experiment C
(d) Experiment D
(e) Experiment E

31.



From the four diagrams above select the one that best represents the water cycle as it is found in nature.. ( )
(a) Diagram A (b) Diagram B (c) Diagram C (d) Diagram D

32. 

In the diagram above select the letter that shows surface flow .... (   )

(a) Letter A (b) Letter D (c) Letter C (d) Letter B

33. An example of the principle of the water cycle is .. (   )

(a) A river flowing into a large lake
(b) Water droplets forming on the window pane
(c) Water evaporating, then the water vapor rising high in the sky to form clouds.
(d) Surface water changing to vapor, the vapor changing to water droplets, and the water droplets falling to the earth's surface.

APPENDIX E

PROGRAMMED UNIT

MODULE I

1. As a substance changes from a liquid to a vapor and floats in the atmosphere billions of tiny particles of the substance called molecules (MOLL-uh-KULS) leave the surface of the liquid and float in the ________________ as vapor.

19. MOLECULES LEAVE THE LIQUID'S SURFACE AND PASS INTO THE ATMOSPHERE TAKING THEIR KINETIC ENERGY WITH THEM THEREBY LOWERING THE LIQUID'S TEMPERATURE.

20. As a liquid changes to a vapor billions of tiny particles of moisture pass from the liquid into the ______________.

1. ATMOSPHERE

2. In order for us to be able to smell perfume it must change from a liquid in an open bottle to a ________________ and float in the atmosphere.

20. ATMOSPHERE

21. After water changes to a vapor we call that vapor w____________ v__________ and it is made up of billions of water molecules.

2. VAPOR

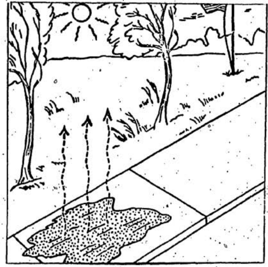
3. Vapor is formed when the smallest particles of a liquid, called molecules pass from the liquid into the at________:

21. WATER VAPOR

22. Warm atmosphere can hold more water vapor than cool atmosphere, therefore, the ____________ the atmosphere becomes the more water vapor it can hold.

3. ATMOSPHERE

4.



The diagram (DY-uh-GRAM) above is an example of tiny particles called ______________ leaving a liquid and passing into the atmosphere.

22. WARMER

23. If the temperature of the atmosphere is lowered the rate at which a liquid changes to a vapor is reduced. If the temperature of the atmosphere is raised the rate at which a liquid is changed to a vapor is increased. ____________ is therefore a factor that influences the rate at which a fluid changes to a vapor.

4. MOLECULES

5. When vapor changes into a liquid the molecules do not leave the surface and float in the atmosphere, rather they combine to form a 1 ______________.

23. TEMPERATURE

24. Water molecules leave the surface of water. If the surface area of the water is large more molecules can ____________.

5. LIQUID

6. List one example of a liquid changing into a vapor.

____

24. LEAVE

25. Surface area and temperature are therefore factors that influence ______________________________.

6. A POOL OF WATER DRYING UP OR AN OPEN BOTTLE OF PERFUME.

7. You are able to set up an experiment to prove that liquids change into vapor. The liquid used in this experiment is duplicating (DO-ple-KAT-ing) fluid instead of water. This fluid is used in machines to make many copies of the same paper. Duplicating fluid is used because it changes into a vapor, faster than water, at room temperature and you are able to smell it. Therefore, it is better to use duplicating fluid in this ______________.

25. THE RATE AT WHICH A LIQUID CHANGES TO A VAPOR.

26. On a warm sunny day when the wind is blowing, water changes to water vapor faster than when the wind is not blowing. Therefore, a third factor that influences the rate at which liquids change to vapor is ______________.

7. EXPERIMENT

8. In order to set up this experiment you must follow the instructions very carefully and keep them with you at all times.

   (a) Go to the kit containing your materials (ma-TER-E-als).
   (b) Open the kit.
   (c) Remove the bottle marked duplicating fluid.
   (d) Now remove the container marked beaker (BEK-er).
   (e) Next take the bottle and beaker back to your seat.
   (f) Place both on your desk.

26. WIND

27. List three factors that influence the rate at which liquids change to vapor and float in the atmosphere ______________, ______________, and ______________.

8. GOOD. NOW YOU HAVE A BOTTLE MARKED DUPLICATING FLUID AND A CONTAINER MARKED BEAKER PLACED ON YOUR DESK.

9. (g) Unscrew the stopper of the container marked duplicating fluid.

(h) Pour the duplicating fluid into the beaker.

27. TEMPERATURE, WIND, SURFACE AREA

28. If the temperature of a liquid is raised high enough, the fluid will begin to bubble. It is then said to be

____________________.

9. GOOD. NOW YOU SHOULD HAVE AN EMPTY BOTTLE AND THE DUPLICATING FLUID SHOULD BE IN THE BEAKER.

10. Do you smell the duplicating fluid? ____________

28. BOILING

29. In boiling water molecules leave and pass into the bubbles in the water and form water vapor. Also, molecules leave the s____________ of the water.

10. YES

11. The fact that you are able to smell the duplicating fluid is proof that it is changing into a vapor. It is changing into a vapor because tiny particles called ______________ are leaving its surface and passing into the atmosphere.

29. SURFACE

30. When water molecules leave the ______________ of the water, we say that the liquid is changing to a vapor. This process is called evaporation (e-VAP-uh-RAY-shun).

11. MOLECULES

12. This experiment shows that ______________________________

____

____

30. SURFACE

31. As well as leaving the surface, molecules in boiling liquid leave the liquid and pass into the ______________ within the liquid.

12. MOLECULES LEAVE A LIQUID'S SURFACE THEREBY CHANGING THE LIQUID INTO A VAPOR THAT FLOATS IN THE AIR.

13. The vapor is made up of molecules that contain kinetic (kin-NET-ick) energy. The k__________ e__________ is heat.

31. BUBBLES

32. In the evaporation of water, molecules escape only from the surface and pass into the atmosphere to form __________.

13. KINETIC ENERGY

14. When the molecules leave a liquid's surface and pass into the atmosphere they carry their kinetic energy or h______ with them.

32. VAPOR

33. The process whereby a liquid changes to a vapor at the liquid's surface and floats in the atmosphere is called ______________.

14. HEAT

15. Kinetic energy is heat and when molecules containing kinetic energy leave a liquid's surface they lower its ____________ by removing some of its heat.

33. EVAPORATION

34. Select an example of evaporation and an example of boiling water from the list below.

(a) A container of water drying up.

(b) Water vapor changing into water droplets.

(c) A river flowing rapidly to the sea.

(d) A pot of bubbling water on a hot stove.

(e) The formation of clouds.

Evaporation ________________________

Boiling water ________________________

15. TEMPERATURE

16. Because a liquid loses some of its heat and becomes cooler in the process of changing to a vapor, the process can be said to be a ______________ one.

34. EVAPORATION (a) A CONTAINER OF WATER DRYING UP
BOILING WATER (b) A POT OF BUBBLING WATER ON A HOT STOVE.

35. Now you must clean up after your experiment.
    (a) Pour the duplicating fluid from the beaker back into the bottle.
    (b) Screw the stopper on the bottle.
    (c) Take a paper towel and dry off the beaker and desk if necessary.
    (d) Place the bottle of duplicating fluid and beaker in your kit.
    (e) Close the kit.

16. COOLING

17. You can prove that the changing of a liquid to a vapor is a cooling process by following these instructions.

(a) Place your finger in the duplicating fluid.

(b) Remove your finger and blow on it.

Your finger now feels wet and ____________.

35. GOOD. NOW YOU HAVE CLEANED UP AFTER YOUR EXPERIMENT.

36. Evaporation, warm air rising, condensation (KON-den-SAY-shun), and precipitation (perh-SIP-ih-TAY-shun) are steps in the water cycle. The part of the water cycle you studied today was ______________.

17. COOL

18. The molecules are leaving the duplicating fluid's surface on your finger, taking their heat with them and thereby lowering the temperature of the fluid remaining on your finger. Therefore, your finger felt wet and _______.

36. EVAPORATION

STOP. THIS IS THE END OF MODULE ONE. NEXT DAY BEGIN ON PAGE ONE OF MODULE TWO.

18. COOL

19. Tell why the changing of a liquid to a vapor is a cooling process. ______________________________

____

TURN TO THE BOTTOM HALF OF PAGE ONE TO FIND THE CORRECT ANSWER.

MODULE II

1. The air over any warm object becomes warm and rises. Because of this we say that w_________ a_________ rises.

22. WARM AIR

23. There are more molecules in a cubic foot of cool air then there are in a cubic foot of warm air. Therefore, because there are more molecules in it, the cubic foot of cool air weighs more than the cubic foot of __________ air.

1. WARM AIR

2. Any situation in which air is warmed and ______________ can be used as an example of warm air rising.

23. WARM

24. When the molecules in a substance are far apart the substance is said to be not so dense as when the molecules are close together. Therefore, we can say that warm air is not so ____________ as cool air.

2. RISES

3. On a calm day smoke from a fire ____________.

24. DENSE

25. Because a cubic foot of warm air is not so dense as a cubic foot of cool air it weighs ____________ than the cool air.

3. RISES

4. Smoke rising from a fire is an example of ______________ ______________ ______________.

25. LESS

26. Cool air settles close to the ground and is therefore able to move in u______________ the warm air.

4. WARM AIR RISING

5. The w__________ __________ over the fire is forced to rise by cold air moving underneath it from all sides of the fire.

26. UNDER

27. As the cool air moves underneath the warm air, the warm air is forced to __________.

5. WARM AIR

6. Is air escaping from an automobile tire an example of warm air rising? ______________

27. RISE

28. Explain why warm air rises above cool air.

____

6. NO

7. Water droplets rising from a boiling pot is another indication that ________________.

28. COOL AIR WEIGHS MORE THAN WARM AIR AND SO THE COOL AIR MOVES UNDERNEATH IT FORCING IT TO RISE.

29. The sun's rays are absorbed by the earth, the earth becomes warm and causes the air above it to become ____________.

7. WARM AIR RISES

8. List one example of warm air rising.

____

29. WARM

30. As one goes higher and higher into the atmosphere there are fewer and fewer particles to absorb the sun's rays and cause heat. Therefore, the higher one goes up in the atmosphere the c__________ it gets.

