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ABSTRACT

Conclusions of an extensive project aimed to prepare lessons and associated materials related to teaching concepts included in the scheme "The Particle Nature of Matter" for grades two through six are presented. The hypothesis formulated for the project was that children in elementary schools can learn theoretical concepts related to the particle nature of matter. Pretests and posttests were prepared and administered on experimental and control subjects. The statistical procedures employed for assessing the attainment of the concepts are described. A description of reliability and validity of test items is included. The criteria for concept achievement were met by most experimental subjects. The children in grades two through six showed interest in learning about the particle nature of matter. Teacher attitudes about teaching this topic at these grade levels were generally positive. (Author/PS)

TECHNICAL REPORT NO. 173

TEACHING THE CONCEPTUAL SCHEME "THE PARTICLE NATURE OF MATTER" IN THE ELEMENTARY SCHOOL

REPORT FROM THE PROJECT ON PROTOTYPIC INSTRUCTIONAL SYSTEMS: SCIENCE

WISCONSIN RESEARCH AND DEVELOPMENT

CENTER FOR COGNITIVE LEARNING

THE UNIVERSITY OF WISCONSIN
Madison, Wisconsin

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Technical Report No. 173

TEACHING THE CONCEPTUAL SCHEME "THE PARTICLE NATURE OF MATTER" IN THE ELEMENTARY SCHOOL

by
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Report from the Project on
Prototypic Instructional Systems: Science
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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report and Practical Paper published in conjunction with it are from the Prototypic Instructional Systems in Elementary Science Project in Program 2. General objectives of the Program are to establish rationale and strategy for developing instructional systems, to identify sequences of concepts and cognitive skills, to develop assessment procedures for those concepts and skills, to identify or develop instructional materials associated with the concepts and cognitive skills, and to generate new knowledge about instructional procedures.

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Abstract

The purpose of this project was to develop a series of lessons and associated materials (tests, demonstrations, pupil activities, etc.) related to teaching concepts included in the scheme "The Particle Nature of Matter" for grades 2 through 6. The hypothesis that served as the base for development is "theoretical concepts related to the particle nature of matter can be learned by pupils in grades 2 through 6 when analogous mechanical models comprehendible to pupils of these ages are employed." The intent was to present abstract ideas in concrete terms.

The processes used in the natural sciences in theory development were employed in the teaching strategies; a real phenomenon was witnessed; the requirements for a useful model were identified; a mechanical model was proposed; and inferences were made from the analogous model to the phenomenon. The result was a theoretical concept that was usable in exploring that particular phenomenon. In subsequent lessons other phenomena not explainable with this present model (theory) were in a similar manner witnessed, and the pupil and teacher proceeded to modify the theory to make it useful in all of the phenomena witnessed up to that point. The concepts in the scheme began with "all matter is made up of particles" and terminated with "molecules are made up of atoms that are held together by electrical forces."

The associated tests were in a motion picture format and the items were of the alternate response type. The use of visual materials to minimize reading was consistent in all phases of the project.

Data in the form of frequencies of responses collected under experimental conditions involving the materials used by regular elementary classroom teachers were analyzed to determine reliability, validity, and usability of the test items. The usability of the materials and strategies and the feasibility of teaching the concepts were judged against criteria including pre- and posttest scores of experimental and control groups, teacher opinions, and pupil opinions. The criteria were met by essentially all concepts at all grade levels. The hypothesis appears to possess some credibility and the materials developed are usable in the hands of regular classroom teachers. Pupils in grades 2 through 6 appear to be interested in learning the particle theory of matter and in participating in theory development using analogous mechanical models.

I
Introduction

Procedures

The intent in this series of lessons is to utilize inductive and deductive procedures that involve generalizations, inference, and invention in formulating theoretical concepts. In the process of generalizing the learner will seek consistencies within results that enable him to make appropriate predictions. The process of inference involves extensive selective reviews by the learner of his past experience and the correlation of incidents from past experience with new experiences. In the black box activity the learner asks himself the question, "What do I know from the past that acts like this?" He then applies his selected experience to the new situation to find out whether it fits in a functional manner —whether it makes explanation possible. The process of invention comes in the way ideas or experiences of the past are put together. Each invented idea must be judged with reference to what it enables a person to do, its usefulness.

Concept Learning

The teaching of theoretical concepts involves placing the learner beyond the level of concrete experiences; hence; educationally there are two alternatives open—omit such teaching until learners have reached the maturity level when they are able to function outside of the concrete realm or develop teaching strategies that bring the concepts into a concrete realm. When and if a functional teaching strategy is developed, other judgments must be made; the fact that children can learn a concept does not mean children <u>should</u> learn the concept at that age, or at all.

> Concepts have been cited as the products of scientific processes, as the basis for further scientific studies, and at times the knowledge that is applied by the technologist.... Concepts are important not only because they are the warp and woof of science, but also because they provide the possessor with a means of coping with the development of knowledge in the future. It seems that one way known to provide for maximum coverage of old and new knowledge is through the development of a classificational system. The formation of concepts or conceptual schemes is one method of classification which results in such economical use of human intelligence. [Pella, 1966, p. 31]

Each concept considered for learning must be judged in terms of its present and future functional values and in terms of the efficiency of learning. Ideally, there is a lowest grade level at which it is efficient to teach a given science principle and this level is not the same for all science principles. Further, it is recognized that the index of maturity of the learner also remains to be identified. It now appears that the index of maturity utilized in learning a concept is related to the teaching strategy utilized. If there is a minimum of reliance on reading and other verbal communication and a maximum reliance on comprehendible analogous models, grade level and IQ, traditionally used as indices of maturity for learning, are of little value as predictors (Pella & Ziegler, 1967; Carey, 1968; Strauss, 1968; Helgeson, 1968; Voelker, 1968).

> . . . We may expect to accomplish a grade placement of material by . . . analyzing the major generalization into smaller generalizations, principles, and concepts from which it has been synthesized and by subsequent

subdivision of these until they are reduced to elements appropriate for the different grades. [NSSE, 1932, p. 49]

Scientific Models

Since theories in science are expressed as words, mathematical formulas, or mechanical inventions that are based upon facts, it is possible to select from among the theories those that can be represented by analogous mechanical models.

Building theoretical models in science must not be interpreted as the construction of replicas but rather must be accepted as the exemplification of ideas; the rare coincidence when a theoretical model turns out to be a replication is the exception. A model formed in science is the result of the inventiveness and past experience of the model former. A model is a portrayal of an idea that may or may not be credible for a real life phenomenon.

Theories do not emerge completely developed in the scientific community. Most theories have an evolutionary history, beginning with a simple idea and continuing through many modifications, additions, and limitations. This occurs because the scientists have agreed that one of the virtues of science is its simplicity. Some of the rules of theory formation are:

1. If there is a choice between two theories that are equally adequate for use in explaining a given phenomenon and if one is complex and the other is simple, the simple theory is chosen.
2. If there is a choice between developing a new theory and modifying an existing theory, both being adequate for use in the same phenomenon, the choice is to modify the existing theory.
3. If there is a choice between a theory that cannot be modified and one that can be modified in the future, both being adequate for use in the same phenomenon, the choice is the theory that can be modified.

It is noted that no concern has been registered for "making the model a replica of nature." The idea that science could develop a photographic image of nature was abandoned many years ago. The desire of the scientist is to help make the world of natural phenomena understandable; this means that he must often create ideas. The creation of ideas in the scientific community is not completely understood. It is not known what parts of an idea are "new" and what parts are newly inferred. It may be argued that a new idea results when old ideas are structured in a new way but this would be of no help to us in this unit. The concern in this unit will be the inferring of old ideas to new situations, a very difficult procedure. The forming of inferences seems to be a very high level mental process and should be approached slowly with children.

Inferences are rational and logical and are based on fact. They are not wild ideas if they are based on facts and are arrived at using the criterion of usefulness. Ideas not accepted in science are those involving supernatural powers or magic. Science depends upon many facts if credible ideas are going to evolve.

As the teacher leads the learners through the phases of the various models for matter, note should be made of the adherence to some rather simple rules generally followed in science:

1. The model proposed must be as simple as possible.
2. The model must be consistent with the facts.
3. An existing model should be modified rather than a new model formed whenever possible.
4. The model need not look like what is being modeled.
5. The model adopted must fit the new as well as the old phenomena.

Concept Selection

Reflection upon these qualities of theoretical models leads one to the conclusion that theoretical concepts vary in complexity. It is further observed that the complexity of the concepts appears to depend upon the number of factors involved and the degree to which the relationship between the facts is quantitative. The concepts in the scheme "The Particle Nature of Matter" included here involve qualitative properties of particles and phenomena. The criteria employed in selecting the concepts to be included in this unit were:

1. They must be theoretical.

2. It must be possible to construct an analogous mechanical model for each.

3. Those included must be instructionally sequential.

4. The phenomena they serve to explain must be within the common experience or be made a part of the common experience of children in grades 2 through 6.

Estimates of the worth of the conceptual scheme, "the Particle Nature of Matter," are revealed in the fact that:

(a) NSTA included the scheme as one of those recommended for curriculum building:

> I. All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa. II. Matter exists in the form of units which can be classified to hierarchies of organization levels. [NSTA, 1964, p. 20]

(b) Feynman, a physicist, and associates have made the following statement:

> If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, or whatever you wish to call it) that things are made up of atoms —little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another. In that one sentence, you will see there is an enormous amount of information about the world, if just a little imagination and thinking are applied. [Feynman, Leighton, & Sands, 1963, pp. 1-2]

Lesson Structure

The lessons in this unit are designed to provide opportunities for young children to learn more about how problems resolved by theory development are attacked. The first lesson aims at the development of classificational concepts where the learner forms operational definitions of matter and energy. In the following lessons the learner is assisted in evolving a model for matter that enables him to explain natural phenomena.

Throughout the lessons the rules for theory formation are followed. The learner is reminded that theoretical models must be useful in explaining specific natural phenomena if they are to be retained and that there are no general models of matter separate from a natural phenomenon involving matter. As the learner proceeds he finds that a model that is useful in explaining a change in the phase of matter from liquid to gas is not necessarily adequate to help explain chemical changes. To the learner, the adequacy of the model must always be judged from the frame of reference of the phenomenon to be explained.

In the lessons the student experiences a natural phenomenon, judges some models, and suggests or judges modifications of a model. Opinions concerned with concept teaching in science are somewhat confused; hence, you are alerted at this point. There are some teachers who believe that the students should discover the theory and there are others who say that discovery of a theory is impossible since theories are inventions of the human mind. The procedure followed here is based on the opinion that theories evolve as more facts are accumulated and as more ideas are invented by people; theories in science are invented by people and not discovered in nature. If you wish to believe that the processes involved in making inferences are discovery you may say that some discovery takes place here.

The lessons that describe the teaching procedure include extensive use of mechanical models and films for suggesting ideas to the learners. The learner judges the reasonableness of adding each inferred idea to the model to be used in explaining the phenomena. Some ideas he accepts, some he rejects, and some he modifies. The factors used in modifying an existing concept to meet the requirements of a new situation are introduced singly so the learner is protected from confusion that is consequent to "too many factors" at one time.

Pupil activity, in addition to manipulating apparatus, witnessing demonstrations, and

viewing films involves the building of models on an overhead projector. The overhead projector activities appear to help the pupils to build mental models involving the idea of particles.

Testing

The evaluation instruments are in the form of motion picture films with each test item identified in terms of the associated concept. The administration and assessment of the results of the test are simple in that the number answered in an acceptable manner per concept is the important indicator. The key and concept identification are included for your reference.

The motion picture type of instrument has been found to be interesting to elementary school children and easily administered. The five items for each concept have been classified into two groups based on the quality of the items. This makes the development of shorter or equivalent forms of a test instrument possible. The classification of the items in terms of quality is found in Chapter III.

Selected Concepts

The concepts from the scheme "The Particle Nature of Matter" selected and ordered as presented experimentally, individually, and in units are:

1. All matter is made up of particles.
2. Particles of matter have spaces between them.
3. Particles of matter are very small.
4. Particles of matter are in motion.
5. Particles of matter move faster when the matter is heated.
6. Particles of matter usually move farther apart when the matter is heated.
7. In the solid state, the particles of matter are packed together in a pattern and move within a small space.
8. In the liquid state, the particles of matter are loosely clustered together and move about.
9. In the gas state, the particles of matter are far apart and move freely.
10. The state of matter can be changed from solid to liquid and from liquid to solid.
11. The state of matter can be changed from liquid to gas and from gas to liquid.
12. The push against the surface by a gas depends upon the number and rate of motion of particles of the gas.
13. Some particles of matter (molecules) are made up of simpler particles (atoms).
14. Some molecules are made up of only one kind of atom (element).
15. Some molecules are made up of two or more kinds of atoms (compounds).
16. Some samples of matter contain more than one kind of molecule (mixtures).
17. Each type of molecule is formed from definite numbers and kinds of atoms.
18. Particles of matter have mass and occupy space.
19. The average size and mass of the atoms of each element do not vary.
20. Atoms are made up of particles: protons, neutrons, and electrons.
21. Electric charges are associated with the particles of matter.
22. The particles of matter attract each other.
23. The mass of an atom is determined by the number and kinds of particles that it contains.
24. All atoms of a given element are made up of the same number of electrons and protons.
25. Molecules are made up of atoms that are held together by electrical forces.

II
Experimental Testing and Results

The lesson plans, models, films, and tests described in this report and included in the accompanying Practical Paper were revised many times based on the results of their use in pilot projects with individual pupils, small groups, and entire populations of elementary schools. The teaching materials described and included in this report are slight modifications (wording of questions, etc.) of those used in the study. Minor problems noted during the last tryout were rectified. The last activity in the project was that of having regular elementary school classroom teachers use the materials in teaching the concepts in a public elementary school.

Problem

Is it feasible to teach selected concepts from the scheme "The Particle Nature of Matter" to elementary school children?

Discussion

Since understanding of the individual concepts gained as a result of the teaching strategies employed was the central goal of the project, the teaching strategies and the materials became the factors under experimental examination. The judgment that none, some, or all of the concepts can be taught must thus be given from this frame of reference. If the judgment is negative, the inference may be either that the concepts are not appropriate to the learning goals or maturity of the pupils or that the strategies are not adequate. It is obvious that these propositions are credible only if it is assumed that the teacher is adequately prepared for the task. If this assumption is not accepted and the outcomes are negative, it may not be possible to reject the concepts or to judge the strategies inappropriate for a given group of pupils.

