

RELATIVE EFFECTIVENESS OF DISCOVERY AND
EXPOSITORY METHODS OF TEACHING CONCEPTS
THROUGH THE SINGLE-CONCEPT FILM

Thesis for the Degree of Ed. D.
MICHIGAN STATE UNIVERSITY
CASTELLE G. GENTRY
1965



This is to certify that the

thesis entitled

Relative Effectiveness of Discovery and Ex-
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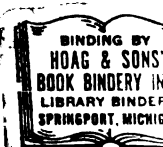
Castelle G. Gentry

has been accepted towards fulfillment
of the requirements for

Ed.D degree in Education


Major professor

Date August 2, 1965



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~~JAN 31 1967~~

~~FEB 1 1967~~

~~DEC 31 1966~~ 77

~~DEC 9 1966~~ 306

M ~~DEC 20 1966~~ 271

~~FEB 02 1967~~ 570

~~FEB 11 1967~~

K ~~FEB 18 1967~~

ABSTRACT

RELATIVE EFFECTIVENESS OF DISCOVERY AND EXPOSITORY METHODS OF TEACHING CONCEPTS THROUGH THE SINGLE-CONCEPT FILM

by Castelle G. Gentry

The abstract consists of three parts: summary, conclusions, and recommendations.

Summary

The broad purpose of the study was to provide guidelines for programing and use of single-concept films. The specific purpose was to analyze the teaching effects of the single-concept film, programed to teach science concepts through two contrasted teaching modes: exposition and discovery.

The concept "Adaptation" was the subject of a four minute film. One film version had the concept

instances ordered from simple to complex, while the second presented the concept instances in a random sequence. The film was shown in four treatment modes: 1) ordered sequence of concept instances using discovery narration, 2) ordered sequence of concept instances using expository narration, 3) random sequence of concept instances using discovery narration, and 4) random sequence of concept instances using expository narration.

The sample consisted of 280 junior high school students selected from eighth grade general science classes. They were tested on three independent variables: sequence of concept instances, intelligence level, and teaching method. And they responded to three criterion tasks: 1) generation of new instances of the concept, 2) application of the concept to problem situations, and 3) recognition of new instances of the concept. These tasks were given immediately after the treatment, and again three weeks later.

The statistical hypotheses were:

1. There is no differential effect for the interaction of intelligence level and teaching method, on

immediate criterion performances, when science concepts are taught through the single-concept film.

2. Method does not have an effect on the retention of science concepts, as taught by the single-concept film, when measured by delayed criterion tasks.

Two analytic procedures were employed: three, three-way univariate factorial analyses of variance, and product-moment correlations.

Conclusions

The conclusions are presented in two parts: variable control and the hypotheses.

Variables which may require greater control or modification are: 1) effect of practice, 2) number of film showings per student, 3) relative shortness of the film, 4) number of instances of the concept, 5) concept

prerequisites, and 6) the novelty effect of the concept instances.

No significant differences were found for the hypotheses. However, a trend contrary to the first hypothesis was noted. It indicated that bright students learned best when taught by single-concept films programmed for the expository method, while less bright learned best when the programing followed the discovery method. This trend reoccurred during three regroupings of the data. In one of the regroupings (i.e., subjects separated by sex) significant differences were found favoring the trend.

A finding not directly relevant to this research, but of importance, was that the three criterion tasks were independent measures of concept formation.

Recommendations

Replication of this study under greater controlled conditions was recommended. Changes suggested included:

1. Students practice discovery method prior to treatment administration.
2. Film viewed by each student more than once.
3. Vary running time of film.
4. Vary number of instances in film.
5. Use commonplace instances of the concept to reduce novelty effect.
6. Determine sub-concepts necessary for attaining concepts.
7. Increase categorization of intelligence.
8. Differentially assign students by sex.
9. Test concepts from other subject areas.
10. Explore trend of bright students learning best through expository programing of single-concept films, contrasted with less bright learning best through the discovery programing of single-concept films.

Castelle G. Gentry

It was proposed that continued research in the development of guidelines for the programing and use of the single-concept film could be aided by these recommendations.

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SINGLE-CONCEPT FILM

By
Castelle G. Gentry

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF EDUCATION

College of Education

1965

626114
6-21-66

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to the following people:

To Dr. Charles Blackman, my major professor, for his advice, assistance, and patience.

To Dr. William Stellwagen for his valuable help in the early development of this thesis.

To Dr. Charles Schuller for his timely advice and assistance.

To Dr. David Krathwohl for his assistance in the development of the design and the statistical procedures of this study.

To Dr. Jean LePere for her assistance in the development of the measurement instruments.

To the students and faculty of Pattengill Junior High School of Lansing for their invaluable cooperation.

To my wife Nancy, and our children Linda, Karen, Melanie, and Jennifer, whose confidence and sacrifice made this endeavor possible.

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CHAPTER I

INTRODUCTION OF THE PROBLEM

AND RELEVANT TERMINOLOGY

The focus of this study is directed toward an instructional medium called the single-concept film. The showing time of this film is usually of short duration; approximately two to five minutes. As its title suggests, it is designed to teach one concept, although it is understood that subconcepts may also be taught in the process. At present, the single-concept film is identified with the cartridge-loaded projectors. That is, the film is packaged in a permanent plastic container which is slid into the projector without the bother of threading; a boon in itself, most teachers would agree. The present and predicted use of this medium is for small groups and for individual use. The sponsors of the medium are convinced that its relatively low price will allow its extensive adoption throughout the educational field.

The single concept film is not new. Bray,¹ in 1926, produced some six hundred of them. Percy Smith,² in England, produced a number during the thirties, as did the Commission on Human Relations of the Progressive Education Association.³ All of these attempts were short-lived. The present movement supporting the single-concept film is making its entrance on the coattails of a technological innovation. It comes as a rider on the extraordinary utility of the new eight millimeter cartridge-loading projectors. An unfortunate effect is that the technological aspects are so striking that little attention has been given to the principles underlying the development and use of the "single-concept film." Its creation and use have been largely the product of the combined intuitions

¹Robert W. Wagner, "The Educational Film in Transition," Audiovisual Instruction, IX, No. 174 (March, 1964).

²Ibid., p. 172.

³Charles F. Hoban, Jr., and E. B. van Ormer, Instructional Film Research 1918-1950 (Rapid Mass Learning), A Report on the Pennsylvania State College Report Jointly Sponsored by the Department of the Army and the Department of the Navy (Port Washington, N. Y.: U. S. Navy Special Devices Center, 1951).

of the film maker and the subject-matter expert. And it is suspected that their intuitions, particularly the film maker's, have been structured by certain mundane expectations:

One factor that tends to work towards the formalization of the nontheatrical motion picture is that the production of such films has become big business. More films are being made than ever before, and more money is being spent on mass production and distribution. The producer who finds himself in a highly competitive market with the knowledge that he must sell at least 500 prints to recover his production costs and show a profit, realistically tries to design his product for the widest possible audience within the limits of the stated objectives of the film. He may envision its use at several grade levels in the public school, speculate on its adaptability with adult groups, and have in mind the possibility that it might be used on television as well. He is tempted to select currently popular themes, to limit experimentation with new and untried formats, and to emulate or rework ideas and treatments found successful in the past.⁴

⁴Robert W. Wagner, "The Formula Film," A. V. Communication Review, III, No. 1 (1955), p. 54.

The Problem

Little or no effort has been expended toward isolating the unique teaching properties of the single-concept film, nor to develop guidelines for its programming. Further, there has been no concerted effort to develop guidelines for the use of single-concept films.

As an important beginning, this study will examine the single-concept film in two contrasted teaching modes. It is hoped that such research will have a number of effects: one, it will provide film makers with guidelines for programming their single-concept films; two, it will further encourage the use of a valuable educative tool; and three, observations from this study might point the direction for further research in programming and use of the single-concept film.

Purpose of the study. This study is designed to analyze the teaching effects of the single-concept film when programed to teach a science concept through

the two contrasted teaching modes of expository and discovery.

Hypotheses in broad research form. In teaching science concepts via the medium of the single-concept film, a differential relationship exists between intelligence level and teaching method. Further, there is a relationship between the teaching method employed and the amount of material retained.⁵

Limitations of this study.

1. It will deal only with one concept in one subject area, and will therefore not be generalizable to other subject areas.
2. Since the teacher is completely removed from the study, it will make no statement as to the effect of teacher interaction.
3. It deals only with one age group in one school.
4. The study will utilize the teaching method called

⁵These hypotheses are restated in a testable form in Chapter III.

"Guided Discovery." It will not concern itself with any of the other varieties of the Discovery Method, except in the historical development of the rationale for guided discovery.

5. Within the proposed limits, the study will allow conclusions concerning the effect of teaching method, sequence of concept instances, and intelligence level, on learning of a concept through the medium of the single-concept film.

Theory related to this study. Three bodies of theory undergird this study; the theory of concept formation, the rationale for the discovery method of teaching, and the use of film as a teaching medium. By concept formation, is meant the process of discovering and identifying detail, relation, or principle through which a series or collection of instances can be classified. The general consensus of learning theorists is that concept formation plays a major role in learning.⁶ In fact, some psychologists contend

⁶D. W. Johnson, The Psychology of Thought and Judgment (New York: Harper and Brothers, 1955).

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that learning and concept formation are synonymous.⁷

The two most clearly stated theories of concept formation depend upon the distinction between abstraction and generalization.⁸ In the composite Photograph Theory, a model first described by Hull,⁹ the primary emphasis is on abstraction. Here the features common to a class of objects or events summate their impressions on the observer, who thus gradually acquires a picture in which the common features stand out strongly while the variable characteristics are washed out. The Active Search Theory emphasizes generalization. Here the concept originates as a hypothesis, after which the conceptualizer tests the concept by trying the hypothesis on fresh members of the class.

⁷David P. Ausubel, "Some Psychological Aspects of the Structure of Knowledge," Education and the Structure of Knowledge, ed. Stanley Elam (Chicago: Rand McNally and Company, 1964), p. 230.

⁸W. Edward Vinacke, "The Investigation of Concept Formation," Psychological Bulletin, XLVIII (January, 1951), p. 6.

⁹C. L. Hull, "Quantitative Aspects of the Evolution of Concepts," Psychological Monograph, XXVIII (1920), p. 4.

At present there is strong support for the combination of these two theories, since experiments show that abstraction and generalization are often difficult to distinguish in the actual behavior of the organism:

Under some conditions, the individual may, in fact, be essentially a passive recipient of sensory impressions which gradually summate into the concept. Under other conditions it may be that an individual proceeds by establishing an hypothesis and then deliberately checking it against the instances. More than likely, they are mutually complementary approaches to a situation and occur as interrelated processes.¹⁰

The classical paradigm of concept formation developed by Hull¹¹ under the influence of Herbart consisted of three steps which, with variations, still forms the essential paradigm for research on concept learning:

1. The subject is presented with a number of experiences, either simultaneously or in succession, each of which contains a certain characteristic common to others.

¹⁰Vinacke, op. cit., p. 7.

¹¹Hull, op. cit., p. 4.

2. The subject is brought to compare deliberately the various situations presented with a view to discovering similarities and differences among them.
3. Lastly, the significant element common to all the experiences is deliberately sought out, found, and formulated in language.

With only slight variations this study has followed Hull's classical Model for concept formation.

As stated in the hypotheses, this study is primarily concerned with the relative effectiveness of teaching methods as applied to the single-concept film. The two methods under study are discovery and expository.

The expository method presents (to the student) a concept with a detailed explanation of its application and the identification of its instances. This method stands deep in pedagogical tradition, but perhaps some comment is appropriate for the purposes of this study. Possible bad effects of the expository method are propounded by Bruner:

Insofar as possible, a method of instruction should have the objective of leading the child to discover for himself. Telling children and then testing them on what they have been told inevitably has the effect of producing bench-bound learners whose motivation for learning is likely to be extrinsic to the task at hand--pleasing the teacher, getting into college, artificially maintaining self esteem.¹²

Others¹³ feel that this view of expository teaching is exaggerated. They freely admit that the above description fits many learning situations in our schools and colleges, but they question that it is inherent in the expository method itself. They maintain that it can be supplemented but not replaced, "because it is the only feasible and efficient method of transmitting large bodies of information."¹⁴ Later in an extended discussion of Guided Discovery it will be noted that there is a measure of agreement between the proponents of the expository method and the position

¹²J. S. Bruner, "After Dewey What," Saturday Review (June 17, 1961), p. 77.

¹³David P. Ausubel, The Psychology of Meaningful Learning (New York: Grune and Stratton, 1963), p. 160.

¹⁴Ibid.

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held in this study. The question becomes one of which method is supplementing the other.

The discovery method needs to be defined, because it has several variations, and the claims for each do not necessarily overlap. The definition of discovery adopted for this study is: the teaching method in which the student is presented instances of objects or events through which run a common relationship or a common element, and is asked to "discover" the common relationship or element. This variation of the discovery method is more structured than some of the "pure" types, which maintain that the student should be responsible for such things as: sequencing, rate of intake of information, and the accumulation of the data necessary to arrive at the solution to a particular problem.¹⁵

The approach of the present study tends to agree with Suchman:

¹⁵M. C. Wittrock, The Learning by Discovery Hypothesis. A Review sponsored by Stanford University with support from the U. S. Office of Education.

The teacher must see to it that the child's efforts at inquiry are rewarded by success, that the child is able to obtain the information that he needs and that he does discover new concepts on his own. The teacher can help the child by posing problems that are reasonably structured and will lead to exciting new discoveries. The teacher can also coach him in the techniques of data collection and organization that will lend power and control to his searching.¹⁶

Claims supporting this method include: "practice in discovering for oneself teaches one to acquire information in a way that makes the information more readily viable in problem solving,"¹⁷ learning by discovery produces knowledge which transfers to new situations,¹⁸ learning by discovery increases retention of knowledge,¹⁹ and learning by discovery serves to

¹⁶ Ibid., p. 4.

¹⁷ J. S. Bruner, "The Act of Discovery," Harvard Educational Review, XXXI (1961), p. 27.

¹⁸ G. L. Anderson, "Quantitative Thinking as Developed under Connectionist and Field Theories of Learning," Learning Theory in School Situations (Minneapolis: University of Minnesota Press, 1949), pp. 40-73.

¹⁹ G. N. Haslerud and Shirley Meyers, "The Transfer Value of Given and Individually Derived Principles," Journal of Educational Psychology, XLIX (1958), pp. 293-298.

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motivate the student.²⁰

This research will be concerned with two of the above claims: 1) learning by discovery produces knowledge which transfers to new situations, and 2) learning by discovery increases retention of knowledge.

The relationship and implications that expository and discovery methods draw from the combined theories of concept formation need to be identified. The desired event is for a student to attain a working understanding of a concept. That is to say, to attain a concept allowing him to go beyond a set of observed critical properties, exhibited by an object or event, to the class identity of the object or event in question. The science concept tested in this study is "Adaptation," or the idea that organisms change in order to better cope with their environment. The teacher's aim is for his students to be able to identify the instances of this concept, to be able to generate

²⁰B. Y. Kersh, "The Motivating Effect of Learning by Directed Discovery," Journal of Educational Psychology, LIII (1962), pp. 65-71.

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new instances from their experiences gained prior to attaining the concept, and to apply the concept to problem situations. By the previous definitions of concept formation, the student may accomplish this by either generalization or abstraction, or through some combination of these two processes. By generalization, then, they may be led to "discover" the hypothesis used as a combining model for the various instances of the concept, or they may be given the hypothesis and shown how the instances of the concept concur with the model. The combination of abstraction and generalization lends itself to both of the two teaching methods.

How does the use of film for teaching a concept fit into the general scheme of concept formation theory? Considering the two parts of the combined theory, it can be assumed that presenting a number of instances that are exemplars of the concept give the learner his best opportunity to recognize the common elements or common relationships that determine the concept. To quote Gagne's design for concept learning:

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Present a suitable variety of stimuli to represent the class, each stimulus having a connection with a common response. Verify by presenting a novel stimulus that is also a member of the class.²¹

The abstracted common elements or relationships can be transformed by the student into a hypothesis or generalization, that is "an instant having these characteristics can be expected to behave in a certain way." The student can then test his hypothesis through the simulated instances provided by the film. As was stated previously, exactly how generalization and abstraction are combined by the student in arriving at the desired concept is not clear. Nonetheless, it seems reasonable that the conditions necessary for generalization and abstraction can be established through the film medium.

²¹Robert M. Gagne, The Conditions of Learning (New York: Holt, Rinehard, and Winston, Inc., 1965), p. 254.

Definition of Terms

1. Criterion Performances consist of three tasks:
 - a) the generation of new instances of the concept taught,
 - b) the application of the concept taught to an appropriate problem situation, and
 - c) the identification of instances of the concept taught, among a collection of instances from several concepts.
2. Concept: an abstraction consisting of some elements or relationships common to particular events and/or things. Possession of a concept is inferred from behavior (success on the criterion performances).
3. Discovery Method: a teaching method whereby a student is presented instances of objects or events, through which run common relationships or common elements and is asked to discover the common relationships or elements.
4. Expository Method: a teaching method whereby a student is presented a concept with a detailed

explanation of its application and the identification of its instances.

5. Single-concept Film: an instructional motion picture of short duration that is designed to teach one concept, although supporting concepts may also be taught as part of the process.

Overview of the Study

The general plan of this study is as follows: Chapter Two will consist of a review of the literature, and its implications for this study. Studies that will be reviewed in depth are: teaching methods (emphasis on discovery), use of film in teaching concepts, and those studies relating teaching method to intelligence. The related areas section of the review of the literature consist of: concept formation studies, transfer of training studies, and retention of learning.

Chapter Three lays out the design of the study. Here data are provided on the sample and the instrumentation, the statistical hypotheses are stated, the plan

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of the study or the experimental design is presented, and the statistical model used to test the hypotheses, with an explanation for its selection included.

The fourth chapter consists of an analysis of the results. Here the hypotheses are restated, and the relevant data for each of the hypotheses is presented. Also, with each hypotheses the probability statement and the statement of rejection or failure to reject are attached. After this presentation of fact, the chapter concludes with an interpretation of the results.

The last chapter will cover the major summary, the conclusions, and implications of the study.

CHAPTER II

REVIEW OF THE LITERATURE

In this chapter, the related literature is surveyed, and its implications for this study are discussed. The areas reviewed include: 1) the use of the film medium in teaching, 2) teaching methods with emphasis on the contrast between the expository and directed discovery methods, 3) the relationship of teaching method to intelligence, 4) concept formation, 5) transfer of training, and 6) retention of learning. The major part of this review will be concentrated in the first three areas.

Researchers have accumulated masses of data supporting the value of film in the learning process. The most comprehensive compilation of this research evidence is found in a government technical report

prepared by Hoban and van Ormer.¹ Since 1950 the amount of research being done on educational films has increased steadily. In nearly all of the educational films, exposition is the method employed for presenting the film content. Rarely is this method contrasted with another. There are innumerable examples of film-teaching contrasted with other methods such as film versus lecture, film versus filmstrip, film versus tape recording, and so on. In some of the research, two versions of the same film were contrasted but, on those occasions when separate versions of the film were compared, they dealt with such factors as sound versus silent, inserted questions versus no questions, one showing versus multiple showings, color versus black and white, amount of narration, audio readability, density of information, and rate of presentation, to name a few. While these factors are important, they do not deal with the focus

¹Charles F. Hoban, Jr., and E. B. van Ormer, Instructional Film Research 1918-1950 (Rapid Mass Learning), A Report on the Pennsylvania State College Project jointly sponsored by the Department of Army and the Department of the Navy (Port Washington, N. Y.: U. S. Navy Special Devices Center, 1951).

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of this study, which is the comparison of teaching methods in film.

A second characteristic of this study makes it especially difficult to find similar studies. The teacher variable has been deliberately removed from this study. The compendium of Hoban and van Ormer,² and succeeding research have, in the main, included the teacher in their studies. In fact they have shown clearly that for optimum use of a film the teacher is essential. But the teacher variable is extremely difficult to control for, and even more difficult to generalize from.³ In order to get an accurate picture of the effect of the medium, the teacher has been removed from the study, while fully realizing that the most successful use of any educational film depends upon the application of the principles of film usage developed through research.

²Ibid.