8. WATER DROPLETS RISING FROM A BOILING POT, OR SMOKE RISING FROM A FIRE.

9. You can set up an experiment to prove that warm air rises. In order to perform this experiment you must read the following instructions carefully and follow directions. You must also keep this paper with you at all times.

   (a) Go to the kit containing your materials.

   (b) Open the kit.

   (c) Remove the candle, saucer, and box of matches from the kit.

   (d) Return to your seat, taking the instructions, candle, saucer, and box of matches with you.

   (e) Place all the materials on your desk.

30. COOLER

31. The higher up in the atmosphere you go the cooler it gets, therefore, the higher up the warm moist air goes the ______________ it gets.

9. GOOD, NOW YOU SHOULD HAVE THE CANDLE, SAUCER, AND BOX OF MATCHES PLACED ON YOUR DESK.

10. (f) Place the candle upright in the center of the saucer.

(g) Take one match from the box and light the candle.

(h) Now blow out the match.

(i) Place the match in the saucer near the base of the candle.

31. COOLER

32. What happens to warm air when it rises? ____________________
____

10. GOOD, NOW YOU HAVE THE CANDLE PLACED IN THE SAUCER AND LIT AND THE MATCH BLOWN OUT.

11. (j) Now place your left hand about six inches above the candle.

(k) When your left hand begins to feel warm remove it.

(l) Place your right hand about six inches off to the side of the candle.

32. WHEN WARM AIR RISES IT COOLS OFF.

33. From the following items select an example of warm air rising:

(a) Rain falling on a plain,

(b) A liquid changing to a vapor,

(c) Air escaping from an automobile tire,

(d) Smoke rising from a fire.

---

11. GOOD

12. How did your left hand feel before you removed it from above the candle? ______________

33. SMOKE RISING FROM A FIRE.

34. The last day you learned about evaporation, the process whereby a liquid is changed to a vapor. Today you learned about w__________ a__________ r__________.

12. WARM

13. In order for your left hand to feel warm the air around the fire on the candle had to become warm and ________ up to your hand.

34. WARM AIR RISING

35. E__________ and w__________ a__________ rising are steps in the water cycle.

13. RISE

14. Your right hand off to the side of the candle continued to feel cool because it was surrounded by ____________ air.

35. EVAPORATION, WARM AIR

36. When warm air moves but not in a direction that is straight upward, we say that the warm air is moving in a lateral (LAT-er-al) direction. When currents or streams of air in the atmosphere move across the earth's surface we say that they are moving in a l__________ direction.

14. COOL

15. What happened to the air around the fire on the candle?

____

36. LATERAL

37. Moisture in the atmosphere may be moved from one place to another. Therefore, evaporation of water can occur in one place and the same water fall to the earth's surface in ____________ place.

15. IT BECAME HEATED AND ROSE.

16. Now follow these instructions carefully.

(a) Blow out the candle.

(b) Make sure the candle is out by rubbing the burnt end on the saucer. Wait a short time to make sure the fire is really out.

(c) Take a paper towel and use it to clean out the saucer.

(d) Place the towel in the garbage container.

(e) Now place the candle, saucer, and box of matches in the kit.

37. ANOTHER

38. Currents or streams of air in the atmosphere move moisture from one area to another and the direction of the movement is not always a straight upward one. Therefore, ___________ in the atmosphere is able to be carried from one place to another by air currents.

16. GOOD. NOW YOU HAVE CLEANED UP AFTER YOUR EXPERIMENT BY PLACING THE CANDLE, SAUCER, AND BOX OF MATCHES IN THE KIT.

17. This experiment proves ______________________.

38. MOISTURE

39. Clouds moving across the sky is an example of the lateral movement of moisture in the at______________.

17. THAT HEATED AIR RISES.

18. When gases are warmed they expand. The air is a mixture of many gases and therefore when the air is heated it e________________.

39. ATMOSPHERE

40. The lateral movement of the clouds is caused by the l________________ movement of air currents in the atmosphere.

18. EXPANDS

19. Expansion is caused by the molecules in a substance moving further apart. Therefore, when the air is heated the ____________ in it move further apart.

40. LATERAL

41. The lateral movement of currents or streams of air in the atmosphere cause the moisture in the air to m____________ in a lateral direction.

19. MOLECULES

20. When the air is heated it expands because the molecules in it move ____________ ____________.

41. MOVE

42. Why is there a lateral movement of moisture in the atmosphere? ______________________________

____

20. FURTHER APART

21. Explain what happens when air is heated. ____________

____

42. BECAUSE CURRENTS OR STREAMS OF AIR IN THE ATMOSPHERE MOVE THE MOISTURE IN A LATERAL DIRECTION.

STOP. THIS IS THE END OF MODULE TWO. NEXT DAY BEGIN ON PAGE ONE OF MODULE THREE.

21. THE AIR EXPANDS BECAUSE THE MOLECULES IN IT MOVE FURTHER APART.

22. The molecules in ______________ are further apart than in cold air.

TURN TO THE BOTTOM OF PAGE ONE TO FIND THE CORRECT ANSWER.

MODULE III

1. The changing of a liquid at its surface to a vapor is called evaporation. Therefore, when water changes to a vapor at its surface we call it ____________.

23. CLOUDS

24. When clouds are formed invisible water vapor has changed into visible w____________ d____________ that can be seen.

1. EVAPORATION

2. When a substance changes from its liquid form to a vapor it becomes invisible. In order for it to become visible again it must change from a vapor back to its ____________ form.

24. WATER DROPLETS

25. From the following list select one example of water vapor and one example of water droplets.

(a) Clouds floating high in the sky.

(b) Rain falling to the earth's surface.

(c) A boiling kettle.

(d) Water molecules leaving the water's surface.

(e) Water flowing over a field.

Water vapor ____________________

Water droplets ____________________

2. LIQUID

3. When water changes from a liquid to a vapor we call the vapor that is formed w__________ v__________.

25. WATER VAPOR (d) WATER MOLECULES LEAVING THE WATER'S SURFACE

WATER DROPLETS (a) CLOUDS FLOATING HIGH IN THE SKY.

26. We call the process whereby a vapor changes to a liquid, condensation. Therefore, when water vapor changes to water droplets we call it con__________.

3. WATER VAPOR

4. Water vapor in a room sometimes comes into contact with a cold window pane. When this happens water droplets are formed. The formation of water droplets on the window pane is an example of water vapor that has changed back to a _____________.

26. CONDENSATION

27. Evaporation is the changing of a liquid to a vapor at the liquid's surface. Therefore, when water changes to water molecules or vapor at the water's surface we call the process _____________.

4. LIQUID

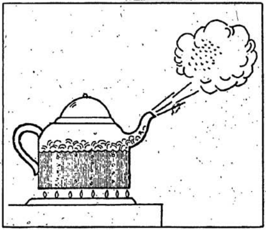
5. Clouds are formed by billions and billions of tiny droplets of water. These tiny droplets have changed from water vapor to liquid. The formation of c__________ is therefore an example of vapor changing to a liquid.

27. EVAPORATION

28. An example of water vapor changing to a liquid is the formation of clouds. Therefore, the formation of clouds is an example of __________.

5. CLOUDS

6.



The diagram above shows water vapor from a kettle changing to ________________

28. CONDENSATION

29. Condensation is a process whereby ______________________

____

6. STEAM OR WATER DROPLETS OR LIQUID

7. Is rain falling to the earth's surface an example of water vapor changing to a liquid? ______________

29. A VAPOR CHANGES TO A LIQUID.

30. When molecules leave the surface of a substance and float in the air we call it evaporation. Therefore, when water molecules leave the water's surface and float in the air we call it ________________.

7. NO

8. List one example of water vapor changing to a liquid.

____

30. EVAPORATION

31. A pool of water drying up, perfume molecules leaving the perfume and passing into the air, and duplicating fluid drying up are all examples of ____________.

8. CLOUD FORMATION, OR WATER DROPLETS FORMING OVER A KETTLE, OR WATER DROPLETS FORMING ON A WINDOW PANE.

9. In order to set up an experiment to show that water vapor changes back to a liquid you must read the following instructions carefully and follow directions. You must also keep these instructions with you throughout the experiment.

(a) Go to the kit containing your materials.
(b) Open the kit.
(c) Remove the container marked beaker.
(d) Go to the refrigerator and remove eight ice cubes.
(e) Place the ice cubes in the beaker.
(f) Go to the sink and half fill the beaker with cold water.

31. EVAPORATION

32. From the items listed below select the process of evaporation and the process of condensation.

(a) Vapor forming within bubbles in boiling water.
(b) Moisture falling to the earth's surface.
(c) The changing of water vapor to water droplets.
(d) Warm air being forced to rise.
(e) The changing of a liquid to a vapor at the liquid's surface.

The process of Evaporation ______________________________

____

The process of Condensation ______________________________

____

9. GOOD. NOW YOU SHOULD HAVE A BEAKER CONTAINING ICE CUBES AND WATER.

10. (g) Now return to your seat and place the beaker on your desk.

(h) Look carefully at the outside of the beaker below the water level.

32. THE PROCESS OF EVAPORATION IS (a) THE CHANGING OF A LIQUID TO A VAPOR AT THE LIQUID'S SURFACE.
THE PROCESS OF CONDENSATION IS (c) THE CHANGING OF WATER VAPOR TO WATER DROPLETS.

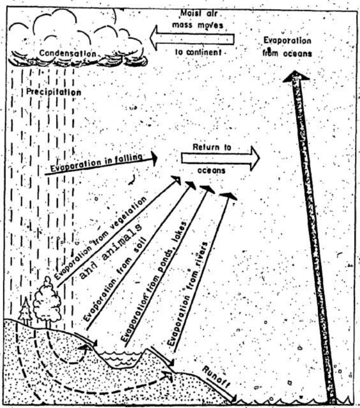
33. Precipitation, vegetation, soil, animals, ponds, lakes, rivers, and oceans are all sources of water. They permit water molecules to leave their surfaces and pass into the air and are therefore sources of e____________.

10. GOOD. NOW WAIT TWO OR THREE MINUTES.

11. The small droplets of water you see on the bottom half of the beaker are called w__________ d__________.

33. EVAPORATION

34.



The diagram shows the sources of evaporation. List the places where evaporation takes place. __________, __________, __________, __________, __________, __________, __________, __________.

11. WATER DROPLETS

12. The warm air in the room came into contact with the ____________ surface of the beaker.

34. PRECIPITATION, VEGETATION, SOIL, ANIMALS, PONDS, LAKES, RIVERS, OCEANS.

35. List three sources of evaporated water. ____________ ____________ ____________.

12. COLD

13. Cool air cannot hold as much water vapor as warm air. The cooler air becomes the less w__________ v__________ it can hold.

