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ABSTRACT

The research program described in this paper is an attempt to apply the integrated fundamental research efforts of the Center to a specific area of the elementary school curriculum, environmental education. The goals of the research program are to provide: (1) new knowledge about the interrelation of process, learning variables, and individual differences which will have implications for cognitive theory, and (2) new information concerning conditions of cognitive learning which can be applied to the development of sound instructional materials and procedures. A research model or framework which specifies the variables and processes of interest was developed. The present paper has not resulted in the establishment of a new research activity within Program 1 of the Center. Rather, it has provided a basis for reorganization of Program 1 so that the goal of integrating research on processes, learning variables, and individual differences could be achieved without the addition of a special "integrative" research activity. (Author/BL)

Working Paper No. 82

Research on Variables and Processes in Cognitive Learning of Environmental Content: Needs and Specifications

Report from the Program on Variables and Processes of Learning and Instruction

Wisconsin Research and Development CENTER FOR COGNITIVE LEARNING

THE UNIVERSITY OF WISCONSIN
Madison, Wisconsin

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Working Paper No. 82

RESEARCH ON VARIABLES AND PROCESSES IN COGNITIVE LEARNING OF ENVIRONMENTAL CONTENT: NEEDS AND SPECIFICATIONS

by

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Report from the Program on Variables

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STATEMENT OF FOCUS

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

This Technical Report is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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ABSTRACT

The research program described in this paper is an attempt to apply the integrated fundamental research efforts of the Center to a specific area of the elementary school curriculum, environmental education. The goals of the research program are to provide: (a) new knowledge about the interrelation of process, learning variables, and individual differences which will have implications for cognitive theory, and (b) new information concerning conditions of cognitive learning which can be applied to the development of sound instructional materials and procedures. A research model or framework which specifies the variables and processes of interest was developed. The present paper has not resulted in the establishment of a new research activity within Program 1 of the Center. Rather, it has provided a basis for reorganization of Program 1 so that the goal of integrating research on processes, learning variables, and individual differences could be achieved without the addition of a special "integrative" research activity.

I
INTRODUCTION

The purpose of this paper is to set out the needs and specifications for research on variables and processes in cognitive learning of environmental material. The first chapter is concerned with the nature and rationale of such a research program and its relation to other Center activities. Chapter 2 describes the content area on which the proposed research will be focused. A model or framework for research activities is presented in Chapter 3. Chapter 4 describes the reorganization of the Center's research program stimulated, in part, by this paper.

Nature of the Research Project

The research described in this paper is proposed as a new research project within Program 1, Conditions and Processes of Learning, of the Wisconsin Research and Development Center. The focus of the research is on fundamental variables and processes in cognitive learning within one area of the elementary school curriculum. The content area of interest is environmental education, for which instructional materials are being developed cooperatively by the personnel of Center Projects 101 and 203. The research will be carried out as an integrated effort of the principal investigators of Program 1. Thus, the nature of the proposed element can best be described as an attempt to apply the integrated fundamental research efforts of Program 1 to a specific area of the elementary school curriculum.

Rationale of the Research Project

The objective of the Wisconsin Research and Development Center for Cognitive Learning is to improve educational practice through programmatic research and development. The fundamental research in Program 1 is directed toward generating new knowledge about cognitive learning and instructional processes which can be utilized in the development of school materials and procedures. However, within the domain of fundamental research on cognitive learning, many tasks are used as tools to study cognitive processes and learning variables. The tasks and stimulus materials which are often used (e.g., paired associate tasks, free-learning tasks, verbal-discrimination tasks, laboratory concept-learning tasks) are useful and sometimes indispensable for isolating and measuring effects of variables on processes. However, from the standpoint of the educational practitioner or the developer of curriculum materials, much of the basic research on cognitive learning appears esoteric because emphasis is placed on the study of processes and variables independent of any specific content which must be mastered by children in school settings. Yet, an understanding of basic processes (e.g., imagery, verbal elaboration, speech processes, hypostatization, motivational-attentional processes) and the variables which influence them is fundamental to improving educational practice. What is needed for the development of sound instructional procedures and materials is research on cognitive processes and variables using content that is of interest to the educator.