³Donald M. Medley, and Harold E. Mitzel, "Measuring Classroom Behavior by Systematic Observation," Handbook of Research on Teaching, ed. N. L. Gage (Chicago: Rand McNally & Co., 1963), II, Part II, pp. 247-48.

Of the work reviewed, open-ended films, like those of Suchman,⁴ come closest to the instructional programing notion. But he, like many others, has tied his research so tightly to the teacher that it is very difficult to separate out the effect of the film. And, he does not compare his discovery films with comparable versions using other teaching methods.

Brenner, Walter, and Kurtz⁵ did a study somewhat analogous to this study. They developed six versions of two different films: The Care and Use of Hand Tools (a training film), and Snakes (an information film). In the two versions relevant to this research, one had questions inserted, making it somewhat similar to the discovery method, and statements were inserted

⁴J. Richard Suchman, The Elementary School Training Program in Scientific Inquiry, A Project sponsored by U. S. Department of Health, Education and Welfare, Office of Education, and by the Research Board of the University of Illinois, Title VII Project, No. 216; National Defense Education Act of 1958, June 1962.

⁵H. R. Brenner, J. S. Walter, and A. K. Kurtz, "The Effects of Inserted Questions and Statements on Film Learning," Progress Report No. 10, State College (Pennsylvania: Pennsylvania State College, Instructional Film Research Program).

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in the same spot in the second version in an expository manner. The results were not conclusive. The effects of inserting statements and questions in the two films varied. They also discovered that when the original film without insertions was shown twice, it proved to be about as effective as the experimental film. In contrast with this study, their criterion specified rote memorization of facts in the film, whereas in this study students are asked to form a concept.

Some other studies have dealt with "dramatization versus exposition" of the content.⁶ A few of them require students to draw conclusions from the dramatic presentations in a manner comparable to the discovery method. But the majority of them use an expository approach in both versions.

Along the same line, Hovland, Lumsdaine, and Sheffield⁷ contrasted two versions of a documentary film dealing with the difficult job in Japan after

⁶Hoban, and van Ormer, op. cit., pp. 15-16 (Chap. 8).

⁷C. I. Hovland, A. A. Lumsdaine, and F. D. Sheffield, Experiments on Mass Communication (Princeton, N.J.: Princeton University Press, 1949), pp. 130-141.

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V-E Day. The events in one of the versions were interpreted by a commentator, while the events in the second version were presented by professional actors, with musical accompaniment. The dramatic presentation had a consistent but slight and unreliable advantage in measures of audience interest and acceptance of authenticity. In contrast with this study, their research is concerned with attitudinal change rather than the attainment of concepts.

In his simulation experiments, Kersh⁸ uses film in an open-ended manner as did Suchman. And as with Suchman, the effectiveness of his method is tied closely to teacher interaction. As was pointed out, the curtailment of the teacher variable severely limits the number of relevant film studies. Because of this limitation, literature on the discovery method is primarily studied outside of the film context.

⁸ Bert Y. Kersh, Classroom Simulation: A New Dimension in Teacher Education, The Final Report, Title VII, Project No. 886; National Defense Education Act of 1958, June 1963, pp. 38-44.

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This paper assumes the reader is familiar with the expository method and its various forms. All varieties are similar in that the learner plays a passive role while the instructor gives complete explanations of the desired information. The learner is periodically tested as to his assimilation of the instructor's message. In contrast with the expository method, the discovery method, while dating back to the work of Judd in 1908,⁹ has not been used extensively. An educator who very early determined some of the working principles for this method was Maria Montessori, who believed "it is necessary for the pupil to perfect himself through his own efforts."¹⁰

As Ausubel has pointed out, the progressive education movement also had some responsibility for the development of the discovery method of teaching:

⁹C. H. Judd, "The Relation of Special Training to Special Intelligence," Education Review, XXVI (1908), pp. 28-42.

¹⁰Maria Montessori, The Montessori Method (London: William Heineman, 1912), pp. 171-172.

The Progressive Education movement obviously furnished several major strands in the design of the discovery method. One aspect of this movement was a growing dissatisfaction with the empty formalism of much educational content in the latter part of the nineteenth century and the early part of the twentieth century; with stultifying drill and catechism-like methods of teaching; with the curriculum's lack of relatedness to the everyday experience of the child, his physical world, and social environment; and with pupils' rote verbalization and memorization of ideas for which they had no adequate reference in experience. Overstatement of the realities underlying this dissatisfaction constituted the basis of the later mystique that all verbal learning is little more than glib verbalism and parrot-like recitation. This led, in turn, to the exaggerated emphasis that progressivists placed on relating the curriculum to the physical and social environment of the child; on direct, immediate, and concrete experience as a prerequisite for meaningful understanding; on active learning and inquiry; and on incidental learning in natural, uncontrived situations.¹¹

A major controversy among advocates of discovery methods has to do with theories of its true value. On one hand there is support for it in its ability to teach information, while the other side insists that its value lies in practicing the method itself. The three major

¹¹D. P. Ausubel, The Psychology of Meaningful Verbal Learning (New York: Grune & Stratton, 1963), p. 139.

claims supported by the former are: the discovery method motivates the students to learn, learning by discovery assures greater transfer than does the expository method, and last, the relatively unstructured discovery method allows a student to fit information into his unique cognitive structure in the manner most natural to him, and according to his particular rate of reception.¹² The proponents of the second view insist that information derived through the practice of the discovery method is secondary, that it is only through the practice of this method that the student truly prepares himself for a world that pays dividends to those who are able to solve their problems rather than having the answers given to them.¹³ Wittrock summarizes these two positions thus:

. . . learning by discovery is both an end and a means for some educational theorists. By discovery a student is supposed to learn regularities and concepts within a discipline. But more importantly he is supposed to learn how to solve problems, to go beyond the data,

¹² J. S. Bruner, "The Act of Discovery," Harvard Educational Review, XXXI (1961), p. 32.

¹³ Ibid., p. 27.

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to behave as a junior scientist. He is supposed to become motivated and enthusiastic about the discipline. He is to know personal satisfaction because he has selected his own sequence of problems and, through active responses of his own, has succeeded at these problems.¹⁴

A second division among proponents of discovery methods is between those who support "independent discovery" where the learner is almost entirely on his own and where the teacher serves only as a resource person, and those who support "guided discovery" in which the student is led to the "discovery." A statement by Craig helps to clarify these views:

Many have advocated relatively independent problem solving in the belief that learning situations should be similar to anticipated transfer situations. This point of view rests on the assumption that future discovery of principles will be through independent problem-solving, hence, more like pupil self-discovery than directed discovery. A different view is that problem-solving and discovery are never independent except in the sense that no one is physically present to prompt the learner. Principles previously learned in an area serve to direct discovery. Out-of

¹⁴M. C. Wittrock, The Learning by Discovery Hypothesis, A Review prepared for the Conference on Learning by Discovery, New York City, January 28-29, 1965, Sponsored by Stanford University with support from the U. S. Office of Education, 1964, p. 10.

school discovery is not independent but directed by the knowledge gained under the direction of previous teachers. The more direction of this kind available to the learner, the more effective his discovery of new relations. The cumulative effect of greater learning through directed discovery over months or years may offset the effect of any lack of similarity between learning and transfer situations and proves to be the best preparation for new discoveries.¹⁵

A more middle-of-the-road view is expressed by Stanley:

It is evident that the young human being must receive considerable instruction but also that he should be eternally vigilant in making additional observations. His life is a complicated blending of instruction and discovery. Many facts will be handed to him outright. At the same time, during every day of his life he will be engaged, almost unknowingly, in inductive reasoning, the process of bringing together a number of experiences and abstracting from them some common factor. The issue becomes, then, not instruction versus discovery, since both are essential, but a consideration of the relative importance to be accorded each in the educative process.¹⁶

¹⁵R. C. Craig, "Directed Versus Independent Discovery of Established Relations," Journal of Educational Psychology, XLVII (1965), p. 233.

¹⁶J. C. Stanley, "The Role of Instruction, Discovery, and Revision in Early Learning," Elementary School Journal, XLIX (1949), p. 457.

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The major criticism of the method is that it is too time consuming. If, say its critics, everyone had to rediscover each fact or idea for himself, progress in acquiring knowledge would stumble to a halt. A second criticism is that the discovery method increases the possibility that the student will learn false information. Critics use a statement by Thorndike in support of this contention:

The attainment of active vs. passive learning at the cost of practice in error may often be a bad bargain The almost universal tolerance of imperfect learning in the early treatment of a topic, leaving it to be improved by the gradual elimination of errors in the later treatments, is probably unsound and certainly is risky.¹⁷

Another reviewer of "learning by discovery" concludes:

The issue of expository teaching versus independent discovery in the learning, retention, and transfer of principles is still very much in doubt because of the non-comparability of the various studies, serious deficiencies in research design, and the failure to hold constant or take into account rote-meaningful,

¹⁷E. L. Thorndike, The Psychology of Wants, Interests, and Attitudes (New York: Appleton-Century, 1935), p. 147.

inductive-deductive, verbalization, ability level, cognitive maturity, subject-matter sophistication, and motivational variables. In general the research findings support Thorndike's well-known conclusion that "refusal to supply information on the ground that the learner will be more profited by discovering the facts himself, runs the risk not only of excessive time-cost but also the strengthening of wrong habits." Providing guidance to the learner in the form of verbal explanation of the underlying principles almost invariably facilitates learning and retention and sometimes transfer as well. Self-discovery methods and the furnishing of completely explicit rules on the other hand, are relatively less effective.

The most efficacious type of guidance (guided discovery) is actually a variant of expository teaching that is very similar to Socratic questioning. It demands the learner's active participation and requires him to formulate his own generalizations and integrate his knowledge in response to carefully programed leading questions; and it is obviously much more highly structured than most discovery methods, with the possible exception of the UICSM [University of Illinois Committee on School Mathematics]. Further research is necessary to determine whether guided discovery is superior to simple didactic exposition in terms of relative effectiveness for the time-cost involved when such factors as cognitive maturity, subject-matter sophistication, and verbal ability are varied.¹⁸

¹⁸Ausubel, op. cit., pp. 171-172.

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The following studies are arranged in a chronological order so that a clearer picture of the development of the discovery method may be perceived. This procedure closely follows the excellent review of M. C. Wittrock, although the emphasis is somewhat different since the purposes of the study do not demand such a comprehensive review.

In Judd's¹⁹ early (1908) empirical study of a discovery method, he tested the ability of two groups to hit a target placed under water. One group was told the principle of refraction and allowed time to practice throwing darts at the submerged target. The second group was not given an explanation of refraction and spent the entire time throwing darts at the submerged object. Judd tested the group by changing the depth of the water. The group given the explanation of refraction was able to hit the target more often than the second group. The purpose in referring to his research is to point out the value of his empirically

¹⁹Judd, op. cit.

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asking the question, "How does independent learning contrast with expository learning?"

The influence of Thorndike slowed experimentation with the discovery method. The following dictum of his tended to discourage research to the contrary:

The teacher and the learner must know the characteristics of a good performance in order that practice may be appropriately arranged. Errors must be diagnosed so that they will not be repeated. When there is lack of clarity about what is being taught or learned, practice may be strengthening the wrong connections as well as the right ones. At the same time, needed connections may be weakened by disuse.²⁰

In 1949 three researchers, Swenson, Anderson and Stacey, set out independently to show that Thorndike's experiments on the memorization of nonsense syllables were too primitive a base from which to generalize to human, complex, verbal learning. It was believed by these researchers that studies using "meaningful" materials might produce results disagreeing with those of Thorndike.

²⁰Ernest R. Hilgard, Theories of Learning (New York: Appleton-Century-Crofts, Inc., 1956), p. 23.

Swenson²¹ randomly assigned, by levels, 332 second graders into three treatment groups: A generalization Group which was treated by a variation of the discovery method, a Drill Group which followed procedures agreeable with Thorndike's connectionism, and a Drill-Plus Group judged as a prototype of methods currently used in the schools. Students in the Generalization Group were encouraged by the teachers to "discover" relationships among number combinations of addition problems (a form of reward). Children in the Drill Group were taught mainly by group drill. A wrong answer was immediately corrected (a form of punishment). In the Drill-Plus Group concrete objects were used to present number combinations, either through pictures or by actual handling of the objects. This was followed by the same drill procedure used with the Drill Group.

During the 20 weeks that the treatments were applied, three sets of facts were taught; an original

²¹Esther J. Swenson, G. L. Anderson, and G. L. Stacey, Learning Theory in School Situations (Minneapolis, University of Minneapolis Press, 1949), pp. 9-39.

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set of facts, an interpolated set of facts, and a final set of facts. Students were tested over all of these facts five different times during the instruction. At the completion of the instruction, three transfer tests were given. The first consisted of 100 facts on subtraction, the second was over 100 addition problems slightly different from those given during instruction, and the last consisted of addition problems with an increased number of digits. The following table summarizes the results.

The best statement that can be made about her findings in reference to the contrast between the discovery and expository methods is that: students given the set to generalize and who are reinforced for developing and verbalizing their generalizations do better than students who are discouraged from verbalizing generalizations. Unfortunately, the effect of the discovery method cannot be separated out from the effects of reward and punishment used in the treatments.

TABLE 2.1

SUMMARY OF SWENSON'S DISCOVERY LEARNING EXPERIMENT

Criteria	Generaliza- tion Group	Drill Group	Drill-Plus Group
Original Facts	Best	Middle	Poorest
Interpolated Facts	(no significant difference among the groups)		
Final Facts	(no significant difference among the groups)		
Transfer (with Adjustment for Mental Age)			
1. Addition Facts	Best	(no significant differ- ence between Drill and Drill-Plus Groups)	
2. Transfer			
a. Subtrac- tion	Best	Middle	Poorest
b. Digit Number	(Generalization and Drill Groups were significantly better than the Drill- Plus Group)		

In a similar research project, Anderson²² also
contrasted Thorndike's connectionism with active discovery.

²²Ibid., pp. 41-73.

His carefully trained teachers taught arithmetic to 389 elementary students. His design consisted of two treatments. The Drill Treatment incorporated the major tenets of Connectionism: students were taught discrete elements, their questions were answered concerning the arithmetic problems, and they were drilled on the discrete elements. In the Active Discovery Treatment, which tended to align itself with field theory, organization was around the following elements: students were encouraged to discover organized patterns among the arithmetic problems, direct questions on the problems were not responded to, and the students were given practice at using generalizations.

The performance criteria were computational skills, problem solving, understanding of social concepts in arithmetic and vocabulary, and of mathematical thinking. The significant differences occurring for the computational skills indicated that the discovery method (meaning method) was best for students scoring high on the ability test, while the drill method seemed best for those scoring low on the ability test. On

tests of mathematical thinking, the discovery method again proved superior (.01 level of significance) to the drill method for high ability students, while the drill method was superior (again at the .01 level) for the low ability students. In the case of the social concepts and vocabulary tests there were no significant differences. For teaching a few specific associations it was found that drill was more effective with both the high and low ability students. A final conclusion was that, if transfer of information to new situations is the learning objective, the discovery or meaning method is superior to drill. Since the teacher variable was not well controlled and the time involved was for a period exceeding six months, care must be taken in interpreting the results.

Gertrude Hendrix²³ compared three treatments using both high school and college students. In the first treatment, a generalization (the sum of the first

²³Gertrude Hendrix, "A New Clue to Transfer of Training," Elementary School Journal, XLVIII (1947), pp. 197-208.

n odd numbers is n square.) was stated, illustrated, and then applied to new problems. In the second treatment, called the Unverbalized Awareness Method, the students were asked to find the sum of the first two odd numbers, then the first three, then the first four, and so on until they showed by a change in behavior (eg. increased rate of solving problems) that they had discovered the generalization stated for Group I. The third treatment, called the Conscious Generalization Procedure, was the same as for Group II, with the additional task of stating verbally the rule they had discovered.

On a transfer test given two weeks later there was no statistical difference. But, the results indicated a trend favoring the Unverbalized Awareness Method. The small number of students used in her study further limits the conclusions to be drawn from it. A major value of the study is that the effect of discovery is measured through transfer of learning.

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Like Swenson and Anderson, Stacey²⁴ argued that, provided the stimuli are meaningful (rather than non-sensical as in Thorndike's studies), the discovery method can aid students in learning. He particularly pointed out the lack of guidance received by Thorndike's subjects. He deliberately used amount of guidance as the major variable in his study. Items consisting of five words were presented to his subjects. The student's task was to determine which one of the five words did not belong with the other four because of some common element possessed by the four and not by the other. Group A was told that a choice was correct or incorrect but not why. Group B was given the same information as Group A and also informed that there was a reason for the item not belonging and allowed to work three sample problems before beginning the learning task. Group C was given the correct answer with each item. Group D was given the correct answer with each item and was allowed to work three sample problems prior to beginning

²⁴Swenson, Anderson, and Stacey, op. cit., pp. 74-103.

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the learning task. Group E's treatment was the same as Group D's except they were also told why the answer was correct.

He used the same instrument for both pretest and post-test. There were no significant differences among the five treatments. On a measure requiring correct reasons for the responses on the pretest and the post-test there was a strong trend favoring methods A and B (Stacey's discovery method). He interprets this to mean strong support for discovery, and that errors made through discovery are not as damaging as are those made through the expository method. In Stacey's study a shift of emphasis may be noted, from a contrast of Connectionism and Field Theory to a contrast between the discovery method and the reception or expository method.

Craig,²⁵ using the same learning task as did Stacey, attempted to prove that guidance could produce

²⁵R. C. Craig, "The Transfer Value of Guided Learning," Bureau of Publications, Teacher's College Columbia University, New York, 1953.

a positive effect on discovery. Of his four treatment groups, Group A was given a minimum of guidance, Group B was given the items grouped according to common principles, Group C received a blank space between the sets of items which were grouped by a common principle and informed that all items in a group were organized into a common principle, and Group D was given all of the information provided by the other groups plus a short statement of each principle. Craig found that in both initial learning and on transfer tasks, the groups with the most clues had a superior ability to discover.

In a follow-up study, Craig²⁶ hypothesized that directed discovery would not only produce superior results on initial learning but on transfer and retention as well. This time he used two treatment groups: a No-help Group who were told only that test items grouped together could be solved by a common principle, and a Directed Group which was given the same information as the first group except the principle was stated above

²⁶Craig, op. cit., pp. 223-234.

each group of four items. Of the three retention tests given, there was no significant difference on the tests given 3 and 17 days after the treatment, but there was a significant difference in favor of the Directed Group on the test given 31 days later. He found no significant differences on transfer to new principles. However, on the test immediately following the treatment, the Directed Group was again superior to the No-help Group.

Studies carried out by Corman²⁷ and Kittell²⁸ tended to support Craig's conclusion that by giving rules transfer could be increased.

Haslerud and Meyers²⁹ got results that contradicted those of Craig, Corman, and Kittell. Their two

²⁷B. R. Corman, "The Effect of Varying Amounts and Kinds of Information as Guidance in Problem Solving," Psychological Monographs, LXXI (1957), pp. 1-21.

²⁸J. E. Kittell, "An Experimental Study of the Effect of External Direction During Learning on Transfer and Retention of Principles," Journal of Educational Psychology, XLVIII (1957), pp. 391-405.

²⁹G. N. Haslerud, and Shirley Meyers, "The Transfer Value of Given and Individually Derived Principles," Journal of Educational Psychology, XLIX (1958), pp. 293-298.

treatments consisted of a No-direction Group, and a Specific Directions Group. The subjects were asked to solve 10 enciphering problems. While there was no statistical difference between the two group's initial learning, the Specific Directions Group had the largest mean performance on the test of transfer to new sentences. The main reason that the researchers favored the No-direction Group treatment was because the percentage of loss on gain scores was less for this group. In his review of this study Wittrock suggests that:

Since each subject was given practice on each of the two experimental conditions, one might expect that the practice at discovering would generalize from one set of items to the other and that the treatments would then be contaminated.³⁰

Elementary and junior high school students (180) in Baltimore were divided into six, ten, and fourteen year old age groups. Half of the students were of average intelligence and the other half were of high intelligence according to IQ scores from the Wechsler Intelligence Scale for Children. A concept attainment

³⁰Wittrock, op. cit., p. 41.