35. ANY THREE OF THESE: PRECIPITATION, VEGETATION, SOIL, ANIMALS, PONDS, LAKES, RIVERS, AND OCEANS.

36. Precipitation may evaporate in the air before it falls to the __________ surface.

13. WATER VAPOR

14. As the air becomes cooler the water molecules in it go together to form tiny droplets of 1 __________.

36. EARTH'S

37. The reason some precipitation might not reach the earth's surface is that it __________ _____ _____ __________.

14. LIQUID

15. The warm air near the beaker was cooled and could not hold as much ____________ ____________.

37. EVAPORATES IN THE AIR

38. Summer, autumn, winter, and spring repeatedly (re-PEET-ed-ly) follow each other always in the same o__________.

15. WATER-VAPOR

16. The water vapor in the air near the beaker cooled off and droplets of water formed on the surface of the beaker. These droplets of water are called ____________ ____________.

38. ORDER

39. Summer, autumn, winter, and sp__________ repeatedly follow each other in the same order.

16. WATER DROPLETS

17. This experiment shows that ______________________________

____

39. SPRING

40. Automobiles passing on a street are not an example of a cycle because they do not repeatedly follow each other in the same ____________.

17. WATER VAPOR CAN CHANGE TO A LIQUID.

18. The higher up in the air one goes the cooler it gets. Therefore, as warm moist air goes higher the ________ it gets.

40. ORDER

41. An example of a series of events that repeatedly follow each other always in the same order is
   (a) Water droplets forming on a window pane.
   (b) Cars passing on a street.
   (c) The seasons of the year.
   (d) The rapids in a river.

18. COOLER

19. As the air becomes cooler the water vapor in it will change to a liquid around particles to form water droplets. Therefore, as warm air rises and becomes cooler __________ __________ are formed.

41. (c) THE SEASONS OF THE YEAR

42. A series of events that repeatedly follow each other always in the same order are referred to as a cycle. Because the seasons of the year repeatedly follow each other always in the same order they can be used as an example of a __________.

19. WATER DROPLETS

20. Warm air rising carries invisible water vapor with it. As the air cools the invisible water vapor in it changes to a 1 ________ called water droplets.

42. CYCLE

43. What is a cycle? ____

____

____

20. LIQUID

21. The water droplets that form because a vapor changes to a liquid are very tiny and can be supported by the air. They therefore remain up in the ____________.

43. A SERIES OF EVENTS THAT REPEATEDLY FOLLOW EACH OTHER ALWAYS IN THE SAME ORDER.

44. Now clean up after your experiment by following these instructions.

(a) Take the beaker of ice water, and empty it into the sink.

(b) Take a paper towel and dry out the beaker.

(c) Place the beaker in the kit.

(d) Close the kit.

21. AIR

22. If the air continues to get cooler, the water vapor in it will continue to change to a liquid and the water droplets will grow la__________.

44. GOOD, NOW YOU HAVE CLEANED UP AFTER YOUR EXPERIMENT.

45. Condensation is another step in the water cycle. Evaporation, warm air rising, and condensation are three steps in the water cycle that always occur in the same o__________.

22. LARGER

23. Clouds are formed by water droplets. Therefore, billions and billions of water droplets floating high above the earth's surface form ____________.

TURN TO THE BOTTOM OF PAGE ONE TO FIND THE CORRECT ANSWER.

45. ORDER

STOP. THIS IS THE END OF MODULE THREE. NEXT DAY BEGIN ON PAGE ONE OF MODULE FOUR.

MODULE IV

1. Moisture sometimes falls to the earth's surface. Rain is moisture and is therefore an example of moisture falling to the earth's ________.

23. RAIN

24. Rain is unfrozen moisture that falls to the earth's ________.

1. SURFACE

2. Snow is moisture and is another example of ____________ falling to the earth's surface.

24. SURFACE

25. Unfrozen moisture falls to the earth when the temperature of the layer of air next to the earth is above 0° Celsius. This unfrozen moisture is called rain. Therefore, when the temperature of the layer of air next to the earth's surface is above 0° Celsius ____________ falls.

2. MOISTURE

3. Dust is not moisture and is therefore ____________ an example of moisture falling to the earth's surface.

25. RAIN

26. Why does rain fall? ______________________________

____

3. NOT

4. Frozen rain is moisture and is yet another example of moisture falling to the earth's ____________.

26. BECAUSE THE TEMPERATURE OF THE LAYER OF AIR NEXT TO THE EARTH'S SURFACE IS ABOVE 0° CELSIUS WHEN WATER DROPLETS ARE FALLING.

27. The air around the earth is made up of warm and cold layers. Therefore, the air is made up of layers that have different t____________.

4. SURFACE

5. List one example of moisture falling to the earth's surface. ______________

27. TEMPERATURES

28. The temperature at one level may be above the freezing point and at another level it may be below the ______________ point.

5. ANY ONE OF THE FOLLOWING IS CORRECT - RAIN, FROZEN RAIN, SNOW.

6. Dust particles and water molecules are able to float in the air because the air is able to support them. Also, tiny droplets of water are able to ____________ in the air because the air is able to support them.

28. FREEZING

29. If the temperature of a falling droplet of water is lowered below the freezing point and the droplet does not freeze it is said to be supercooled. This means that water droplets reaching the earth's surface might be ____________ if they passed through a cold layer of air.

6. FLOAT

7. Billions and billions of these tiny water droplets float in the air and form __________ that sometimes shut out the sun.

29. SUPERCOOLED

30. If a supercooled droplet of water strikes a particle in the air it freezes. Also, when it strikes the surface of the earth it __________.

7. CLOUDS

8. Clouds are able to float in the air because they are made up of tiny water d__________ that are able to be supported by the air.

30. FREEZES

31. Moisture that freezes when it comes into contact with the earth's surface is called frozen rain. Therefore, supercooled moisture when it strikes the earth's surface and freezes becomes __________ __________.

8. DROPLETS

9. Why are clouds able to float high in the air? ____________

____

31. FROZEN RAIN

32. What causes frozen rain? ____________________

____

9. BECAUSE THEY ARE MADE UP OF TINY WATER DROPLETS THAT THE AIR IS ABLE TO SUPPORT.

10. As the warm air continues to get cooler, the water vapor in it continues to form water droplets around particles. Therefore, the tiny droplets of water increase in size to form l________ d________.

32. FROZEN RAIN OCCURS WHEN WATER DROPLETS THAT HAVE BEEN SUPERCOOLED STRIKE THE EARTH'S SURFACE AND FREEZE ON CONTACT.

33. Frozen rain, snow, and rain are examples of moisture falling to the earth's surface. The term used to describe moisture falling to the earth's surface is precipitation. Therefore, we say that frozen rain, snow, and rain are examples of p________.

10. LARGER DROPLETS

11. Tiny droplets of water are not very heavy and therefore are supported by the ____________.

33. PRECIPITATION

34. In order for precipitation to occur moisture must fall to the earth's ____________.

11. AIR

12. The large droplets of water are too heavy for the air to support so they ____________ to the surface of the earth.

34. SURFACE

35. If molecules of water leave the surface of a pool of water and pass into the atmosphere we call the process evaporation. In the process of evaporation moisture does not fall to the earth's surface. Therefore, evaporation is not an example of p____________.

12. FALL

13. Why do large droplets of water fall to the earth's surface?

____

35. PRECIPITATION

36. Condensation occurs when a vapor changes to a liquid. When precipitation occurs moisture falls to the earth's surface. Is condensation an example of precipitation?

____

13. BECAUSE THEY ARE TOO HEAVY FOR THE AIR TO SUPPORT.

14. In order to set up an experiment to show that moisture falls to the earth's surface you must read the following instructions carefully and follow directions. You must keep these instructions with you throughout the experiment.

(a) Go to the kit containing your materials.
(b) Remove the container marked flask from the kit.
(c) Remove the beaker and saucer.
(d) Also remove the two-holed stopper that has the two delivery tubes and rubber tubes attached.
(e) Next remove the plastic (PLAS-tik) bag, small piece of wire, and roll of scotch tape.
(f) Now take all the materials you have removed from the kit to your desk.
(g) Place all the materials on your desk.

36. NO

37. From the following processes select an example of precipitation.

(a) Warm air rising,

(b) Vapor changing to a liquid,

(c) Moisture falling to the earth's surface,

(d) A liquid changing to a vapor.

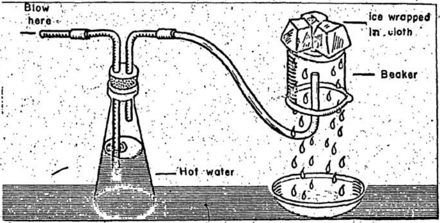
14. NOW YOU SHOULD HAVE A FLASK, BEAKER, SAUCER, TWO-HOLED STOPPER WITH ATTACHMENTS, PLASTIC BAG, SMALL PIECE OF WIRE, AND ROLL OF SCOTCH TAPE ON THE TOP OF YOUR DESK.

15. (h) Take the plastic bag; go to the refrigerator; and place ten ice cubes in it.
(i) Wrap the piece of wire around the mouth of the bag and place it on your desk.
(j) Now take the flask and pour hot water from the tap into it until it is half full.
(k) Next place the flask on your desk.

37. (c) MOISTURE FALLING TO THE EARTH'S SURFACE.

38. Some of the precipitation that falls to the earth flows to the lower levels of the earth's surface. This shows that moisture flows over part of the earth's ________.

15. WHEN YOU PUT THESE MATERIALS TOGETHER THEY SHOULD LOOK LIKE THE ARRANGEMENT IN THIS DIAGRAM.



16. (l) Put the two-holed stopper in the flask. Notice that one delivery tube extends down into the water and that the other does not.
(m) Tape the end of the rubber tubing to the inside of the beaker. Be careful you do not close off the end of the rubber tube.
(n) Place the bag of ice on the bottom of the beaker.
(o) Now turn the beaker upside down so that the bag of ice is on top.
(p) Hold the beaker above the saucer.
(q) Now blow gently into the short rubber hose. Do this several times.
(r) Notice that droplets of water are forming on the inside of the beaker.
(s) Continue to blow into the rubber tube until water droplets fall from the beaker into the saucer.