The intent of the proposed research is to bridge the distinction between process and content by concentrating basic research efforts on variables and cognitive processes within the content area of environmental education. The project will serve as a vehicle for bringing the learning and individual-difference variables suggested by the different process orientations of Program 1 personnel to bear on a specific content area. By taking this approach the project should accomplish two purposes: (a) provide new knowledge about the interrelation of processes, learning variables, and individual differences which will have implications for cognitive theory, and (b) provide new information concerning conditions of cognitive learning which can be applied to the development of sound instructional materials and procedures which allow for differences among students in rate and style of learning.

Relation to Other Center Activities

The proposed research is integrally related to the ongoing research of the principal investigators in Program 1. The variables and processes which will be investigated within the area of environmental education will be those which have been studied by these investigators within the context of non-school-related tasks. That is, variables related to processes (e.g., imagery, motivation-attention, hypostatization) which have produced important effects in laboratory tasks will be investigated in relation to academic learning in either laboratory or school settings.

The proposed research is also related to Projects 101 and 203 which are jointly developing a series of ecological readers and related instructional materials to supplement the science curriculum at the elementary school level. Each reader in the series centers on a current environmental problem. Briefly, the major objectives of the readers are: (a) to provide children information and instruction that will enable them to acquire concepts and principles from science, social studies, and environmental management which are necessary for understanding the multidimensional nature of environmental problems, and (b) to teach children decision-making skills so that they may deal more effectively with environmental problems now and as adults.

The staff of Project 203 is taking major initiative in identifying environmental themes and concepts to be included in the readers. The analysis of concepts to be included in each reader and the writing of the readers is a joint effort of Projects 101 and 203. The staff of Project 101 is engaged in systematic applied research on instructional variables to determine how to facilitate learning by children for whom the materials are intended. The research of Project 101 is directly applicable to the development of environmental and other curriculum materials. Thus, the mission of Project 101 in cooperation with Project 203 is to produce curriculum materials soundly based on instructional research.

While the focus of the proposed research is on exploring fundamental variables and processes in cognitive learning, it will also contribute important information which can be used in the development of the environmental instructional materials. Experimental materials for the proposed research will be drawn, to a large extent, from Projects 101 and 203. As research utilizing these materials is carried out, information concerning variables which facilitate acquisition and retention will be shared with Projects 101 and 203. To facilitate the sharing of information among those involved in the basic research and those involved in instructional research and development activities related to environmental content, it is proposed that the manager or research associate of Project 101, of Project 203, and of the proposed research project be affiliated with all of the projects and regularly attend staff meetings of each project. This integration would insure: (a) that information and recommendations arising from the proposed basic research program on the learning of environmental concepts and principles can be utilized to improve the present instructional materials or a second generation of materials and (2) that materials as they are developed become available for use in basic research on cognitive learning.

Since much of the proposed research activity is concerned with variables in written instructional materials, the results may have implications for development of materials in content areas other than environmental education.

II

CONTENT AREA OF THE RESEARCH PROJECT

The research will focus on the learning of environmental concepts in the elementary grades using materials being developed jointly by Project 203, Individually Guided Elementary Science: Man and His Environment, and Project 101, Variables and Processes of Cognitive Learning. A review of the developmental activities, strategies, and products of Projects 203 and 101 will help to delineate the substantive area of the proposed research.

Environmental Education in the Elementary Grades

A recent paper by Voelker (1970) points to a deficiency of the current science curriculum in helping the child to understand the interrelationships between science and society. This understanding is crucial in dealing with environmental problems today. As Voelker states:

> Our society has changed from an agrarian society to one heavily influenced by science and technology but the elementary school science program has not responded. It does not consider that a major societal need is to understand the environment for the sake of preserving it rather than merely appreciating nature's beauty. Children have a definite need to understand themselves and their relationship to the environment so they can more ably solve their problems as well as contribute to solving societal problems. They need to understand their environment and the interactions between the universe and self; science programs must be organized to promote these understandings. Children need to learn how to use scientific knowledge to help them make personal and societal decisions concerning their interaction with their environment. To do this they need to learn to consider the social, political, and economic aspects of their society in conjunction with their understanding of the physical and biological world. (Pp. 2-3)

The approach adopted by Project 203 to correct this deficiency in science education involves the development of ecological readers, with each reader focusing on a major environmental problem such as air pollution, water pollution, or population. A set of readers and associated visual aids and tests will be prepared to deal with each of the high-priority social problems resulting from the interaction of man and his environment.

<u>General Nature of the Ecological Readers</u>

The first readers to be developed will be directed toward children with a reading level approximating that of an average fourth grader. Following evaluation of the readers at this level, a decision will be made concerning development of a version of the materials to be used with the primary grades.