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task was presented under general and explicit instructions. Data were analyzed using t-tests, F-ratio, mean scores, standard deviation, variance, and rank order correlations. The results were analyzed for errors, number of students who achieved the criterion of success, and number of students who verbalized the concept correctly. Results indicated that, under nonspecific instructions, superior intelligence is associated with more effective concept attainment; under explicit instructions students of average intelligence improved while those of superior intelligence remained unchanged, and performance improved throughout the age range studied.³¹

In a study of intelligence levels, Klausmeier and Loughlin³² obtained results which have meaning for

³¹S. F. Osler and S. R. Weiss, "Studies in Concept Attainment: III. Effect of Instructions at Two Levels of Intelligence," Journal of Experimental Psychology, LXIII (1962), pp. 528-533.

³²H. J. Klausmeier and L. J. Loughlin, "Behavior Problem Solving Among Children of Low, Average, and High Intelligence," Journal of Educational Psychology, LII (1961), pp. 148-152.

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the choice of instructional method for different levels of intelligence. Sixty fifth grade boys and sixty fifth grade girls acted as subjects. They were divided into three intelligence levels: 1) 20 boys and 20 girls with intelligence scores of 55-80, 2) 20 boys and 20 girls with scores of 90-110, and 3) 20 girls and 20 boys with scores of 120-146. Each child, after a period of pre-training, was assigned an arithmetic problem that was graded in difficulty for his or her intelligence level. Close observation was made of the child's method of solving his particular problem. Results indicated that application and verification of information are correlated with intelligence. Since verification and application skills are necessary for the student learning through the discovery method, it suggests that the brighter student would be more successful in using the discovery method than the less bright. The same study noted that below average subjects do not persist at the task when they find their first solution to be incorrect, while above average students do persist. Since use of the discovery method requires a great deal of

persistence, the implication is again that bright students would be more successful with the discovery method than the less bright.

The research of Kersh directs our attention away from "meaningfulness" of the learning task as the intervening variable responsible for the effect of the discovery method. In his early work³³ he randomly assigned sixty subjects to six treatments. The first 20 were called the No-help Group and were required to discover the desired rules without aid. The second 20 formed the Direct-reference Group and were given help in the form of perceptual aids (symbol patterns). The third group was called the Rule-given Group and was told the rules directly and given practice in applying them. Each of these three groups were further broken into two sub-groups on the basis of the problems-to-be-solved being presented either in Hindu-Arabic form, or in the more nearly iconic form.

³³ Bert Y. Kersh, "The Adequacy of Meaning as an Explanation for the Superiority of Learning by Independent Discovery," Journal of Educational Psychology, XLIX (1958), pp. 282-292.

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Teaching two rules, the Odd-numbers rule, and the Constant-difference rule was the task set for the six treatments. The students were taught individually. Several of them were unable to discover the intended rules within the 60-90 minutes time period scheduled. Immediately following the learning period, the subjects were given 20 problems to solve. From four to six weeks later the students were retested. Kersh was not primarily interested whether the student got the correct answer, but rather in the method used to solve the problem. The No-help Group produced more acceptable methods on the test of transfer to new examples of rules than did the others. The Directed Group did best on the first test. On the retest the No-help or Discovery Group was superior although not with high reliability. Kersh interprets this last fact as meaning that as a result of their experience during the learning period, the No-help Group were motivated to continue learning after the learning period whereas subjects in the other treatment groups were not. In Kersh's words:

Presumably, the motivating power is of the type that lies in acquired interest or ego involvement in a task, and develops to the extent that the individual relies on his own cognitive capacities in learning.³⁴

And finally:

The results of this experiment suggest that when the learner is forced to rely on his own cognitive capacities, it is more likely that he will become motivated to continue the learning process or to continue practicing the task after the learning period. Consequently, the learning becomes more permanent and is more effectively transferred than when the learner is not motivated.³⁵

In a follow-up study, Kersh tested the hypothesis that guided discovery motivates the student to practice more and thus to remember and transfer more than if he were taught directly. His data supported the hypothesis.³⁶

Gagne and Brown³⁷ assigned 33 ninth and tenth

³⁴ Ibid., p. 291.

³⁵ Ibid., p. 292.

³⁶ Bert Y. Kersh, "The Motivating Effect of Learning by Directed Discovery," Journal of Educational Psychology, LIII (1962), pp. 65-71.

³⁷ R. M. Gagne and L. T. Brown, "Some Factors in the Programing of Conceptual Learning," Journal of Experimental Psychology, LXII (1961), pp. 313-321.

graders to three treatments designed to teach principles pertaining to a number series. The first treatment was called the Discovery Program which asked the subject for a rule for the number series, and although hints were given, the rules were not stated. The second treatment was labeled the Guided Discovery Program and proceeded very much as did the Discovery Program except the questions were more specific and items presented examples of relationships within the number series. The last treatment was called the Rule and Example Program which provided the subject with the correct principle (formula) which the student was allowed to copy before working several examples.

The students went through the same program on two different days. They were then measured in three ways: on the time required to solve the problems, number of clues necessary to solve the problems, and a weighted time score combining these. All subjects were required to derive the formula for the sum of n terms in a number series.

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The results favored the Guided Discovery Group, with the Discovery Group second and the Rule and Example Group last. All measures were statistically significant below the .01 level.

Bruner³⁸ offers an explanation for the superiority of the discovery method in one of his studies. He presented 30 paired-associates to three groups of twelve-year-old children. One group was told only to remember the pairs, and that they would be asked to repeat them at a later time. The second group was told to remember them by using a word or idea to tie the associates together (e.g. Chair-forest: "Chairs are made from trees in the forest"). Bruner calls the words or ideas tying associates together "mediators." The third group was asked to use the second group's mediators for remembering their paired-associates. Bruner found that the children who developed their own mediators did best. In fact, after going through the thirty pairs once, they recovered up to 95% of the second words when

³⁸Bruner, op. cit., pp. 31-32.

presented with the first word of the pair, while the other groups reached a maximum of less than 50%. The value of the discovery method seems to lie in its flexibility of information handling. Bruner concludes:

. . . in general, material that is organized in terms of a person's own interests and cognitive structures is material that has the best chance of being accessible in memory.³⁹

Gagne and Brown also gave as an explanation for the superiority of self-discovery of a principle over being taught the principle, that the former procedure allows the principle to fit better into the individual's existing verbal system.⁴⁰

There is considerable research evidence supporting the hypothesis that redundancy of relevant information facilitates performance on concept learning. The data from studies by Bourne and Haygood⁴¹ suggest that

³⁹ Ibid, p. 32.

⁴⁰ Gagne and Brown, op. cit., pp. 319-320.

⁴¹ L. E. Bourne, and R. C. Haygood, "Supplementary Report: Effect of Redundant Relevant Information Upon the Identification of Concepts," Journal of Experimental Psychology, LXI (1961), pp. 259-260.

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simplification in audio visual presentations, while desirable, should not be done at the expense of needed redundant relevant information. The treatment conditions of this study have adhered to the cautions of Bourne and Haygood.

Work by Smoke,⁴² Hovland and Weiss,⁴³ and Bruner,⁴⁴ have shown rather conclusively the superior teaching value of positive instances of concepts over negative instances. Some later work by Huttenlocker⁴⁵ indicated that if positive instances are sequenced properly with negative instances of a concept the results are superior to the use of all positive instances.

⁴²K. L. Smoke, "Negative Instances in Concept Formation," Journal of Experimental Psychology, XVI (1933), pp. 583-588.

⁴³C. I. Hovland, and W. Weiss, "Transmission of Information Concerning Concepts Through Positive and Negative Instances," Journal of Experimental Psychology, XLV (1953), pp. 175-182.

⁴⁴J. S. Bruner, J. J. Goodnow, and A. Austin, A Study of Thinking (New York: Wiley, 1957), pp. 119-122.

⁴⁵J. Huttenlocker, "Some Effects of Negative Instances on the Formation of Simple Concepts," Psychological Reports, XI (1962), pp. 35-42.

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His use of extremely simplified concepts raises the question of whether his combinations would still hold for a concept as complex as "adaptation." The decision was made to accept earlier findings treating more complex concepts which support the use of positive instances only.

Huttenlocker⁴⁶ and Bruner,⁴⁷ among other researchers, take issue with Vinacke's statement about the sequential order of instances of a concept:

The order of the instances (of a concept) does not particularly matter if an equal amount of time is allowed to each.⁴⁸

Studies of sequencing in programmed learning have tended to agree with Vinacke. For example, Roe, Case, and Roe⁴⁹ reported no difference in the learning

⁴⁶ Ibid.

⁴⁷ Bruner, Goodnow, and Austin, op. cit., pp. 96-103.

⁴⁸ W. E. Vinacke, "The Investigation of Concept Formation," Psychological Bulletin, XLVIII (1951), p. 22.

⁴⁹ K. V. Roe, H. W. Case, and A. Roe, "Scrambled Versus Ordered Sequence in Autoinstructional Programs," Journal of Educational Psychology, LIII (1962), pp. 101-104.

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of programed materials presented in the original sequence as compared with the same program with the instances arranged in a random sequence.

Because of the complexity of the problem, this study attempted only to control for the effect of sequencing by: 1) keeping the time for presentation of each instant of the concept as nearly equal as was possible; and 2) providing both an ordered and a random treatment of sequences.

A question adjunctive to this study was the degree to which a student attains a concept. A major finding by Hull⁵⁰ was that the ability to state a concept requires greater abstracting ability than recognizing instances of the concept. In order to distinguish between the effects of teaching method on different conceptual tasks and the degree of attainment of the concept, three criterion variables were used in this study. They were, in decreasing order of difficulty: the application of the newly learned concept

⁵⁰C. L. Hull, "Quantitative Aspects of the Evolution of Concepts," Psychological Monograph, XXVIII (1920), p. 85.

to a problem situation; generation of new instances of the concept; and recognition of a new instance of the concept.

Summary

The review of the literature relevant to this study has illustrated the diversity of specific interests among the researchers.

Research on the usage of film in teaching is plentiful but for the most part not appropriate to this study. Its inappropriateness is due primarily to two factors: few researchers contrast alternate versions of a film using two distinct instructional methods, and fewer still have the effect of the teacher variable completely removed from the treatment as has been attempted here.

A great deal of evidence has been provided in support of the Directed Discovery Method of teaching, along with its historical development. The major lines

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of divergence of the proponents of the discovery approach have been presented. One group maintains that the advantage of discovery lies in learning content, while the second insists that its major value lies in the actual practice of the method. This study limits its concern to the method's application in teaching content; specifically the teaching of science concepts through the single-concept film.

Of special interest was the evidence garnered from among the several studies in support of the motivational, transference, and retention effects of the discovery method.

Other studies were selected for their support of the treatment of the science concept taught by the single-concept film. Some of the elements considered were: redundancy of information, intelligence level, positive versus negative instances of the concept, sequencing of the concept, instances, and the degree of attainment of the concept.

CHAPTER III

THE EXPERIMENTAL DESIGN

The Population

The population consisted of students in nine, eighth grade General Science II classes of Pattengill Junior High School, in Lansing, Michigan. This urban junior high school draws its students from families whose incomes vary from high to low, and whose members include all races.

The Sample

Of the population, 288 students were available to take part in the experiment. Because of illness and transferring to other schools, 4 students were lost from the experiment. In order to satisfy design and statistical requirements, 4 other students were randomly selected

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out of the experimental treatments, leaving a total of 280. Of this number, 146 were boys, and 134 were girls. Ages varied from 13 years 2 months to 15 years 3 months. The variance in IQ was great; ranging from a low of 51 to a high of 138.

Instrumentation

This section describes the content, the medium, the apparatus, and the testing materials used in the experiment.

Content. The concept "Adaptation" was selected on the basis of teacher judgment and a pretest. The General Science II teachers at Pattengill were given a list of concepts that pertained to the area of study in the time period for which the treatment was planned. There was unanimous agreement among them that "Adaptation" was one of the concepts that was not held by their students. A pretest was devised to test their conviction (Appendix A). A random selection of 30 students was used

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in the pretest. The results substantiated the teachers' claims. An agreement was reached with those teachers whose classes were participating in the experiment, not to introduce the concept prior to the experiment.

Medium. The concept "Adaptation" was the subject of two, four minute films. The films consisted of ten instances of the concept; these instances were excerpted from existing film. Both biological and behavioral instances of adaptation were included in the two films. The same instances appeared in both films, but the order of presentation of the instances varied. In one of the films the instances were randomly assigned their position, while in the second film they were ordered from easy to difficult as determined by a pilot study using other eighth grade general science students.

Each of these films was used to teach both by the discovery method and by the expository method. This was accomplished through the provision of two sound tracks for each film. When the film was utilized in the expository mode, the sound track stated the concept

and gave careful explanations of the instances of the concept presented by the film. When using this same film for the discovery method, the second sound track directed the student to find the relationship or common element among the instances of the concept as presented by the film. Where necessary, the sound tracks also clarified instances of the concept in order to prevent misinterpretation. Scripts for the Discovery and Expository narrations are in Appendix B. Support for the use of narration in the control of visual stimuli (motion pictures) may be found in research studies by McClusky,¹ Einbecker,² Jaspen,³ and McGuire.⁴

¹S. D. McClusky and H. Y. McClusky, "Comparison of motion pictures, slides, stereographs and demonstration as a means of teaching how to make a reed mat and a pasteboard box," Visual Education, ed. F. N. Freeman (Chicago: University of Chicago Press, 1924), pp. 310-334.

²W. F. Einbecker, "Comparison of Verbal Accompaniment to Films," School Review, XLI (1933), pp. 185-192.

³N. Jaspen, Effects on Training of Experimental Film Variables, Study II, Progress Report No. 14-15-16. State College, Pennsylvania: Pennsylvania State College, Instructional Film Research Program, 1950.

⁴W. J. McGuire, "Slow Motion, Added Narration and Distributed Showing as Factors Influencing Teaching

Apparatus. The apparatus selected to show the two films to the treatment groups was the Technicolor cartridge-loaded projector with the Audio-Sell sound attachment. The device synchronized the narrated tape with the film.

Criterion Performance. Three tasks were devised to determine the relative effects of the treatments. In their order of increasing difficulty they were: 1) To identify instance instances of the concept from a collection of examples of several concepts, 2) to generate new instances of the concept taught in the film, and 3) to apply the newly learned concept to problem situations. A copy of these tests, along with the rating scales developed to guide scorers, may be found in Appendix C. These tasks fitted roughly into Bloom's taxonomic scheme⁵ of intellectual ability and

Effectiveness of a Training Film," Visual Communication, ed., John Ball and Francis C. Byrnes (Washington, D. C.: The Department of Audiovisual Instruction of the National Education Association, 1960), p. 96.

⁵B. S. Bloom (ed.), Taxonomy of Educational Objectives (New York: David McKay Company, Inc., 1956).

skills. The identification of new instances of the concept demanded of the student a level of comprehension,

such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications.⁶

The second task, that of generation of new instances of the concept, was a translation problem where the student was required to paraphrase or render the communication from one form to another. The most difficult task, using the newly learned concept to solve a problem, fitted Bloom's Application Category.⁷

The first two tasks were evaluated by three judges using a five point rating scale. Inter-judge reliability was investigated by means of correlations (Tables 3.1 and 3.2). The high correlations between the judges' scores indicated an extremely high inter-judge reliability. It was noted that the correlations

⁶Ibid., p. 204.

⁷Ibid., p. 120.

were highest for Task I. The third task was treated as a true or false test. Its inter-item reliability was evaluated by the Kuder-Richardson Formula 20 at .7013.

TABLE 3.1

PRODUCT-MOMENT CORRELATIONS
BETWEEN JUDGES SCORES FOR
TASK I

Judge	Judge A	Judge B	Judge C
A		.917	.966
B			.938
C			

TABLE 3.2

PRODUCT-MOMENT CORRELATIONS
BETWEEN JUDGES SCORES FOR
TASK II

Judge	Judge A	Judge B	Judge C
A		.799	.871
B			.836
C			

Experimental Design and Analysis

Hypotheses. The following hypotheses were investigated in order to determine the effectiveness of the discovery method of teaching, as opposed to the expository method, when applied to the medium of single-concept films:

1. Directional Hypotheses One. The nature of the unique relationship (e.g. interaction) between intelligence and method is of the following form:

- a. All immediate criterion performances of students above an IQ of 100 will be greater if they are taught science concepts through the discovery method, than if they are taught by the expository method, regardless of the sequence of the concept instances.

Symbolically: $H_{1a}: M_1 > M_2$

Legend: M_1 = Discovery method group mean;
 M_2 = Expository method group mean.

- b. All immediate criterion performances of students below or equal to an IQ of 100 will be greater if they are taught science concepts through the expository method, than if they are taught through the discovery method, regardless of the sequence of the concept instances.

Symbolically: $H_{1b}: M_2 > M_1$

Legend: M_1 = Discovery method group mean;
 M_2 = Expository method group mean.

2. Directional Hypothesis Two. The retention of science concepts, as measured by delayed criterion performances, will be greater for all students taught by the discovery method than for those taught by the expository method, regardless of the sequence of the concept instances.

Symbolically: $H_2: M_1 > M_2$

Legend: M_1 = Discovery method group mean;
 M_2 = Expository method group mean.

3. Statistical Hypothesis One. In the relationship between intelligence and method (e.g. the unique component called interaction) there will be no difference among the cell means for the immediate criterion other than that which could be accounted for independently by intelligence and method, regardless of the sequence of concept instances.

Symbolically: $H_{01}: M_1 = M_2$

Legend: M_1 = Discovery method group mean;
 M_2 = Expository method group mean.

4. Statistical Hypothesis Two. No differences will be found in the retention of science concepts when presented through the single-concept film as measured by delayed criterion performances, between students taught by the discovery method, and students taught by the expository method, regardless of the sequence of the concept instances.

Symbolically: $H_{02}: M_1 = M_2$

Legend: M_1 = Discovery method group mean;
 M_2 = Expository method group mean.

Treatments and Assignment of Students. The median of the IQ scores (100) was used as a point for separating the students into two levels. These two groups responded to four treatment conditions:

1. The ordered sequence of the concepts was viewed, and the discovery tape was heard.

2. The random sequence of the concepts was viewed, and the discovery tape was heard.
3. The ordered sequence of the concepts was viewed, and the expository tape was heard.
4. The random sequence of the concepts was viewed, and the expository tape was heard.

The procedure for assigning subjects to the four treatment conditions was as follows; within the two IQ levels the subjects were ranked by their IQ scores, these ranks were divided into quartets, and then the members of each quartet were randomly assigned to the treatments. No student was allowed to participate in more than one treatment. Each treatment was administered in a separate room. Directions to each student, within limits, were the same.

Analysis of Data. The statistical procedure involved a three, three-way univariate factorial analyses of variance with an inspection of the data (means and standard deviations of the factor levels). For

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each analysis the main effects were: 1) sequence of concept instances, 2) intelligence level, and 3) teaching method. The dependent variables were: 1) generation of new instances of the concept, 2) application of the concept to problem situations, and 3) recognition of new instances of the concept. The interpretation underlying analysis of variance--normal distribution of errors, equal error variance (homogeneity), and independence of error portions entering into the respective observations--follow Hays.⁸ He reported that for a relatively large number of observations per cell (above 25) it has been both theoretically and empirically determined that the requirement for normal distribution of errors may be violated without serious consequences. Similarly, when an equal number of observations were maintained in each cell the assumption of homogeneity of variance could be violated without causing serious consequences. In deference to these two assumptions, 35 observations were reported for each

⁸W. L. Hays, Statistics for Psychologists (New York: Holt, Rinehart, and Winston, Inc., 1963), pp. 396, 408.

cell. In satisfying the third assumption--independence --the usual restrictions were placed on the selection and use of the subjects: they were randomly assigned to treatments, each student was used in only one treatment, and safeguards were provided to prevent interaction among students during the treatment period.

A number of Pearson product-moment correlations were also run to determine if the three criterion tasks were independent, and to establish inter-judge reliability. Again, the question of underlying assumptions was based upon the authority of Hays, who noted that as long as one was not predicting beyond the sample, the assumption of linearity could be violated without serious consequence. In fact, the usual consequence of violating this assumption was an underestimate of the true relationship. In concluding he stated:

So long as there are N distinct cases, each having two numerical scores, X and Y , then the descriptive statistics of correlation and regression may be used.⁹

⁹Ibid., pp. 509-510.