Criteria

The criteria for the acceptance of a concept are:

1. fifty percent of the experimental group earn a score of 60% (three of five items correct) or higher on the locally produced test;
2. the concept posttest mean score earned by the experimental group is higher than that of the control group;
3. the concept posttest mean score earned by the experimental group is higher than the corresponding pretest score;
4. the opinions of the classroom teachers are generally positive; and
5. the opinions of the pupils are generally positive.

Instruments Used

The scores earned on the locally-produced motion picture type tests, Forms C, M, S, U, and X, consisting of five items per concept, were used to indicate the levels of pupil achievement. The instruments served both as pre- and posttests.

Teacher opinions were ascertained through the use of a locally prepared checklist that was completed by each teacher immediately following his teaching of a given concept (Appendix A).

Pupil opinions were ascertained through the use of a locally prepared checklist that was

completed by each pupil following his study of a given concept (Appendix B).

Experimental Procedure

School Selection

In order to produce data that would allow some generalizations, it was necessary to:

1. compare experimental and control groups in terms of concept test achievement scores,
2. ascertain the opinions of classroom teachers relative to the appropriateness of the concepts and the suitability of the materials and teaching strategies, and
3. ascertain the opinions of pupils relative to the suitability of the materials.

These requirements necessitated the involvement of:

1. two or more similar classes per grade,
2. teachers from schools using self-contained classrooms who were willing to devote some of their time to the learning of the concepts, how to use the materials, and to teaching the concepts; and
3. a school system that would be willing to allow the experiment to be carried on in one or more schools.

Teacher Preparation

The classroom teacher instructional program consisted of one 2-hour period per week conducted by members of The University of Wisconsin Research and Development Center staff. The content of each teacher instruction session included the concepts and teaching strategies to be used by the teachers in the 5 days to follow.

Teaching Period

The term of the experiment, including both teaching and testing, involved 40 school days and each pupil instructional period was 30 minutes in length. The experimental classes at all grade levels received instruction related to a given concept on the same day.

Results

The elementary school selected had the following characteristics:

1. two or more classes per grade level,
2. pupils at each grade level except grade 6 were randomly assigned to classes (One group of academically talented pupils from several area schools formed one sixth grade class [AT-6]; however, all other pupils at that grade level were randomly assigned.), and
3. the teachers and administrators were willing to participate in the program.

Experimental Class Selection

The school principal selected one class at each grade level 2 through 6 to become the experimental population.

Population

Number. The numbers of pupils per grade level varied slightly from grade to grade and section to section; however, the numbers at each grade level in the experimental and control groups who completed all of the pre- and posttests were about equal (Table 1).

Pre-and Posttests

The locally developed concept tests were administered as pre- and posttests to the experimental and control groups. All pretests (Forms C, M, S, U, and X) were administered to both groups prior to any instruction related to the concepts. Posttests were administered to the control and experimental groups by the University production staff immediately following the teaching of the related lessons to the experimental groups.

The questionnaires related to the individual concepts were completed by the teachers and pupils on the day that the lesson on a concept was completed.

Comparability. The credibility of the assumption of comparability of the control and experimental groups may be tested for grades 2 and 5. Note from Table 2 that the groups are similar in IQ, reading, mathematics, and science (5th grade).

Table 1

Numbers of Students in Experimental and Control Classes Completing the Test Items by Grade Level

Grade Level	Experimental		Control	
	Pre	Post	Pre	Post
2	26	26	23	23
3	23	22	24	24
4	27	26	27	27
5	26	25	27	26
6	26	25	25	24
Total	128	124	126	124

Table 2

Mean Scores on Standardized Tests for the Second and Fifth Grade Experimental and Control Classes

	Second Grade		Fifth Grade	
	Experimental N = 26	Control N = 22	Experimental N = 25	Control N = 23
IQ (Kuhlman-Anderson)	114.1	110.1	114.7	116.5
Reading (Stanford Achievement Test)*	4.54	4.59	5.84	5.83
Mathematics (SAT)*	6.00	5.36	5.84	6.30
Science (SAT)*	----	----	6.08	5.82

*Scores in stanine units

III
Tests

The orientatic · of the concepts and the teaching strategy employed in this unit placed very little emphasis on reading as a tool for learning. Consistent with this idea, the development of the evaluation procedures employed also minimized reading. Basic to the plan to minimize reading in this unit was the belief that the conceptual background development possibilities of an individual are not limited to the reading level of the individual; the conceptual level of the individual may exceed his technical reading vocabulary. The evaluation instruments developed for this unit of study, therefore, had to meet the criterion of "demanding minimal reading skills and vocabulary."

Item Criteria

All items used in the tests were expected to satisfy at least six of the eight criteria that follow:

1. The item is concerned with the selected concept. (Each item must be specific to a given concept.)

2. The proportion of the population selecting the accepted response when the instrument was administered following instruction is greater than 0.50, the level attributable to random guessing.

3. The proportion of the population selecting the accepted response to each item is greater when the instrument is administered as a posttest than when it is administered as a pretest.

4. The proportion of the instructed population is greater than the proportion of the noninstructed population choosing the accepted response to each item when the instrument is administered as a posttest.

5. The proportion of the instructed population at each class level selecting the accepted response to each item increases progressively with grade level when the instrument is administered as a posttest.

6. The items are not of extreme difficulty when included as a posttest for the instructed population ($-2\sigma \leq X_{50} \leq +2\sigma$).

7. The items are positive discriminators when included as a posttest for the instructed population ($\beta \geq +0.30$).

8. The items are usable with groups in a classroom.

In addition to minimal reading the following characterize the evaluation instruments:

1. The items are stated in an objective form.

2. There are five individual items related to each concept.

3. Each test item involves a natural phenomenon and the theoretical concept is useful in explaining the phenomenon.

4. All items are in the media of colored still or motion pictures and sketches.

5. Written captions are included so the teacher may read them to the pupils.

6. The five items related to an individual concept in a given test are sequenced at random.

7. Sample items are included to serve in giving directions to the pupils.

8. The total evaluation instrument consists of five parts and five items per concept; 1. Concepts 1-6, 2. Concepts 7-11, 3. Concepts 12-16, 4. Concepts 17-21, and 5. Concepts 22-25.

9. The pupils indicate their responses on separate answer sheets.

The Test

The items included in each of the five test parts are indicated for your information. It is impossible to show the several colors used to avoid the development of student clues and for you to observe the motion; however, each sketch includes shading and an indication that the sketch is dynamic or static.

The five items related to each concept and the position of each item relative to other items are indicated. For example, Test Part C includes Concepts 1-6 and item C-5 is the fifth item on the test, Test Part M includes Concepts 7-11 and M-15 is the 15th item on the test, Test Part S includes Concepts 12-16, Test Part U includes Concepts 17-21, and Test Part X includes Concepts 22-25.

For a detailed explanation, see Concepts 1-25 in Chapter IV of the accompanying Practical Paper (No. 173).

Evaluation of the Items

The evaluation of the items included two phases; determination of the usability of this type of item and determination of the quality of the items. A more complete analysis may be found in a report by Doran (1969).

Phase I

The field test employed to determine the usability of this type of pictorial test involved all of the pupils in grades 2 through 6 in one elementary school. The criteria of usability employed were "the pupils can respond to the choices" and "the responses following a period of instruction are above the chance level."

In order to examine the usability of the test type it was necessary to administer all items as parts of a pretest and a posttest and also to teach all of the concepts at the several grade levels. It was admitted that these data would give some bases for judgment; however, it was quickly observed that certain clues could unconsciously be built into the items. Some clues noted as possible were: (a) The color red is more dominant in the desired choices. (b) The desired choices include more circles. (c) The choice that inclues motion is the one desired. In order to gain information relative to this problem, it was necessary to observe the reactions and responses of children to each of the items. In addition, the individual tests were studied by 12 graduate students in science education for this purpose.

This phase of the study of the instruments resulted in the recasting of many of the questions to eliminate some and also to introduce a variety of natural phenomena that were needed to make certain of the items reasonable. The general question "Which is the better model for matter?" was quickly found to be not appropriate for the unit or the testing technique since in such a question there is no frame of reference. Hence, those captions had to be rewritten in terms of "phenomena to be explained." This first field test essentially resulted in the complete rewriting of the items.

Phase II

This phase of the item evaluation was more formally structured since it was judged that Phase I had provided the prerequisite facts and the desire was to account for as many variables as possible.

The Generalized Item Analysis Program (Baker & Martin, 1968) was utilized in computing item statistics: difficulty, X_{50}, and β.

The quality of the individual items in terms of the eight accepted criteria is included in Tables 3 and 4 (see pages 11 and 12 respectively); examination of those reveals that:

1. With the exception of Concept 12, there are three or more items per concept that satisfy six or more of the eight criteria.

2. Criterion No. 5, "The proportion of the experimental population at each class level selecting the accepted response to each item increases progressively with grade level when the instrument is administered as a posttest," is not satisfied by all except two items (C 18 and M 24). This may be due to the failure in

Table 3

Total Number of Criteria Satisfied by Each Item
Arranged According to Item Number and Concept Number

Concept Number	Item Number	Total Number of Criteria Satisfied	Concept Number	Item Number	Total Number of Criteria Satisfied	Concept Number	Item Number	Total Number of Criteria Satisfied	Concept Number	Item Number	Total Number of Criteria Satisfied
	C-1	7*		M-1	7*		S-5	6*		U-2	7*
	C-4	7*		M-6	6*		S-8	7*		U-12	7*
1	C-12	7*	7	M-10	7*	13	S-12	7*	19	U-14	7*
	C-20	6*		M-12	5		S-19	6*		U-16	5
	C-26	7*		M-17	6*		S-23	7*		U-18	7*
	C-2	7*		M-2	4		S-2	7*		U-1	7*
	C-7	6*		M-8	6*		S-9	6*		U-6	7*
2	C-11	7*	8	M-13	7*	14	S-14	7*	20	U-9	7*
	C-16	7*		M-19	6*		S-17	7*		U-15	7*
	C-27	7*		M-22	7*		S-25	6*		U-20	7*
	C-5	5		M-4	7*		S-3	6*		U-7	7*
	C-17	6*		M-7	5		S-7	7*		U-11	6*
3	C-19	7*	9	M-15	6*	15	S-13	6*	21	U-17	7*
	C-23	7*		M-21	6*		S-15	6*		U-21	6*
	C-30	7*		M-24	8*		S-18	7*		U-25	6*
	C-9	5		M-5	6*		S-4	4		X-2	7*
	C-14	5		M-14	6*		S-11	7*		X-6	7*
4	C-21	6*	10	M-16	7*	16	S-16	7*	22	X-12	6*
	C-25	7*		M-23	7*		S-21	5		X-17	5
	C-29	6*		M-25	7*		S-24	7*		X-19	7*
	C-8	6*		M-3	7*		U-3	7*		X-1	5
	C-15	4		M-9	7*		U-5	6*		X-7	6*
5	C-18	8*	11	M-11	7*	17	U-13	7*	23	X-9	6*
	C-22	7*		M-18	7*		U-19	7*		X-14	5
	C-24	7*		M-20	7*		U-24	7*		X-18	7*
	C-3	5		S-1	7*		U-4	7*		X-4	6*
	C-6	7*		S-6	5		U-8	7*		X-8	7*
6	C-10	7*	12	S-10	5	18	U-10	6*	24	X-11	7*
	C-13	6*		S-20	5		U-21	7*		X-16	7*
	C-28	5		S-22	4		U-23	5		X-20	7*
										X-3	5
										X-5	7*
									25	X-10	7*
										X-13	7*
										X-15	7*

* Indicates that the item satisfied at least six criteria.

Table 4

Items Ranked by "Goodness"

Concept Number	Rank of Quality				
	Highest				Lowest
1	C-12	C-4	C-1	C-26	C-20
2	C-27	C-16	C-2	C-11	C-7
3	C-23	C-30	C-19	C-17	C-5
4	C-25	C-9	C-29	C-21	C-14
5	C-18	C-24	C-22	C-15	C-8
6	C-6	C-10	C-13	C-3	C-28
7	M-10	M-1	M-12	M-17	M-6
8	M-13	M-8	M-22	M-19	M-2
9	M-24	M-4	M-21	M-15	M-7
10	M-16	M-23	M-25	M-5	M-14
11	M-20	M-11	M-18	M-9	M-3
12	S-1	S-10	S-6	S-22	S-20
13	S-8	S-12	S-23	S-19	S-5
14	S-17	S-14	S-2	S-9	S-25
15	S-18	S-7	S-13	S-3	S-15
16	S-11	S-24	S-16	S-21	S-4
17	U-19	U-13	U-24	U-3	U-5
18	U-21	U-8	U-4	U-10	U-23
19	U-12	U-14	U-2	U-18	U-16
20	U-1	U-6	U-20	U-15	U-9
21	U-17	U-7	U-25	U-11	U-22
22	X-6	X-19	X-2	X-12	X-17
23	X-18	X-9	X-7	X-14	X-1
24	X-8	X-11	X-16	X-20	X-4
25	X-13	X-5	X-10	X-15	X-3

the use of the unit to reach the limits of the intellectual maturity of the population, that is, all of the concepts may properly be included. A second explanation relates to the possibility that the form of the test item provides clues to pupils of all levels of maturity.

It may be inferred from the summary statistics related to these test items that fewer than five items per concept could be used in testing pupils or that equivalent forms of the test could be developed. These practices would be based on the assumption that each of the items for each concept is equally "good."

If that assumption is not credible, it is only reasonable to want to use the best items. For that reason, the items related to each concept have been rated in an order of descending quality (Table 4). The arrangement of the five items per concept in terms of their relative quality was accomplished as follows:

1. The items were ordered in terms of the number of criteria satisfied.

2. If there were equivalent ratings assigned to two or more items in 1, they were ranked in terms of the β values (difference greater than 0.25).

3. If there were two or more equivalent ratings noted for items when 1 and 2 were applied, they were divided according to proportion of the past experimental scores earned on the items that were greater than 0.50.

4. If 2 and 3 failed to make the separation of two or more items possible, they were ranked according to pre-post gain scores earned by the experimental group.

5. If 2, 3, and 4 failed to enable the separation of two or more, they were ranked according to differences between posttest scores earned by experimental and control groups.