Recently completed work by Roth, Pella, and Schoenfeld (1970) and ongoing studies at the Center have produced lists of basic environmental resources management themes considered appropriate for inclusion in the K-12 or K-16 curriculum by national panels of scholars in science and science-related disciplines. Themes selected from this list plus principles selected from various areas of science (e.g., earth science, biological sciences) will provide the substantive content of the readers. The basic concepts embodied in these general themes and principles are to be systematically analyzed to identify: (a) relevant, irrelevant, and critical attributes; (b) supraordinate, coordinate, and subordinate concepts, and (c) examples and nonexamples. Concept definitions appropriate to the children's vocabulary also will be formulated. Following the analysis of concepts, the major relationships among them will be specified as a basis for writing the printed materials.

In addition to the development of concepts in science, social studies, and environmental resources management, a decision-making component will be included in the readers. Emphasis will be placed on the role of concepts such as <u>consequence</u>, <u>risk</u>, and <u>limitation</u> in considering alternate solutions to environmental problems. An attempt will be made to show that environmental problems can be viewed from different perspectives (e.g., political, technological, economic, etc.) and that all the dimensions of the problem must be considered when decisions regarding problem solution are made. The readers will illustrate that there are competing interest groups involved with the creation and resolution of any environmental problem. Thus, it is intended that through the readers children will gain an understanding of the complexity of environmental problems.

General Objectives of the Reader Series

The series of readers is designed to develop a set of general objectives. These overall objectives can be related to any environmental problem and are concerned with fostering decision making, adopting a posture of environmental resources management, and working toward a quality environment. The general objectives for environmental education as outlined by Voelker (in preparation) are listed below:

Project 203: Man and His Environment

OBJECTIVES--General

1. Given a situation involving an environmental problem, the student can produce or identify one or more potential effects of taking one or more actions pertinent to the problem.

2. Given a situation, the student can identify those factors which have an effect on the environment and state the probable effect.

3. The student can show the interrelationship between his daily activities and environmental quality.

4. The student can show how his everyday activities affect the environment.

5. Given an issue with environmental overtones, the student can identify two or more groups who might be involved in resolving the issue and state what their viewpoint on the issue is apt to be.

6. Given a problem with environmental overtones, the student can produce two or more alternative solutions. For each solution specified, he can indicate the advantages (profit) and the disadvantages (cost, risk, limitations, and consequences).

7. Given a problem with environmental overtones accompanied by a list of suggested alternative solutions, the student can identify for each alternative the advantages (profit) and disadvantages (cost, risk, limitations, and consequences) to a specified individual or a group.

8. Given a situation describing a past problem, the decision-making process, and the resulting solution, the student can explain why or why not the same solution would now be considered a responsible one.

9. Given a situation, the student can distinguish between needs and wants for the people involved.

In addition to the general objectives related to environmental resources management and environmental decision making, there is a set of objectives related to the attainment of selected concepts from science, social studies, and environmental resources management. The concept attainment objectives are derived from a schema for testing the level of concept mastery developed by Frayer, Fredrick, and Klausmeier (1960).

Selection of Environmental Topics

Each of the readers in the series will be develpped around a particular environmental problem. The problems selected are: (a) land use, (b) air pollution, (c) water pollution, and (d) electrical energy. However, it is recognized that any environmental problem such as land use is far too broad to be covered adequately in a single reader. Therefore, it is the intent in each reader to select one restricted problem in a general topical area and develop it in a way that gives the child an in-depth understanding of the specific problem within the area as well as adequate understanding of the overall dimension of the area.

The Design of a Reader

Each single reader related to an environmental problem has certain ingredients. Briefly, these consist of a set of environmental resources management themes, the development of principles and concepts from the sciences and social studies, and a general format. Perhaps these ingredients can best be illustrated within the context of the first reader, Man from M.A.N. (Heal, Marten, Roy, and Voelker, 1971), which deals with the general topic of land use.