An Orthogonal Factor Analysis of the above obtained correlation matrix was run in order to determine dependence or independence of the criterion variables. The factors were rotated by means of the verimax rotation, and the rotation was halted or stopped according to the Kiel-Rigley criterion.

Chronological Procedure of the Experiment.

Three weeks prior to the administration of the treatments, the subjects were given an intelligence test.¹⁰ Results from this test, as was mentioned earlier, were used to assign the students to the four treatment conditions.

Two weeks before administration of the treatments, a pilot study was run using a group of students considered comparable to the subjects in the major study. The pilot study was designed to accomplish four things: to ascertain that the students did not possess the proposed concept, to determine the ordered sequence of the concept instances, to train administrators in the use of the

¹⁰ Otis Quick-Scoring Mental Ability Tests, Beta Test: Form Cm.

apparatus and in handling their respective groups, and to train judges in the use of the scales developed for evaluation of the test data. The results from this pilot study indicate that the four aims were satisfactorily met.

On April 22, the films were shown to the four treatment groups. Immediately after viewing the film the students were required to take the three criterion tests. Treatment and testing conditions, except for the three independent variables being tested, were held as near constant as circumstances would allow.

Approximately three weeks later the students were given the delayed post-test, which was the same as the one given for the immediate post-test. The purpose in re-administering this test was to determine retention effects.

In the period between the post-test and the delayed post-test and immediately following the delayed post-test the judges scored the tests. The data they provided were placed on IBM cards in a form commensurate

with the requirements of the two computer programs:

FACREP¹¹ and FANOD,¹² used to analyze the data.

Summary

The sample consisted of 280 junior high school students from nine, eighth grade General Science II classes from Pattengill Junior High School in Lansing, Michigan.

The plan of this study was to teach the concept "Adaptation" through the use of a single-concept film. This single-concept film was shown to the subjects in four modes: 1) with the instances of the concept in an ordered sequence using the discovery narration, 2) with the instances of the concept in a random sequence using the discovery narration, 3) with the concept

¹¹D. F. Kiel, A. L. Kenworthy, W. L. Ruble, Use of Analysis of Variance Routines on the CDC 3600 (East Lansing: Michigan State University, 1963), p. 22.

¹²J. J. DeJonge and F. M. Sim, Factor Analysis Programs: Fanod 3 and Fanim 3 (East Lansing: Michigan State University, 1964), pp. 1-7.

instances in an ordered sequence using the expository narration, and 4) with the concept instances in a random sequence also using the expository narration.

Subjects were randomly assigned to the treatments, after an initial separation on the basis of high and low intelligence using an IQ of 100 as a dividing point.

Three criterion tasks were devised to determine the degree of concept attainment: 1) the generation of new instances of the concept taught by the film, 2) the application of the new concept to problem situations, and 3) the recognition of new instances of the concept taught in the single-concept film.

Judges were used to evaluate student responses on the first two tasks. They were guided by two rating scales devised for that purpose.

The data were analyzed through two models: a three, three-way univariate factorial analysis of variance, and a Pearson product-moment correlation. The first model was used to determine the independence of the criterion tasks and inter-judge reliability.

Kuder-Richardson Formula Twenty was used to establish inter-item reliability in task three.

The chronological order of events in the experiment was summarized through the description of four administrations: 1) intelligence tests, 2) treatments, 3) immediate post-tests, and 4) delayed post-tests.

CHAPTER IV

ANALYSIS OF RESULTS

The first section of this paper presents the findings of the analyses related to each of the hypotheses. Included are: relevant data from the analyses of variance and the product-moment correlations, the probability statement, and the statement of acceptance or rejection of the hypotheses. The second section deals with the interpretation of the data.

Statement of Statistical Hypotheses

Statistical Hypotheses 1. In the relationship between intelligence and method (e.g. the unique component called interaction) there will be no difference among the cell means for the immediate criterion performances other than that which could be accounted for independently by the main effects, intelligence and

method, regardless of the sequence of the concept instances.

Statistical Hypotheses 2. When students are taught concepts by means of the single-concept film, there is no difference in means on the delayed criterion performances between those taught through the discovery method, and those taught by the expository method, regardless of the sequence of concept instances in the film, or of intelligence level.

Probability Statement

For the analysis of variance, the level of significance for rejecting the statistical hypotheses was set at the five percent level of confidence.

Analysis of Variance

On the basis of the five percent level of confidence, no significant differences were found for the

interaction between intelligence level and method for Hypothesis One nor were there any significant differences for retention due to competing methods as proposed by Hypothesis Two. Tables 4.1, 4.2, and 4.3 summarize the respective analyses of the immediate criterion performances: 1) generation of new instances of the concept, 2) application of the new concept to the problem situations, and 3) recognition of new instances of the concept from a collection of examples of several concepts.

The element of the data in Tables 4.1, 4.2, and 4.3 particularly pertinent to Hypothesis One is the interaction of intelligence with method (AC). Although no significant difference was noted, plotting the means (figs. 4.1, 4.2, and 4.3) revealed a trend indicating an interaction between intelligence and method. This trend was consistent throughout all analyses. However, its direction was opposite to what had been predicted by the Directional Hypothesis. The trend

indicated that bright students (with IQ's above 100) learned best through the expository method, while the below median students (with IQ's equal to or below 100) learned best through the discovery method of programing single-concept films. A fuller explanation of this is found in the interpretation section of this chapter.

TABLE 4.1¹

ANALYSIS OF THE IMMEDIATE CRITERION PERFORMANCE WITH
TWO LEVELS OF INTELLIGENCE: GENERATION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	272.06	49.06	Reject
B. Sequence	1	4.63	.83	
C. Method	1	4.13	.74	
AB.	1	.01	.00	
AC.	1	4.63	.83	
BC. Interactions	1	8.23	1.48	
ABC.	1	.70	.13	
Error	272	5.55		

*Reject if $F > F_{.95}(1, 272) = 3.89$.

¹For this table and for all ensuing analyses of variance tables, the Sums of Squares are not included since to do so would be superfluous. If the reader needs this information it can be easily derived by multiplying the Degrees of Freedom by the respective Mean Square.

TABLE 4.2

ANALYSIS OF THE IMMEDIATE CRITERION PERFORMANCE WITH
TWO LEVELS OF INTELLIGENCE: APPLICATION OF THE
CONCEPT TO PROBLEM SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	504.91	90.32	Reject
B. Sequence	1	13.73	2.46	
C. Method	1	1.16	.21	
AB.	1	12.01	2.15	
AC. Interactions	1	5.16	.92	
BC.	1	9.66	1.73	
ABC.	1	4.63	.83	
Error	272	5.59		

*Reject if $F > F_{.95}(1, 272) = 3.89$.

TABLE 4.3

ANALYSIS OF THE IMMEDIATE CRITERION PERFORMANCE WITH
TWO LEVELS OF INTELLIGENCE: RECOGNITION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	669.60	64.57	Reject
B. Sequence	1	2.23	.22	
C. Method	1	2.60	.25	
AB.	1	10.80	1.04	
AC. Interactions	1	20.09	1.94	
BC.	1	.60	.06	
ABC.	1	5.43	.52	
Error	272	10.37		

*Reject if $F > F_{.95}(1, 272) = 3.89$.

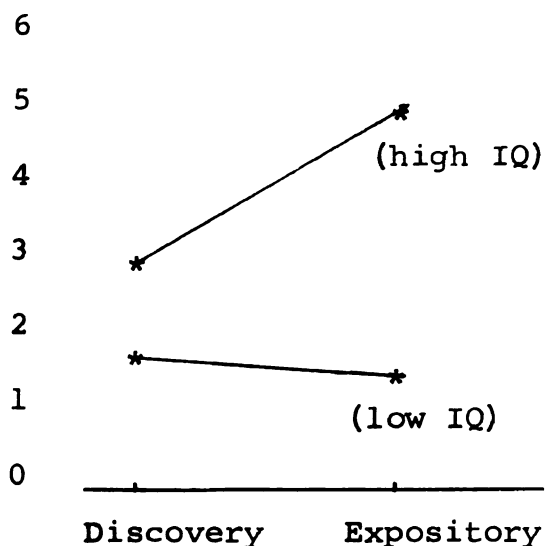


Figure 4.1--A plot of immediate Post-task I means for the Intelligence-method interaction.

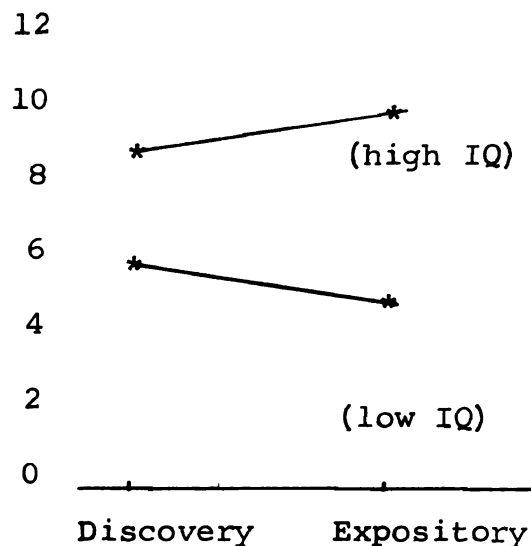


Figure 4.2--A plot of immediate Post-task II means for the intelligence-method interaction.

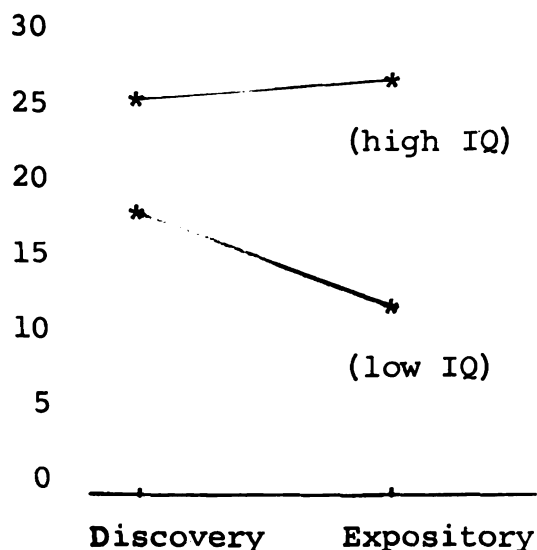


Figure 4.3--A plot of immediate Post-task III means for the intelligence-method interaction.

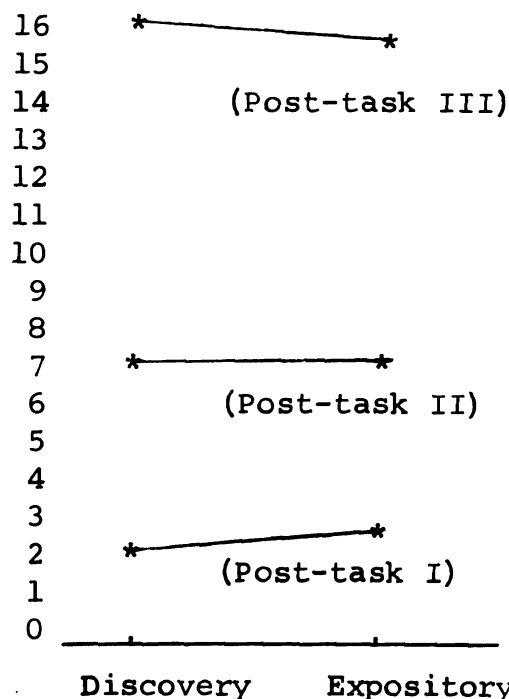


Figure 4.4--A plot of the means for delayed Post-tasks I, II, and III of the method variable.

Hypothesis Two (directional) predicted that all students, regardless of intelligence level or sequence of the concept instances, would retain more, as measured by the delayed criterion performances,² when taught through the discovery method, than when taught through the expository method. No significant differences were found between students taught through the discovery method when contrasted with those taught by the expository method. Further, a plot of the means (refer to Figure 4.4) revealed no consistent trends. Tables 4.4, 4.5, and 4.6 summarize the results of the analyses of variance on the delayed criterion performances. A more complete listing of the means, along with the standard deviations, may be found in Appendix D.

Interpretation

Several factors suggest explanations for the results of these analyses. Among them are lack of precision

²The delayed criterion performances are the same as the immediate criterion performances. The former were given 3 weeks after administering the treatment.

TABLE 4.4

ANALYSIS OF THE DELAYED CRITERION PERFORMANCE WITH TWO
LEVELS OF INTELLIGENCE: GENERATION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	317.16	52.97	Reject
B. Sequence	1	13.73	2.29	
C. Method	1	16.51	2.76	
AB.	1	1.16	.19	
AC. Interactions	1	18.51	3.09	
BC.	1	4.63	.77	
ABC.	1	1.43	.24	
Error	272	5.99		

*Reject if $F > F_{.95(1, 272)} = 3.89$.

TABLE 4.5

ANALYSIS OF THE DELAYED CRITERION PERFORMANCE WITH
TWO LEVELS OF INTELLIGENCE: APPLICATION OF THE
CONCEPT TO PROBLEM SITUATIONS

Sources of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	455.18	90.09	Reject
B. Sequence	1	5.43	1.07	
C. Method	1	.60	.12	
AB.	1	.43	.09	
AC. Interactions	1	.03	.01	
BC.	1	.18	.03	
ABC.	1	1.03	.20	
Error	272	5.05		

*Reject if $F > F_{.95(1, 272)} = 3.89$.

TABLE 4.6

ANALYSIS OF THE DELAYED CRITERION PERFORMANCE WITH TWO
LEVELS OF INTELLIGENCE: RECOGNITION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	1064.70	80.48	Reject
B. Sequence	1	3.66	.28	
C. Method	1	.51	.04	
AB.	1	2.06	.16	
AC. Interactions	1	32.91	2.55	
BC.	1	1.16	.09	
ABC.	1	17.50	1.36	
Error	272	12.91		

*Reject if $F > F_{.95}(1, 272) = 3.89$.

due to the grossness of the intelligence levels used, the possibility that the criterion tasks are not functioning as expected, and imperfect experimental conditions.

Precision. The factors listed above would tend to increase the estimate of the within variance by adding to the truly systematic and instrumental based errors. The within variance is, in essence, an estimate of the sampling error which is a function of individual variance in each cell population and sample size only. The above factors, acting as sources of error, contaminate the

estimate of within variance, and the resulting increase of the estimate of within variance decreases the size of the F ratio thereby producing F values smaller than the true F values. Because of this condition there will be situations in which the hypotheses should be rejected but will not since the F value is reduced. That is, the power of the analysis of variance is reduced.

In order to increase precision the data were regrouped in three ways: 1) the students were divided into three intelligence levels, 2) the middle IQ group was removed and the analysis run for the extreme groups, and 3) the subjects were divided on the basis of sex and the data re-analyzed on this basis.

In the first regrouping of the data, the three intelligence levels were: high (107-138), middle (93-106), and low (63-92). This rearrangement resulted in the loss of four subjects who were randomly selected out in order to maintain equal numbers of subjects per cell. The new N equaled 276, and the n per cell equaled 23. The analyses of variance for this regrouping is summarized in Tables 4.7, 4.8, and 4.9.

TABLE 4.7

ANALYSIS OF VARIANCE OF IMMEDIATE CRITERION PERFORMANCE
WITH THREE LEVELS OF INTELLIGENCE: GENERATION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	2	178.22	34.51	Reject**
B. Sequence	1	2.84	.55	
C. Method	1	3.71	.72	
AB.	2	18.54	3.59	
AC. Interaction	2	1.10	.21	
BC.	1	7.67	1.48	
ABC.	2	3.24	.63	
Error	264	5.16		
*Reject if $F > F_{.95(1, 264)} = 3.89.$				
**Reject if $F > F_{.95(2, 264)} = 3.04.$				

TABLE 4.8

ANALYSIS OF VARIANCE OF IMMEDIATE CRITERION PERFORMANCE
WITH THREE LEVELS OF INTELLIGENCE: APPLICATION OF THE
CONCEPT TO PROBLEM SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	2	331.05	65.17	Reject**
B. Sequence	1	10.57	2.08	
C. Method	1	1.45	.29	
AB.	2	2.82	.55	
AC. Interactions	2	2.46	.48	
BC.	1	11.36	2.24	
ABC.	2	4.70	.93	
Error	264	5.08		
*Reject if $F > F_{.95(1, 264)} = 3.89.$				
**Reject if $F > F_{.95(2, 264)} = 3.04.$				

TABLE 4.9

ANALYSIS OF VARIANCE OF IMMEDIATE CRITERION PERFORMANCE
WITH THREE LEVELS OF INTELLIGENCE: RECOGNITION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	2	444.79	42.80	Reject**
B. Sequence	1	2.45	.24	
C. Method	1	.06	.01	
AB.	2	10.07	.97	
AC. Interactions	2	3.53	.34	
BC.	1	.36	.03	
ABC.	2	7.35	.71	
Error	264	10.39		
*Reject if $F > F_{.95(1, 264)} = 3.89.$				
**Reject if $F > F_{.95(2, 264)} = 3.04.$				

It may be noted that there were no significant differences found for the interactions between intelligence level and teaching method as proposed by Directional Hypothesis One, and when intelligence was considered as a three level factor instead of two, the F values decreased indicating that there was no interaction and grossness of the categorization could not be blamed for wiping out the interaction between intelligence and method. Plotting of the means for these analyses (Figures 4.5,

4.6, and 4.7) produced the same trend found in the first analyses. That is, bright students learn best through the expository method when taught by single-concept films, while slow students do best when taught by the discovery method. A complete listing of the means and standard deviations for the three regroupings of the data may be found in Appendix D.

The delayed criterion performances were also regrouped into three IQ levels and an analysis of variance run on them to determine retention effects. Tables 4.10, 4.11, and 4.12 summarize the results.

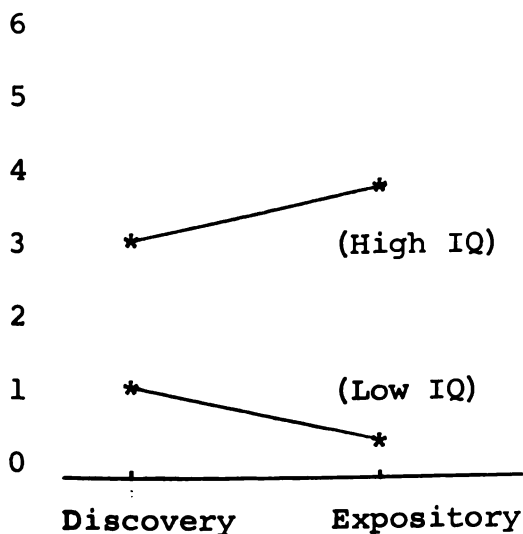


Figure 4.5--A plot of immediate Post-task I means of the intelligence-method interaction.

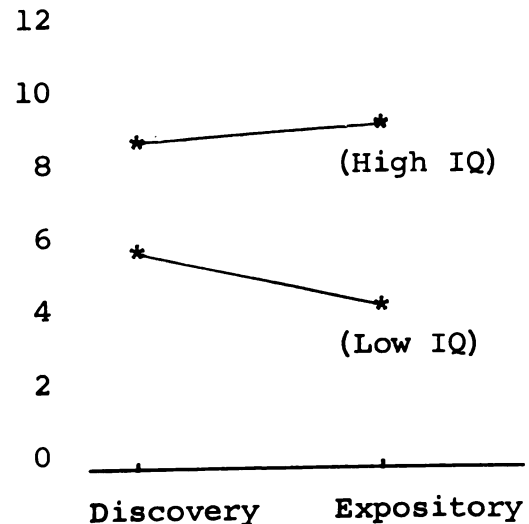


Figure 4.6--A plot of immediate Post-task II means of the intelligence method interaction.