38. SURFACE

39. The name given to moisture flowing across the earth's surface is surface flow. Therefore, when moisture flows over the earth's surface to lower levels we call it ______ ______.

16. THESE DROPLETS ARE MOISTURE FALLING INTO THE SAUCER.

17. The water droplets falling into the saucer can be compared to moisture falling to the earth's ____________.

39. SURFACE FLOW

40. A stream flowing down a hillside is an example of ____________ ____________.

17. SURFACE

18. This experiment can be used to show ____________________

____________________.

40. SURFACE FLOW

41. After a small amount of rainfall we get a small amount of surface flow. After a large amount of rainfall we get a ____________ amount of surface flow.

18. MOISTURE FALLING TO THE EARTH'S SURFACE.

19. In the experiment the water droplets on the inside of the beaker became too heavy for the air to support so they ______________ into the saucer.

41. LARGE

42. In order for moisture on the earth to find its way to lower levels of the earth's surface it sometimes flows over the s______________ of the earth.

19. FELL

20. If water vapor condenses at a temperature below 0° Celsius snow forms. Also, in order for snow to fall the temperature of the layer of air next to the earth's surface must be below __________.

42. SURFACE

43. How does some of the moisture that falls on a hill get into a lake in the valley below?

____

20. 0° CELSIUS

21. If the temperature of the layer of air next to the earth's surface is below 0° Celsius moisture falls to the earth's surface in the form of ______________.

43. BY FLOWING OVER THE EARTH'S SURFACE OR BY FLOWING DOWN A HILLSIDE.

44. Evaporation, warm air rising, condensation, and precipitation are steps in the water cycle. Therefore, precipitation is part of the w______________ c______________.

21. SNOW

22. Why does snow fall? ______________________________

____

44. WATER CYCLE

45. Now follow these instructions in order to put away the materials you just used in your experiment.

(a) Remove the two-holed stopper from the flask.

(b) Remove the tape from the inside of the beaker.

(c) Now take the flask and pour the water from the flask, into the sink.

(d) Take the ice out of the bag and place it in the sink.

(e) Fold up the bag and place the wire around it.

(f) Now take a paper towel and dry off the saucer and beaker.

(g) Good. Now take the bag, roll of tape, saucer, beaker, two-holed stopper, attachments, and flask back to the kit.

(h) Place all the materials in the kit and the paper towel in the garbage.

(i) Good. Now you have cleaned up after your experiment.

STOP. THIS IS THE END OF MODULE FOUR. NEXT DAY BEGIN ON PAGE ONE OF MODULE V.

22. BECAUSE THE TEMPERATURE OF THE LAYER OF AIR NEXT TO THE EARTH'S SURFACE IS BELOW 0° CELSIUS.

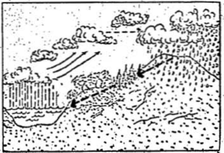
23. If the temperature of the layer of air next to the earth's surface is above 0° Celsius the water droplets fall to the earth in their liquid form, which is called rain. Therefore, when the temperature of the layer of air next to the earth's surface is above 0° Celsius ____________ falls.

TURN TO THE BOTTOM HALF OF PAGE ONE TO FIND THE CORRECT ANSWER.

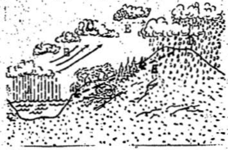
MODULE V

1. So far in this program you have learned about the four steps in the water cycle. They are evaporation, warm air rising, condensation, and precipitation. How many steps are there in the water cycle? ____________

17.



18. Here is another diagram of the water cycle.



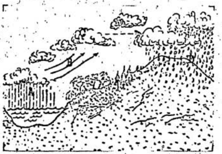
Now identify the symbol for lateral movement in the diagram of the water cycle by placing its letter in this space. ______

1. FOUR

2. The processes of evaporation, warm air rising, condensation, and precipitation are steps in the water cycle that repeatedly follow each other always in the same order. Therefore, if we start with evaporation the next step in the water cycle is ______________.

18. E

19. Here is the diagram of the water cycle again.



Now match the names of the steps in the water cycle with the letters in the diagram.

A. ______________ B. ______________

C. ______________ D. ______________

2. WARM AIR RISING

3. The next step in the water cycle is condensation. If we were to write three steps in the water cycle in their order of occurrence we would write evaporation, warm air rising, and ______________.

19. A. EVAPORATION, B. WARM AIR RISING, C. CONDENSATION D. PRECIPITATION.

20. Draw a diagram of the water cycle in the space provided, letter it, and write the name of each step in the space provided.

A. ______________

B. ______________

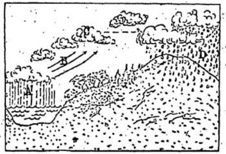
C. ______________

D. ______________

3. CONDENSATION

4. The four steps in the water cycle are complete when we include the process of precipitation. The four steps in the water cycle are evaporation, warm air rising, condensation, and ______________.

20.



A. EVAPORATION
B. WARM AIR RISING
C. CONDENSATION
D. PRECIPITATION

21. In order to set up an experiment to show the principle of the water cycle you must read the following instructions carefully and follow directions, You must also keep these instructions with you during the experiment.

(a) Go to the kit containing your materials.

(b) Remove the container marked florence flask.

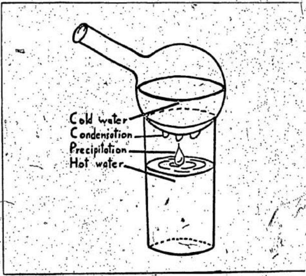
(c) Remove the beaker.

4. PRECIPITATION

5. The steps in the ____________ ____________ in their order of occurrence are evaporation, warm air rising, condensation, and precipitation.

21. NOW YOU HAVE THE BEAKER AND THE FLORENCE FLASK.

22. (d) Take the beaker to the kettle and pour hot water from the kettle into the water until the beaker is half full.
(e) Now pour ice water from the jug into the florence flask until it is half full.
(f) Tip the beaker so as to moisten its sides up to the top.
(g) Now place the florence flask in the beaker at an angle as shown in this diagram.
(h) Place the florence flask and beaker on your desk.



5. WATER CYCLE

6. List the steps in the water cycle in their order of occurrence.

(i) ____________ (water changing to a vapor)

(ii) ____________ (heated air being forced to rise)

(iii) ____________ (water vapor changing to water droplets)

(iv) ____________ (moisture falling to the earth's surface).

22. GOOD. NOW WAIT FOR TWO OR THREE MINUTES.

23. In the experiment water leaves the surface of the hot water. This is called e____________.

6. (i) EVAPORATION, (ii) WARM AIR RISING, (iii) CONDENSATION (iv) PRECIPITATION

7. Now see if you can list the four steps in the water cycle in their order of occurrence.

(i) ____________

(ii) ____________

(iii) ____________

(iv) ____________

23. EVAPORATION

24. The warm moist air then rises and contacts the cold surface of the ____________ ____________.

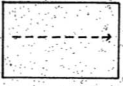
7. (i) EVAPORATION, (ii) WARM AIR RISING, (iii) CONDENSATION (iv) PRECIPITATION

8. Before you can label the steps in a diagram of the water cycle it is first necessary to learn the symbol for each ______________ in the diagram.

24. FLORENCE FLASK

25. When the warm air strikes the flask the water molecules combine on the flask to form ______________ ______________.

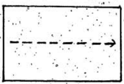
8. STEP

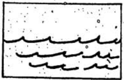
9. The symbol for lateral movement is 

Draw the symbol for lateral movement.

25. WATER DROPLETS

26. The changing of a vapor back to a liquid is called condensation. The changing of water vapor to water droplets on the flask is called ______________.

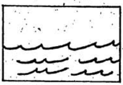
9. 

10. The symbol for water is 

Draw the symbol for water

26. CONDENSATION

27. As condensation continues the water droplets become larger and fall from the flask into the beaker. The falling moisture in nature might be in the form of snow, rain, or frozen rain. We call this falling moisture ____________.

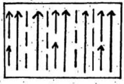
10. 

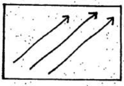
11. The symbol for evaporation is 

Draw the symbol for evaporation.

27. PRECIPITATION

28. The experiment you set up demonstrated the principle of the water cycle because water evaporated, warm air rose, condensation occurred, and precipitation fell. These events can repeat themselves always in the same ____________.

11. 

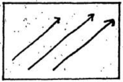
12. The symbol for warm air rising is 

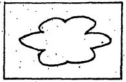
Draw the symbol for warm air rising.

28. ORDER

29. This experiment demonstrates the ______________________________

______________________________.

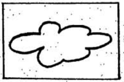
12. 

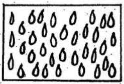
13. The symbol for condensation is 

Draw the symbol for condensation.

29. PRINCIPLE OF THE WATER CYCLE

30. The series of events known as evaporation, warm air rising, condensation, and precipitation repeatedly follow each other always in the same order. When these events occur in nature they are known as the ____________ ____________.

13. 

14. The symbol for precipitation is 

Draw the symbol for precipitation.

30. WATER CYCLE

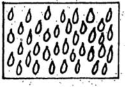
31. An example of the principle of the water cycle as it occurs in nature is.

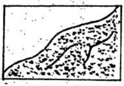
(a) Water condensing on a cold window.

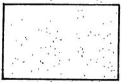
(b) Moisture falling to the earth's surface.

(c) Water vapor condensing to form clouds high in the sky.

(d) Surface water changing to vapor, vapor changing to water droplets, and the droplets falling onto the earth's surface.

14. 

15. The symbol for land is 

Draw the symbol for land. 

31. (d) SURFACE WATER CHANGING TO VAPOR, VAPOR CHANGING TO WATER DROPLETS, AND THE DROPLETS FALLING ONTO THE EARTH'S SURFACE.

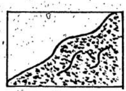
32. Now follow these instructions in order to put away the materials you just used.

(a) Take both the florence flask and the beaker.

(b) Pour the contents of both into the sink.

(c) Take a paper towel and dry both containers.

(d) Throw the paper towel in the garbage.

15. 

16. Draw the symbol for each of the following words.

(1) Water

(2) Evaporation

(3) Warm air rising

(4) Condensation

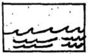
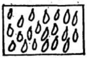
(5) Precipitation

(6) Land

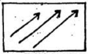
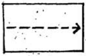
(7) Lateral Movement

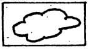
32. GOOD. NOW YOU HAVE CLEANED UP AFTER YOUR EXPERIMENT.