One of the major land use problems concerns decisions about the use of various wetlands, such as marshes. The first reader focuses on the problem of who needs marshes. The multidimensional nature of the problem is brought out by considering the different perspectives of several competing groups which have an interest in the future of a particular marsh and are involved in the decision-making process. Some of the interest groups depicted in the reader are (a) a family unit interested in the aesthetic and recreational values of the marsh, (b) a conservation group interested in the preservation of the marsh for its ecological benefits, (c) the Chamber of Commerce of a city close by the marsh which is interested in the marsh as a highway site and economic benefit to the community, and (d) a highway planning department only incidentally interested in the marsh because it is in a location which would make an efficient traffic route. The complexity of the problem of what to do with the marsh is developed throughout the reader, along with the need for studying such problems thoroughly from many perspectives before decisions are made.

The environmental resources management these developed in the reader were selected from the Roth et al. (1970) list. Some examples of themes which were well developed in the reader include:

1. There are certain risks taken, and limitations experienced, when manipulating the natural environment.
2. Conventional benefit-cost analyses do not always result in sound conservation decisions.
3. Aesthetic resources and recreational facilities of economic and noneconomic value are becoming increasingly important in leisure-time activities.
4. Individual citizens should be stimulated to become well informed about resource issues, problems, management procedures, and ecological principles.

In addition to the environmental resources management themes, broad principles from biological and earth science were developed in the reader. The biological concepts were taken from Thompson's (1970) list. Some examples of biological principles which were well developed in the reader are:

1. Energy passes through a network of organisms beginning with green plants--the food producers--then to animals which eat plants, then animals that eat those animals, and so on. At each transfer, energy is dissipated and less life can be sustained.
2. The survival and well-being of an organism depend in part upon the availability of water, energy or energy-yielding substances, minerals, and in some cases certain essential organic compounds that cannot be synthesized.
3. With minor exceptions, living things obtain their energy

directly or indirectly from the sun through the process of photosynthesis.

Principles related to earth science were selected from lists developed by Caldwell, 1955; Henson, 1969; and Janke, 1969. These principles deal mainly with the characteristics of lakes and wetlands.

In order to develop the themes from environmental resources management and the principles from biological and earth science, many specific concepts were presented either directly or indirectly within the reader. Some examples of concepts which were analyzed for explicit presentation in the body of the printed material include the concepts of wetland, marsh, profit, food chain, and energy cycle.

Relation of the Research Project to the Environmental Education Project

As described in previous sections, the Environmental Education Project is concerned with the development of instructional materials in the form of ecological readers which will result in:

1. acquisition of facts, concepts, and principles related to the relationship of man and his environment,
2. acquisition of decision-making concepts and skills related to environmental problems,
3. acquisition of positive attitudes toward preserving the environment and the necessity for individuals to involve themselves in decisions concerning environmental problems.

The proposed research will be concerned mainly with the first goal of the ecological readers, namely the acquisition of facts, concepts, and principles related to the environment. However, the research will also concern itself, to some extent, with the second and third goals of the Environmental Education Project.

As materials on the environment become available, they can be utilized as experimental materials useful in seeking answers to basic questions related to conceptual learning. Answers to such questions as:

1. Given either a textual or nontextual representation of the to-be-learned content,
   a. what variables related to the syntactic and semantic aspects of the content affect learning?
   b. what variables affect the attentional-motivational proper-

ties of the content?

c. what types of adjunct aids to the text affect learning and processing?

2. What characteristics of the learner interact with the above variables?
3. With children too young to learn effectively from a text, what kinds of alternative modes of representation are effective? Will other methods benefit older children? Again, what learner variables are related to effective learning from different materials?
4. What social-psychological factors in the learning situation affect learning whether from prose or other modes of representation?
5. What social-psychological manipulations will facilitate the formation of normative values and bring about consistent changes in behavior, given that the cognitive content has been mastered? What environmental factors in the classroom or school affect social behavior and learning of children?

III

MODEL FOR A PROGRAM OF RESEARCH ON VARIABLES AND PROCESSES IN COGNITIVE LEARNING OF ENVIRONMENTAL CONTENT

The substantive content of the proposed research was outlined in the preceding chapter. In this chapter a model for a program of research in cognitive learning using environmental content will be presented. As the model is presented, examples of the types of variables to be investigated will be indicated.

The model for research represents a framework within which the different process orientations of the principal investigators involved in the proposed research can be integrated and related to a single subject. The model is intended to be flexible and inclusive enough to allow for a wide range of ideas and experimental manipulations. Yet, at the same time, it is intended to provide a means for structuring, directing, and integrating the efforts related to the research program.

The model provides for a classification of variables into the following categories: representation of content, adjunct aids to text, learner variables, and dependent variables. A definition and representative variables for each category are presented in the following section.