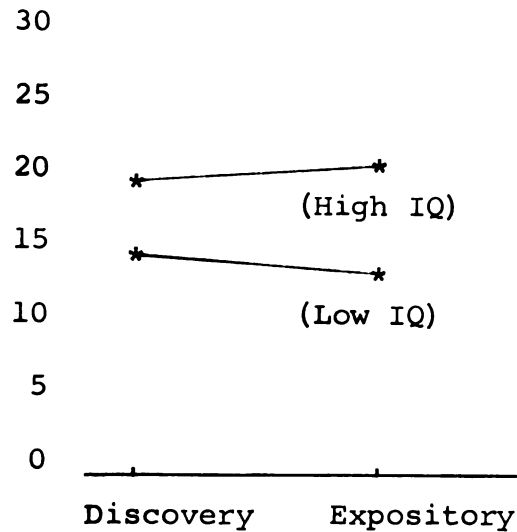


Figure 4.7--A plot of immediate Post-task III means of the intelligence-method interaction.

TABLE 4.10

ANALYSIS OF VARIANCE OF DELAYED CRITERION PERFORMANCE
WITH THREE LEVELS OF INTELLIGENCE: GENERATION OF
NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	2	198.62	34.68	Reject
B. Sequence	1	10.18	1.78	
C. Method	1	17.25	3.01	
AB.	2	8.87	1.55	
AC. Interactions	2	10.60	1.85	
BC.	1	4.44	.77	
ABC.	2	.33	.06	
Error	264	5.73		
*Reject if $F > F_{.95}(1, 264) = 3.89.$				
**Reject if $F > F_{.95}(2, 264) = 3.04.$				

TABLE 4.11

ANALYSIS OF VARIANCE OF DELAYED CRITERION PERFORMANCE
WITH THREE LEVELS OF INTELLIGENCE: APPLICATION OF
THE CONCEPT TO PROBLEM SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	2	318.55	71.06	Reject**
B. Sequence	1	5.80	1.29	
C. Method	1	.93	.21	
AB.	2	.72	.16	
AC. Interactions	2	.79	.18	
BC.	1	.06	.01	
ABC.	2	.13	.03	
Error	264	4.48		

*Reject if $F > F_{.95(1, 264)} = 3.89$.

**Reject if $F > F_{.95(2, 264)} = 3.04$.

TABLE 4.12

ANALYSIS OF VARIANCE OF THE DELAYED CRITERION PERFORMANCE
WITH THREE LEVELS OF INTELLIGENCE: RECOGNITION OF NEW
INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	2	612.71	48.77	Reject**
B. Sequence	1	1.60	.13	
C. Method	1	.44	.03	
AB.	2	15.96	1.27	
AC. Interaction	2	2.14	.17	
BC.	1	1.05	.08	
ABC.	2	9.80	.78	
Error	264	12.56		

*Reject if $F > F_{.95(1, 264)} = 3.89$.

**Reject if $F > F_{.95(2, 264)} = 3.04$.

In the analysis of the delayed criterion performances there was no significant evidence to support the directional hypothesis that method affects retention, although it was noted that precision increased substantially in Task I and moderately so in Task II (not significantly so). Again, there was no consistent trend for Hypothesis Two.

The second regrouping was similar to the one above except that the middle intelligence level (93-106) was excluded. The results of this analysis are summarized in Tables 4.13, 4.14, 4.15, 4.16, 4.17, and 4.18.

TABLE 4.13

ANALYSIS OF VARIANCE OF IMMEDIATE CRITERION PERFORMANCE
WITH MIDDLE INTELLIGENCE LEVEL EXCLUDED: GENERATION OF
NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	356.17	74.27	Reject
B. Sequence	1	.54	.11	
C. Method	1	2.17	.45	
AB.	1	23.67	4.94	Reject
AC. Interactions	1	2.17	.45	
BC.	1	11.50	2.40	
ABC.	1	2.63	.55	
Error	176	4.80		

*Reject if $F > F_{.95(1, 176)} = 3.91$.

TABLE 4.14

ANALYSIS OF VARIANCE OF IMMEDIATE CRITERION PERFORMANCE
WITH MIDDLE INTELLIGENCE LEVEL EXCLUDED: APPLICATION OF
THE CONCEPT TO PROBLEM SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	661.96	125.31	Reject
B. Sequence	1	5.22	.99	
C. Method	1	2.40	.45	
AB.	1	5.22	.99	
AC. Interactions	1	3.96	.75	
BC.	1	4.57	.87	
ABC.	1	8.27	1.56	
Error	176	5.28		

*Reject if $F > F_{.95}(1, 176) = 3.91$.

TABLE 4.15

ANALYSIS OF VARIANCE OF IMMEDIATE CRITERION PERFORMANCE
WITH MIDDLE INTELLIGENCE LEVEL EXCLUDED: RECOGNITION OF
NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	873.92	93.72	Reject
B. Sequence	1	1.57	.17	
C. Method	1	.66	.07	
AB.	1	.92	.10	
AC. Interactions	1	5.92	.63	
BC.	1	5.92	.63	
ABC.	1	3.40	.36	
Error	176	9.32		

*Reject if $F > F_{.95}(1, 176) = 3.91$.

TABLE 4.16

ANALYSIS OF VARIANCE OF THE DELAYED CRITERION PERFORMANCE
WITH MIDDLE INTELLIGENCE LEVEL EXCLUDED: GENERATION OF
NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	396.20	77.98	Reject
B. Sequence	1	.35	.07	
C. Method	1	17.04	3.35	
AB.	1	5.57	1.09	
AC. Interactions	1	19.57	3.85	
BC.	1	1.76	.35	
ABC.	1	.20	.04	
Error	176	5.08		

*Reject if $F > F_{.95(1, 176)} = 3.91$.

TABLE 4.17

ANALYSIS OF VARIANCE OF THE DELAYED CRITERION PERFORMANCE
WITH MIDDLE INTELLIGENCE LEVEL EXCLUDED: APPLICATION OF
CONCEPT TO PROBLEM SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	635.67	134.39	Reject
B. Sequence	1	7.04	1.49	
C. Method	1	.02	.00	
AB.	1	.02	.00	
AC. Interaction	1	.35	.07	
BC.	1	.20	.04	
ABC.	1	.09	.02	
Error	176	4.73		

*Reject if $F > F_{.95(1, 176)} = 3.91$.

TABLE 4.18

ANALYSES OF VARIANCE OF THE DELAYED CRITERION PERFORMANCE
WITH MIDDLE INTELLIGENCE LEVEL EXCLUDED: RECOGNITION OF
NEW INSTANCES OF THE CONCEPT

Sources of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	1180.20	103.43	Reject
B. Sequence	1	.78	.07	
C. Method	1	.20	.02	
AB.	1	20.89	1.83	
AC. Interaction	1	1.39	.12	
BC.	1	9.59	.84	
ABC.	1	4.26	.37	
Error	176	11.41		

*Based on a confidence of F equal to or greater than 3.91.

The only factor on the immediate Post-task proving significant, other than the expected intelligence variable, was the intelligence-sequence interaction (AB). This was only true for one of the tasks, that of generation of new instances of the concept (Table 4.13). A look at the means for this analysis shows that the strength of the interaction comes from the bright students. They did significantly better when the instances of the concept were arranged in a random sequence. While the hypotheses were not directly concerned with the variable of sequence

of instances of the concept, it was interesting to speculate on its causes.

Although the intelligence-method interaction (AC) was not significant for the immediate Post-tasks, an inspection of the means (Figures 4.8, 4.9, 4.10) revealed the same trend previously experienced: bright students learn best by the expository method, while slow students learn best through the discovery method.

On the delayed Post-tasks there was no significant evidence indicating that method had an effect on retention.

The third attempt at increasing precision was by means of regrouping the data on the basis of sex. This approach was selected because of the possibility of systematic variance due to sex differences affecting the error variance. Tables 4.19, 4.20, and 4.21 summarize the results for males on the immediate criterion performances.

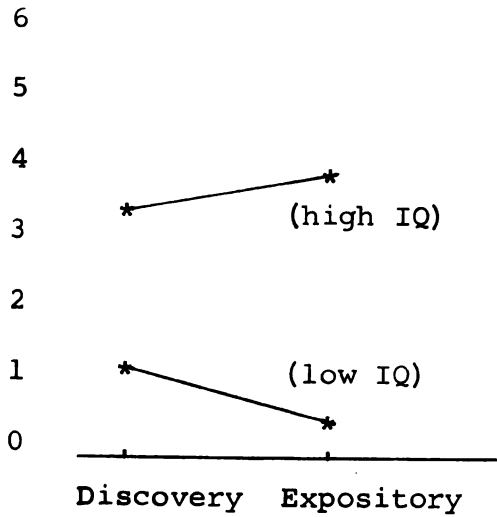


Figure 4.8--A plot of immediate Post-task I means of the intelligence-method interaction.

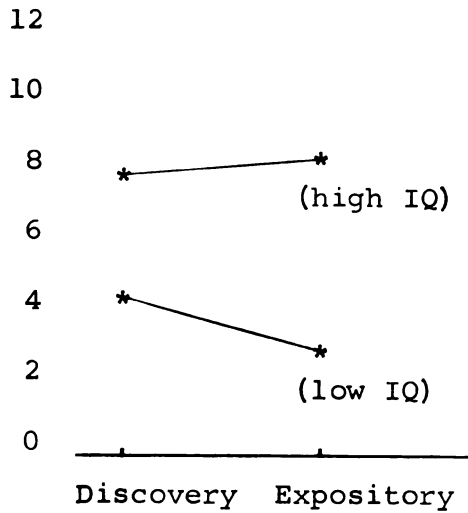


Figure 4.9--A plot of immediate Post-task II means of the intelligence-method interaction.

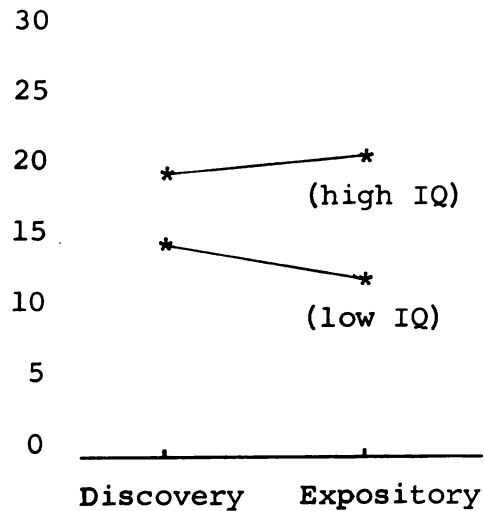


Figure 4.10--A plot of immediate Post-task III means of the intelligence-method interaction.

TABLE 4.19

ANALYSES OF VARIANCE FOR THE IMMEDIATE CRITERION PERFORMANCE FOR MALES: GENERATION OF NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	171.11	30.16	Reject
B. Sequence	1	35.11	6.19	Reject
C. Method	1	25.31	4.46	Reject
AB.	1	4.51	.80	
AC. Interactions	1	15.31	2.70	
BC.	1	1.01	.18	
ABC.	1	1.51	.27	
Error	72	5.67		

*Reject if $F > F_{.95(1, 72)} = 3.98$.

TABLE 4.20

ANALYSES OF VARIANCE FOR THE IMMEDIATE CRITERION PERFORMANCE FOR MALES: APPLICATION OF THE CONCEPT TO PROBLEM SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	127.51	21.64	Reject
B. Sequence	1	12.01	2.04	
C. Method	1	1.01	.17	
AB.	1	6.61	1.12	
AC. Interaction	1	23.11	3.92	
BC.	1	.01	.00	
ABC.	1	2.81	.48	
Error	72	5.89		

*Reject if $F > F_{.95(1, 72)} = 3.98$.

TABLE 4.21

ANALYSES OF VARIANCE FOR THE IMMEDIATE CRITERION PERFORMANCE FOR MALES: RECOGNITION OF NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	277.51	31.04	Reject
B. Sequence	1	1.01	.11	
C. Method	1	6.61	.74	
AB.	1	4.51	.50	
AC. Interaction	1	46.51	5.20	Reject
BC.	1	.01	.00	
ABC.	1	10.51	1.18	
Error	72	8.94		

*Reject if $F > F_{.95(1, 72)} = 3.98$.

Of the immediate Post-tasks, only in post-task three was there a significant difference obtained for the interaction of intelligence and method (Table 4.21, factor AC). However, it may be worth noting that in the other two tasks the F statistic was much closer to significance than in previous analyses.

The results of a similar analysis on the delayed post-task scores produced highly significant differences at the five percent level of confidence again for the boys, but not for the girls. Tables 4.22 and 4.24 show

that method made a significant difference in the amount boys retained for generation of new instances of the concept and for recognizing new instances of the concept. A look at the means (Figures 4.11, 4.12, and 4.13) for these tasks reinforced the trend of bright boys doing best through the expository programming of single-concept films, while the less bright students did best when taught through the discovery method. As the evidence in Table 4.23 indicated, the differences were not significant for the second criterion task. Nor did the means support the trend mentioned above.

TABLE 4.22

ANALYSES OF VARIANCE FOR THE DELAYED CRITERION PERFORMANCE
FOR MALES: GENERATION OF NEW INSTANCES OF THE CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	183.01	39.87	Reject
B. Sequence	1	43.51	9.48	Reject
C. Method	1	9.11	1.99	
AB.	1	17.11	3.73	
AC. Interactions	1	46.51	10.13	Reject
BC.	1	.31	.07	
ABC.	1	.31	.07	
Error	72	4.59		

*Rejected if $F > F_{.95(1, 72)} = 3.98$.

TABLE 4.23

ANALYSES OF VARIANCE FOR THE DELAYED CRITERION PERFORMANCE
FOR MALES: APPLICATION OF THE CONCEPT TO PROBLEM
SITUATIONS

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	127.51	19.04	Reject
B. Sequence	1	6.61	.99	
C. Method	1	4.51	.67	
AB.	1	.31	.05	
AC. Interactions	1	1.51	.23	
BC.	1	.01	.00	
ABC.	1	2.81	.42	
Error	72	6.70		

*Rejected if $F > F_{.95(1, 72)} = 3.98$.

TABLE 4.24

ANALYSES OF VARIANCE FOR THE DELAYED CRITERION PERFORMANCE
FOR MALES: RECOGNITION OF NEW INSTANCES OF THE
CONCEPT

Source of Variance	Degrees of Freedom	Mean Square	F Statistic	Decision*
A. Intelligence	1	418.61	31.18	Reject
B. Sequence	1	9.11	.68	
C. Method	1	1.01	.08	
AB.	1	5.51	.41	
AC. Interaction	1	94.61	7.05	Reject
BC.	1	9.11	.68	
ABC.	1	21.01	1.57	
Error	72	13.42		

*Rejected if $F > F_{.95(1, 72)} = 3.98$.

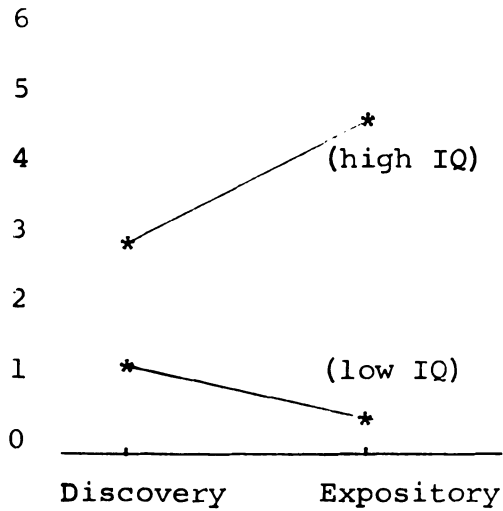


Figure 4.11--A plot of delayed Post-task I means of the intelligence-method interaction.

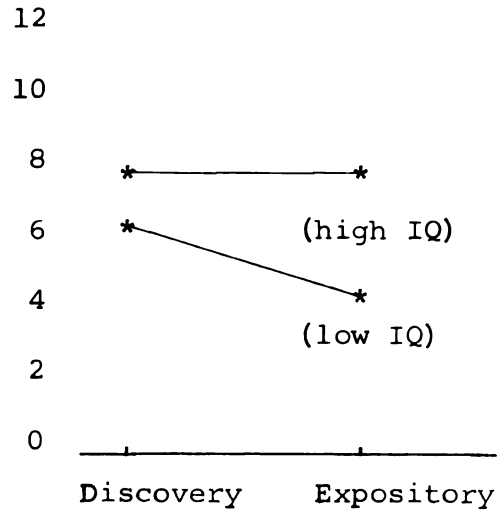


Figure 4.12--A plot of delayed Post-task II means of the intelligence-method interaction.

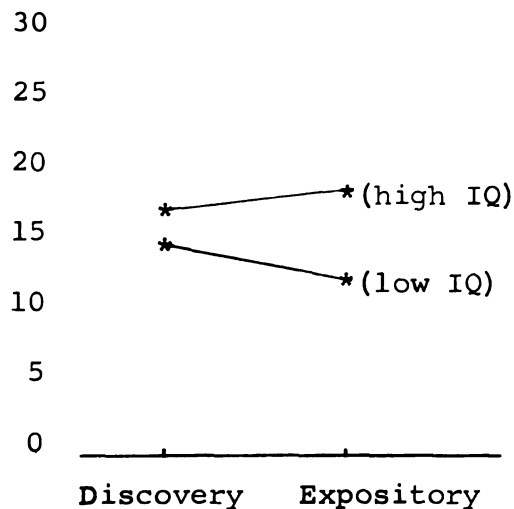


Figure 4.13--A plot of delayed Post-task III means of the intelligence-method interaction.

The possibility that sex differences were contributing systematic variance to the estimate of the random variance (within) has been supported by this analysis. Male-female differences are in evidence. When the analyses were run for females, the results washed out completely, but for males the F ratios increased substantially for the intelligence-method interaction on both immediate and delayed performance tasks, although Task II of the delayed tasks (Table 4.23) remained low. This increase in F values indicated that, for males on immediate tasks and for two of the three delayed tasks, the intelligence-method interaction does exist, and is consistent with the trends noted earlier. The small F values noted earlier must have been due to the inclusion of the females. These findings suggest that method should be differentially assigned to boys and girls. For girls it doesn't seem to matter which method is used, but for boys the choice of method appears to be critical.

This increase in F values resulting from the removal of the systematic sex difference from the within variance estimate caused the writer to believe that the

intelligence-method interaction was a true interaction for males and would be very much in evidence in a properly controlled experiment treating males and females as experimental variables.

A possible explanation for this differentiation between males on the two IQ levels might have been due to their attitude toward the teaching methods. Bright students have been consistently rewarded by the expository method. Thus, in moving from a procedure which had provided past successes to one whose merits were unknown, may have produced anxieties that reduced their learning effectiveness. The less bright student has, relatively speaking, been punished by the expository procedure. On the other hand there was no reason for the discovery method to be threatening to him. In fact, in his need to gain some of the extrinsic rewards enjoyed by his brighter counterpart, he may have been openly receptive to the discovery method.

Pushing conjecture a little farther, a possible reason for the trend washing out in the analysis for the girls may have been due to the relative maturation of

verbal abilities. The girls, particularly at that age level, had a more effective command of verbal processes than did boys, and this facility may have hidden any small effect attributable to an intelligence-method interaction.

Criterion Tasks. There are implications in the analyses of variance that the three criterion tasks: generation of new instances of the concept, application of the concept to problem situations, and recognition of new instances of the concept may be measuring different abilities. In Tables 4.22 and 4.24 there is a significant interaction between intelligence and teaching method, but in Table 4.23 this difference has washed out despite the assumption that all three tasks were measuring the same thing--concept attainment. To test the possibility that these tasks might in fact be measuring different things, correlations were run between them. The findings are presented in Table 4.25.

It is noted that the correlations between the tasks are small, substantiating the hypothesis that, for the most part, these are different tasks requiring

different abilities for their completion. Such a contention is supported when the squared values of the correlation coefficient are noted. These values range from .19 to .29, indicating that the amount of common variance in the tasks is small (e.g. 19%, 19.4%, 29.5%) for task correlations I and II, II and III, I and III respectively. Further, one might think of the correlations as test-retest reliability coefficients, and if one insists that the tasks measure the same thing the criticism then becomes one of low reliability. The data matrix was factor analyzed in order to obtain a picture of the source of these correlations and to determine, if possible, the underlying structure of the instruments. The results of this analysis are presented in Table 4.26.