6. If 2, 3, 4, and 5 failed to enable the separation of two or more items, they were ranked according to the X_{50} above -2σ.

IV
Concept Feasibility

Lessons

Evaluation of the lessons is reported in three parts: (1) the two grades for which current data were available are described in terms of correlations among sex, age, IQ, scores earned on standardized general achievement tests, and scores earned on the pre- and posttest; (2) the mean scores earned on the total test by each group in the total population and by each group at each grade level; and (3) the data for determining each of the criteria of feasibility. A more complete analysis of the lessons can be found in a report by Green (1970).

Correlative Data

The assumption was made that within any particular grade level the degree of student performance on the posttest would not be strongly related to sex, age, IQ, or scores earned on standardized general achievement test. From Tables 5 and 6 it can be seen that although the data are not consistent, this assumption cannot be accepted without qualification.

Total Test

A summary of the results of the total test, when administered to the control and experimental groups as a pretest and a posttest, is presented in Tables 7 and 8 and in Figures 1 and 2.

It is noted from Tables 7 and 8 and Figures 1 and 2 that when the total pre- and posttest scores earned by all the experimental and control groups are treated using the Hoyt Analysis of Variance procedure that the internal consistency reliabilities were 0.50 or above, a level considered adequate for decisions about group achievement (Harris, 1968). The reliabilities of the posttest scores for the experimental groups at each grade level were also consistently above 0.50.

It should be pointed out that the reliability coefficient obtained for the total population might be spuriously high because of the tendency for a wide range of scores obtained over a range of age groups to increase the estimate (Walker & Lev, 1969, p. 233). On the other hand, the reliability estimates for the more homogeneous groups at each grade level (Table 8), although somewhat lower, are still well above the 0.50 level in most cases.

Feasibility Criteria

The data related to Criterion 1, "50% of the treatment group at any particular grade level must answer at least 60% (three of five) of the items correctly," included in Table 9 reveal that the condition was met for many concepts in experimental and control classes prior to instruction and for essentially all concepts in the experimental classes following instruction.

When the level of achievement is raised to 80% it can be seen that a much larger difference exists between the number of concepts meeting the criterion on the pre- and posttest by the experimental group and between the number meeting the criterion on the posttest by the control and experimental groups.

Criterion 2 and Criterion 3 will be presented together utilizing the data in Tables D-1 through D-25 and Figures D-1 through D-25 (Appendix D). The data for a single concept are displayed in each Table and

Table 5

Correlations Among Sex, Age, Standard Scores, and Total Test Scores—Experimental Group—Grade 2

	Sex	Age	IQ	Reading	Math	Pre	Post
Sex	1.000						
Age	-.241*	1.000					
IQ	-.464	-.154	1.000				
Reading	-.365	.000	.447*	1.000			
Math	-.423*	-.024	.301	.548**	1.000		
Pre	.045	.035	.141	.074	.114	1.000	
Post	-.177	-.057	.394*	.524**	.593***	.262	1.000

* = Significant at .05 level. ** = Significant at .01 level. *** = Significant at .001 level.

Table 6

Correlations Among Sex, Age, Standard Scores, and Total Test Scores—Experimental Group—Grade 5

	Sex	Age	IQ	Reading	Math	Science	Pre	Post
Sex	1.000							
Age	-.021	1.000						
IQ	-.582**	-.371*	1.000					
Reading	-.585**	-.219	.767***	1.000				
Math	-.342	-.154	.607***	.662***	1.000			
Science	-.543**	-.101	.660***	.811***	.385	1.000		
Pre	-.209	-.009	.310	.579**	.185	.653***	1.000	
Post	-.473*	-.001	.501**	.739***	.229	.718***	.706***	1.000

* = Significant at .05 level. ** = Significant at .01 level. *** = Significant at .001 level.

Table 7

Mean, Standard Deviation, Reliability, and Standard Error of Measurement of Total Pretest and Posttest Scores—Control and Experimental Groups

		Mean	Standard Deviation	Reliability	Standard Error of Measurement
Pretest	Control	72.20	7.83	0.60	4.93
	Experimental	74.09 (76.41)[1]	8.65 (10.22)	0.67 (0.77)	4.94 (4.89)
Posttest	Control	76.06	8.37	0.66	4.88
	Experimental	89.23 (93.07)	12.02 (14.45)	0.85 (0.91)	4.57 (4.37)

[1] Data using results from academically talented 6th graders (6-AT) are shown in parentheses.

Table 8

Mean, Standard Deviation, Reliability, and Standard Error of Measurement of Total Pretest and Posttest Scores— Control and Experimental Groups

Grade	Administration	Treatment	Mean	Standard Deviation	Reliability	Standard Error of Measurement
2	Pretest	Cont.	66.43	5.92	0.26	5.07
		Exp.	68.11	7.72	0.57	5.06
	Posttest	Cont.	70.87	6.44	0.40	4.97
		Exp.	88.04	10.92	0.82	4.67
3	Pretest	Cont.	69.58	6.84	0.49	4.86
		Exp.	71.27	7.80	0.58	5.00
	Posttest	Cont.	70.83	6.99	0.50	4.90
		Exp.	82.50	9.79	0.76	4.76
4	Pretest	Cont.	73.18	6.60	0.45	4.88
		Exp.	73.27	7.48	0.57	4.86
	Posttest	Cont.	76.52	6.32	0.40	4.89
		Exp.	85.62	12.48	0.87	4.53
5	Pretest	Cont.	74.27	7.37	0.56	4.86
		Exp.	74.92	7.44	0.56	4.93
	Posttest	Cont.	78.92	8.25	0.66	4.77
		Exp.	93.04	11.76	0.85	4.44
6	Pretest	Cont.	76.29	8.45	0.68	4.72
		Exp.	82.92	5.65	0.30	4.71
	Posttest	Cont.	82.67	7.50	0.61	4.67
		Exp.	96.32	10.33	0.83	4.22
6-AT	Pretest	Exp.	89.36	8.30	0.71	4.44
	Posttest	Exp.	144.72	4.06	0.56	2.67

Figure combination. Criterion 2 was "the mean score earned on the posttest by the experimental group at any particular grade level must be greater than that earned by the control group." Criterion 3 was "the mean score earned on the posttest by the experimental group at any particular grade level must be greater than that earned on the pretest."

From Tables D-1 through 25 and Figures D-1 through 25 (Appendix D), it may be noted that Criterion 2 was satisfied for

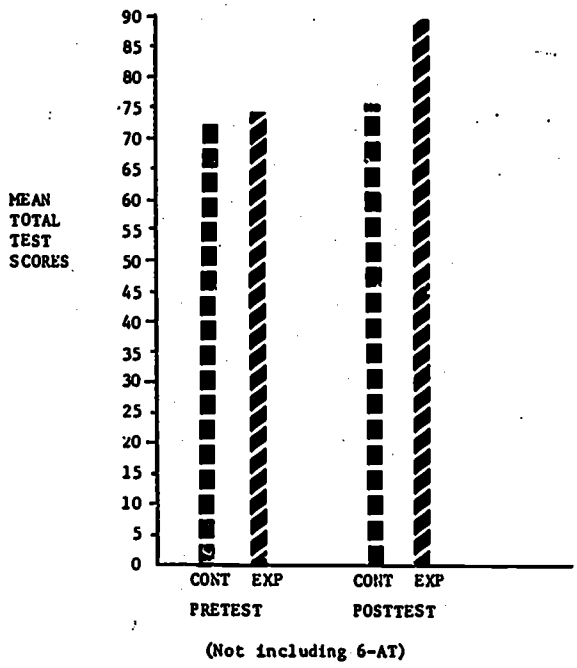

Fig. 1. Mean Scores Earned by the Control and Experimental Groups on the Total Pretest and Posttest.

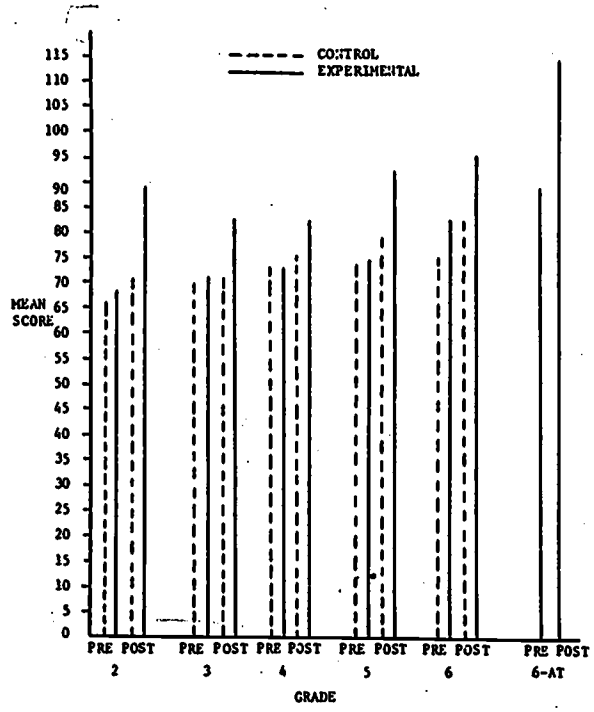

Fig. 2. Total Pretest and Posttest Mean Scores by Grade for Control and Experimental Groups.

Concepts 1 through 25 at all grade levels with the following exceptions:

1. Second grade—Concept 25
2. Third grade—Concepts 5 and 10
3. Fourth grade—Concepts 2, 13, 16, and 23
4. Fifth grade—Concept 23
5. Sixth grade—Concepts 4, 22, and 23

From Tables D-1 through 25 and Figures D-1 through 25 (Appendix D), it may be noted that Criterion 3 was satisfied for Concepts 1 through 25 at all grade levels with the following exceptions:

1. Third grade—Concepts 5, 18, and 23
2. Fourth grade—Concepts 5 and 25
3. Sixth grade—Concepts 12, 16, and 23

The data related to Criteria 4 and 5 shown in Table 10 reveal that Criterion 4, "positive teacher opinion," was satisfied for all concepts in grades 4, 5, 6, and 6-AT and for most concepts at grades 2 and 3. "Positive student opinion," Criterion 5, was definitely positive.

Table 11 is a summary of the five criteria and the grade levels at which they were satisfied. It can be seen that the greatest preponderance of the concepts satisfied four of the five criteria at all grade levels. However, two concepts, 2 and 23, did not satisfy four of the five criteria at two grade levels, and Concept 5 did not satisfy four of the five criteria at one grade level.

Table 9

Criterion 1: Concepts in Which 50% of Class Earned a Score of 60% or Higher

Concept Number	Pretest										Posttest									
	Control Group					Experimental Group					Control Group					Experimental Group				
	Grade					Grade					Grade					Grade				
	2	3	4	5	6	2	3	4	5	6	6-AT	2	3	4	5	6	2	3	4	5	6	6-AT
1															x	x	xx	x		xx	x	xx
2		x	x			x	x	x	x	x	x	x	x		x	x	xx	x		x	xx	xx
3	x	x	xx	x	x	x	x	x	x	x	x	x	xx	xx	x	x	xx	xx	xx	xx	xx	xx
4	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	x	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
5	x	xx	x	x	xx	x	x	xx	xx	xx	xx	x	x	x	x	xx	xx	xx	xx	xx	xx	xx
6	x	x	x	x	x	x	x	x	x	xx	x	x	x	x	x	xx	x	xx	xx	xx	xx	xx
7	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
8		x	x	x	x	x	x	x	x	x	xx	x	x	x	x	x	xx	x	x	x	xx	xx
9											x						x			x	x	xx
10	x	xx	xx	xx	xx	x	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
11	x	x	x	x	xx	x	x	x	xx	xx		x	x	x	x	xx	x	xx	xx	xx	xx	xx
12	xx	xx	xx	xx	xx	x	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
13	x				x					x	x			x		x	x	x	x	x	xx	xx
14											x						x	x	x	x	xx	xx
15		x	x	x	xx	x	x	x	x	xx	xx	x	x	x	xx	xx	xx	xx	xx	xx	xx	xx
16	x	x	x	x	xx	x	x	x	xx	x	xx	x	x	xx	x	x	x	xx	xx	xx	xx	xx
17	x	x	x			x	x		x	x	xx	x	x	x	x	x	xx	xx	x	xx	xx	xx
18	x	x	x	xx	x	x	x	x	x	x	xx	x	x	x	xx	xx	x	x	x	xx	xx	xx
19											x				x	x	x		x	x	x	xx
20	x	x		xx	x	x	x	x	x	xx	xx	x	x	x	xx	xx	xx	xx	xx	xx	xx	xx
21	x	x	x	x	x		x	x	x	xx	xx	x	x	x	xx	xx	xx	xx	xx	xx	xx	xx
22		x	x	x	x	x	x	x	x	x	xx	x	x	x	xx	xx	xx	x	xx	xx	xx	xx
23	x	xx	xx	x	x	xx	xx	xx	x	x	xx	x	x	xx	xx	xx	xx	xx	x	x	x	xx
24	x	x		x	x	x	x	x	x	xx	xx	x	xx	x	xx	xx	x	xx	xx	xx	xx	xx
25			x	x	x		x	x	x	x	x	x	x	x	x	xx	xx	xx	xx	xx	xx	xx	xx

x = 50% of class earned a score of 60% or higher. xx = 50% of class earned a score of 80% or higher.

Table 10
Teacher and Student Evaluation of Concept Feasibility

Concept Number	Grade Level at Which Concept is Not Considered Feasible	
	By Teacher	By Students
1		
2	3	3
3		
4	3	
5		
6		
7	2,3	
8		
9		
10		
11	(Cont. in next column)	

(Table 10 cont.)

Concept Number	Grade Level at Which Concept is Not Considered Feasible	
	By Teacher	By Students
12	2,3	
13	2	
14	3	
15	2	
16	2	
17		
18		
19	2	
20	3	
21	3	
22	3	
23	3	
24	3	
25	3	

Table 11

Summary of the Five Criteria of Feasibility by Grade

(Boxes indicate concepts where 4 of the 5 criteria were not met at the grade level.)