Representation of Content

Instruction can be in the form of text or prose, films, aural presentations, or pictures. Individuals may also learn by interacting with physical models or games which demonstrate the concepts and principles to be learned.

For example, in teaching children the concept of marsh, prose passages can be used which embody the characteristics of a marsh, the definition of a marsh, and the relation of marsh to other concepts such as river and lake. In place of printed instructional material, film or slides which show actual or animated versions of marshes could be presented along with narration which describes and defines a marsh. A strictly aural version of the same material could be presented. Another alternative to text would be to present a model of a marsh which would demonstrate its characteristics to the child as he actively manipulated the parts of the model. Physical models may be useful in teaching concepts and principles, to young children, especially, because they allow a higher degree of active manipulation than other teaching techniques. From interacting with a model, a child may attain concepts on an enactive level (Bruner, 1964) which may facilitate his later understanding of the concepts on a verbal-symbolic level.

It is realized that several modes of representation may be used in conjunction with one another. However, research can be directed to determining the relative effectiveness of different ways to teach the same material. Presumably, the effectiveness of a given method would depend upon the content (i.e., specific concepts and principles to be taught) and the characteristics of the learners. It is also realized that mode of representation is a complex variable. That is, different modes may differ in concreteness, arousal properties, or in the degree of active manipulation of materials by the students. Research comparing various modes of representation is needed so that variables and processes underlying differences can be specified.

However, it is not anticipated that a major thrust of the proposed research will be comparison of modes of representation. Rather, the research will center on three classes of variables which can be manipulated within textual or nontextual representation of content.

Structural aspects of instructional materials. The structural aspects of the material refer to the syntactic and semantic characteristics of informative sentences. The syntactic characteristics of the material are concerned with the grammatical structure of sentences in written or verbal instructions. For example, sentences may be active-affirmative or passive-affirmative in structure. Other grammatical structures are active and passive queries, active- and passive-negative sentences, and so on. Sentences may also differ in complexity in terms of self-embedding, and number of independent and dependent clauses (Miller, 1962).

Syntactic variables of written instructional material may affect the cognitive processing of the learner. Rothkopf (1970) has distinguished three types of activity entailed in learning from text: (a) translating, (b) segmenting, and (c) processing. Translation involves decoding written material into corresponding overt or implicit speech. Segmentation breaks the string of vocal and subvocal articulations produced by the translating activities. Functionally, according to Rothkopf, the segmentation stage of reading establishes connection within the string of utterances or near-utterances that are produced in the translation stage. Processing includes cross-sentence interpretation and review. These activities, particularly those related to segmentation, could be affected by the syntactic characteristics of sentences. For example, complex sentences (e.g., self-embedded sentences, compound sentences, or sentences with dependent clauses) may be much more difficult to segment than syntactically simple sentences. Processing of complex sentences in terms of their relation to other sentences in the text may also be more difficult than simple sentences. Another syntactical variable which may influence segmenting and processing activities is the type of sentence (e.g., active, passive). One possibility which may be explored is that individuals differ in their preference for different types of grammatical structures.

Concerning semantic aspects of instructional materials, Davidson (1969) asserts that a major goal of research should be to answer the question, "What are the semantic components of induced and self-generated cognition that will produce optimal learning for school children?" (p.10) Induced cognition means that learning materials presented to the child might be structured, linguistically, in ways that evoke potentiating meaning responses. If the evocations are appropriate to the child's competencies, then they will facilitate learning. Structuring materials in such semantically appropriate ways essentially induces tuition. That is, the materials are presented in such a way that the individual learns "in spite of himself." Another way to induce cognition is to direct or instruct the child to generate his own semantic structures. Induced cognition can be distinguished from self-generated cognition in which the learner generates his own cognitive structures without the support of specially structured material or instructions. The occurrence of self-generated cognition can be inferred from performance or from subject reports. Variables related to the semantic structuring of the instructional material are of concern here. Later in this chapter, the questions of how one directs a child to generate his own semantic structures and what types of training procedures might lead to self-generated cognition will be considered.