TABLE 4.25

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS:
BETWEEN IMMEDIATE CRITERION TASKS I, II, AND III
ACROSS ENTIRE SAMPLE

	Task I	Task II	Task III
Task I		.432	.440
Task II			.504
Task III			

TABLE 4.26

ROTATED FACTOR LOADINGS FOR ORTHOGONAL FACTOR ANALYSIS
OF THE MAJOR CORRELATION MATRIX

Variables		Factor 1	Factor 2	Factor 3
Post-task I	1	.9499	.2187	.1174
	2	.9308	.2244	.1292
	3	.9604	.2123	.1188
	4	.9668	.2193	.1277
	5	.9630	.2256	.1078
Post-task II	6	.2037	.9120	.1249
	7	.2139	.8880	.1547
	8	.2163	.9283	.1129
	9	.2248	.9631	.1406
	10	.2057	.9576	.1344
Post-task III	11	.2763	.3384	.8993

The relative independence of the three tasks is again in evidence when one notes the loadings on the three resulting factors. Factor 1 might be called a Task I factor, since all measures loading on this factor involve Task I. Task II and Task III measures have very low loadings on factor 1. Similarly, measures loading on factor 2 involve Task II, and measures loading on factor 3 involve Task III. The existing structure, therefore, closely resembles a simple structure case

(all dependent tasks).³ It was suspected, then, that the existing correlations might be due to intelligence and not truly be a function of the tasks. Knowing that the correlations increase or decrease due to increased number of IQ levels, the same analysis was run for three separate intelligence groupings (high, middle, and low). Such an analysis should indicate whether or not the correlation in evidence is due simply to IQ difference in people (e.g. concomitant factor) or due to a true relationship in the measure. If the former were true, the correlation would decrease when one analyzes within IQ groupings as contrasted with across IQ groupings. If the latter were true, the correlation would increase or stay the same. In each case the correlations (Tables 4.27, 4.28, and 4.29) dropped and the factor structure tended even more toward simple structure. This tendency was very obvious in the case of low intelligence (Table 4.30), although less so for middle and high intelligence (Tables 4.31 and 4.32 respectively). The same results were found for an analysis of the delayed post-tasks.

³Lee J. Cronbach, Essentials of Psychological Testing (New York: Harper & Brothers, 1960), pp. 255-256.

TABLE 4.27

MINOR PEARSON PRODUCT-MOMENT CORRELATION MATRIX OF
IMMEDIATE CRITERION TASKS I, II, AND III FOR
LOW INTELLIGENCE

	Task I	Task II	Task III
Task I		.0652	.1812
Task II			.0838
Task III			

TABLE 4.28

MINOR PEARSON PRODUCT-MOMENT CORRELATION MATRIX OF
IMMEDIATE CRITERION TASKS I, II, AND III FOR
MIDDLE INTELLIGENCE

	Task I	Task II	Task III
Task I		.3807	.3264
Task II			.4529
Task III			

TABLE 4.29

MINOR PEARSON PRODUCT-MOMENT CORRELATION MATRIX OF
IMMEDIATE CRITERION TASKS I, II, AND III FOR
HIGH INTELLIGENCE

	Task I	Task II	Task III
Task I		.2309	.3089
Task II			.3771
Task III			

TABLE 4.30

ROTATED FACTOR LOADINGS FOR ORTHOGONAL FACTOR ANALYSIS
OF THE MAJOR CORRELATION MATRIX LOW IQ
IMMEDIATE POST-TASKS

Variables		Factor 1	Factor 2	Factor 3
Post-task I	1	.9564	.0421	.0443
	2	.8414	.0873	.1109
	3	.9699	.0475	.0340
	4	.9946	.0622	.0656
	5	.9817	.0521	.0459
Post-task II	6	-.0100	.9511	.0865
	7	.0389	.8749	.0588
	8	.0205	.9494	-.0955
	9	.0180	.9983	.0183
	10	.0103	.9843	-.0063
Post-task III	11	.1284	.0844	.9857

TABLE 4.31

ROTATED FACTOR LOADINGS FOR ORTHOGONAL FACTOR ANALYSIS
OF THE MAJOR CORRELATION MATRIX OF MIDDLE IQ ON
IMMEDIATE POST-TASKS

Variables		Factor 1	Factor 2	Factor 3
Post-task I	1	.9501	.2248	.0995
	2	.9484	.1297	.0771
	3	.9722	.1550	.0944
	4	.9795	.1763	.0931
	5	.9702	.1902	.0864
Post-task II	6	.1763	.8846	.0718
	7	.1088	.8869	.0999
	8	.2051	.8806	.1597
	9	.1797	.9743	.1232
	10	.1875	.9506	.1484
Post-task III	11	.1958	.2924	.9354

TABLE 4.32

ROTATED FACTOR LOADINGS FOR ORTHOGONAL FACTOR ANALYSIS
OF THE MAJOR CORRELATION MATRIX OF HIGH IQ ON
IMMEDIATE POST-TASKS

Variables		Factor 1	Factor 2	Factor 3
Post-task I	1	.9694	.1191	.0801
	2	.9537	.1244	.0998
	3	.9796	.1131	.0837
	4	.9886	.1092	.0981
	5	.9847	.1312	.0598
Post-task II	6	.1262	.8840	.0556
	7	.1428	.8832	.1168
	8	.1127	.9398	.1231
	9	.1399	.9820	.1120
	10	.0936	.9751	.1064
Post-task III	11	.2208	.2622	.9388

Hence, it is not unreasonable to assume that the measures are independent, and while this fact has no direct bearing upon the purposes of this study (other than to increase precision) the development of three independent tests of concept formation represents an original and important research finding, and should be pursued extensively in another context.

A second question that comes to mind concerns the validity of testing outcomes of a treatment depending on

visual stimuli with a purely verbal device. Schalock⁴ and his associates suggest that the results of a measurement would be more meaningful if a filmic treatment were also tested with film. There are apparent difficulties in this approach for the criterion task of generating new instances of the concept, but certainly Tasks I and II of this study could be presented through film.

Treatment Conditions. The question arises, were there aspects of the treatment conditions that might account for the unexpected results? Some aspects which seem to bear consideration are: running time of film, number of times film was viewed, the number of instances of the concept, the arrangement of the instances, validity of the concept, and variables not controlled for.

The film has a running time of approximately four minutes. Is this too short an exposure for teaching

⁴H. D. Schalock, et al., Motion Pictures as Test Stimuli: An Application of New Media to the Prediction of Complex Behavior, A Final Report, Title VII, Project No. 971, Dec. 1964.

this rather complex concept? In conjunction with this question, would it have been better to have shown the film to each subject more than once? Hoban and van Ormer⁵ cite evidence that there is a tremendous learning advantage accrued from repetitive showings of a film. Researchers have measured increases in comprehension and retention for extra showings of a film that range as high as 35% for one extra showing, 42.4% for two extra showings, and 43.5% for three extra showings. The researcher of this study was not unaware of these facts at the initiation of the research; the decision to show the film only once was made to reduce the number of contaminating variables. In retrospect it might have been wiser to have set up a control group where the effect of multiple showings could have been observed.

The four minute treatment film, in both the random and ordered sequence versions, was made up of ten instances of the concept adaptation. The question in

⁵ Charles F. Hoban, Jr., and E. B. van Ormer, Instructional Film Research 1918-1950. (Rapid Mass Learning), A Report of the Pennsylvania State Collge Project jointly sponsored by the Department of the Army and the Department of the Navy (Port Washington, N. Y.: U. S. Navy Special Devices Center, 1951), pp. 34-35 (chap. 8).

this case asks about the density of information. Perhaps an analysis of the visual and auditory information in the film would reveal that the "seven bits" limitation⁶ has been exceeded. Travers,⁷ in his support of the theory that the human receiver is capable only of receiving information through one sense modality at a time, states that when information is presented to two senses at the same time, as is the case in the sound motion picture, the receiver is constantly switching back and forth between the visual and aural channels. He cites research under his sponsorship which indicated that "where there is an auditory and a visual input of information of relatively high information density (in relation to what the processing system can handle), then the switching process itself may interfere with the taking in of information."⁸

⁶George A. Miller, "The Magical Number 7, plus or minus 2: Some limits on our capacity for processing information, *Psychological Review*, LXIII (1956), pp. 81-97.

⁷Robert M. Travers, "The Transmission of Information to Human Receivers," AV Communication Review, XII, No. 4 (1964), pp. 373-385.

⁸Ibid., p. 376.

Such evidence defends the thought that the present research design might have been improved by the control of another variable where the number of instances of the concept in the film would be varied while keeping the showing time constant.

A factor worthy of consideration is the concept itself. Adaptation was chosen for a number of reasons, some of them mentioned earlier: it was a concept normally taught in the time period in which the students were available for treatment, teacher judgment and a pretest indicated that the students did not possess it, and there was a wealth of film present containing instances of the concept. In selecting the instances of the concept there was an attempt to get novel examples. It is wondered if perhaps the unusualness of these instances might not have detracted from the teaching objective, particularly among the discovery treatments. Another question about the concept might be in reference to its prerequisites. Did the individual student have in his repertoire the necessary subconcepts to allow him to arrive at the concept of Adaptation?

Last, it is possible that the effect of practice may be a variable confounding the results of this study. Nearly all of the formal learning of the subjects has been of an expository nature. They expect to receive verbal statements and demonstrations of concepts, principles, and processes. They do not have a comparable set for digging out unknowns from an array of data. Students are used to being told what they are going to see, what they see, and what they have seen. Their experience in viewing films has conditioned them to expect that points of major importance will be repeated several times, thus allowing them to ignore much of a film's content. In a film, such as the experimental film used in this study, each of the segments contribute to the learning of the concept, and ignoring large portions of it could logically distort the learning effect. It seems reasonable that a preliminary training period in discovery for the subjects could have affected the outcomes of this study.

Summary

Chapter Four consisted of two major parts. The first section presented the findings of the analyses for each of the hypotheses. These findings included: relevant data from the analyses of variance and correlations, the probability statement, and statements of acceptance or rejection of the hypotheses. The second section dealt with the interpretation of the data.

At the .05 level of confidence no significant differences were found for the interaction between intelligence level and teaching method in support of the first hypothesis, nor was there a significant difference between methods in support of the second hypothesis. Plotting the means revealed a trend contrary to Directional Hypothesis One of this study. The trend indicated that bright students ($IQ > 100$) learned best through the expository method of programing of single-concept films, while the less bright ($IQ \geq 100$) learned best through the discovery method of programing.

In the interpretation section, several factors were examined and data were regrouped in an attempt to

discover the causes underlying the results of the analyses. Various aspects of precision, independence of criterion tasks, and experimental conditions were examined.

Precision. In order to increase precision, the data were regrouped on intelligence in three ways.

First, the students were regrouped on three intelligence levels in order to gain precision on this factor and the data were re-analyzed. Again, no significant differences were found, but the F values did rise appreciably. Plotting of the means revealed the same trend seen in the original analyses; bright students learned best from the single-concept film when it was programed with the expository method, while the less bright learned best through the discovery method of programing. A similar analysis of the delayed criterion tasks failed to produce significant evidence of method affecting retention.

Second, an analysis was run where the middle group of the three intelligence groups was excluded in order to observe the effect of the treatments on the extreme groups. Except for a significant difference

between intelligence and sequence of concept instances (order vs. random), the results were the same as for the three intelligence groupings above. The means indicated that bright children do significantly better when the instances of the single-concept film are arranged in a random sequence.

Third, the subjects were regrouped on the basis of their sex because of the possibility of systematic variance, due to sex differences, affecting the error variance. On the immediate Post-task III (recognition of new instances of the concept) significant differences were found for the intelligence-method interaction, for males only. And in the other two immediate post-tasks, for the same interaction, the F values were close to significance. An analysis of the delayed post-tasks produced comparable results. The trends from previous analyses were supported there; that is, bright boys learned best through the expository method, while the less bright learned best through the discovery method of programing single-concept films. The conclusion drawn from these analyses is that the possibility that

sex differences were contributing systematic variance to the estimate of the within variance has been supported. The findings indicate that method should be differentially assigned to boys on the basis of their intelligence level.

Criterion Tasks. Correlations were run between the three criterion tasks in order to test the possibility that they were not measuring the same thing. The small correlations between the tasks supported the possibility that the tasks were indeed measuring different things. A factor analysis of the data matrix gave further support to this contention.

Similar correlations and factor analyses were run separately for the three intelligence levels (high, middle, and low). In each case the correlations dropped and the factor analyses tended toward simple structure indicating that the correlation results were due to IQ differences in the subjects. It was noted that, while the discovery of this fact resulted from an attempt to increase precision, the development of three independent tests for the formation of a concept is a valuable research finding and should be pursued extensively in another context.

Treatment Conditions. Other factors considered as possible causes of the results were: limited running time of the single-concept film, number of repetitive instances in the film, the question of prerequisite concepts, and the effects of practice.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The summary is composed of three parts: the problem, the design and procedure of the study, and the analysis.

The Problem. This study was designed to analyze the teaching effects of the single-concept film when programmed to teach science concepts through two contrasted teaching modes: expository and discovery.

The design and Procedure of the Study. The sample consisted of 280 junior high school students selected from nine, eighth grade General Science II classes from Pattengill Junior High School in Lansing, Michigan.

The plan of this study was to teach the concept "Adaptation" by means of the single-concept film. This single-concept film was shown to the subjects in four

modes: 1) with the instances of the concept in an ordered sequence using the discovery narration, 2) with the instances of the concept in a random sequence using the discovery narration, 3) with the concept instances in an ordered sequence using the expository narration, and 4) with the concept instances in a random sequence also using the expository narration.

Subjects were randomly assigned to treatments after an initial separation on the basis of high and low intelligence, using an IQ of 100 as a dividing point.

Three criterion tasks were devised to determine the degree of concept attainment: 1) the generation of new instances of the concept taught by the film, 2) the application of the new concept to problem situations, and 3) the recognition of new instances of the concept taught in the single-concept film.

Three judges independently evaluated student responses on the first two tasks. They were guided by two rating scales devised for that purpose. The third task was objective in nature (true-false) and was machine scored.

Two procedures of analysis were employed: three, three-way univariate factorial analyses of variance, and

Pearson product-moment correlations. The analyses of variance were used to test the hypotheses under consideration. Correlation coefficients were calculated in order to determine the independence, or non-independence of the criterion tasks and inter-judge reliability. Kuder-Richardson formula 20 was used to establish inter-item reliability in Task III.

Analysis. The two statistical (null) hypotheses were:

1. There is no differential effect for the interaction of intelligence level and teaching method when science concepts are taught through the single-concept film, regardless of the sequence of the concept instances.
2. Method does not have an effect on the retention of science concepts taught by the single-concept film as measured by the delayed criterion tasks, regardless of IQ level, and sequence of concept instances.

The directional research hypotheses were:

1. There is a differential effect for the interaction of intelligence level and teaching method when teaching science concepts through the single-concept film regardless of the sequence of concept instances. These interactions take two forms: bright students ($IQ > 100$) perform best on the criterion tasks when the concept is taught through the discovery method, and less bright students ($IQ \leq 100$) perform best on the criterion tasks when the concept is learned through the expository method.
2. The retention of science concepts as measured by delayed criterion tasks is greater for all students taught through single-concept films using discovery method programing, than for those taught by single-concept films using expository programing, regardless of the IQ level and the sequence of concept instances.

There were no significant differences found for either of the hypotheses. An inspection of the means

indicated a consistent trend contrary to the first (directional) hypothesis. The trend indicated that bright students learn best when taught through the expository method, and the less bright students learn best through the discovery method.

Operating under the assumption that there should in fact be significant main and interaction effects, a reason for the non-significant F values was sought. If in fact there exist such causes, their effect would have to be one of increasing the within sum of squares, thereby decreasing the power of precision of the F statistic. Two possible sources of non-random error were considered. First, it was thought possible that the categories of the intelligence factor were too grossly defined. Second, the investigator was concerned with the possibility that sex differences might exist and thereby be contributing systematic differences which were thrown into the error term. Following this line of thinking the data were regrouped in three ways: 1) the analyses were re-run with three intelligence levels (high, middle, and low), 2) the analyses were re-run with the middle group excluded, and 3)

the analyses were re-run with subjects divided on the basis of sex with separate runs for males and females.

The first two data regroupings did not obtain significant differences for the treatments, but in several cases the F value increased appreciably and the trend noted in the original analyses was repeated. The third regrouping, on the basis of sex, proved more fruitful. While there was no evidence indicating that assignment of method was important for girls, it produced significant differences for the boys. An inspection of the means indicated that this differential effect was in the same direction as the trend mentioned earlier; bright boys learn best through the expository method, and the less bright learn best through the discovery method. These findings support the investigator's contention that sex differences do exist and have had a suppressing effect on the F values.

Pearson product-moment correlations were run between the criterion tasks in order to test the possibility that the tasks were not measuring the same thing. The correlations (over total N) between the tasks were low, giving further support to the idea that the tasks were

measuring different abilities. A Factor analysis of the measures supported these findings. The same analysis run within IQ groupings indicated an even stronger tendency toward simple structure.

Conclusions

The conclusions of this study, within those limitations enumerated in Chapter I, are presented in two parts: variable control, and the hypotheses.

Variable Control. In several cases a clear rationale was made about control procedures for variables affecting the study. However, in some cases study results raised a question about how this control might be modified to improve the study. In other instances variables were not seen as crucial to results and were largely uncontrolled, but outcomes of the study indicated a more crucial role for a number of them. Variables that fall reasonably into these two categories were: 1) effect of practice, 2) number of film showings per student, 3) relative shortness of the film, 4) number of instances

of the concept of the film, 5) concept prerequisites, and 6) the novelty effect of the concept instances.

It is possible that the students lack of training in learning by the discovery method affected the outcomes of this study.

There is evidence that showing the film twice increases retention and understanding of the film content as high as 35 percent. Such an increase might have also affected this analysis.

The experimental film used in this study is approximately four minutes long. There is a question as to whether this is enough exposure to insure learning of a concept as complex as Adaptation.

A large number of instances of the concept were included in the relatively short four minute film. It is possible that examples with more extensive development of the few would have had a more desirable effect.

There is also the need to answer the question of what concepts must be present in the student's repertoire in order for him to grasp the concept being taught.

Novel examples of the concept were chosen in the hopes of emphasizing the distinguishing elements of the

concept. Perhaps, the very novelty of the instances tended to distract the student from the instructional objective.

Finally, it is not clear just what abilities the criterion instruments are measuring. A surface, content inspection of the tasks leads one to believe that the tasks are measuring the same ability. But statistical evidence indicated that the three tasks are independent measures, suggesting that more than one ability is involved in concept formation. This important outcome should be researched thoroughly in a context where the major emphasis is on the formation of concepts.

The Hypotheses. It must be concluded from the original analyses of this study that there is no differential effect of intelligence and teaching method resulting from teaching science concepts through the single-concept film, nor is the retention of science concepts as measured by delayed criterion tasks, when taught through the single-concept film, significantly affected by the differential assignment of the two methods.

Post hoc consideration of the data gives support to a trend, indicated by the original analyses, that bright students learn best through the expository method, while the less bright learn best by the discovery method. Statistically significant evidence of this trend, for boys, existed for one of the post-tasks.

The conclusions and recommendations that follow are intended to aid those persons continuing research in the development of guidelines for the programing and use of the single-concept film.

Recommendations

It is suggested that in replicating this study an attempt should be made to control more factors.

Changes recommended include the following:

1. Students should be given practice in the discovery method prior to administering the treatment.
2. The film should be shown to each student more than once, under controlled conditions to determine the effect of multiple showings.

3. The running time of the film should be varied.
4. The number of instances of the film should be varied.
5. The concept should be taught with more commonplace examples in order to reduce the novelty effect that might be present.
6. Study is needed to determine the subconcepts required by the student prior to his attainment of the concept.
7. Intelligence should be divided into a larger number of categories.
8. The effect of differential assignment on the basis of sex should be studied.
9. Concepts in other areas should be taught to increase generalizability of the findings.
10. The trend of bright students learning best through the expository method of programing single-concept films, and slow students learning best by the discovery method needs to be explored in depth.

Finally, in considering these conclusions and recommendations in the light of the broad purposes outlined in Chapter I of the study, it would seem that this work can be regarded as a first step toward developing guidelines for the programing and use of single-concept films. While this study has not provided immediate support for the use of the single-concept film in the field, it has indicated a number of promising directions for further research.