Grade Level	2					3					4					5					6					6-AT				
Criterion Number	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	(2)	3	4	5
Concept Number																														
1	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
2	x	x	x	x	x	x	x	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
4	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x
5	x	x	x	x	x	x			x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
7	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
9	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
10	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
11	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
12	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x
13	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
14	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
15	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
16	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x
17	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
18	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
19	x	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
20	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
21	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
22	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x
23	x	x	x	x	x	x	x			x	x		x	x	x	x		x	x	x	x			x	x	x		x	x	x
24	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
25	x		x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x

V
Summary and Conclusions

Summary

1. The test contained three or more items for each of the 25 concepts, with the exception of Concept 12, that satisfied six or more of the eight item criteria.

2. The item criteria that were satisfied by most of the items were as follows:

   a. The item is concerned with the selected concept (Criterion 1).

   b. The proportion of the population selecting the accepted response when the instrument was administered following instruction is greater than 0.50, the level attributable to random guessing (Criterion 2).

   c. The proportion of the population selecting the accepted response to each item is greater when the instrument is administered as a posttest than when it is administered as a pretest (Criterion 3).

   d. The proportion of the instructed population is greater than the proportion of the noninstructed population choosing the accepted response to each item when the instrument is administered as a posttest (Criterion 4).

   e. The items are not of extreme difficulty when included as a posttest for the instructed population ($-2\sigma \leq X_{50} \leq +2\sigma$) (Criterion 6).

   f. The items are positive discriminators when included as a posttest for the instructed population ($\beta \geq +0.30$) (Criterion 7).

   g. The items are usable with groups in a classroom (Criterion 8).

3. Criterion 5, "The proportion of the instructed population at each class level selecting the accepted response to each item increases progressively with grade level when the instrument is administered as a posttest," was met by only two items.

4. The five items related to each concept could be arranged in an order of "goodness" or quality for purposes of constructing a test of the particle nature of matter with fewer items.

5. The reliability (Hoyt internal consistency) of the total test when administered to the total population or to specific grades was above 0.50, a level considered adequate for decisions about group achievement.

6. Four of the following five criteria were met by all grade levels for each of the 25 concepts with the exception of numbers 2, 5, and 23 where they were not met at one or two of the grade levels:

   a. 50% of the experimental group earned a score of 60% (3 of 5 items correct) or higher on the test (Criterion 1).

   b. The concept posttest mean score earned by the experimental group was higher than that of the control group (Criterion 2).

   c. The concept posttest mean score earned by the experimental group was higher than the corresponding pretest score (Criterion 3).

   d. The opinions of the classroom teachers were generally positive (Criterion 4).

   e. The opinions of the pupils were generally positive (Criterion 5).

Conclusions

1. A motion picture format emphasizing the identification of models for explaining natural phenomena is a useful method for producing test items which are valid, reliable, and usable in testing concepts related to the particle nature of matter in grades 2 through 6.
2. The feasibility of teaching selected concepts related to the particle nature of matter in grades 2 through 6 is confirmed by analysis of test results and by the positive opinions of teachers and students.

Appendices

Appendix A
Teacher Evaluation Checklist

CONCEPT NUMBER _____ GRADE LEVEL _____

(circle your answer)

Do you believe that it is feasible to teach this concept at this grade level? YES NO

If no, why not?

STUDENTS:

Did the students have a sufficient background of science knowledge to begin to study this concept? YES NO

If no, what was lacking?

Was the vocabulary appropriate for the students? YES NO

If no, what words gave trouble?

Were the students able to follow the lesson? YES NO

If no, why not?

Do you think most of the students understood the concept? YES NO

Did the lessons create any additional discipline problems? YES NO

If yes, what was the cause?

Do you feel that the students were interested in the lesson and seemed to enjoy it? YES NO

How would you judge the level of difficulty of this concept?

Appropriate for: ___superior students ___superior and excellent students

___superior, excellent and average students ___all students.

Additional Comments:

LESSONS:

Was the lesson, as described, satisfactory for use in teaching the concept?	YES	NO
If not, where did it fail?		
Were the lesson plans and background information adequate for you as a teacher of this concept?	YES	NO
If not, what was missing?		
Do you feel that the lesson restricted your teaching of this concept?	YES	NO
If yes, how?		
Was the allotted time adequate for the lesson?	YES	NO
Was the amount of student activity provided for in the lesson excessive?	YES	NO
Was the amount of student activity provided for in the lesson too meagre?	YES	NO
Additional Comments:		

EQUIPMENT AND SUPPLIES:

Were the available equipment and supplies adequate?	YES	NO
If not, what was missing?		
Were the skills involved in the manipulation of the equipment appropriate for the students' level of development?	YES	NO
If not, what gave them trouble?		
Were the visual aids adequate?	YES	NO
If not, what could be improved?		
Was the demonstration equipment too difficult for you to set up or handle?	YES	NO
If yes, what gave you trouble?		
Additional Comments:		

TABULATION OF STUDENT CHECKLIST

Do you think this idea was too hard for you to learn?	YES	NO
Did you enjoy this lesson?	YES	NO

Appendix B
Student Evaluation Checklist

Do you think this idea was too hard for you to learn? YES___ NO___

Did you enjoy this lesson? YES___ NO___

Appendix C

Tables C-1—C-75: Data on Test Items
Related to Concepts 1-25

Table C-1
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 1

Item Number	Control: All Grades	Experimental: All Grades	Experimental: Grade Level 2	3	4	5	6
C-1	Pre .40 Post .49	Pre .45 Post .85	.19 .77	.30 .91	.41 .81	.58 .88	.77 .88
C-4	Pre .38 Post .42	Pre .36 Post .64	.31 .81	.22 .50	.19 .46	.62 .80	.46 .60
C-12	Pre .21 Post .30	Pre .22 Post .57	.08 .85	.13 .59	.07 .46	.54 .60	.27 .52
C-20	Pre .21 Post .27	Pre .20 Post .44	.23 .65	.26 .73	.15 .15	.19 .52	.15 .60
C-26	Pre .48 Post .52	Pre .45 Post .65	.31 .69	.22 .59	.37 .38	.50 .84	.42 .72

Table C-2
Statistics of the Test Items Related to Concept No. 1 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
C-1	-1.29	1.30
C-4	-0.38	2.27
C-12	-0.20	2.31
C-20	+0.16	2.09
C-26	-0.50	1.14

Table C-3
Evaluation of the Test Items Related to Concept No. 1

Item Number	1	2	3	4	5	6	7	8
C-1	*	*	*	*		*	*	*
C-4	*	*	*	*		*	*	*
C-12	*	*	*	*		*	*	*
C-20	*		*	*		*	*	*
C-26	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-4
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 2

Item Number	Control: All Grades	Experimental: All Grades	Experimental: Grade Level 2	3	4	5	6
C-2	Pre .72 Post .79	Pre .83 Post .88	.81 .88	.78 .91	.81 .92	.92 .80	.81 .88
C-7	Pre .25 Post .31	Pre .27 Post .33	.19 .38	.30 .18	.26 .19	.31 .52	.27 .36
C-11	Pre .43 Post .47	Pre .52 Post .53	.42 .69	.52 .45	.44 .35	.58 .56	.62 .60
C-16	Pre .66 Post .62	Pre .73 Post .77	.77 .88	.74 .68	.56 .65	.88 .76	.73 .88
C-27	Pre .34 Post .46	Pre .40 Post .57	.46 .73	.39 .55	.30 .35	.46 .60	.38 .64

Table C-5

Statistics of the Test Items Related to Concept No. 2 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
C-2	-1.94	0.76
C-7	+0.57	1.23
C-11	-0.12	0.94
C-16	-1.16	0.86
C-27	-0.22	1.66

Table C-6

Evaluation of the Test Items Related to Concept No. 2

Item Number	Criterion Number 1	2	3	4	5	6	7	8
C-2	*	*	*	*		*	*	*
C-7	*		*	*		*	*	*
C-11	*	*	*	*		*	*	*
C-16	*	*	*	*		*	*	*
C-27	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-7

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 3

Item Number	Control: All Grades		Experimental: All Grades		Grade Level 2	3	4	5	6
C-5	Pre	.73	Pre	.72	.81	.78	.81	.54	.65
	Post	.79	Post	.67	.73	.68	.58	.72	.64
C-17	Pre	.91	Pre	.84	.77	.70	.85	.96	.88
	Post	.96	Post	.91	.96	.91	.85	.88	.96
C-19	Pre	.80	Pre	.85	.81	.87	.85	.88	.85
	Post	.81	Post	.90	.92	.91	.88	.84	.92
C-23	Pre	.54	Pre	.63	.73	.74	.63	.50	.58
	Post	.60	Post	.65	.65	.73	.69	.52	.64
C-30	Pre	.26	Pre	.20	.08	.22	.07	.38	.27
	Post	.27	Post	.65	.85	.55	.50	.72	.64

Table C-8

Statistics of the Test Items Related to Concept No. 3 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
C-5	-0.52	1.55
C-17	-1.64	1.44
C-19	-1.99	0.81
C-23	-0.43	1.70
C-30	-0.58	0.93

Table C-9

Evaluation of the Test Items Related to Concept No. 3

Item Number	Criterion Number 1	2	3	4	5	6	7	8
C-5	*	*				*	*	*
C-17	*	*	*			*	*	*
C-19	*	*	*	*		*	*	*
C-23	*	*	*	*		*	*	*
C-30	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-10
Proportions of the Control and Experimental Groups Choosing
the Accepted Responses to the Test Items Related to Concept No. 4

Item Number	Control		Experimental					
	All Grades		All Grades		Grade Level 2	3	4	5	6
C-9	Pre	.97	Pre	.98	1.00	.96	1.00	.96	1.00
	Post	.94	Post	1.00	1.00	1.00	1.00	1.00	1.00
C-14	Pre	.88	Pre	.96	.96	1.00	.96	.92	.96
	Post	.85	Post	.93	.92	.82	1.00	.92	.96
C-21	Pre	.38	Pre	.37	.35	.26	.44	.38	.38
	Post	.31	Post	.48	.54	.36	.42	.56	.48
C-25	Pre	.71	Pre	.71	.73	.74	.67	.88	.54
	Post	.71	Post	.73	.62	.77	.65	.84	.80
C-29	Pre	.94	Pre	.96	1.00	.96	.96	.92	.96
	Post	.95	Post	.96	.96	.95	1.00	.92	.96

Table C-11
Statistics of the Test Items Related to
Concept No. 4 When Administered to the
Experimental Group as Part of a Posttest

Item Number	X_{50}	β
C-9	-----	----
C-14	-2.28	0.83
C-21	+0.07	2.15
C-25	-0.76	1.45
C-29	-1.80	4.21

Table C-12
Evaluation of the Test Items Related to
Concept No. 4

Item Number	Criterion Number 1	2	3	4	5	6	7	8
C-9	*	*	*	*		X	X	*
C-14	*	*		*			*	*
C-21	*		*	*		*	*	*
C-25	*	*	*	*		*	*	*
C-29	*	*		*		*	*	*

* Indicates criterion was satisfied.
X Indicates value was not calculated.

Table C-13
Proportions of the Control and Experimental Groups Choosing
the Accepted Responses to the Test Items Related to Concept No. 5

Item Number	Control		Experimental					
	All Grades		All Grades		Grade Level 2	3	4	5	6
C-8	Pre	.75	Pre	.72	.77	.57	.85	.69	.69
	Post	.65	Post	.67	.54	.36	.62	.88	.92
C-15	Pre	.65	Pre	.75	.85	.52	.81	.77	.77
	Post	.59	Post	.74	.69	.59	.77	.80	.84
C-18	Pre	.60	Pre	.69	.65	.61	.74	.69	.73
	Post	.50	Post	.70	.62	.64	.69	.76	.80
C-22	Pre	.86	Pre	.83	.73	.91	.81	.81	.88
	Post	.83	Post	.85	.88	.77	.69	.96	.92
C-24	Pre	.63	Pre	.68	.46	.70	.56	.81	.88
	Post	.58	Post	.77	.69	.73	.81	.84	.80

Table C-14

Statistics of the Test Items Related to Concept No. 5 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
C-8	-0.69	0.83
C-15	-----	-----
C-18	-0.62	1.64
C-22	-1.80	0.69
C-24	-0.87	1.73

Table C-15

Evaluation of the Test Items Related to Concept No. 5

Item Number	Criterion Number 1	2	3	4	5	6	7	8
C-8	*	*		*		*	*	*
C-15	*	*		*		X	X	*
C-18	*	*	*	*	*	*	*	*
C-22	*	*	*	*		*	*	*
C-24	*	*	*	*		*	*	*

* Indicates criterion was satisfied.
X Indicates value was not calculated.

Table C-16

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 6

Item Number	Control: All Grades		Experimental: All Grades		Grade Level 2	3	4	5	6
C-3	Pre	.92	Pre	.90	.96	.91	1.00	.81	.81
	Post	.93	Post	.89	.96	.86	.92	.76	.92
C-6	Pre	.52	Pre	.55	.42	.43	.56	.58	.77
	Post	.53	Post	.78	.69	.68	.69	.96	.88
C-10	Pre	.69	Pre	.71	.77	.78	.67	.54	.81
	Post	.81	Post	.88	.73	.86	.96	.92	.92
C-13	Pre	.39	Pre	.42	.42	.48	.44	.31	.46
	Post	.43	Post	.45	.42	.41	.46	.52	.44
C-28	Pre	.52	Pre	.54	.35	.61	.56	.42	.77
	Post	.53	Post	.51	.58	.59	.46	.40	.52

Table C-17

Statistics of the Test Items Related to Concept No. 6 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
C-3	-1.55	1.25
C-6	-0.93	1.53
C-10	-1.88	0.79
C-13	+0.15	1.51
C-28	-0.03	0.96

Table C-18

Evaluation of the Test Items Related to Concept No. 6

Item Number	Criterion Number 1	2	3	4	5	6	7	8
C-3	*	*				*	*	*
C-6	*	*	*	*		*	*	*
C-10	*	*	*	*		*	*	*
C-13	*		*	*		*	*	*
C-28	*	*				*	*	*

*Indicates criterion was satisfied.