What semantic properties of learning materials facilitate learning? In general, learning materials which are structured in a concrete, active form are more memorable than materials structured in an abstract, static form. The process underlying this difference may be "imagery." That is, concrete words and sentences are more likely to lend themselves to the formation of images (Davidson, 1970; Levin, 1971; Paivio, 1969). In teaching concepts which are relatively abstract and complex, it may not be possible to structure the material in a concrete form. In this case, it may well be that the use of semantic structures which render abstract content more concrete may facilitate learning. The process of changing an abstract entity into one that is concrete has been called "hypostatization" by Davidson (1970, 1971). The process of hypostatization as represented in the use of simile, analogy, and extended metaphor may provide a bridge between symbolic (verbal-abstract) representation and iconic (image-concrete) representation. The effect of the use of such semantic structures as simile, analogy, and metaphor in written instruction will be explored.

In conclusion, it should be noted that, while variables affecting the syntactic and semantic structure of the material apply mainly to written instructional materials, they can also be manipulated within nontextual representations which have a verbal component. For example, in the narrative portion of a slide presentation, metaphor or different types of syntactic structures may be employed.

Motivational-attentional aspects of instructional material. While variables related to the semantic and syntactic structure of the material can affect the internal representation and processing of information by the subject, they may also influence learning through their effects on the motivational-attentional state of the learner. The interest and research on motivational-attentional aspects of learning material has largely grown out of the theoretical development of the concept of arousal and its relation to learning and retention. According to the theoretical formulations of Berlyne (1960), the collative properties of a stimulus (i.e., its degree of novelty, complexity, incongruity) are a source of arousal. Moreover, according to Berlyne (1964), "The extent to which an external stimulus is productive of information or its opposite, uncertainty, is one of the prime determinants of arousal and other attentional processes" (p. 132).

The concept of arousal has been incorporated into a theory of learning and retention by Walker and Tarte (1963). According to the Walker and Tarte theory, during learning an active perseverative trace process is set up which persists for a considerable length of time. Permanent memory is laid down during this active phase in a gradual fashion. During the active period there is a degree of temporary inhibition of recall which serves to prevent disruption of the perseverating trace. High arousal during the learning process will result in a more intense active trace process. The more intense activity will result in greater ultimate memory but greater temporary inhibition against recall.

Studies manipulating the arousal-producing properties of the stimulus material in order to test the Walker and Tarte hypothesis have been carried out (e.g., Farley, 1969; Jones & Farley, 1970; Kleinsmith & Kaplan, 1963). These studies typically have utilized verbal-learning tasks (e.g., paired-associate, serial and free learning) and stimulus materials such as nonsense syllables, words, and geometric forms. The general findings of such studies suggest that arousal facilitates long-term retention. The relation of arousal and immediate recall is unclear. Some studies have found arousal to be detrimental to short-term retention; other studies have found no inhibitory effect. While the above studies and others have provided important information concerning the relation of the arousal-producing properties of stimuli to retention, there is need for research utilizing situations and tasks more directly comparable to those of the classroom.

One focus of the proposed research will be on the effects in short- and long-term retention of variations in the arousal-producing properties of the instructional material related to environmental education. For example, textual representations of the environmental material may be made more interesting by manipulating the complexity of sentence and/or paragraph structure (positive correlations have been found between complexity and interestingness of visual stimuli). Words rated for level of interestingness, arousal, or novelty may be used to vary the arousal-producing properties of text. Variations in the degree of uncertainty of the material may be achieved through manipulation of the logical sequencing of sentences within passages. The Miller and Selfridge (1950) technique for generating word strings of varying orders of approximation to English sentences can be adapted for constructing passages of various orders of approximation to logically constructed prose. There is greater uncertainty in low-order approximations to a logical passage, since one cannot easily predict the next sentence or idea from the present one (i.e., the present sentence provides little information). High-order approximations are more predictable. That is, they produce less uncertainty than low-order approximations. The relationship of degrees of uncertainty to arousal and to short- and long-term retention of the material will be tested.

As noted earlier, variations in sentence and/or paragraph complexity, rated interestingness or novelty of words comprising a passage, and logical sequencing of sentences in a passage may influence the subject's processing of the material as well as his level of arousal. In experiments concerned with the arousal-inducing function of such variables in textual or nontextual materials, physiological measures of activation (e.g., heart rate, GSR) will be taken during learning. In addition to these measures, recording of eye movements as the subject reads the text or views slides or film can be made in order to determine the subject's distribution of attention and the characteristics of the material which control attention.