APPENDIX

APPENDIX A

PRETESTS USED IN A PILOT STUDY TO DETERMINE THE STUDENTS' KNOWLEDGE OF THE CONCEPT "ADAPTATION"

PRETEST I

Below are a number of statements, if you agree with a statement encircle "A" on your answer sheet. If you disagree, encircle "D" on your answer sheet.

EXAMPLE: 0.1 All horses are black.

On your Answer Sheets: 0.1 A (D)

1. The bodies of many animals will change if their environment changes.
2. The plants and animals that we see are basically unchanged over the thousands of years.
3. There are plants that catch insects and use their bodies for nourishment.
4. The ancestors of birds, have always had wings.
5. Men, living millions of years in the future, may look a great deal different from men of today.
6. One of the reasons for breathing is to remove useless gases from the body.
7. The main purpose of the circulatory system is to keep the body warm.

8. Some animals are capable of growing two heads.
9. All plants produce seeds.
10. If examples were here before us, it would be easy to recognize the ancestor of the robin that lived a million years ago.
11. The offspring of animals who have been subjected to x-rays may be quite different from those offspring of animals who have not been treated with x-rays.
12. The blood in humans is exactly the same for all individuals.
13. It is possibly true that at one time the bodies of men were completely covered with hair.
14. In the future, there may be human diseases that we have never had in the past.
15. Dinosaurs can no longer be found on earth because they could not change fast enough to match the changes in their environment.

PRETEST II

Below are a number of examples arranged in groups of three. The examples in each of these groups are expressing one main idea or concept. It is your task to determine what concept best describes each of these groups of three. The same concept may be applied to more than one group if you are convinced that the examples in the groups refer to the same thing. Study the following three examples carefully:

- Diffusion 0.1
- a. Sugar placed in water seems to disappear.
 - b. The girl's perfume could be smelled all the way across the room.
 - c. The red dye slowly spread to all parts of the container.

- a. The ameoba divided into two smaller ameobas.
- Reproduction 0.2
- b. The uniting of the sperm and the egg cell formed a seed.
 - c. The small piece of potato grew into a new potato plant.

- a. The eggs laid by the ant were fertilized.
- Reproduction 0.3
- b. The willow branch stuck into the soil of the riverbank began to grow.
 - c. A shoot and root began to grow from the covered end of the rose bush branch.

Write the best answer you can think of for the following suggestions, and place your answer on the answer sheet. Please do not write on this test.

- a. Flounders have developed the unusual ability of changing their color to match their surroundings.
- ____ 1. b. Bats of today, unlike their ancestors of a few thousand years ago, can find their way in the dark by sending out sound waves ahead of them.
- c. Certain ants have learned to keep another insect type, the aphid, a prisoner. The ants periodically remove a sweet liquid from the aphids.

- a. There are some animals in which bleeding is difficult to stop.
- ____ 1.
 - b. When the O_2 content in swamp water drops to a certain level, the fish in the swamp die.
 - c. Cancer occurs in all organisms.
- a. Whenever Bill eats eggs, his temperature rises.
- ____ 3.
 - b. During the flowering time of golden rod, Jane sneezes constantly.
 - c. It is difficult to make a skin graft, from one person, grow on another.
- a. A crayfish is able to lock his claw into place when grasping an enemy, and then deliberately breaks off his own claw. He escapes while the enemy tries to break loose the locked claw.
- ____ 4.
 - b. The Snyr bird has over many generations stopped building nests. Instead, they lay their eggs in the Albatross' nest, who raises the baby Snyr birds as her own.
 - c. When the climate changed to a colder one, some of the bears survived because they were able to slow their bodily processes down and sleep through the winter.
- a. The tadpole develops legs and loses his tail and gills.
- ____ 5.
 - b. The butterfly that breaks out of the pupa is nothing like the caterpillar which locked it-self in.
 - c. Mosquito larva live under water, but the flying adult mosquito would drown if he were placed under water.

- a. Mushrooms get their nourishment from dead and living plants.
- ___ 6. b. Tapeworms live in the intestines of animals.
- c. Athletes foot is caused by a tiny fungus which gets its nourishment from animals.
- a. When leaving bright sunlight and going into a darkened room, it is difficult to see but after a few minutes full vision is restored.
- ___ 7. b. At the end of fall, the brown coat of the snowshoe rabbit begins turning white. It remains white throughout the winter.
- c. Man is able to be heard much farther than his voice normally carries, by using a telephone.
- a. Robins who have never seen other robins' nests will build their nests in the same way.
- ___ 8. b. Certain species of pigeon, when let out in unknown territory, miles from their home, are able to fly directly to their home.
- c. Each species of spider spins a particular web pattern.
- a. Bees, while drawing nectar from flowers, carry pollen from one flower to another.
- ___ 9. b. A brisk wind can fill the air with pollen.
- c. Corn tassels, which contain pollen, grow above the ears of corn. The pollen falls from the tassels and some of the pollen lands on the corn silk below.

- a. Termites and certain tiny protozoa have learned to live together. The protozoans which live in the termites' stomach digest the wood that the termite eats. The termite cannot digest the wood by himself.
- ___10. b. The feet of young boys are very tender when they first begin going barefoot in the spring, but in a short time a thick protecting callus grows over the bottoms of their feet.
- c. The skunk of today is somewhat different from the skunk of several thousand years ago. He is different because he possesses a gland that his ancestors did not have. This gland produces a very disagreeable odor that serves to discourage animals that would attack the skunk.

PRETEST III

Most, but not all, of the following examples can be grouped under five headings or concepts: Instinct, Allergy, Metamorphosis, Adaptation, and Paracitism. Read each item and mark each on your answer sheet.

Allergy	a	<u>EXAMPLE:</u>	0.1	Sugar placed in water
Adaptation	b			seems to disappear.
Instinct	c			
Metamorphosis	d			
Paracitism	e	On Answer Sheet:		
None of these	f			

0.1 a b c d e (f)

1. Flounders have developed the unusual ability of changing their color to match their surroundings.
2. There are some animals in which bleeding is difficult to stop.

3. Whenever Bill eats eggs, his temperature rises.
4. A crayfish is able to lock his claw into place when grasping an enemy, and then deliberately breaks off his own claw. He escapes while the enemy tries to break loose from the locked claw.
5. The tadpole develops legs and loses his tail and gills.
6. Mushrooms get their nourishment from dead and living plants.
7. When leaving bright sunlight and going into a darkened room, it is difficult to see but after a few minutes full vision is restored.
8. Robins who have never seen other robins' nests will build their nests in the same way.
10. Termites and certain tiny protozoa have learned to live together. The protozoans which live in the termites' stomach digest the wood that the termite eats. The termite cannot digest the wood by himself.
11. The skunk of today is somewhat different from the skunk of several thousand years ago. He is different because he possesses a gland that his ancestors did not have. This gland produces a very disagreeable odor that serves to discourage animals that would attack the skunk.
12. Corn tassels, which contain pollen, grow above the ears of corn. The pollen falls from the tassels and some of the pollen lands on the corn silk below.
13. Each species of spider spins a particular web pattern.
14. Man is able to be heard much farther than his voice normally carries, by using a telephone.
15. Athletes foot is caused by a tiny fungus which gets its nourishment from animals.

16. Mosquito larva live under water, but the flying adult mosquito would drown if he were placed under water.
17. When the climate changed to a colder one, some of the bears survived because they were able to slow their bodily processes down and sleep through the winter.
18. It is difficult to get a skin graft taken from one person to grow on another.
19. Cancer occurs in all organisms.
20. Certain ants have learned to keep another insect type, the aphid, a prisoner. The ants periodically remove a sweet liquid from the aphids.
21. Bats of today, unlike their ancestors of a few thousand years ago, can find their way in the dark by sending out sound waves ahead of them.
22. When the O_2 content in swamp water drops to a certain level, the fish in the swamp die.
23. During the flowering time of golden rod, Jane sneezes constantly.
24. The Snyr bird has, over many generations, stopped building nests, instead they lay their eggs in the Albatross' nest, who raises the baby snyr birds as her own.
25. The butterfly that breaks out of the pupa is nothing like the caterpillar which locked itself in.
26. Tapeworms live in the intestines of animals.
27. When leaving bright sunlight and going into a darkened room, it is difficult to see but after a few minutes full vision is restored.
28. Certain species of pigeon, when let out in unknown territory, miles from their home, are able to fly directly to their home.

29. A brisk wind can fill the air with pollen.
30. The feet of young boys are very tender when they first begin going barefoot in the spring, but in a short time a thick protecting callus grows over the bottoms of their feet.

APPENDIX B

SCRIPTS FOR THE DISCOVERY AND EXPOSITORY NARRATION OF THE FILM

Script I - Discovery

The ten examples in this film are connected by an idea that is common to all of them. It is your task to discover the idea that connects all of these examples. Occasionally, I will direct your attention to facts about the examples in this film. Listen and watch carefully.

1.

Scientists believe that at one time baby deer did not have white spots on their coats. Furthermore, by the time this fawn is one year old, all of his spots will have disappeared. Would it be an advantage to him if he could keep his spots?

2.

Would it make a difference to this giraffe if his neck and tongue were even longer? If a giraffe depends upon the foliage of trees for their food, what do you suppose has happened to giraffes whose necks and tongues were much shorter?

3.

The ancestors of the fish you are about to see were trapped in this cave thousands of years ago. Unlike his ancestors, this fish has neither pigment to protect him from the sun, nor eyes with which to see, but he does have something they did not. He has tiny growths on his head with which he can sense vibrations made by other animals moving in the water. Would he be better off, in his cave environment, if he were exactly like his ancestors?

4.

The nitrogen in the soil, in which the Venus Fly Trap plant grows, was used up by similar plants long ago. But the Venus Fly Trap plant is able to get the nitrogen

it needs from the bodies of the insects it captures.
What do you suppose happened to the relatives of this plant who did not have the ability to catch insects?

5.

Sometime in the past, the water animals that the Archer Fish killed for food died out. By chance, some of the Archer Fish had a groove in their upper jaw that enabled them to fire tiny pellets of water at insects above the surface of their pond. What do you think happened to those Archer Fish who were hatched without this groove?

6.

The small fish attached to the shark is called a Remora. One of his upper fins has a suction disc on it. By attaching this disc to the shark he gets free transportation, and protection from his enemies. He also shares the shark's food. Fossil remains of the Remora's ancestors show that they lacked this suction disc. Which of the two were better off?

7.

The peculiar looking yellow fish is called the Angler Fish. Fossils show that over several years the Angler has developed a fleshy growth on his head that greatly resembles a fishing worm. He wiggles it enticingly at each passing fish. Sometimes their curiosity gets the best of them.

8.

The Spade-Foot Toad depends upon insects for its food, and during dry periods these insects die out. To carry him over this dry spell, nature has developed in the toad the ability to slow down all of his bodily processes. As a result he uses up very little energy. He simply digs into the protecting soil and goes to sleep until the rain and the insects return.

9.

The Hermit Crab has one serious weakness, his soft abdomen, or stomach, is unprotected. To correct this weakness he pushes his soft abdomen into an empty

snail shell and, turtle-fashion, wears it for protection. When he outgrows this shell, he will search out another, larger shell.

10.

Sometime in the past, the area in which this air breathing spider lived was invaded by enemies too strong to fight off. Some of these spiders, called Diving Spiders, escaped by building nests among plants below the water's surface. In order to breathe they use their hairy hind legs to carry air bubbles down to their nests.

Conclusion

Considering these ten examples you have just seen, what is the common idea that connects them all together?

Script II - Expository

1. The following examples illustrate the concept "adaptation." Adaptation is the idea that living things

change to fit their surroundings. A rabbit's coat changing from brown in summer, to white in winter is an obvious change; but others, like the changes in the coat of a fawn are not so obvious. Scientists tell us that there was a time when baby deer were not born with these camouflaging spots. It was by a lucky chance thousands of years ago, that a fawn was born with this characteristic. And since a spotted coat increased the fawn's chances of escaping detection by his enemies, he survived and reproduced, while others without spots did not.

2. Since the giraffe depends upon speed to escape his enemies, he tends to live in flat areas that have little ground cover. His food comes mainly from the foliage of trees. As this breed has gradually developed a longer neck and tongue, he has become more successful in obtaining food.
3. Fish that are trapped in a completely dark cave have no need for pigment to protect them from the sun, or eyes with which to see. This blind cave fish has made a very interesting adjustment. Instead of eyes, he

has developed little growths on his head which enable him to detect vibrations in the water. By these vibrations he can determine if it is an enemy or food that is approaching.

4. Plants as well as animals have unusual ways of better fitting their surroundings. The venus fly trap plant that you see here has perfume glands which attract insects. The insects trigger the trap by touching tiny hairs. The plant absorbs the insect in order to get nitrogen, an element not readily found in the soil where this plant is grown.
5. The Archer fish has developed a most unusual weapon to bring insects within his reach. Making use of a groove that has developed in his upper jaw, he fires drops of water at insects above the surface of his pond. He is deadly at any distance up to twelve feet.
6. Some animals increase their chances of survival by forming partnerships with other animals. The Remora fish has a small suction disk on one of its fins which it uses to attach itself to a shark. It not only gets

free transportation and protection from its enemies, but when the shark makes a kill it also shares the food. It is not clear what benefit the shark derives from this relationship.

7. The yellow angler fish has, over several thousands of years, developed a fleshy growth on his head that closely resembles a large fishing worm. He wiggles this growth enticingly at each passing fish. Like any good fisherman, he gets his share.
8. In a period of drought, the insects that the spadefoot toad feeds on tend to disappear. The toad, to carry himself over this dry period, buries himself in the soil and goes to sleep. His bodily processes slow down so that he uses very little energy. When the rains come a week or a month later, he digs out and resumes his normal activities.
9. There are a number of fish that regard the soft body of the hermit crab as good eating. But he has developed a clever way of escaping them. He forces his soft abdomen or stomach into an empty snail shell,

and turtle-like, uses it for protection. When he outgrows his present shell, he searches out a larger one.

10. Some time in the past, the area in which this air breathing spider survived was invaded by enemies too strong to fight off. Some of these spiders, called diving spiders, escaped by building nests among plants below the water's surface. In order to breathe they use their hairy hind legs to carry air bubbles down to their nests.

Conclusion

Notice that in each of the ten examples that you have seen, living things have changed in order to better fit their surroundings.

APPENDIX C

THE TEST MANUAL WITH TESTS, AND DIRECTIONS FOR SOCRING TESTS

MANUAL OF DIRECTIONS

Treatment for Single-Concept Film Study

Verbal instructions to be given by the Tester to the subjects will be printed in capital type. Directions for the administrator will be given in lower case letters.

Pull blinds. Set up projection equipment.

HELLO, MY NAME IS _____. YOU ARE TAKING PART IN A NEW WAY OF LEARNING CONCEPTS. I AM GOING TO SHOW YOU A FILM CONTAINING TEN EXAMPLES OF SOME COMMON AND UNUSUAL PLANTS AND ANIMALS. ALL OF THE TEN EXAMPLES IN THE FILM ARE CONNECTED BY ONE MAIN IDEA OR CONCEPT. IT IS YOUR TASK TO LEARN THAT IDEA FROM THE FILM. AS YOU VIEW THE FILM WATCH AND LISTEN CAREFULLY SO THAT YOU WILL UNDERSTAND THE MAIN IDEA THAT IS COMMON TO ALL OF THE TEN EXAMPLES THAT YOU SEE IN THE FILM.

REMOVE ALL OBJECTS FROM YOUR DESK.

Make sure that all objects have been removed from the students' desks.

IT IS VERY IMPORTANT THAT YOU TALK WITH NO ONE EXCEPTING ME DURING THE REMAINDER OF THIS EXPERIMENT. THE FILM IS ONLY FIVE MINUTES LONG. AS SOON AS YOU ARE FINISHED VIEWING IT, I WILL GIVE YOU A SERIES OF QUESTIONS TO ANSWER IN ORDER TO DETERMINE HOW WELL YOU HAVE LEARNED THE CONCEPT THE FILM IS ATTEMPTING TO TEACH. LET ME REMIND YOU OF THE IMPORTANCE OF NOT TALKING TO ANY OF YOUR FELLOW STUDENTS UNTIL AFTER THE TESTING HAS BEEN COMPLETED.

Turn off the lights. Show the film. Stay by the projector so that you can control the film speed so that it will match the audio.

The instructions for giving the test follow:

Post-tasks for Single-concept Film Study

Verbal instructions given by the Tester to the subjects will be printed in capitals. Directions to the Tester will be given in lower case letters.

Immediately after showing the film; turn on the lights and open the curtains.

WE ARE NOW GOING TO GIVE YOU SOME TESTS THAT MEASURE YOUR ABILITY TO USE THE INFORMATION GIVEN IN THE FILM. PLEASE CLEAR YOUR DESK OF ALL OBJECTS.

Allow time necessary.

THIS TEST BOOKLET WILL NOW BE PASSED TO YOU. Hold booklet up. DO NOT OPEN THE BOOKLET UNTIL I DIRECT YOU TO. PART OF THE TEST IS TO SEE IF YOU CAN FOLLOW DIRECTIONS. AS SOON AS YOU RECEIVE THE TEST BOOKLET, PRINT YOUR NAME, THE DATE _____, AND YOUR HOME ROOM NUMBER AT THE TOP OF THE TEST BOOKLET IN THE SPACE PROVIDED.

Have the test booklets passed, or pass them yourself. It is very important that none of the copies are carried out by the subjects, since the test will be given again at a later date. Allow students time to write their name, the date, and their home room number.

IS THERE ANYONE WHO HAS NOT FINISHED WRITING THEIR NAME, THE DATE, AND THEIR HOME ROOM NUMBER? Give help if needed.

TURN YOUR TEST BOOKLET TO PAGE ONE. READ THE DIRECTIONS SILENTLY WHILE I READ THEM ALOUD. Read the directions for Post-task I. ARE THERE ANY QUESTIONS ABOUT THE DIRECTIONS?

Answer only those questions which help clarify the directions.

NUMBER EACH OF YOUR EXAMPLES. IF YOU HAVE DIFFICULTY SPELLING A WORD DO THE BEST YOU CAN. IF YOU HAVE NEED FOR MORE SPACE FOR YOUR EXAMPLES WRITE THEM ON THE BACK OF THE PAGE. YOU WILL HAVE TEN MINUTES TO COMPLETE THIS SECTION. BEGIN.

Allow ten minutes.

STOP. TURN TO PAGE TWO AND READ THE DIRECTIONS SILENTLY WHILE I READ THEM ALOUD.

Read the directions for Post-task II to the students.

ARE THERE ANY QUESTIONS ABOUT THE DIRECTIONS FOR THIS SECTION?

Allow time for questions. Answer only those questions which help clarify the directions.

YOU HAVE 15 MINUTES TO COMPLETE THIS SECTION. BEGIN.

Allow 15 minutes to complete Post-task II.

STOP. TURN TO PAGE FOUR. READ THE DIRECTIONS FOR POST-TASK III SILENTLY WHILE I READ THEM ALOUD.

Read the directions aloud to the students.

ARE THERE ANY QUESTIONS ABOUT THE DIRECTIONS?

Answer only those questions which help clarify the directions.

YOU WILL HAVE TEN MINUTES TO COMPLETE THIS SECTION. BEGIN.

Allow ten minutes to complete this section.

STOP. CLOSE YOUR BOOKLET. LAY DOWN YOUR PENCIL.

Pick up all of the test booklets. Make certain that you get one from each student. Discourage others from picking up the test booklets. As you pick up the booklets make sure the student has placed his name on the front of the booklet.

NAME _____ DATE _____ HOMEROOM _____

DO NOT TURN THIS PAGE
OR WRITE ON THIS BOOKLET
UNTIL DIRECTED TO DO SO

POST-TASK I

The ten examples in the film that you saw were connected by an idea that is common to all of them. To show how clearly you understand this idea, list as many examples as you can think of which were not shown in the film.

After each new example that you list, briefly explain why you think it illustrates the main idea of the film. You will have ten minutes to complete this section.

DO NOT TURN THIS PAGE
UNTIL DIRECTED TO DO SO

POST-TASK II

The ten examples that you saw in the film were connected by an idea that is common to all of them. See if you can use this idea to solve the following problems. You have fifteen minutes to complete this section.