THIS IS THE END OF THE PROGRAMMED UNIT ON THE WATER CYCLE.

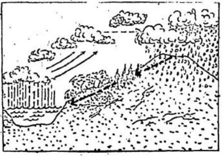
16. (1) WATER  (5) PRECIPITATION 

(2) EVAPORATION  (6) LAND 

(3) WARM AIR RISING  (7) LATERAL MOVEMENT 

(4) CONDENSATION 

17. When the symbols for evaporation, warm air rising, condensation, precipitation, land, water, and lateral movement are put together in a meaningful way they look like this.



Draw the diagram. It is a diagram of the water cycle.

TURN TO THE BOTTOM HALF HALF OF PAGE ONE TO FIND THE CORRECT ANSWER.

APPENDIX F

Posttest

POSTTEST

NAME ______________

You should read the instructions carefully. Answers must be filled in on this sheet. This examination must be completed in thirty minutes.

From the four or five given items select the one that makes the statement correct and place the letter of that item in the brackets at the right.

Sample: The world's mightiest river is the .... (a)
(a) Amazon (b) Nile (c) Volga (d) Mississippi

1. An example of evaporation is a .... ( )
   (a) River flowing to the sea
   (b) Window pane with water droplets forming on it
   (c) Pool of water drying up
   (d) Kettle of boiling water

2. The changing of a liquid into a vapor at the liquid's surface is called .... ( )
   (a) Oxidation (b) Evaporation (c) Combustion (d) Precipitation

3. In evaporation energetic molecules escape from a liquid, thereby lowering its .... ( )
   (a) Temperature (b) Boiling Point (c) Saturation Point (d) Density

4. Five experiments have been set up on the tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the process of evaporation........................... ( )
   (a) Experiment A
   (b) Experiment B
   (c) Experiment C
   (d) Experiment D
   (e) Experiment E

5. Each of the following factors influence the rate of evaporation except .... ( )
   (a) Wind (b) Depth (c) Temperature (d) Surface Area

6. An example of warm air rising is .... ( )

   (a) An aircraft rising from a runway
   (b) Smoke rising from a fire
   (c) Wind making the trees move
   (d) Air escaping from an automobile tire

7. Warm air rises above cold air because warm air is ... ( )

   (a) Drier than cold air
   (b) Denser than cold air
   (c) Heavier than cold air
   (d) Lighter than cold air

8. When air is heated it .... ( )

   (a) Falls (b) Contracts (c) Settles (d) Expands

9. Five experiments have been set up on tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that proves warm air rises .... ( )

   (a) Experiment A
   (b) Experiment B
   (c) Experiment C
   (d) Experiment D
   (e) Experiment E

10. An example of condensation is .... ( )

   (a) A lake freezing over
   (b) The formation of clouds
   (c) A rainstorm
   (d) The changing of a liquid to a gas

11. When warm air rises it becomes .... ( )

   (a) Drier (b) Thicker (c) Cooler (d) Lighter

12. Five experiments have been set up on the tables at the front of the room. Each experiment has been labelled A,B,C,E, or E. Select the experiment that shows the process of condensation .... ( )

   (a) Experiment A
   (b) Experiment B
   (c) Experiment C
   (d) Experiment D
   (e) Experiment E

13. When condensation occurs water vapor becomes .... ( )

   (a) Gas (b) Rain (c) Solid (d) Water Droplets

14. Water molecules that are invisible and float in the air are called .... ( )

   (a) Water Droplets (b) Water Vapor (c) Atoms (d) Particles

15. There is lateral atmospheric movement of moisture because .... (   )

    (a) Tiny droplets of moisture propel themselves across the sky.
    (b) Moisture in the atmosphere has a tendency to escape into space.
    (c) Currents in the atmosphere carry moisture from one area to another.
    (d) The moisture remains in one place in the atmosphere and it is the earth that moves.

16. An example of a cycle is .... (   )

    (a) The seasons of the year
    (b) The pages in a book
    (c) A series of events
    (d) A waterfall

17. Water is able to leave the surface of animals, lakes, soil, vegetation, oceans, and rivers and pass into the earth's atmosphere by the process of .... (   )

    (a) Precipitation (b) Condensation (c) Evaporation (d) Oxidation

18. Some of the moisture that falls to the earth finds its way to lower levels of the earth's surface by ..... (   )

    (a) Flowing over the land
    (b) Being absorbed into the vegetation
    (c) Evaporating into the atmosphere
    (d) The process of vaporization

19. Some of the moisture that starts falling towards the earth's surface does not reach it. The reason for this is that it .... (   )

    (a) Goes into space (b) Contracts (c) Burns up (d) Evaporates

20. A series of events that repeatedly follow each other in the same order is called a .... (   )

    (a) Cycle (b) Rotation (c) Sequence (d) Circle

21. Five experiments have been set up on the tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the process of precipitation.......................... (   )

    (a) Experiment A
    (b) Experiment B
    (c) Experiment C
    (d) Experiment D
    (e) Experiment E

22. Precipitation falls as snow when the temperature of the layer of air next to the earth's surface is .... ( )

    (a) Below 0° Celsius (c) 16° Celsius
    (b) 30° Celsius (d) Continually changing

23. An example of precipitation is .... ( )

    (a) Water falling over a dam
    (b) The evaporation of perspiration
    (c) A frozen rain storm
    (d) Water evaporating from a lake

24. The process whereby moisture falls from the air to the earth's surfrce is called .... ( )

    (a) Precipitation (b) Combustion (c) Condensation (d) Oxidation

25. Large droplets of water fall toward the earth's surface because .... ( )

    (a) The low temperature forces them to fall,
    (b) Strong winds blow them towards the earth,
    (c) They are too heavy for the air to support,
    (d) The air around them is very light.

26. Clouds are made up of billions of tiny droplets of water that are able to float in the air because .... ( )

    (a) The air supports them,
    (b) Evaporation keeps them up there,
    (c) They tend to fly away into space,
    (d) The sun and moon attract them.

27. When supercooled droplets of water come into contact with the earth's surface they freeze. This type of precipitation is called .... ( )

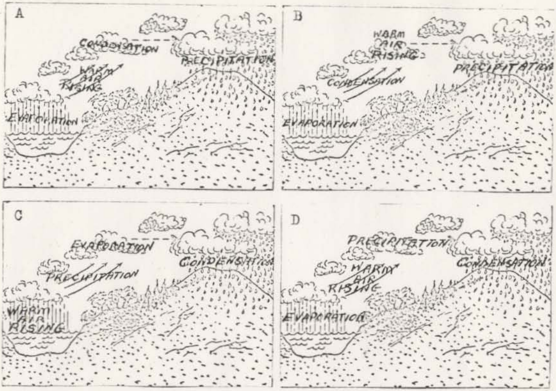
    (a) Snow (b) Dew (c) Rain (d) Frozen rain

28. If the temperature of the layer of air next to the earth is above 0° Celsius and moisture falls to the earth's surface it falls as .... ( )

    (a) Snow (b) Dew (c) Rain (d) Frozen rain

29. An example of the principle of the water cycle is.... ( )

    (a) Water evaporating, then the water vapor rising high in the sky to form clouds.
    (b) Surface water changing to vapor, the vapor changing to water droplets, and the water droplets falling to the earth's surface
    (c) Water droplets forming on the window pane.
    (d) A river flowing into a lake.

30. 

From the four diagrams above select the one that best represents the water cycle as it is found in nature . (   )

(a) Diagram A (b) Diagram B
(c) Diagram C (d) Diagram D

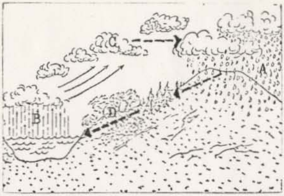
31. The principle of the water cycle is made up of a series of steps that repeatedly follow each other in the same order. Identify the correct order. .... (   )

(a) Evaporation, Warm air rising, Condensation, Precipitation
(b) Precipitation, Condensation, Evaporation, Warm air rising
(c) Warm air rising, Evaporation, Condensation, Precipitation
(d) Condensation, Evaporation, Warm air rising, Precipitation

32. Five experiments have been set up on the tables at the front of the room. Each experiment has been labelled A,B,C,D, or E. Select the experiment that shows the water cycle .... (   )

(a) Experiment A
(b) Experiment B
(c) Experiment C
(d) Experiment D
(e) Experiment E

33.



In the diagram above select the letter that shows surface flow. .... (   )

(a) Letter B (b) Letter C (c) Letter D (d) Letter A

APPENDIX G

Words Selected and Looked Up in The Thorndike-Lorge Word List

The following is a list of the words that were selected from the program and looked up in the Thorndike and Lorge Word List in order to see if they were appropriate for grade seven students. Each word is followed by the number or letters that followed it in the column labelled, General Type of Reading Material. The number or letters that follow each word indicate its occurrences per million words. One equals at least one occurrence per million and not so many as two per million; two equals at least two occurrences per million and not so many as three per million; and similarly up to forty-nine; A equals at least fifty per million and not so many as one hundred per million; AA Equals one hundred or over per million.

1. Substance	A	15. Prove	AA
2. Change	AA	16. Duplicating	8
3. Liquid	31	17. Fluid	15
4. Vapor	27	18. Temperature	A
5. Atmosphere	38	19. Instructions	45
6. Billion	11	20. Materials	5
7. Particle	17	21. Kit	10
8. Molecule	3	22. Container	8
9. Perfume	21	23. Beaker	1
10. Float	A	24. Kinetic	not listed
11. Example	AA	25. Energy	41
12. Diagram	6	26. Influences	A
13. Combine	A	27. Process	A
14. Experiment	A	28. Evaporation	6

29.	Formation	19	55.	Refrigeration	11
30.	Necessary	AA	56.	Moist	19
31.	Condensation	3	57.	Moisture	21
32.	Precipitation	2	58.	Vegetation	11
33.	Cycle	8	59.	Sources	A
34.	Object	AA	60.	Repeatedly	6
35.	Situation	A	61.	Series	A
36.	Considered	1	62.	Event	A
37.	Underneath	21	63.	Lateral	5
38.	Automobile	A	64.	Delivery	14
39.	Indication	13	65.	Scotch tape	16
40.	Continued	AA	66.	Attachments	8
41.	Surrounded	A	67.	Plastic	3
42.	Wick	4	68.	Arrangement	45
43.	Expand	15	69.	Saucer	7
44.	Mixture	39	70.	Hose	9
45.	Cubic	8	71.	Compared	A
46.	Dense	19	72.	Different	AA
47.	Explain	AA	73.	Describe	A
48.	Underneath	21	74.	Program	46
49.	Invisible	22	75.	Occurrence	9
50.	Visible	25	76.	Necessary	A
51.	Contact	31	77.	Symbol	17
52.	Formation	19	78.	Identify	20
53.	Items	26	79.	Principle	A
54.	Select	A	80.	Rotate	6
			81.	Demonstrated	16

APPENDIX H

List of Materials Contained In Each Kit

The following is a list of the materials contained in each kit assigned to the students in the experimental group.