Table C-19
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 7

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
M-1	Pre	.21	Pre .22	.12	.26	.19	.35	.19
	Post	.29	Post .70	.77	.50	.65	.80	.76
M-6	Pre	.92	Pre .86	.85	.87	.85	.65	.88
	Post	.90	Post .93	.96	.95	.85	.88	1.00
M-10	Pre	.93	Pre .92	.85	1.00	.89	.88	1.00
	Post	.94	Post .97	.85	1.00	1.00	1.00	1.00
M-12	Pre	.85	Pre .84	.77	.76	.89	.81	.92
	Post	.85	Post .94	.81	.91	1.00	1.00	.96
M-17	Pre	.90	Pre .84	.81	.82	.81	.73	1.00
	Post	.84	Post .94	.92	.86	.96	.92	1.00

Table C-20
Statistics of the Test Items Related to Concept No. 7 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
M-1	-0.64	1.49
M-6	-2.07	0.99
M-10	-1.92	3.61
M-12	-----	----
M-17	-2.08	1.06

Table C-21
Evaluation of the Test Items Related to Concept No. 7

Item Number	Criterion Number 1	2	3	4	5	6	7	8
M-1	*	*	*	*		*	*	*
M-6	*	*	*	*			*	*
M-10	*	*	*	*		*	*	*
M-12	*	*	*	*		X	X	*
M-17	*	*	*	*			*	*

* Indicates criterion was satisfied.
X Indicates value was not calculated.

Table C-22
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 8

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
M-2	Pre	.75	Pre .62	.62	.52	.78	.73	.46
	Post	.73	Post .48	.31	.27	.46	.48	.84
M-8	Pre	.80	Pre .85	.69	.87	.93	.88	.85
	Post	.87	Post .93	.88	.86	1.00	.92	.96
M-13	Pre	.19	Pre .25	.35	.17	.26	.08	.38
	Post	.23	Post .62	.65	.55	.65	.48	.76
M-19	Pre	.12	Pre .16	.19	.26	.04	.15	.19
	Post	.13	Post .45	.62	.32	.31	.56	.44
M-22	Pre	.89	Pre .89	.73	.91	.93	.92	.96
	Post	.89	Post .93	.92	.95	.96	.84	.96

Table C-23

Statistics of the Test Items Related to Concept No. 8 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
M-2	+0.08	1.02
M-8	-2.14	0.93
M-13	-0.41	1.11
M-19	+0.16	1.25
M-22	-1.98	1.09

Table C-24

Evaluation of the Test Items Related to Concept No. 8

Item Number	Criterion Number 1	2	3	4	5	6	7	8
M-2	*					*	*	*
M-8	*		*	*			*	*
M-13	*	*	*	*		*	*	*
M-19	*		*	*		*	*	*
M-22	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-25

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 9

Item Number	Control: All Grades		Experimental: All Grades		Grade Level 2	3	4	5	6
M-4	Pre	.27	Pre	.27	.19	.39	.15	.27	.35
	Post	.15	Post	.57	.77	.45	.38	.52	.72
M-7	Pre	.33	Pre	.39	.50	.35	.37	.35	.38
	Post	.19	Post	.27	.19	.14	.12	.56	.36
M-15	Pre	.80	Pre	.80	.65	.83	.81	.81	.88
	Post	.83	Post	.91	.85	.82	.96	.96	.96
M-21	Pre	.08	Pre	.07	.04	.04	.04	.08	.15
	Post	.15	Post	.25	.23	.18	.12	.40	.32
M-24	Pre	.40	Pre	.30	.38	.22	.41	.23	.31
	Post	.21	Post	.69	.58	.59	.65	.72	.92

Table C-26

Statistics of the Test Items Related to Concept No. 9 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
M-4	-0.22	1.49
M-7	+0.84	1.03
M-15	-2.36	0.69
M-21	+0.92	1.07
M-24	-0.80	0.81

Table C-27

Evaluation of the Test Items Related to Concept No. 9

Item Number	Criterion Number 1	2	3	4	5	6	7	8
M-4	*	*	*	*		*	*	*
M-7	*			*		*	*	*
M-15	*	*	*	*			*	*
M-21	*		*	*		*	*	*
M-24	*	*	*	*	*	*	*	*

*Indicates criterion was satisfied.

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Table C-28
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 10

Item Number	Control: All Grades		Experimental: All Grades		Experimental: Grade Level 2	3	4	5	6
M-5	Pre	.82	Pre	.80	.73	.70	.78	.88	.88
	Post	.85	Post	.85	.73	.82	.88	.84	1.00
M-14	Pre	.56	Pre	.56	.58	.57	.56	.54	.58
	Post	.69	Post	.58	.62	.45	.54	.68	.60
M-16	Pre	.80	Pre	.71	.54	.83	.52	.85	.85
	Post	.86	Post	.90	.81	.86	.92	.96	.96
M-23	Pre	.78	Pre	.81	.69	.83	.67	.92	.96
	Post	.84	Post	.90	.73	.86	.92	1.00	.96
M-25	Pre	.75	Pre	.72	.65	.70	.70	.69	.85
	Post	.75	Post	.86	.85	.73	.85	.96	.92

Table C-29
Statistics of the Test Items Related to Concept No. 10 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
M-5	-1.17	2.11
M-14	-0.26	1.24
M-16	-1.32	6.59
M-23	-1.28	5.05
M-25	-1.70	0.84

Table C-30
Evaluation of the Test Items Related to Concept No. 10

Item Number	Criterion Number 1	2	3	4	5	6	7	8
M-5	*	*	*			*	*	*
M-14	*	*	*			*	*	*
M-16	*	*	*	*		*	*	*
M-23	*	*	*	*		*	*	*
M-25	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-31
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 11

Item Number	Control: All Grades		Experimental: All Grades		Experimental: Grade Level 2	3	4	5	6
M-3	Pre	.40	Pre	.44	.31	.35	.63	.58	.31
	Post	.47	Post	.56	.46	.82	.58	.48	.52
M-9	Pre	.68	Pre	.73	.62	.70	.70	.65	.96
	Post	.69	Post	.85	.92	.82	.69	.92	.92
M-11	Pre	.56	Pre	.53	.46	.30	.48	.58	.81
	Post	.61	Post	.73	.62	.59	.73	.76	.96
M-18	Pre	.83	Pre	.74	.69	.70	.67	.73	.92
	Post	.88	Post	.94	.88	.86	.92	1.00	1.00
M-20	Pre	.51	Pre	.66	.62	.48	.63	.65	.88
	Post	.60	Post	.77	.46	.59	.77	1.00	1.00

Table C-32

Statistics of the Test Items Related to Concept No. 11 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
M-3	-0.26	0.83
M-9	-1.28	1.46
M-11	-0.72	1.79
M-18	-1.94	1.26
M-20	-0.75	4.14

Table C-33

Evaluation of the Test Items Related to Concept No. 11

Item Number	Criterion Number 1	2	3	4	5	6	7	8
M-3	*	*	*	*		*	*	*
M-9	*	*	*	*		*	*	*
M-11	*	*	*	*		*	*	*
M-18	*	*	*	*		*	*	*
M-20	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-34

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 12

Item Number	Control: All Grades		Experimental: All Grades	Grade Level 2	3	4	5	6
S-1	Pre	.53	Pre .50	.31	.52	.48	.38	.81
	Post	.79	Post .90	.92	.82	.88	.92	.96
S-6	Pre	.90	Pre .88	.77	.78	.93	.88	1.00
	Post	.92	Post .98	1.00	.86	1.00	1.00	1.00
S-10	Pre	.80	Pre .82	.69	.70	.89	.85	.96
	Post	.75	Post .90	.88	.77	.92	.96	.92
S-20	Pre	.66	Pre .76	.77	.61	.81	.77	.81
	Post	.60	Post .58	.38	.45	.69	.72	.64
S-22	Pre	.79	Pre .88	.81	.83	.85	.92	.96
	Post	.73	Post .86	.85	.73	.88	.92	.92

Table C-35

Statistics of the Test Items Related to Concept No. 12 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
S-1	-1.61	1.37
S-6	-----	----
S-10	-----	----
S-20	-0.26	1.23
S-22	-----	----

Table C-36

Evaluation of the Test Items Related to Concept No. 12

Item Number	Criterion Number 1	2	3	4	5	6	7	8
S-1	*	*	*	*		*	*	*
S-6	*	*	*	*		X	X	*
S-10	*	*	*	*		X	X	*
S-20	*	*				*	*	*
S-22	*	*		*		X	X	*

* Indicates criterion was satisfied.
X Indicates value was not calculated.

Table C-37
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 13

Item Number	Control: All Grades		Experimental: All Grades		Experimental: Grade Level 2	3	4	5	6
S-5	Pre	.23	Pre	.20	.23	.30	.11	.12	.23
	Post	.23	Post	.27	.50	.18	.19	.20	.28
S-8	Pre	.42	Pre	.59	.42	.61	.48	.65	.77
	Post	.53	Post	.80	.85	.77	.77	.88	.72
S-12	Pre	.56	Pre	.40	.50	.48	.33	.27	.42
	Post	.56	Post	.60	.46	.50	.58	.56	.92
S-19	Pre	.67	Pre	.56	.42	.61	.52	.58	.69
	Post	.63	Post	.56	.50	.45	.54	.52	.76
S-23	Pre	.60	Pre	.55	.54	.39	.44	.54	.81
	Post	.60	Post	.72	.62	.65	.77	.84	.72

Table C-38
Statistics of the Test Items Related to Concept No. 13 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
S-5	+1.46	0.45
S-8	-1.17	1.02
S-12	-0.37	1.04
S-19	-0.18	1.27
S-23	-0.89	0.85

Table C-39
Evaluation of the Test Items Related to Concept No. 13

Item Number	Criterion Number 1	2	3	4	5	6	7	8
S-5	*		*	*		*	*	*
S-8	*	*	*	*		*	*	*
S-12	*	*	*	*		*	*	*
S-19	*	*		*		*	*	*
S-23	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-40
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 14

Item Number	Control: All Grades		Experimental: All Grades		Experimental: Grade Level 2	3	4	5	6
S-2	Pre	.44	Pre	.48	.42	.48	.37	.42	.69
	Post	.38	Post	.65	.69	.73	.62	.52	.72
S-9	Pre	.15	Pre	.15	.12	.13	.07	.19	.23
	Post	.23	Post	.47	.42	.32	.54	.52	.52
S-14	Pre	.20	Pre	.31	.23	.48	.22	.27	.38
	Post	.30	Post	.67	.69	.45	.62	.76	.80
S-17	Pre	.63	Pre	.56	.54	.61	.63	.42	.62
	Post	.54	Post	.66	.62	.55	.77	.64	.72
S-25	Pre	.34	Pre	.43	.54	.39	.30	.42	.50
	Post	.32	Post	.50	.46	.32	.46	.52	.72

Table C-41

Statistics of the Test Items Related to Concept No. 14 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
S-2	-0.72	0.66
S-9	+0.10	1.57
S-14	-0.74	0.74
S-17	-0.54	1.37
S-25	+0.00	1.48

Table C-42

Evaluation of the Test Items Related to Concept No. 14

Item Number	Criterion Number 1	2	3	4	5	6	7	8
S-2	*	*	*	*		*	*	*
S-9	*		*	*		*	*	*
S-14	*	*	*	*		*	*	*
S-17	*	*	*	*		*	*	*
S-25	*		*	*		*	*	*

*Indicates criterion was satisfied.

Table C-43

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 15

Item Number	Control: All Grades		Experimental: All Grades		Experimental: Grade Level 2	3	4	5	6
S-3	Pre	.77	Pre	.84	.81	.87	.93	.77	.85
	Post	.76	Post	.84	.77	.86	.81	.84	.92
S-7	Pre	.26	Pre	.38	.27	.30	.22	.46	.65
	Post	.37	Post	.90	.92	.86	.92	.84	.96
S-13	Pre	.75	Pre	.70	.69	.61	.74	.69	.73
	Post	.85	Post	.80	.77	.64	.85	.88	.84
S-15	Pre	.39	Pre	.44	.35	.52	.41	.43	.50
	Post	.35	Post	.48	.38	.23	.73	.52	.48
S-18	Pre	.78	Pre	.81	.77	.70	.93	.88	.77
	Post	.84	Post	.89	.77	.82	.96	.92	.96

Table C-44

Statistics of the Test Items Related to Concept No. 15 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
S-3	-1.35	1.08
S-7	-1.73	1.14
S-13	-1.09	1.20
S-15	+0.09	1.01
S-18	-1.32	2.34

Table C-45

Evaluation of the Test Items Related to Concept No. 15

Item Number	Criterion Number 1	2	3	4	5	6	7	8
S-3	*	*		*		*	*	*
S-7	*	*	*	*		*	*	*
S-13	*	*	*			*	*	*
S-15	*		*	*		*	*	*
S-18	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-46
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 16

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
S-4	Pre	.72	Pre .67	.69	.87	.59	.69	.54
	Post	.69	Post .42	.19	.59	.31	.72	.32
S-11	Pre	.65	Pre .57	.31	.48	.48	.73	.85
	Post	.63	Post .81	.88	.82	.77	.76	.80
S-16	Pre	.73	Pre .70	.54	.70	.85	.65	.73
	Post	.76	Post .84	.77	.86	.85	.88	.84
S-21	Pre	.48	Pre .59	.42	.65	.56	.65	.69
	Post	.57	Post .57	.42	.55	.69	.60	.60
S-24	Pre	.60	Pre .59	.58	.43	.67	.62	.65
	Post	.56	Post .80	.88	.68	.85	.76	.80

Table C-47
Statistics of the Test Items Related to Concept No. 16 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
S-4	+0.33	0.78
S-11	-1.32	0.86
S-16	-1.53	0.85
S-21	-0.26	0.99
S-24	-1.23	0.92

Table C-48
Evaluation of the Test Items Related to Concept No. 16

Item Number	Criterion Number 1	2	3	4	5	6	7	8
S-4	*					*	*	*
S-11	*	*	*	*		*	*	*
S-16	*	*	*	*		*	*	*
S-21	*	*				*	*	*
S-24	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-49
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 17

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
U-3	Pre	.51	Pre .59	.62	.52	.56	.62	.62
	Post	.57	Post .81	.88	.73	.85	.76	.80
U-5	Pre	.73	Pre .70	.62	.70	.78	.73	.65
	Post	.73	Post .86	.85	.86	.96	.76	.88
U-13	Pre	.56	Pre .55	.50	.43	.52	.62	.69
	Post	.52	Post .67	.85	.73	.31	.72	.76
U-19	Pre	.50	Pre .48	.62	.30	.44	.38	.62
	Post	.53	Post .69	.73	.59	.62	.72	.80
U-24	Pre	.52	Pre .59	.38	.78	.56	.46	.77
	Post	.52	Post .65	.77	.55	.50	.64	.80

Table C-50

Statistics of the Test Items Related to Concept No. 17 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
U-3	-1.52	0.69
U-5	-2.10	0.61
U-13	-0.54	1.36
U-19	-0.66	1.20
U-24	-0.55	1.04

Table C-51

Evaluation of the Test Items Related to Concept No. 17

Item Number	Criterion Number 1	2	3	4	5	6	7	8
U-3	*	*	*	*		*	*	*
U-5	*	*	*	*			*	*
U-13	*	*	*	*		*	*	*
U-19	*	*	*	*		*	*	*
U-24	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-52

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 18

Item Number	Control: All Grades		Experimental: All Grades		Grade Level 2	3	4	5	6
U-4	Pre	.54	Pre	.53	.46	.57	.44	.69	.50
	Post	.56	Post	.66	.62	.68	.50	.80	.72
U-8	Pre	.71	Pre	.61	.46	.57	.74	.58	.69
	Post	.61	Post	.75	.46	.82	.73	.88	.88
U-10	Pre	.89	Pre	.82	.69	.91	.89	.69	.92
	Post	.82	Post	.86	.85	.82	.88	.92	.84
U-21	Pre	.52	Pre	.47	.50	.39	.44	.42	.58
	Post	.58	Post	.64	.69	.50	.62	.72	.64
U-23	Pre	.45	Pre	.51	.46	.52	.56	.35	.65
	Post	.40	Post	.41	.35	.09	.35	.60	.64

Table C-53

Statistics of the Test Items Related to Concept No. 18 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
U-4	-0.52	1.35
U-8	-0.88	1.19
U-10	-2.15	0.59
U-21	-0.49	1.01
U-23	+0.33	0.95

Table C-54

Evaluation of the Test Items Related to Concept No. 18

Item Number	Criterion Number 1	2	3	4	5	6	7	8
U-4	*	*	*	*		*	*	*
U-8	*	*	*	*		*	*	*
U-10	*	*	*	*			*	*
U-21	*	*	*	*		*	*	*
U-23	*			*		*	*	*

*Indicates criterion was satisfied.