1. The Aberdeen angus is a beef steer that is usually born without horns, but recently an offspring from pure Aberdeen angus parents was born with horns.
 - a. Explain to the best of your ability why this happened.
 - b. Is it important to this breed of animal that some of the offspring are different from their parents? Explain your answer.
2. We are told by archeologists (scientists who study fossils) that the camel has changed greatly over the centuries. For example, at one time he did not have the hump in which camels now store water.
 - a. Explain to the best of your ability why this happened.
 - b. Is it important to this breed of animal that this should happen. Explain your answer.
3. After we stand in a cold shower for a few minutes, the temperature of the water seems to be much warmer than when we first got under the shower. Similarly, after our hands have been in hot dish water for a short time, the water does not seem to be as hot as it was when we first placed our hands in it.
 - a. Explain to the best of your ability why this happened.
 - b. Is it important that this should happen? Explain your answer.

DO NOT TURN THIS PAGE
UNTIL DIRECTED TO DO SO

POST-TASK III

The ten examples that you saw in the film are connected by an idea that is common to all of them. Read the following statements carefully, and encircle the numbers next to the statements that you feel best indicate the idea that was common to the ten examples you saw in the film. Take ten minutes to finish this section.

1. All plants and animals require water.
2. Termites and protozoa (tiny one-celled animals) have formed an unusual partnership. The protozoa live in the termite's stomach and breaks down food swallowed by the termite. Otherwise, the termite would die.
3. Flounders (a breed of fish) have developed the ability of changing the color of their bodies to match their surroundings.
4. The spider spins a sticky web in which he catches edible insects.
5. Flies are the only insects which have red blood. All others have either clear or green blood.
6. There are some animals in which bleeding is very difficult to stop. Human beings, who have this condition, are called hemophiliacs.
7. An octopus has the same number of legs as does a spider.
8. The puffer fish, unlike his early ancestors, can swell up so large that attacking fish cannot swallow him.
9. Most male birds are brightly colored. Despite this fact, they are usually very difficult to see when they are sitting perfectly still.
10. The circulation of the blood was discovered by an English scientist named Priestly.

11. Crabs have developed an unusual way of defending themselves. They lock one of their claws onto an enemy and then deliberately break off the claw. While the enemy struggles to free himself, the crab escapes.
12. The green katydid, over thousands of years, has come to closely resemble the leaves of the plants upon which it feeds.
13. Man, like dogs, may catch the disease called rabies.
14. One of the major differences between male and female mosquitos is their eating habits. The males mouth part is made for chewing, while the female has a sharp mouth which is good for puncturing the skins of animals.
15. Some birds, when let out in an unfamiliar area, can fly directly to their nests. Some of the ancestors of these birds did not have this ability.
16. When the oxygen content in swamp water drops below a certain level, the fish living in the swamp die.
17. Increasing age tends to reduce the effectiveness of most plants and animals. However, there are a select few who, if it were not for predators, accidents and disease, would live forever.
18. When traveling in a forest, we can return to a desired place by learning to use the stars or the sun to guide us.
19. Although both bats and birds have wings with which to fly, they are not related.
20. The vice-roy butterfly has come to look a great deal like the beautiful monarch butterfly. Birds have a strong dislike for the monarch's taste.

21. It is difficult to make a skin graft taken from one person grow on another person.
22. The feet of young boys are very tender when they first begin going barefoot in the spring, but in a short time a thick protecting callus grows over the bottoms of their feet.
23. The Snyr bird has, over many generations, stopped building nests. Instead they lay their eggs in the Albatross' nest, who raises the baby Snyr birds as her own.
24. Athletes foot is caused by a tiny fungus which gets its nourishment from animals.
25. Corn tassels, which contain pollen, grow above the ears of corn. The pollen falls from the tassels and some of the pollen lands on the corn silk below.

EVALUATION OF POST-TASKS

Post-Task I - Generation of new instances of the concept.

- A. Criteria for judging
 - 1. Not a repeat of the filmed examples.
 - 2. Answer must indicate that organism has changed in order to improve its conditions.
- B. Score will be the total number of valid instances listed by the student.
- C. Judging will be carried out by three science teachers.
 - 1. Judges will score Post-Task I independently.
 - 2. The three independent scores will be averaged to get final score.

Post-Task II - Application of the concept to a problem.

- A. The following scale will be used to evaluate the solutions to the three problems:
 - 0 - definitely do not have the concept
 - 1 - doubtful if subject has concept
 - 2 - subject may have the concept
 - 3 - subject probably has the concept
 - 4 - definitely has the concept
- B. A student's score on the three problems in Post-Task II will be determined by the following steps:
 - 1. Each of the three judges will score the three problems according to the scale in (A). Each will take an average of the score assigned to each problem.

2. The three average scores determined by the three judges will in turn be averaged to give the student's final score for Post-task II.

Post-Task III - Recognition of instances of the concept.

- A. The task will be treated as a "True or False" test. Each correct answer will be treated as +1. No correction for guessing. Score is number right.

Evaluation of Post-task I

I. Criteria for judging examples in Post-task I.

- a. The answer must indicate that the organism has changed to better fit his surroundings.
- b. The answer should not be a repeat of the filmed examples which follow:
 - (1) The development of spots by fawns
 - (2) The development of long neck and tongue by giraffe
 - (3) Blind cave fish that has lost functional use of eyes, but has developed growths on its head which allow it to sense vibrations made by other animals moving in the water.
 - (4) The development of trap by Venus Fly Trap plant in order to get needed nitrogen.
 - (5) Archer fish has developed a groove in upper jaw which allows him to fire pellets of water at insects above the pond.

- (6) Remora fish attaches itself to a shark by a suction disc it has developed in order to get food, protection, and transportation.
- (7) Angler fish has developed a fleshy growth on its head that resembles a fishing worm. It uses this growth to capture food.
- (8) Spade-foot Toad buries itself in the soil when food is scarce. Its bodily processes are slowed down so that it does not use much energy.
- (9) The Hermit Crab protects his soft abdomen by pushing it into a snail shell, and wearing it turtle-fashion.
- (10) A Diving Spider that lives under water by carrying bubbles of air down to its under water nest.

- 2. The score will be the total number of valid instances listed by the student.
- 3. Judging will be carried out by three science teachers.
 - a. The three judges will score Post-task I independently.
 - b. The three independent scores will be averaged to get the final score.

Evaluation of Post-task II

I. Scale

- 0 - definitely do not have concept
- 1 - doubtful if subject has concept
- 2 - subject may have concept
- 3 - subject probably has the concept
- 4 - definitely has the concept

******(In scoring, judges are to look at the two parts under each problem and assign only one score for each problem. The score should be in favor of the best answer of the two parts. Example: for problem one, (1a) is scored 3, (1b) is scored 1-- the final score for problem one would be 3.)

II. Model answers for the five categories of the scale:

0 - definitely do not have concept

- (1a) When the Aberdeen angus is born it is not grown. As it grows their horns develop.

This could be caused by the mother getting hurt.

The mother might have mated with a steer with horns.

- (1b) No, it just isn't necessary.

Yes, because then they would look like their parents and you couldn't tell them apart.

Because they don't come from the same animal or flower and so they are different.

- (2a) He may have mated with an animal that did have a hump and they've been this way ever since.

Camels have always had humps.

Because maybe there are other kinds of camels.

- (2b) Yes, because they are made for the desert, and that is why they have a hump on their back.

Yes so we can see the difference between them.

Yes, because it wouldn't seem right somehow.

- (3a) Because the cold water runs so long it begins to get hotter.

Yes because drinking warm water would be terrible.

Yes, if it didn't when you were in cold water you would catch cold.

1 - doubtful if subject has concept

- (1a) Because the other steer probably has some hormones or something mixed in the blood-streams of the body to cause such functions.

Because they say that all things are not alike, so the one with horns is different.

It would have to depend on the mother, if it is born with horns.

- (1b) No, because you wouldn't want the offspring to look just like you.

Yes, because if everything in this world was the same it would look pretty dull.

Yes, because then you can tell which is which. Like he is the baby or this one is older.

- (2a) I was told that two different camel breeds met and as the result the baby was born with a hump.

Over the years scientists have experimented with animals.

No, because if it was caused by the weather then other animals living in the desert would have humps.

- (2b) Yes, because people can use them when they go across the desert.

No, this is nature.

Yes, because other camels would not like him without his hump.

- (3a) Your body gets numb.

Your blood gets to the same temperature.

Because of the heat being transferred from the body to the water.

- (3b) If it didn't happen there wouldn't be any dishes washed, and we wouldn't take any baths.

Because you wouldn't want it to stay hot all the time.

Yes because if you was to keep your hands in hot water you could possibly burn them.

2 - subject may have concept

- (1a) It is just nature's way of making them different.

Because his ancestors once had them.

I think it is to protect him, because his mother Aberdeen may be in an area that is dangerous.

- (1b) Because this would decide whether the plant or animal would be better or worse. Or how it would effect its whole way of life.

Because if everything was the same we wouldn't have different kinds of plants or animals, and we wouldn't have the different thoughts about these different things.

Yes, because they can't be the same way as the parents are all the time.

- (2a) Because probably, the camel needs to drink much more water now than he did before.

This might have happened because the animal lived in a hot climate where little water could be found.

The camel didn't drink so much before, so no hump. Now that the camel drinks a large amount of water he gets his hump.

- (2b) Yes, because the camel is used mostly in the desert, and there is little water in the desert so it is good that they have humps to store water.

Yes because he would die of thirst without water.

Yes because it makes it easier for camels to travel long distances.

- (3a) The hot water makes the blood in your hands warmer, so you don't notice the heat.

Because our body temperature gets used to the new temperature.

Your hand will build a resistance to the temperature.

- (3b) Yes, for if it didn't we always would have to drink all water the same temperature. And to drink warm water would be awful.

Yes, because you could die of too sudden a change.

Yes, because it wouldn't be as hot to your hands after a while.

3 - subject probably has the concept

- (1a) In every race, no matter if plant or animal or person, there is a need for something different in life.

Because they change from year to year.

It happened so that they can protect themselves.

- (1b) Yes, because maybe they can improve.

Yes, so that there will be new kinds.

Some plants and animals need to be different from their parents because there might be a reason why the parents can't get along.

- (2a) Just as horses used to be very small, camels have inherited or grown a hump.

Because he needed this hump to survive.

When the camel didn't have the hump he couldn't live in as dry places as he can today.

- (3a) When you are in an environment for so long, your body temperature tends to equalize with the environment.

Your body gets accustomed to the water so you can't tell if it is hot or cold.

When you put hands into hot water, your hands are colder than the water so you let off some cold molecules that cool the water a little and you absorb some hot molecules so your hands and the water have a closer temperature.

- (3b) Yes, so you could be comfortable and could work or shower easier.

Yes, because otherwise you could only handle those things that have the same temperature as you do.

Yes, to show us how hot, so we will not be burned.

4 - definitely has concept

- (1a) This is probably caused by the change that takes place in all animals.

Nature keeps producing animals a little bit different than their parents so that the animals will improve so they can live better.

This happened in order to improve the breed.

- (1b) They may need this different thing for protection or for the place they live in. They may need it so they can adjust to their surrounding.

Yes, because sometime the children will need something else that their parents didn't need.

Yes, because with the changing conditions of the world, all animals and plants have to change or else become extinct.

- (2a) It had to adjust to the desert.

Maybe there was a baby camel born that by some sort of accident had a hump and it never went away.

In order to survive the changes in the climate when it turned dryer, the camel race had to find some way to carry more water in order to survive.

- (2b) Yes, every camel should be able to change in order to survive in his environment.

Yes, because if they did not change the camel might become extinct.

Yes, because this is one way that nature can provide animals with things that will make life easier.

- (3a) Because your body usually stays at a steady temperature. But when the temperature changes outside it makes your nerves react. They send a message to your mind. After a time it feels normal.

Because the skin becomes conditioned to that temperature.

The body is able to regulate its temperature to fit the type of environment it is in.

- (3b) Yes, humans have to adjust to different conditions too.

Yes, because if we couldn't adjust, we couldn't live.

Yes, because if it didn't, you could not live under unusual temperatures or different climates.

APPENDIX D

MEANS AND STANDARD DEVIATIONS OF FACTOR LEVELS FOR TEACHING METHOD, AND FOR THE INTELLIGENCE-METHOD INTERACTION

Legend:

High IQ = 1
Middle IQ = 3
Low IQ = 2
Discovery = 4
Expository = 5

I.--Original Analyses of Variance - Immediate Post-tasks

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	2.6000	2.8812
task	1	5	3.1000	2.8343
I	2	4	.8857	1.6378
	2	5	.8714	1.7439
		4	1.7428	2.4884
		5	1.9857	2.5976
Post-	1	4	7.7428	2.0689
task	1	5	7.8857	2.5283
II	2	4	5.3285	2.4889
	2	5	4.9285	2.3975
		4	6.5357	2.5822
		5	6.4071	2.8685
Post-	1	4	17.9571	3.5033
task	1	5	18.3000	3.2631
III	2	4	15.4000	2.9012
	2	5	14.6714	3.1333
		4	16.6785	3.4521
		5	16.4857	3.6707

II.--Original Analyses of Variance - Delayed Post-tasks

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	2.6000	3.0187
task	1	5	3.6000	2.6778
I	2	4	.9857	1.8454
	2	5	.9571	2.0531
		4	1.7928	2.6211
		5	2.2785	2.7223
Post-	1	4	7.3000	2.2024
task	1	5	7.4142	2.3559
II	2	4	4.8428	2.2691
	2	5	4.7714	2.1139
		4	6.1285	2.6412
		5	6.0357	2.4972
Post-	1	4	17.6857	3.5896
task	1	5	18.2857	3.4479
III	2	4	14.4714	3.8437
	2	5	13.7000	3.4192
		4	16.0785	4.0412
		5	15.9928	4.1230

III.--Data Regrouped on Three IQ Levels - Immediate Post-tasks

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	3.0434	3.0980
task	1	5	3.4782	2.8498
I	2	4	.4982	1.0052
	2	5	.4782	.9366
	3	4	1.6739	2.2015
	3	5	1.9347	2.6533
		4	1.7318	2.4865
		5	1.9637	2.6037

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-task II	1	4	8.3043	2.1173
	1	5	8.3695	2.5065
	2	4	4.8043	2.2471
	2	5	4.2826	2.3157
	3	4	6.4782	2.0948
	3	5	6.5000	2.4845
		4	6.5289	2.5749
		5	6.3840	2.8803
Post-task III	1	4	17.7173	3.4426
	1	5	17.9565	3.0980
	2	4	13.7173	2.5962
	2	5	13.2391	2.9225
	3	4	16.0869	3.3053
	3	5	16.2391	3.7605
		4	15.8405	3.5231
		5	15.8115	3.7988

IV.--Data Regrouped on Three IQ Levels - Delayed Post-tasks

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-task I	1	4	2.9130	2.9046
	1	5	4.1739	2.7511
	2	4	.6304	1.4508
	2	5	.5869	1.3916
	3	4	1.8043	2.7778
	3	5	2.0869	2.5632
		4	1.7826	2.6214
		5	2.2826	2.7312
Post-task II	1	4	7.8260	1.9241
	1	5	7.9347	2.3036
	2	4	4.1956	2.1563
	2	5	4.1304	2.2371
	3	4	6.3260	1.9328
	3	5	6.0217	2.0164
		4	6.1304	2.6576
		5	6.0144	2.5083

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	18.1521	3.5525
task	1	5	18.3913	3.4671
III	2	4	13.2608	3.2278
	2	5	13.1521	3.2177
	3	4	16.7826	3.7351
	3	5	16.4130	3.9416
		4	16.0652	4.0529
		5	15.9855	4.1416

V.--Data Regrouped with Middle IQ Level Excluded - Immediate
Post-tasks

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	3.0434	3.0980
task	1	5	3.4782	2.8498
I	2	4	.4982	1.0052
	2	5	.4783	.9366
		4	1.7608	2.6285
		5	1.9782	2.5932
Post-	1	4	8.3043	2.1173
task	1	5	8.3695	2.5065
II	2	4	4.8043	2.2471
	2	5	4.2826	2.3157
		4	6.5543	2.7946
		5	6.3260	3.1591
Post-	1	4	17.7173	3.4426
task	1	5	17.9565	3.0980
III	2	4	13.7173	2.5962
	2	5	13.2391	2.9225
		4	15.7173	3.6383
		5	15.5978	3.8203

VI.--Data Regrouped with Middle IQ Group Exluded - De-
layed Post-tasks

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	2.9130	2.9046
task	1	5	4.1739	2.7511
I	2	4	.6304	1.4508
	2	5	.5869	1.3916
		4	1.7717	2.5553
		5	2.3804	2.8200
Post-	1	4	7.8260	1.9241
task	1	5	7.9347	2.3036
II	2	4	4.1956	2.1563
	2	5	4.1304	2.2371
		4	6.0326	2.9592
		5	6.0108	2.7315
Post-	1	4	18.1521	3.5525
task	1	5	18.3913	3.4671
III	2	4	13.2608	3.2278
	2	5	13.1521	3.2177
		4	15.7065	4.1761
		5	15.7717	4.2429

VII.--Data Regrouped with Subjects Separated by Sex -
Immediate Post-tasks (Boys)

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviations</u>
Post-	1	4	2.5500	3.2682
task	1	5	4.5500	3.2682
I	2	4	.7500	1.1641
	2	5	.5000	1.0000
		4	1.5250	2.6016
		5	2.6500	3.0930
Post-	1	4	7.2500	2.1974
task	1	5	8.1000	2.2918
II	2	4	5.8000	2.8946
	2	5	4.5000	2.2360
		4	6.5250	2.6407
		5	6.3000	2.8840

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	16.1000	3.3857
task	1	5	18.2000	2.5874
III	2	4	13.9000	3.3857
	2	5	12.9500	2.2589
		4	15.0000	3.5228
		5	15.5750	3.5797

VIII.--Data Regrouped with Subjects Separated by Sex -
Delayed Post-tasks (Boys)

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	2.5000	3.0174
task	1	5	4.7000	2.8302
I	2	4	1.0000	1.8064
	2	5	.1500	.4893
		4	1.7500	2.5695
		5	2.4250	3.0541
Post-	1	4	7.1500	2.7003
task	1	5	6.9500	2.5438
II	2	4	4.9000	2.6734
	2	5	4.1500	2.2307
		4	6.0250	2.8866
		5	5.5500	2.7544
Post-	1	4	17.0500	4.5011
task	1	5	19.0000	2.8654
III	2	4	14.6500	3.7735
	2	5	12.2500	3.2424
		4	15.8500	4.2760
		5	15.6250	4.5611

IX.--Data Regrouped with Subjects Separated by Sex-
Immediate Post-tasks (Girls)

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	3.1000	2.7510
task	1	5	2.9500	2.2820
I	2	4	.6500	1.3484
	2	5	1.2500	2.7120
		4	1.8750	2.4722
		5	2.1000	2.6194
Post-	1	4	8.5500	2.4381
task	1	5	7.7500	2.9177
II	2	4	5.2000	2.3078
	2	5	4.7500	2.6532
		4	6.8750	2.8928
		5	6.2500	3.1439
Post-	1	4	17.4500	4.1609
task	1	5	18.5000	2.7047
III	2	4	14.8500	2.5188
	2	5	13.9000	3.0932
		4	16.1500	3.6412
		5	16.2000	3.6947

X.--Data Regrouped with Subjects Separated by Sex -
Delayed Post-tasks (Girls)

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	3.8000	3.8607
task	1	5	3.8000	2.2384
I	2	4	1.1000	1.9166
	2	5	1.4000	2.5422
		4	2.4500	3.3046
		5	2.6000	2.6583
Post-	1	4	8.4000	2.3033
task	1	5	7.6000	2.4793
II	2	4	4.1000	2.2454
	2	5	4.9000	1.8035
		4	6.2500	3.1276
		5	6.2500	2.5394

	<u>IQ</u>	<u>Method</u>	<u>Mean</u>	<u>Standard Deviation</u>
Post-	1	4	18.4000	3.3633
task	1	5	19.3500	2.7198
III	2	4	14.1000	3.5377
	2	5	14.1000	2.9540
		4	16.2500	4.0430
		5	16.7250	3.8629

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