	Number	Item
1.	1	Beaker
2.	1	Box of matches
3.	1	Candle
4.	1	Container of duplicating fluid
5.	1	Erlenmeyer Flask
6.	1	Florence Flask
7.	1	Roll of Tape
8.	1	Saucer
9.	1	Two-holed stopper with attachments of glass and rubber tubing.
10.	1	Plastic bag
11.	1	Piece of Wire

12. Instructions to students, practice module, objectives, and modules I, II, III, IV, and V.

APPENDIX I

Unadjusted and Adjusted Pretest Scores

Table 5. Unadjusted and Adjusted Scores Obtained by the Grade Seven Class on the Pretest.

Students	Unadjusted Scores	Adjusted Scores
1	14	8
2	16	11
3	24	21
4	21	17
5	15	9
6	19	16
7	14	9
8	10	2
9	12	5
10	17	12
11	14	7
12	17	12
13	16	11
14	19	15
15	15	11
16	20	16
17	10	4
18	13	7
19	13	6
20	20	16
21	11	4
22	15	9
23	12	5
24	14	8
25	15	11
26	28	27
27	14	8
28	11	4
29	12	5
30	20	17

APPENDIX J

Instructions To Students

INSTRUCTIONS FOR STUDENTS

Read the following instructions carefully. If necessary, you may read the instructions a second time in order to make sure that you understand them.

In each module (MOD-ul) or section of study you are to use the kit that has been given to you. In the kit you will find five modules. You are to use one module each day for five days. You are to use module one on the first day, module two on the second day, and so on until you have finished module five on the fifth day. Also, in the kit you will find the things to be used in setting up the experiments that are described in the modules.

Read the frame or statement on the top of page one. Fill in the blank and turn to page two in order to find the correct answer. Next, read the frame on the top of page two, fill in the blank and turn to page three in order to find the correct answer. When you get to the middle of each module, you will be told to turn to the bottom half of page one in order to find the correct answer. Then, proceed along the bottom half of the pages until you arrive at the end of each module.

A few of your answers might be wrong. However, do not worry about it. Learn the correct answer and continue. You may take all the time you need in order to complete each module. Please do not waste time.

The next page in these instructions is the first page in a practice module. Please fill in the blank in the first frame and proceed as directed.

APPENDIX K

Practice Module

PRACTICE MODULE

1. I am a student at Coley's Point Elementary School. This year I am in Grade ______________.

FILL IN THE BLANK. TURN TO THE TOP OF PAGE TWO FOR THE CORRECT ANSWER.

4. CONCEPTION

5. Newfoundland is a province in the country of ____________.

1. SEVEN OR 7.

THIS IS THE ANSWER TO THE QUESTION ON THE TOP OF PAGE 1.

2. I am a grade seven student at ____________ ____________ Elementary School.

THIS TIME PROCEED AS BEFORE.

5. CANADA

6. Newfoundland is a province of Canada, and I live in Newfoundland. Therefore, I also live in ____________.

2. COLEY'S POINT (CORRECT ANSWER)

3. The Coley's Point Elementary School is in the community of ____________ ____________, Conception Bay.

6. CANADA

7. People who live in Canada are called Canadians. I live in Canada. Therefore, I am a ____________.

3. COLEY'S POINT

4. Coley's Point is a community in ____________ Bay, Newfoundland, Canada.

IN ORDER TO FIND THE ANSWER TO THIS QUESTION TURN BACK TO THE BOTTOM HALF OF PAGE ONE.

7. CANADIAN

THIS IS THE END OF THE PRACTICE MODULE. NOW READ THE OBJECTIVES OF THE PROGRAM ON THE NEXT PAGE.

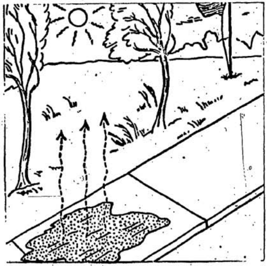
APPENDIX L

Five parallel Modules Given to the
Teacher in the Control Group

MODULE I

A substance changes from a liquid to a vapor and floats in the atmosphere. As this happens many tiny particles of the substance called <u>molecules</u> leave the surface of the liquid and float in the atmosphere as vapor. Perfume is a substance that changes from a liquid in an open bottle to a vapor that floats in the atmosphere. This must happen in order for you to be able to smell the perfume. Vapor is formed when the smallest particles of a liquid called molecules pass from the liquid and float in the atmosphere.

The following <u>diagram</u> is an example of tiny particles of a substance called molecules leaving a liquid's surface and passing into the atmosphere. When a vapor changes into a liquid the molecules do not leave the liquid's surface and float in the atmosphere; rather, they combine to form a liquid.



A pool of water drying up is one example of a liquid changing into a vapor. Another example of a liquid changing into a vapor is molecules of perfume leaving an open bottle of perfume.

You can prove that a liquid changes to a vapor and floats in the air by placing some duplicating fluid in a beaker. When you smell the duplicating fluid it is proof that it is changing from a liquid to a vapor and floating in the atmosphere. Duplicating fluid is used in this experiment because it changes into a vapor faster than water at room temperature and we are able to smell the duplicating fluid.

Draw a diagram of a beaker containing duplicating fluid on the board, and explain what happens in the process of evaporation.

The duplicating fluid changes into a vapor. Tiny particles of the fluid called molecules are leaving its surface and passing into the atmosphere. This experiment proves that molecules leave the surface of a liquid and pass into the atmosphere as vapor.

The vapor is made up of molecules that contain kinetic energy. This kinetic energy is heat and when molecules leave a liquid's surface and pass into the atmosphere they carry their kinetic energy or heat with them. Therefore, when molecules containing kinetic energy leave the surface of a liquid they lower its temperature by removing some of its heat. A liquid loses some of its heat in the process of changing to a vapor and because of this the process can be said to be a cooling one.

You are able to prove that the process whereby a liquid changes to a vapor is a cooling one. This can be done by placing one of your fingers in duplicating fluid, removing your finger, and blowing on it. Your finger feels cool because molecules are leaving the duplicating fluid and taking their heat with them. Therefore, the temperature of the fluid remaining on your finger is lowered. This causes your finger to feel wet and cool.

The changing of a liquid into a vapor is a cooling process because molecules leave the liquid, taking their kinetic energy with them, thereby lowering the liquid's temperature.

As a liquid changes to a vapor billions of tiny particles of moisture pass from the liquid into the atmosphere. When water changes to a vapor the vapor that is formed is called water vapor. Water vapor is made up of billions of water molecules.

Warm atmosphere can hold more water vapor than cool atmosphere. Therefore, the warmer the atmosphere becomes the more water vapor it can hold. If the temperature of the atmosphere is lowered, the rate at which a liquid changes to a vapor is reduced. If the temperature of the atmosphere is raised, the rate at which a liquid is changed to a vapor is increased. Temperature is therefore a factor that influences the rate at which a liquid changes to a vapor.

Water molecules leave the surface of water. If the surface area of the water is large more molecules can leave. Surface area and temperature are two factors that influence the rate at which a liquid can change into a vapor. On a warm sunny day when the wind is blowing, water changes to a vapor faster than when the wind is not blowing. Therefore, a third factor that influences the rate at which liquids change to a vapor is wind.

Three factors that influence the rate at which liquids change to vapor and float in the atmosphere are temperature, surface area, and wind.

If the temperature of a liquid is raised high enough the liquid will begin to bubble. The liquid is then said to be boiling. When water boils molecules leave the water and pass into the bubbles within the water. Also, molecules leave the surface of the water.

When molecules leave the surface of the water, the water is said to be changing into a vapor. This process is called evaporation. In a boiling liquid molecules not only leave the liquid's surface, but also leave the liquid and pass into bubbles within the liquid. In the process of evaporation, molecules leave only the surface of the liquid and pass into the atmosphere to form vapor.

The process whereby a liquid changes to a vapor at the liquid's surface and floats in the atmosphere is called evaporation. An example of evaporation is a container of water drying up. An example of boiling is a pot of bubbling water on a hot stove.

Evaporation, warm air rising, condensation, and precipitation are steps in the water cycle. The part of the water cycle you studied today was evaporation.

MODULE II

The air over any warm object becomes warm and rises. Therefore, it is said that warm air rises. Any situation in which air is warmed and rises can be used as an example of warm air rising. Smoke rising from a fire on a calm day can be taken as an example of warm air rising. The warm air over a fire is forced to rise by cold air moving underneath it from all sides of the fire. Air escaping from an automobile tire is not an example of warm air rising. However, steam rising from a boiling pot is another indication that warm air rises. Examples of warm air rising are steam rising from a boiling pot and smoke rising from a fire.

You can prove that warm air rises by taking a candle, lighting it, placing your left hand over the candle and your right hand off to the side. If you were to do this your left hand would feel warm or hot..

Draw a diagram of a lighted candle on the board and explain what would happen to the air around the candle in a real situation.

In order for your left hand to feel warm the air around the fire on the candle would become warm and rise up to your hand. Your right hand off to the side of the candle would continue to feel cool because it would be surrounded by cool air. This experiment when conducted proves that warm air rises.

When gases are heated they expand. The air is a mixture of many gases and therefore when the air is heated it expands. Expansion is caused by the molecules in a substance moving further apart. Therefore, when the air is heated the molecules in it move further apart, and this causes the air to expand. When the air is heated it expands because the molecules in it move further apart.

The molecules in warm air are further apart than in cold air. There are more molecules in a cubic foot of cool air than there are in a cubic foot of warm air. When the molecules in a substance are far apart, the substance is not so dense as when the molecules are close together. Hence, it can be said that warm air is not so dense as cool air. A cubic foot of warm air is not so dense as a cubic foot of cool air and therefore it weighs less than the cool air.

Cool air settles close to the ground and is able to move underneath the warm air. As the cool air moves underneath the warm air, the warm air is forced to rise. Warm air rises above cool air because the cool air weighs more than warm air. Therefore, cool air moves underneath warm air forcing it to rise.