Table C-55
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 19

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
U-2	Pre .25		Pre .36	.62	.17	.37	.31	.31
	Post .47		Post .55	.77	.50	.42	.60	.44
U-12	Pre .31		Pre .34	.23	.22	.33	.50	.38
	Post .46		Post .66	.62	.68	.69	.64	.68
U-14	Pre .25		Pre .37	.23	.43	.37	.27	.54
	Post .37		Post .56	.62	.27	.58	.56	.72
U-16	Pre .33		Pre .35	.38	.30	.41	.27	.38
	Post .45		Post .42	.23	.41	.54	.44	.48
U-18	Pre .37		Pre .48	.35	.48	.56	.50	.50
	Post .54		Post .56	.54	.41	.65	.64	.52

Table C-56
Statistics of the Test Items Related to Concept No. 19 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
U-2	-0.18	0.93
U-12	-0.71	0.72
U-14	-0.24	0.75
U-16	+0.31	0.86
U-18	-0.24	0.72

Table C-57
Evaluation of the Test Items Related to Concept No. 19

Item Number	Criterion Number 1	2	3	4	5	6	7	8
U-2	*	*	*	*		*	*	*
U-12	*	*	*	*		*	*	*
U-14	*	*	*	*		*	*	*
U-16	*		*			*	*	*
U-18	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-58
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 20

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
U-1	Pre .44		Pre .43	.50	.43	.33	.42	.46
	Post .75		Post .81	.92	.86	.69	.76	.84
U-6	Pre .82		Pre .82	.88	.87	.74	.73	.88
	Post .83		Post .90	.92	.82	.81	.92	1.00
U-9	Pre .69		Pre .70	.69	.57	.70	.73	.81
	Post .88		Post .89	.73	1.00	.81	.96	.96
U-15	Pre .52		Pre .45	.50	.39	.33	.42	.62
	Post .44		Post .65	.65	.59	.50	.72	.80
U-20	Pre .56		Pre .58	.46	.61	.52	.58	.73
	Post .59		Post .75	.62	.82	.77	.72	.84

Table C-59

Statistics of the Test Items Related to Concept No. 20 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
U-1	-1.00	2.06
U-6	-1.40	2.01
U-9	-1.43	1.61
U-15	-0.49	1.35
U-20	-0.80	1.58

Table C-60

Evaluation of the Test Items Related to Concept No. 20

Item Number	Criterion Number 1	2	3	4	5	6	7	8
U-1	*	*	*	*		*	*	*
U-6	*	*	*	*		*	*	*
U-9	*	*	*	*		*	*	*
U-15	*	*	*	*		*	*	*
U-20	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-61

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 21

Item Number	Control: All Grades		Experimental: All Grades		Grade Level 2	3	4	5	6
U-7	Pre	.79	Pre	.77	.66	.78	.93	.69	.81
	Post	.89	Post	.92	.88	.91	.88	.92	1.00
U-11	Pre	.81	Pre	.78	.50	.83	.70	.92	.96
	Post	.81	Post	.91	.85	.91	.92	.88	1.00
U-17	Pre	.40	Pre	.39	.27	.30	.37	.38	.62
	Post	.54	Post	.69	.69	.77	.65	.56	.80
U-22	Pre	.15	Pre	.30	.23	.17	.41	.23	.42
	Post	.22	Post	.47	.50	.23	.46	.44	.68
U-25	Pre	.61	Pre	.66	.65	.52	.70	.73	.69
	Post	.85	Post	.85	.77	.91	.92	.76	.88

Table C-62

Statistics of the Test Items Related to Concept No. 21 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
U-7	-1.58	1.94
U-11	-2.32	0.72
U-17	-0.60	1.59
U-22	+0.10	1.40
U-25	-1.22	1.54

Table C-63

Evaluation of the Test Items Related to Concept No. 21

Item Number	Criterion Number 1	2	3	4	5	6	7	8
U-7	*	*	*	*		*	*	*
U-11	*	*	*	*			*	*
U-17	*	*	*	*		*	*	*
U-22	*		*	*		*	*	*
U-25	*	*	*			*	*	*

*Indicates criterion was satisfied.

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Table C-64
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 22

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
X-2	Pre	.68	Pre .63	.50	.65	.63	.69	.69
	Post	.77	Post .82	.81	.82	.85	.80	.84
X-6	Pre	.43	Pre .38	.46	.52	.33	.27	.35
	Post	.40	Post .56	.65	.64	.38	.64	.52
X-12	Pre	.75	Pre .83	.88	.70	.74	.88	.92
	Post	.90	Post .88	.96	.73	.85	.96	.88
X-17	Pre	.79	Pre .80	.69	.74	.81	.88	.88
	Post	.83	Post .79	.81	.68	.81	.88	.76
X-19	Pre	.44	Pre .45	.50	.52	.41	.50	.35
	Post	.48	Post .55	.58	.55	.50	.56	.56

Table C-65
Statistics of the Test Items Related to Concept No. 22 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
X-2	-1.18	1.25
X-6	-0.21	1.27
X-12	-1.45	1.38
X-17	-0.95	1.62
X-19	-0.15	1.27

Table C-66
Evaluation of the Test Items Related to Concept No. 22

Item Number	Criterion Number							
	1	2	3	4	5	6	7	8
X-2	*	*	*	*		*	*	*
X-6	*	*	*	*		*	*	*
X-12	*	*	*			*	*	*
X-17	*	*				*	*	*
X-19	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-67
Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 23

Item Number	Control		Experimental					
	All Grades		All Grades	Grade Level 2	3	4	5	6
X-1	Pre	.76	Pre .81	.73	.83	.85	.77	.88
	Post	.84	Post .81	.92	.59	.88	.80	.80
X-7	Pre	.71	Pre .80	.69	.83	.74	.81	.92
	Post	.71	Post .75	.69	.64	.85	.76	.80
X-9	Pre	.60	Pre .55	.54	.65	.59	.50	.50
	Post	.66	Post .57	.62	.73	.46	.56	.52
X-14	Pre	.38	Pre .38	.35	.39	.37	.31	.46
	Post	.47	Post .41	.58	.55	.35	.24	.36
X-18	Pre	.83	Pre .85	.85	.78	.89	.85	.88
	Post	.83	Post .90	.81	.91	.96	.96	.88

Table C-68

Statistics of the Test Items Related to Concept No. 23 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
X-1	-1.17	1.10
X-7	-1.41	0.55
X-9	-0.29	0.80
X-14	+0.42	0.64
X-18	-1.81	1.03

Table C-69

Evaluation of the Test Items Related to Concept No. 23

Item Number	Criterion Number 1	2	3	4	5	6	7	8
X-1	*	*				*	*	*
X-7	*	*		*		*	*	*
X-9	*	*	*			*	*	*
X-14	*		*			*	*	*
X-18	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-70

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 24

Item Number	Control: All Grades		Control: All Grades	Experimental: Grade Level 2	3	4	5	6
X-4	Pre	.80	Pre .84	.73	.87	.78	.92	.88
	Post	.77	Post .79	.65	.91	.88	.84	.68
X-8	Pre	.47	Pre .57	.54	.65	.70	.38	.58
	Post	.47	Post .66	.54	.68	.69	.64	.76
X-11	Pre	.50	Pre .58	.65	.48	.48	.73	.54
	Post	.60	Post .70	.85	.59	.62	.76	.68
X-16	Pre	.63	Pre .72	.73	.61	.81	.69	.73
	Post	.71	Post .81	.58	.82	.81	.92	.92
X-20	Pre	.56	Pre .60	.46	.57	.52	.62	.85
	Post	.67	Post .74	.77	.59	.65	.80	.88

Table C-71

Statistics of the Test Items Related to Concept No. 24 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
X-4	-1.07	1.15
X-8	-0.54	1.18
X-11	-0.68	1.23
X-16	-1.01	1.65
X-20	-1.13	0.70

Table C-72

Evaluation of the Test Items Related to Concept No. 24

Item Number	Criterion Number 1	2	3	4	5	6	7	8
X-4	*	*		*		*	*	*
X-8	*	*	*	*		*	*	*
X-11	*	*	*	*		*	*	*
X-16	*	*	*	*		*	*	*
X-20	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Table C-73

Proportions of the Control and Experimental Groups Choosing the Accepted Responses to the Test Items Related to Concept No. 25

Item Number	Control		Experimental				
	All Grades	All Grades	Grade Level 2	3	4	5	6
X-3	Pre .63	Pre .72	.54	.74	.81	.81	.69
	Post .72	Post .70	.73	.77	.58	.68	.76
X-5	Pre .53	Pre .59	.38	.65	.59	.62	.73
	Post .52	Post .76	.81	.82	.58	.72	.88
X-10	Pre .42	Pre .59	.27	.65	.78	.62	.62
	Post .59	Post .72	.65	.68	.65	.80	.80
X-13	Pre .55	Pre .52	.46	.48	.67	.46	.54
	Post .53	Post .77	.77	.82	.88	.64	.72
X-15	Pre .60	Pre .51	.58	.57	.44	.58	.38
	Post .52	Post .61	.62	.68	.54	.60	.64

Table C-74

Statistics of the Test Items Related to Concept No. 25 When Administered to the Experimental Group as Part of a Posttest

Item Number	X_{50}	β
X-3	-0.61	1.73
X-5	-0.93	1.14
X-10	-0.77	1.13
X-13	-1.02	1.01
X-15	-0.53	0.65

Table C-75

Evaluation of the Test Items Related to Concept No. 25

Item Number	Criterion Number 1	2	3	4	5	6	7	8
X-3	*	*				*	*	*
X-5	*	*	*	*		*	*	*
X-10	*	*	*	*		*	*	*
X-13	*	*	*	*		*	*	*
X-15	*	*	*	*		*	*	*

*Indicates criterion was satisfied.

Appendix D

Tables D-1—D-25 and Figures D-1—D-25: Group Mean Test Scores by Grade for Concepts 1-25

Table D-1

Control and Experimental Group Mean Test Scores by Grade - Concept 1

		Grade					
		2	3	4	5	6	6-AT
Pre	C	1.36	1.18	1.70	1.83	1.93	----
	E	1.44	1.08	1.18	2.25	2.00	2.28
Post	C	1.30	1.33	1.85	2.61	2.79	----
	E	3.77	2.68	2.27	3.64	3.32	4.96

AT = Academically Talented

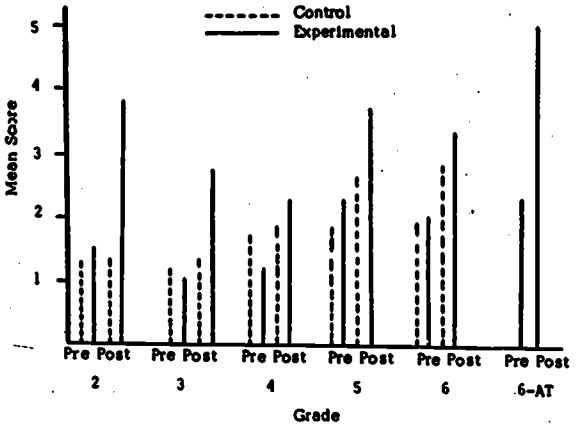

Fig. D-1. Graph of Table D-1.

Table D-2

Control and Experimental Group Mean Test Scores by Grade - Concept 2

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.04	2.07	2.59	2.34	2.14	----
	E	2.55	2.62	2.37	2.93	2.70	2.32
Post	C	2.56	2.75	2.55	2.69	2.67	----
	E	3.58	2.77	2.46	3.24	3.36	4.60

AT = Academically Talented

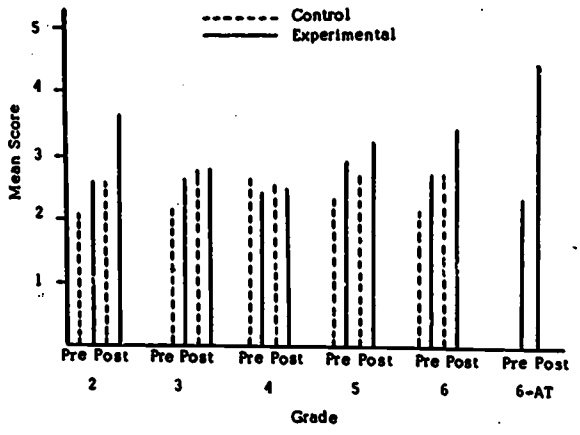

Fig. D-2. Graph of Table D-2.