The sun's rays are absorbed by the earth, the earth becomes warm and causes the air above it to become warm. However, as one goes higher and higher into the atmosphere there are fewer and fewer particles to absorb the sun's rays and cause heat. The higher one goes up in the atmosphere the cooler it gets. Therefore, the higher up in the atmosphere the warm moist air goes the cooler it gets. When warm air rises it cools off.

The last day you learned about evaporation, the process whereby a liquid is changed to a vapor. Today you are learning about warm air rising. Evaporation and warm air rising are steps in the water cycle.

When warm air rises it does not always move straight upward. Instead it may move in a lateral (or sideways) direction. When currents or streams of air in the atmosphere move across the earth's surface we say that they are moving in a lateral direction.

Moisture in the atmosphere may be moved from one place to another. Therefore, evaporation of water can occur in one place and the same water may fall to the earth's surface in another place. Currents or streams of air in the atmosphere carry moisture from one place to another.

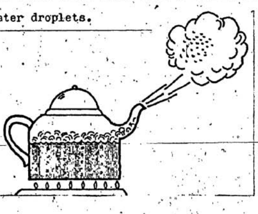
Clouds moving across the sky is an example of the lateral movement of moisture in the atmosphere. The lateral movement of clouds is caused by the lateral movement of the streams of air in the atmosphere. There is a lateral movement of moisture in the atmosphere because currents or streams of air in the atmosphere move moisture in a lateral direction.

MODULE III

The changing of a liquid to a vapor at the liquid's surface is called evaporation. Therefore, when water changes to a vapor at the water's surface it is called evaporation. When a substance changes from its liquid form to a vapor it becomes invisible. In order for it to become visible again a substance must change from a vapor back to its liquid form.

When water changes from a liquid to vapor the vapor that is formed is called water vapor. Water vapor in a room sometimes comes into contact with a cold window pane. When this happens water droplets are formed. The formation of water droplets on the window pane is an example of water vapor that has changed back to a liquid. Clouds are formed by billions and billions of these tiny droplets of water. These tiny droplets have changed from water vapor to liquid. The formation of clouds is, therefore, an example of vapor changing to a liquid. However, rain falling to the earth's surface is not an example of water vapor changing to a liquid.

The following diagram is an example of vapor changing to a liquid. It shows water vapor from a boiling kettle changing to water droplets.



Examples of water vapor changing to a liquid are cloud formation, water droplets forming over a kettle, and water droplets forming on a window pane.

You can prove that water vapor changes back to a liquid by taking eight ice cubes, placing them in a beaker, half filling the beaker with cold water, and waiting two or three minutes. If you were to conduct such an experiment small droplets of water would form on the outside of the beaker.

Draw a diagram of the beaker, containing water and ice cubes, on the board. Explain to the class what happens as water vapor changes to small droplets of water on the surface of the beaker.

The warm air in the room comes into contact with the surface of the beaker. Cool air cannot hold as much water vapor as warm air. The cooler air becomes the less water vapor it can hold. As the air becomes cooler the water molecules in it go together to form tiny droplets of liquid. The warm air near the beaker becomes cooler and is unable to hold as much water vapor. The water vapor in the air near the beaker cools off and droplets of water form on the surface of the beaker. These droplets of water are called water droplets. This experiment when conducted proves that water vapor changes back to a liquid.

The higher up in the air one goes the cooler it gets. Therefore, as warm moist air rises higher the cooler it gets. As the air becomes cooler, the water vapor in it changes to a liquid around tiny particles to form water droplets. Therefore, as warm air rises and becomes cooler water droplets are formed. Warm air rising carries invisible water vapor with it. As the air cools the invisible water vapor in it changes to a liquid called water droplets.

The tiny water droplets that form, because a vapor changes to a liquid, are very small and can be supported by the air. Hence, they remain up in the air. If the air continues to get cooler, the water vapor in it will continue to change to a liquid and the water droplets will grow larger. Billions and billions of water droplets floating high above the earth's surface form clouds. When clouds are being formed invisible water vapor changes to visible water droplets. An example of water vapor is water molecules leaving the water's surface. An example of water droplets is a cloud floating high in the sky.

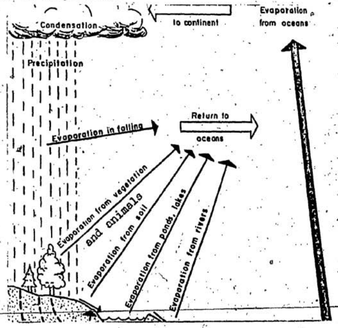
The process whereby vapor changes to a liquid is called condensation. When water vapor changes to water droplets it is condensation. On the other hand, evaporation is the changing of a liquid to a vapor at the liquid's surface. Therefore, when water changes to water molecules or vapor at the water's surface it is called evaporation.

The formation of clouds is an example of water vapor changing to a liquid. The process whereby a vapor changes to a liquid is called condensation.

The process whereby molecules leave the surface of a substance and float in the air is called evaporation. Therefore, when molecules leave the water's surface and float in the air it is called evaporation. A pool of water drying up, perfume molecules leaving the perfume and passing into the air, and duplicating fluid drying up are all examples of evaporation.

An example of the process of condensation is the changing of water vapor to water droplets. An example of the process of evaporation is the changing of a liquid to a vapor at the liquid's surface.

Precipitation, vegetation, soil, animals, ponds, lakes, rivers, and oceans are all sources of water. They permit water molecules to leave their surfaces and pass into the air and are therefore sources of evaporation. The diagram below shows the sources of evaporation.



If one had to list three sources of evaporation any of the following would be acceptable. (i) Precipitation, (ii) Vegetation, (iii) Soil, (iv) Animals, (v) Ponds, (vi) Lakes, (vii) Rivers, (viii) Oceans.

Precipitation may evaporate in the air before it falls to the earth's surface. This means that some of the precipitation that starts falling towards the earth's surface does not reach it. The reason some precipitation might not reach the earth's surface is that it evaporates in the air.

Summer, autumn, winter, and spring repeatedly follow each other always in the same order. Therefore, the seasons of the year are an example of a cycle. Automobiles passing on a street are not an example of a cycle because they do not repeatedly follow each other always in the same order. The seasons of the year repeatedly follow each other always in the same order. Therefore, they can be used as an example of a cycle.

A cycle is a series of events that repeatedly follow each other always in the same order.

The main part of today's lesson dealt with condensation which is another step in the water cycle. Evaporation, warm air rising, and condensation are three steps in the water cycle that always occur in the same order.

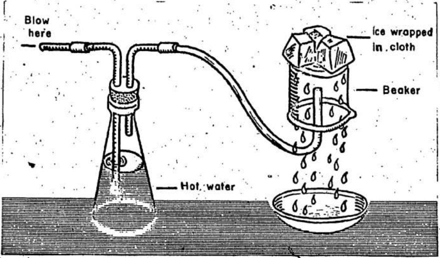
MODULE IV

Moisture sometimes falls to the earth's surface. Rain is moisture and is therefore an example of moisture falling to the earth's surface. On the other hand, dust is not moisture and is not an example of moisture falling to the earth's surface. Frozen rain is moisture and is yet another example of moisture falling to the earth's surface. Any one of the following is an example of moisture falling to the earth's surface: (i) rain, (ii) frozen rain, (iii) snow.

Dust particles and water molecules are able to float in the air because the air is able to support them. Also, tiny droplets of water are able to float in the air because the air is able to support them. Billions and billions of these tiny water droplets float in the air and form clouds that sometimes shut out the sun. Clouds are able to float in the air because they are made up of tiny water droplets that are able to be supported by the air.

As the warm air continues to get cooler, the water vapor in it continues to form water droplets around particles. Therefore, the tiny droplets of water increase in size to form large droplets. The large droplets of water are too heavy for the air to support so they fall to the earth's surface.

An experiment can be carried out in order to show that moisture falls to the earth's surface. When materials such as a two-holed stopper, glass and rubber tubing, a flask, a beaker, a saucer, a bag of ice, and hot water are put together they should look like the arrangement in this diagram.



If you were to blow gently into the short rubber hose you would notice droplets of water forming on the inside of the beaker. If you were to continue blowing the water droplets would fall from the beaker into the saucer. The water droplets that would fall into the saucer can be compared to moisture falling to the earth's surface. This experiment can be used to show that moisture falls to the earth's surface. In the experiment the water droplets on the inside of the beaker become too heavy for the air to support so they fall into the saucer.

When water vapor condenses at a temperature below 0° Celsius snow forms. Also, in order for snow to fall the temperature of the layer of air next to the earth's surface must be below 0° Celsius. When the temperature of the layer of air next to the earth's surface is below 0° Celsius moisture falls to the earth's surface in the form of snow.

When the temperature of the layer of air next to the earth's surface is above 0° Celsius, the water droplets fall to the earth's surface as rain. Rain is unfrozen moisture that falls to the earth's surface. Rain falls to the earth's surface because the temperature of the layer of air next to the earth is above 0° Celsius when water droplets are falling.

The air around the earth is made up of warm and cold layers. Therefore, the air is made up of layers that have different temperatures. The temperature at one level may be above the freezing point and at another level it may be below the freezing point. If the temperature of a falling droplet of water is lowered below the freezing point, and the droplet does not freeze, it is said to be supercooled. This means that water droplets reaching the earth's surface might be supercooled if they passed through a cold layer of air. When a supercooled droplet of water strikes a dust particle in the air it freezes. Also, when a supercooled droplet strikes the earth's surface it freezes. Moisture that freezes when it comes into contact with the earth's surface is called frozen rain. Frozen rain occurs when water droplets that have been supercooled strike the earth's surface and freeze on contact.

In order for precipitation to occur moisture must fall to the earth's surface. If water molecules leave the surface of a pool of water and pass into the atmosphere we call the process evaporation. In the process of evaporation moisture does not fall to the earth's surface. Therefore, evaporation is not an example of precipitation. Condensation occurs when vapor changes to a liquid. Precipitation occurs when moisture falls to the earth's surface. Therefore, condensation is not an example of precipitation. An example of precipitation is moisture in any form falling to the earth's surface.

Some of the precipitation that falls to the earth's surface flows over the surface to lower levels. The name given to moisture flowing over the earth's surface is surface flow. A stream flowing down a hillside is an example of surface flow. After a small amount of rainfall there is a small amount of surface flow. After a large amount of rainfall there is a large amount of surface flow. Moisture that falls on a hill may get into a lake in a valley below by flowing down the hillside which is part of the earth's surface.