Table D-3

Control and Experimental Group Mean Test Scores by Grade - Concept 3

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.96	2.70	3.33	3.07	3.21	----
	E	3.07	3.17	3.22	3.03	3.11	3.08
Post	C	3.39	3.58	3.48	3.54	3.12	----
	E	4.11	3.77	3.50	3.68	3.80	4.44

AT = Academically Talented

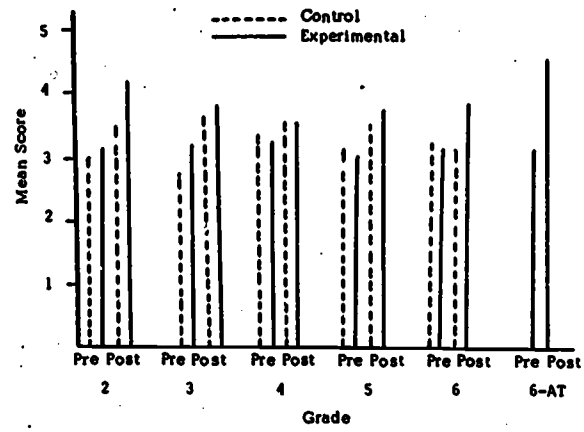

Fig. D-3. Graph of Table D-3.

Table D-4

Control and Experimental Group Mean Test Scores by Grade - Concept 4

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.36	3.55	3.89	3.62	3.75	----
	E	3.89	3.75	4.04	3.78	3.70	3.76
Post	C	3.22	3.62	3.92	3.77	4.25	----
	E	4.04	3.91	4.08	4.24	4.20	4.80

AT = Academically Talented

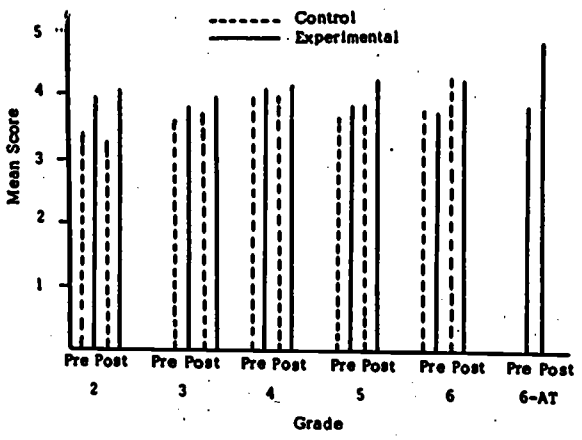

Fig. D-4. Graph of Table D-4.

Table D-5

Control and Experimental Group Mean Test Scores by Grade - Concept 5

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.04	3.04	3.52	3.14	3.68	----
	E	3.33	3.17	3.78	3.50	3.81	3.68
Post	C	2.83	3.12	2.81	3.08	3.96	----
	E	3.42	3.09	3.58	4.24	4.28	4.56

AT = Academically Talented

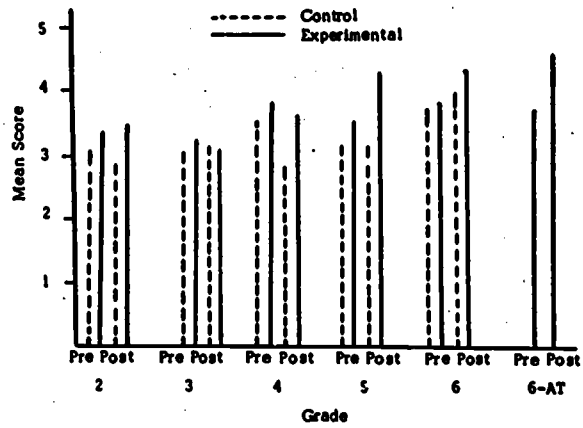

Fig. D-5. Graph of Table D-5.

Table D-6

Control and Experimental Group Mean Test Scores by Grade - Concept 6

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.80	2.59	2.81	2.65	3.35	----
	E	2.81	3.08	3.22	2.46	3.48	2.84
Post	C	3.35	3.08	3.18	3.11	3.42	----
	E	3.38	3.41	3.50	3.56	3.68	4.36

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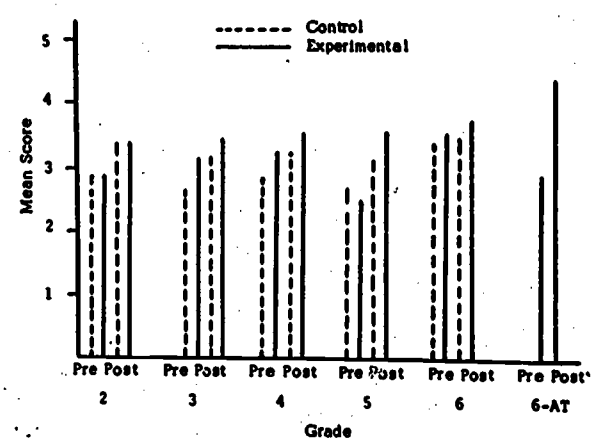

Fig. D-6. Graph of Table D-6

Table D-7

Control and Experimental Group Mean Test Scores by Grade - Concept 7

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.72	3.59	3.92	3.86	4.03	----
	E	3.41	3.75	3.63	3.68	3.85	4.28
Post	C	3.83	3.37	4.18	3.88	3.83	----
	E	4.31	4.23	4.46	4.60	4.72	5.00

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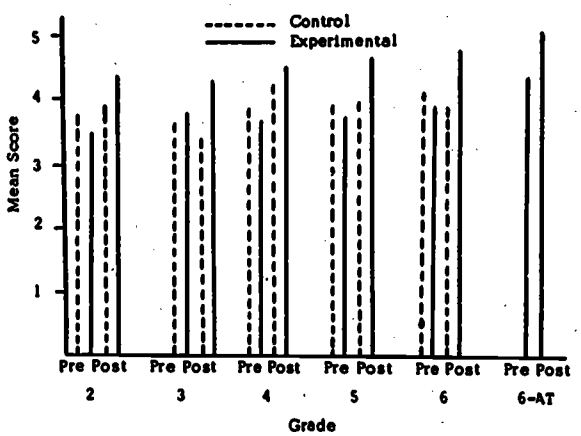

Fig. D-7. Graph of Table D-7.

Table D-8

Control and Experimental Group Mean Test Scores by Grade - Concept 8

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.36	2.78	3.07	2.79	2.68	----
	E	2.63	2.67	2.92	2.82	2.85	3.60
Post	C	2.43	2.75	3.15	2.96	2.87	----
	E	3.38	2.95	3.38	3.28	3.96	4.68

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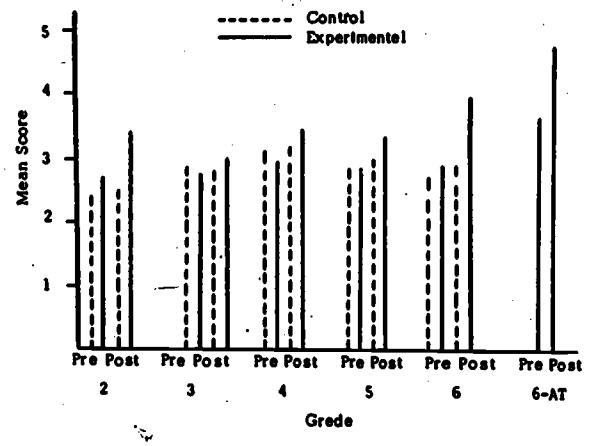

Fig. D-8. Graph of Table D-8.

Table D-9

Control and Experimental Group Mean Test Scores by Grade - Concept 9

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.00	1.37	1.89	2.07	2.03	----
	E	1.78	1.75	1.78	1.75	2.11	2.24
Post	C	1.52	1.12	1.63	1.69	1.67	----
	E	2.61	2.18	2.23	3.16	3.28	3.60

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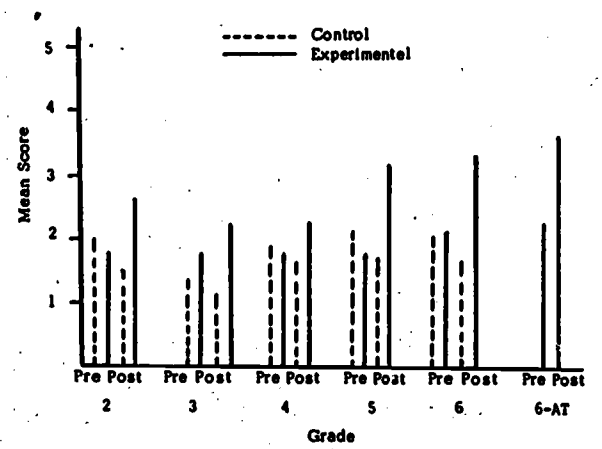

Fig. D-9. Graph of Table D-9.

Table D-10

Control and Experimental Group Mean Test Scores by Grade - Concept 10

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.32	3.30	3.96	3.76	4.11	----
	E	3.22	3.58	3.22	3.96	4.15	3.80
Post	C	3.69	4.08	3.81	4.00	4.33	----
	E	3.73	3.73	4.11	4.44	4.44	4.68

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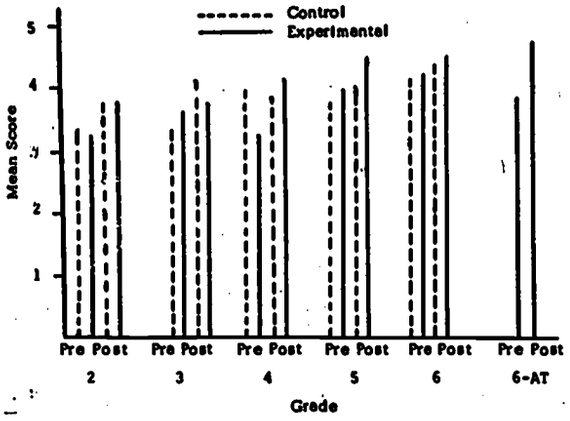

Fig. D-10. Graph of Table D-10.

Table D-11

Control and Experimental Group Mean Test Scores by Grade - Concept 11

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.72	2.55	2.89	3.14	3.78	----
	E	2.70	2.54	3.11	3.18	3.89	4.04
Post	C	2.74	2.75	3.22	3.38	4.12	----
	E	3.35	3.68	3.69	4.16	4.40	4.80

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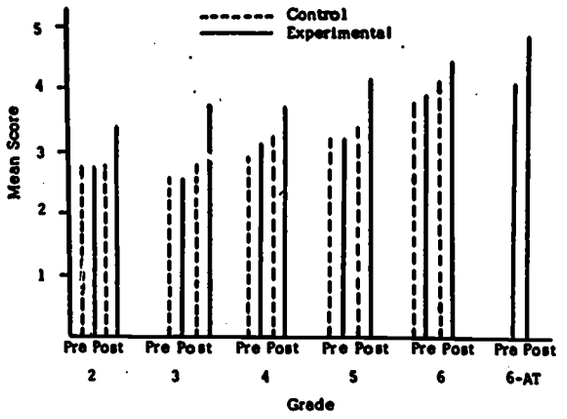

Fig. D-11. Graph of Table D-11.

Table D-12

Control and Experimental Group Mean Test Scores by Grade - Concept 12

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.20	3.74	3.70	4.03	3.78	----
	E	3.33	3.42	3.96	3.82	4.48	4.36
Post	C	3.43	3.58	4.03	3.65	4.17	----
	E	4.04	3.64	4.38	4.52	4.44	4.64

AT = Academically Talented

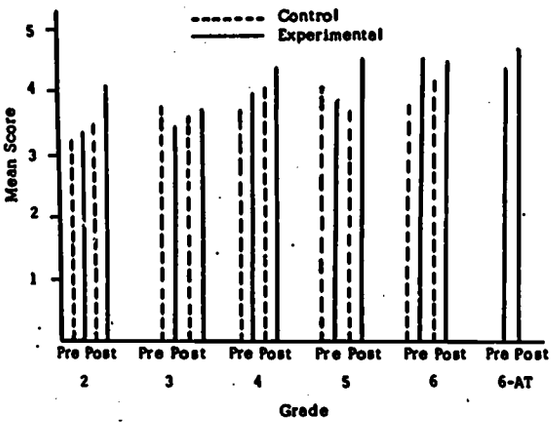

Fig. D-12. Graph of Table D-12.

Table D-13

Control and Experimental Group Mean Test Scores by Grade - Concept 13

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.84	2.18	2.15	2.41	2.78	----
	E	2.15	2.37	1.89	2.18	2.89	2.68
Post	C	2.43	2.46	2.96	2.04	2.87	----
	E	2.92	2.54	2.85	3.00	3.40	3.88

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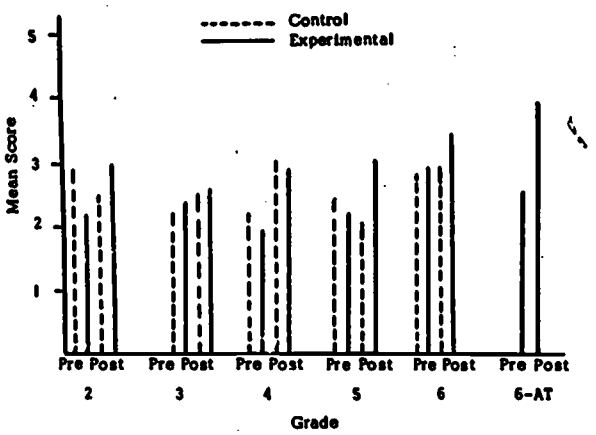

Fig. D-13. Graph of Table D-13.

Table D-14

Control and Experimental Group Mean Test Scores by Grade - Concept 14

		Grade					
		2	3	4	5	6	6-AT
Pre	C	1.76	1.59	1.81	1.62	2.14	----
	E	1.89	2.08	1.59	1.78	2.37	2.56
Post	C	1.83	1.67	1.55	1.69	1.62	----
	E	2.88	2.36	3.00	2.96	3.48	4.80

AT = Academically Talented

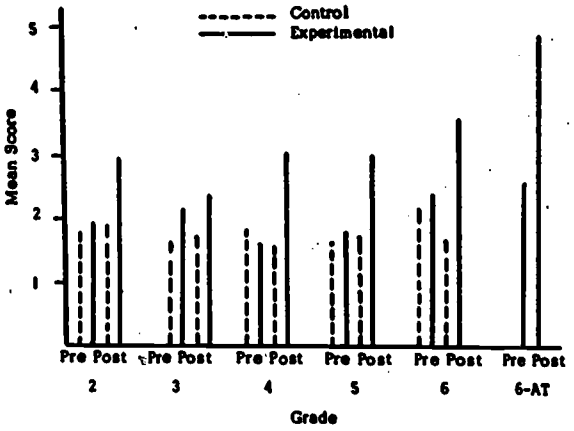

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Table D-15

Control and Experimental Group Mean Test Scores by Grade - Concept 15

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.52	2.96	2.89	3.07	3.32	----
	E	2.92	2.96	3.22	3.18	3.48	3.80
Post	C	2.87	2.54	3.18	3.46	3.79	----
	E	3.61	3.41	4.27	4.00	4.16	4.52

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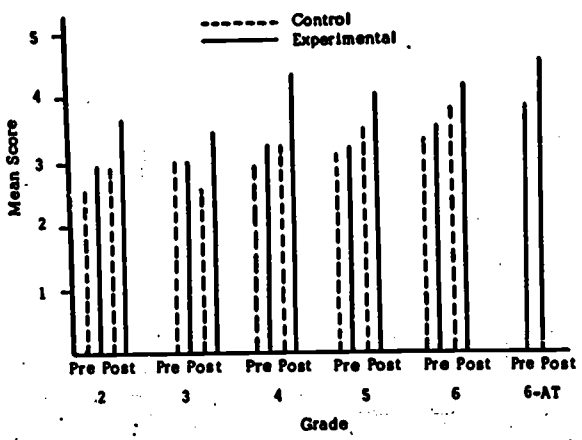

Fig. D-15. Graph of Table D-15.

Table D-16

Control and Experimental Group Mean Test Scores by Grade - Concept 16

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.08	3.07	3.33	3.10	3.07	----
	E	2.59	3.12	3.15	3.46	3.48	3.88
Post	C	2.96	2.92	3.63	3.23	3.25	----
	E	3.15	3.50	3.46	3.72	3.36	4.08

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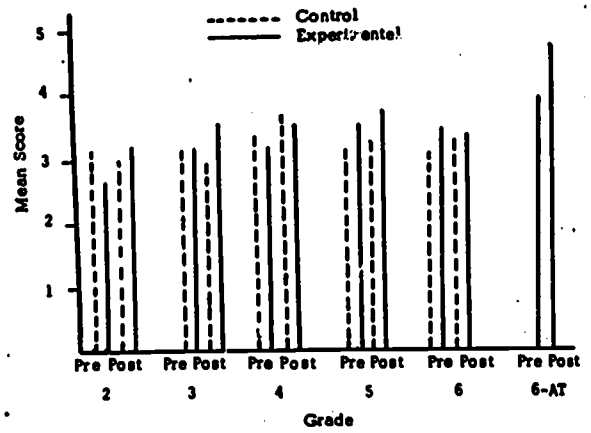

Fig. D-16. Graph of Table D-16.

Table D-17

Control and Experimental Group Mean Test Scores by Grade - Concept 17

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.96	3.30	3.00	2.34	2.28	----
	E	2.70	2.79	2.85	2.86	3.33	3.48
Post	C	2.83	2.75	3.18	2.81	2.79	----
	E	4.08	3.45	3.23	3.60	4.40	4.72

AT = Academically Talented

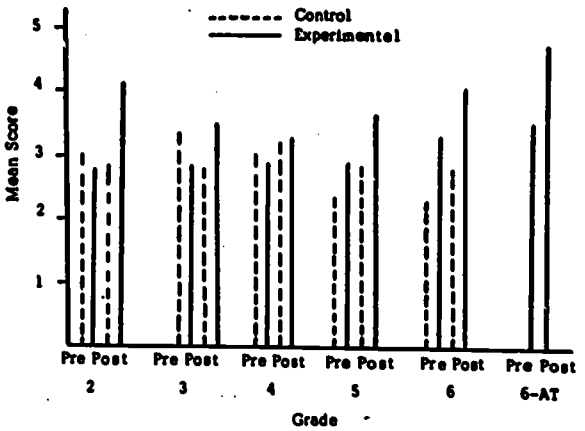

Fig. D-17. Graph of Table D-17.

Table D-18

Control and Experimental Group Mean Test Scores by Grade - Concept 18

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.48	3.04	3.26	3.31	3.18	----
	E	2.52	2.96	3.07	2.78	3.33	4.00
Post	C	2.78	2.42	3.04	3.23	3.42	----
	E	2.96	2.91	3.08	3.92	3.72	4.40

AT = Academically Talented

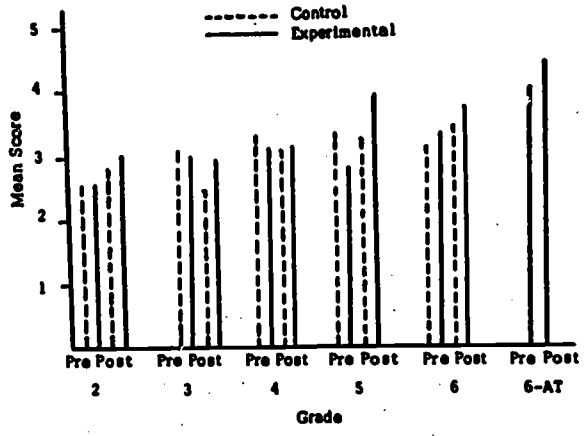

Fig. D-18. Graph of Table D-18.

Table D-19

Control and Experimental Group Mean Test Scores by Grade - Concept 19

		Grade					
		2	3	4	5	6	6-AT
Pre	C	1.60	1.04	1.52	1.79	1.86	----
	E	1.81	1.54	2.04	1.82	2.04	3.28
Post	C	2.00	1.92	2.41	2.61	2.46	----
	E	2.77	2.27	2.88	2.88	2.84	4.76

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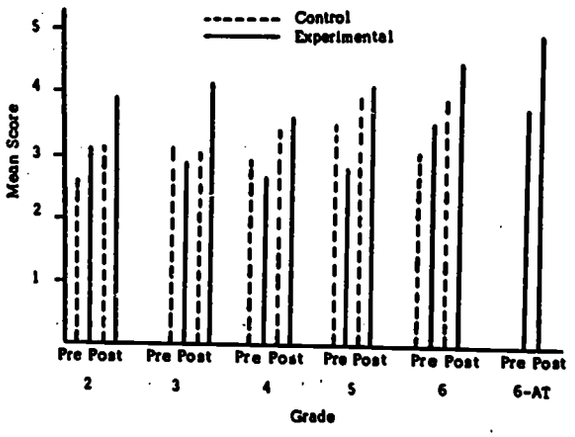

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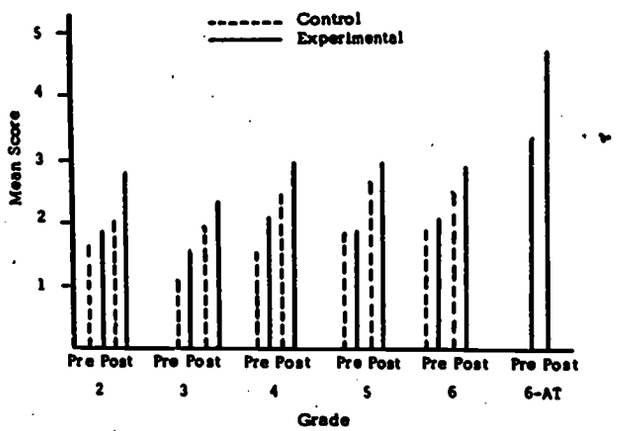

Fig. D-19. Graph of Table D-19.

Table D-20

Control and Experimental Group Mean Test Scores by Grade - Concept 20

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.56	3.11	2.89	3.45	3.03	----
	E	3.07	2.83	2.63	2.78	3.48	3.76
Post	C	3.09	3.00	3.41	3.88	3.87	----
	E	3.85	4.09	3.58	4.08	4.44	4.88

AT = Academically Talented

Table D-21

Control and Experimental Group Mean Test Scores by Grade - Concept 21

		Group					
		2	3	4	5	6	6-AT
Pre	C	2.40	2.67	2.74	2.86	2.93	----
	E	2.22	2.58	3.11	2.96	3.44	3.72
Post	C	3.30	3.21	2.96	3.42	3.71	----
	E	3.69	3.73	3.85	3.56	4.36	4.76

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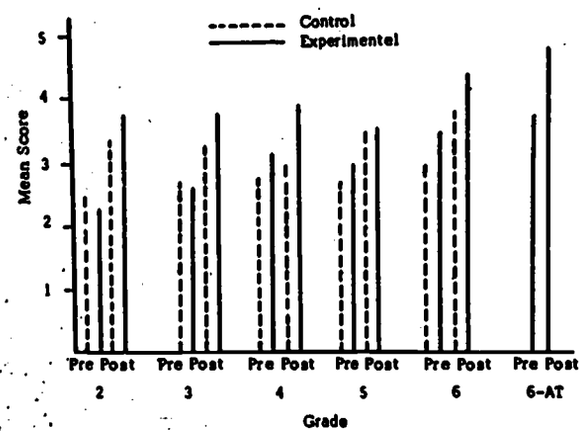

Fig. D-21. Graph of Table D-21.

Table D-22

Control and Experimental Group Mean Test Scores by Grade - Concept 22

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.32	3.00	3.22	3.44	3.11	----
	E	2.96	3.12	2.92	3.25	3.22	4.08
Post	C	3.13	3.00	3.37	3.77	3.58	----
	E	3.81	3.41	3.38	3.84	3.56	4.28

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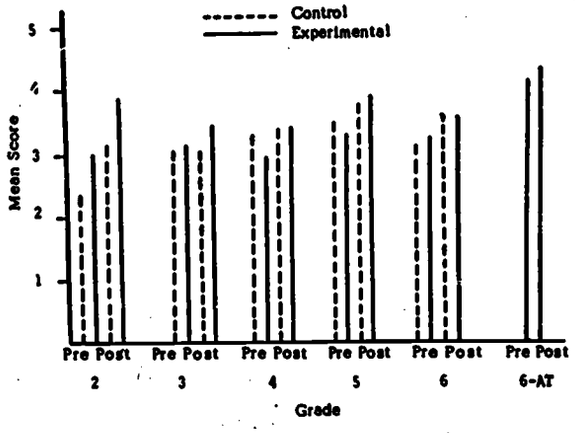

Fig. D-22. Graph of Table D-22.

Table D-23

Control and Experimental Group Mean Test Scores by Grade - Concept 23

		Grade					
		2	3	4	5	6	6-AT
Pre	C	3.00	3.41	3.63	3.17	3.07	----
	E	3.18	3.50	3.44	3.28	3.63	3.56
Post	C	3.52	3.25	3.63	3.73	3.37	----
	E	3.61	3.41	3.50	3.32	3.36	4.40

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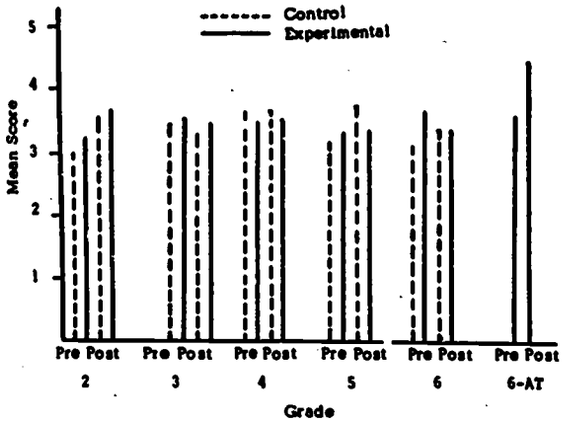

Fig. D-23. Graph of Table D-23.

Table D-24

Control and Experimental Group Mean Test Scores by Grade - Concept 24

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.72	3.30	2.67	2.86	3.11	-----
	E	3.07	3.21	3.30	3.36	3.55	3.92
Post	C	3.09	3.29	2.92	3.50	3.29	-----
	E	3.38	3.59	3.65	3.96	3.92	4.80

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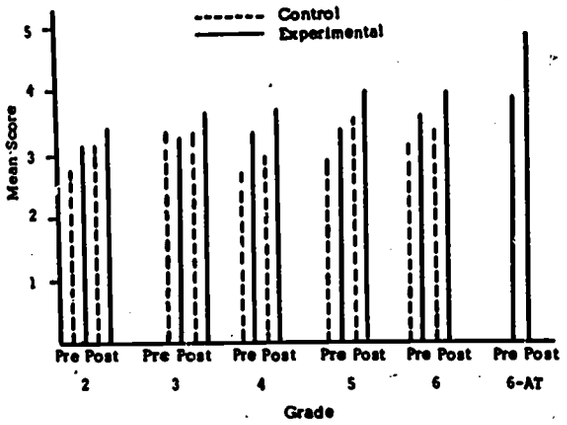

Fig. D-24. Graph of Table D-24.

Table D-25

Control and Experimental Group Mean Test Scores by Grade - Concept 25

		Grade					
		2	3	4	5	6	6-AT
Pre	C	2.40	2.44	2.78	3.21	2.50	----
	E	2.30	3.04	3.30	3.07	3.00	3.32
Post	C	3.74	2.75	2.41	3.15	3.42	----
	E	3.58	3.77	3.23	3.44	3.80	4.36

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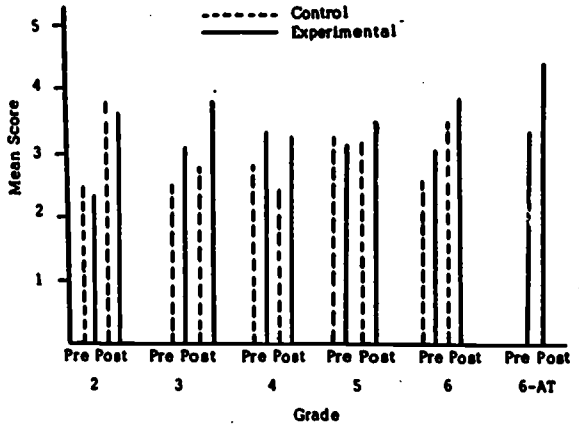

Fig. D-25. Graph of Table D-25.

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