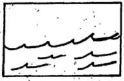
Evaporation, warm air rising, condensation, and precipitation are steps in the water cycle. Therefore, precipitation is part of the water cycle.

MODULE V

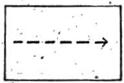
There are four steps in the water cycle. They are evaporation, warm air rising, condensation, and precipitation. These steps repeatedly follow each other always in the same order. If you start with evaporation the next step in the water cycle is warm air rising. The next step in the water cycle after warm air rising is condensation. Therefore, if you were to write three steps in the water cycle in their order of occurrence you would write evaporation, warm air rising, and condensation. The four steps in the water cycle are complete when the process of precipitation is added. The four steps in the water cycle in their order of occurrence are evaporation, warm air rising, condensation, and precipitation.

Evaporation is the process whereby water changes to a vapor. Warm air rising, as the name implies, is heated air being forced to rise. Condensation is the process whereby water vapor changes to water droplets. Precipitation is the name given to moisture falling to the earth's surface. The four steps in the water cycle in their order of occurrence are evaporation, warm air rising, condensation, and precipitation.

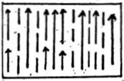
Before you can label the steps in a diagram of the water cycle it is first necessary to learn the symbol for each step in the diagram.

The symbol for water is 

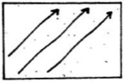
The symbol for lateral movement is



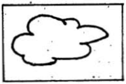
The symbol for evaporation is



The symbol for warm air rising is

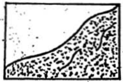


The symbol for condensation is

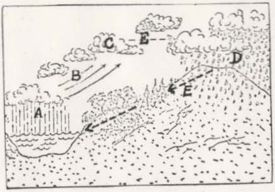


The symbol for precipitation is

The symbol for land is



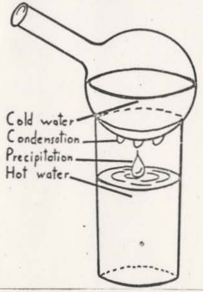
When the symbols for evaporation, warm air rising, and condensation, precipitation, land, water, and lateral movement are put together in a meaningful way they look like this:



The letter placed by the symbol for lateral movement in the diagram above is the letter E.

Now match the names of the steps in the water cycle with the letters in the diagram. The letter A indicates evaporation, the letter B indicates warm air rising, the letter C indicates condensation, and the letter D indicates precipitation.

You can set up an experiment to show the principle of the water cycle. In order to conduct this experiment you need a beaker half full of hot water and a Florence flask half full of cold water. Next arrange these materials as shown by the diagram below.



In this experiment water vapor leaves the surface of the hot water in the beaker. This is called evaporation. The warm moist air then rises and contacts the cold surface of the Florence flask. When the warm air strikes the flask the water molecules combine on the flask to form water droplets. The changing of water vapor back to water droplets on the surface of the flask is called condensation. The process of condensation continues until the water droplets become larger and fall from the flask into the beaker. In nature the falling moisture might be in the form of snow, rain, or frozen rain. This falling moisture is called precipitation. The series of events described above repeat themselves always in the same order. This experiment demonstrates the principle of the water cycle.

When the series of events known as evaporation, warm air rising, condensation, and precipitation occur in nature they are known as the steps in the water cycle. An example of the water cycle as it occurs in nature is surface water changing to vapor, vapor changing to water droplets, and the droplets falling onto the earth's surface.

APPENDIX M

Procedural Instructions for the Teacher in the Control Group

PROCEDURAL INSTRUCTIONS FOR THE TEACHER IN THE CONTROL GROUP

Before you start teaching the unit of study on the topic, "The Principle of the Water Cycle," please read the following instructions very carefully.

1. The unit of study consists of five modules. You are to lecture on module one on the first day, module two the second day and so on, until you finish module five on the fifth day. The term lecture as it is here used refers to a teaching procedure in which the teacher makes an outline of the content of each module and talks to the class concerning that content. Also, the teacher places diagrams on the chalkboard, uses flash-cards when introducing new words, and dictates important parts of the content in such a manner as to permit students to write these parts in their notebooks.

2. You must complete each module in a period of time not in excess of one hour. You may find that you can complete each module in less than one hour. If you finish your lecture before the hour has expired permit the students to read the books that they have selected previously.

3. Each day before you start lecturing give the students their notebooks and after you finish lecturing take their note-books from them.

4. Follow the content of each module very carefully.

(i) Do not select examples from outside the modules.

(ii) Draw all diagrams found in the modules on the chalkboard and have the students draw them in their notebooks.

Also, draw diagrams of the experiments on the chalkboard and have students draw them in their notebooks.

(iii) Do not repeat yourself more than two times when dealing with a particular point, unless it is otherwise indicated by the modules. Dictate to the students the underlined parts of each module and insist that the students write these parts in their notebooks. In order to ensure that all students are able to write the underlined parts of each lecture in their notebooks, you may find it necessary to repeat yourself more than twice.

(iv) Ignore any question from the class that is outside the content being covered in each module. You can do this by telling the class that the question is outside the lesson, there is insufficient time to deal with the question, or by telling the students in the class to look up the answer during their library periods.

5. If a student has a pertinent question, you can reward him by saying, "Good question." Then proceed to answer his question.

6. Do not review work that will have been covered on the previous day or days unless it is otherwise indicated in the modules.

7. Students must take notes on selected areas of the unit of study. However, if they wish to take notes on other aspects of the unit of study they should be permitted to do so.

8. The unit of study makes use of words that are above the grade seven reading level. These words are underlined and

placed on flash-cards. When the underlined words appear, use flash-cards to introduce them.

In summary, follow these procedures:

(a) Make an outline of each module.

(b) Give each student his notebook at the start of the class.

(c) All examples used must come from the modules.

(d) Draw all diagrams and experiments on the chalkboard.

(e) Dictate the underlined parts of the unit and insist that the students write them in their notebooks.

(f) Answer only pertinent questions.

(g) Use flash-cards for underlined words.

(h) Do not review work unless otherwise indicated.

(i) Do not repeat yourself more than two times when dealing with a particular point unless it is otherwise indicated.

(j) Complete one module per day.

(k) Take the notebooks from the students at the end of each lecture.

APPENDIX N

Figures 10, 11, 12, and 13.

Figure 10. A Graphic Comparison of the Experimental Group's Unadjusted Scores as Obtained on the Pretest, Posttest, and Retention Test.

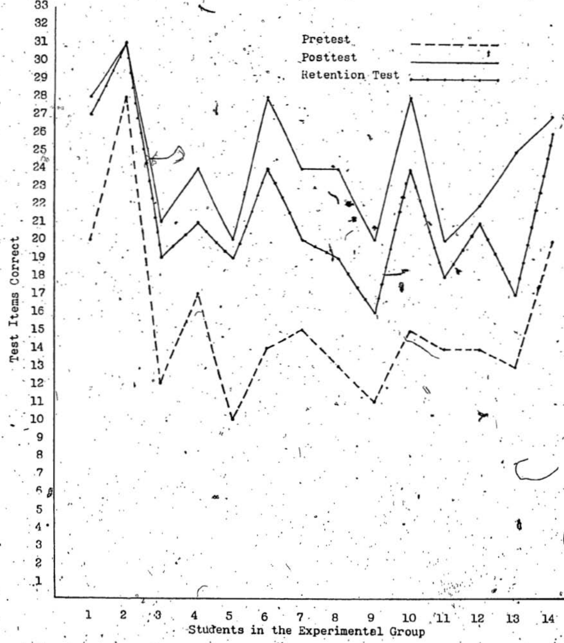


Figure 11. A Graphic Comparison of the Experimental Group's Adjusted Scores as Obtained on the Pretest, Posttest, and Retention Test.

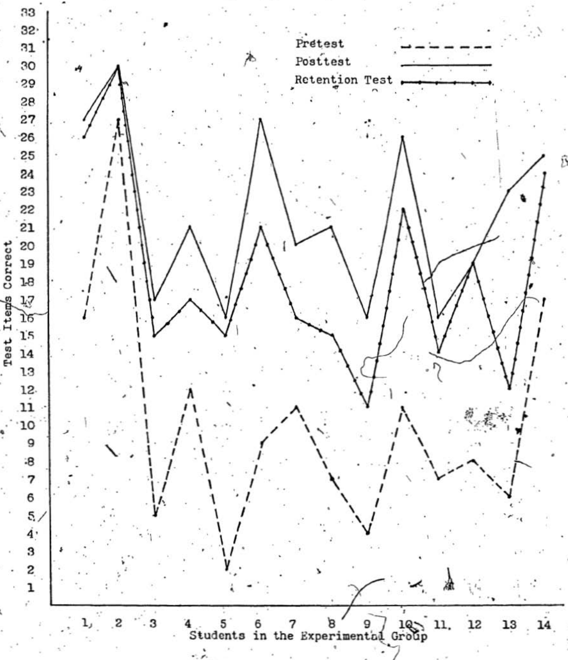


Figure 12. A Graphic Comparison of the Control Group's Unadjusted Scores as Obtained on the Pretest, Posttest, and Retention Test.

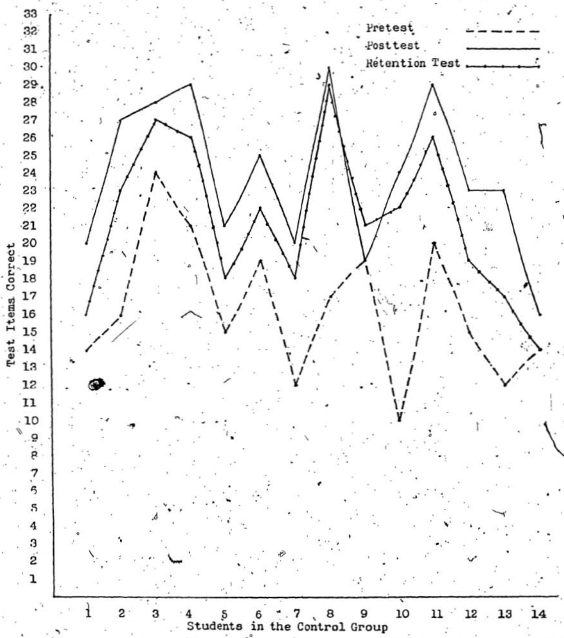


Figure 13. A Graphic Comporison of the Control Group's Adjusted Scores as Obtained on the Pretest, Posttest, and Retention Test.