Social-psychological context. The third class of variables to be manipulated with either written or nonwritten environmental material is somewhat different from the other two, since it is not concerned with characteristics of the instructional material itself. Rather, this category includes variables related to the social-psychological setting in which the material is presented. The classroom is a social setting and children learn not only by interacting with the instructional material but also by interacting with one another and the teacher. Thus, this aspect of the proposed research project will deal with the effects of such social-psychological variables as group structure, classroom atmosphere, and competitive versus cooperative group attitudes on the learning of the environmental content.

In addition to social-psychological variables related to the learning of environmental material, social-psychological research related to the formation of normative values and the development of consistent behavior patterns related to the environment may be undertaken. The research on development of norms and consistent behavior patterns would not involve the learning of environmental content. Rather, the focus of such research would be on the question, "Given that learning of the environmental content has occurred, what kinds of social-psychological variables will influence the values and actions based on that knowledge?"

A third aspect of the social-psychological research deals with the physical and social environment of the classroom and school. For example, a study will investigate the effects of classroom physical space on the social behavior and learning of children.

To summarize the preceding section on the proposed research model, syntactic, semantic, and arousal properties of textual or nontextual instructional material will be manipulated as well as social-psychological variables in order to assess the effects of these variables on learning. Although the choice of variables in the above section is dictated by theoretical concern with processes involved in children's learning and retention, information related to factors which facilitate learning will be supplied to Projects 203 and 101. Further research of a developmental nature by these projects may then be needed to determine the feasibility of incorporating such factors into the instructional materials.

<u>Adjunct Aids to Text--Functions and Examples</u>

The previous section on representation of content was largely concerned with the characteristics of textual and nontextual instructional materials which may affect the learning of environmental material. This section concerns only textual representation, and the discussion is directed toward the use of adjunct aids, independent of the text itself, to facilitate learning from text. An adjunct aid is defined here as any means or device used to elicit and/or support learner activities related to processing information contained in text. By this definition, adjunct aids may be inserted within text (e.g., questions, typographical cues, pictures) or they may be separate from text (e.g., slides, verbal directions). Adjunct aids may precede, follow, or be simultaneous with the reading of the text.

Frase (1971) has outlined nine possible functions which adjunct aids to text might serve. These functions include use of adjunct aids to arouse, direct, simplify, prompt, pace, sequence, maintain, amplify, and train learning activities. Frase's outline of the functions of adjunct aids provides a convenient framework for discussion of further variables and processes of interest to this study.

Arousal. According to Frase, an adjunct aid might serve an arousal function by requiring some response from the learner, either overt or covert. For example, a question may arouse learning activities. Also, introductory comments or advance organizers that provide a superordinate context may later arouse responses to related information in the text (Ausubel, 1960). Arousal is given a strictly associative interpretation by Frase. That is, a specific response is required in order to insure that the learner carries out the activities that the response implies. For example, if a subject supplies the correct response to a question, one can infer that he has carried out certain activities such as searching for information in the text.

As indicated in the earlier discussion of motivational-attentional factors in learning and retention, the concept of arousal may be given a nonassociative interpretation. That is, adjunct aids such as questions may serve a motivational function by increasing the subject's level of arousal. The nonassociative arousal properties of adjunct aids may be assessed through the use of physiological measures of activation. The proposed research includes study of the effects of the nonassociative arousal properties of pictures, questions, statements, and the like, or short- and long-term retention of information from the text. Adjunct aids used in such research should elicit the same responses or irrelevant responses (control of associative arousal function) while differing in their motivational-attentional properties. For example, an irrelevant picture inserted in text may have a "surprise" or nonassociative arousal effect but not elicit a relevant response in the associative sense.

Direction. An adjunct aid can direct attention to some aspect of the text. Such aids might take the form of directions to study some selected portion of the text. Inferential questions which require processing selected sentences also perform a directive function. An interesting variation on this theme might be the use of a "pre-prose warm-up" task to familiarize subjects with selected aspects of the text. For example, in a verbal-discrimination task the items in pairs might be words, phrases, or sentences from the text. It may be possible by means of such pre-prose tasks to control what the subject attends to in the text. That is, the saliency of various aspects of the text may be influenced by prior reinforcement or nonreinforcement of attending responses to those aspects. Investigation of pre-prose tasks as adjunct aids to influence later information processing is planned as part of the proposed research.

Simplification. A third function of adjunct aids is to simplify reading activities. According to Frase, simplification may involve both information load and processing activities. For example, a simple factual question may allow the learner to eliminate much of the text and arrive at a correct answer directly without being encumbered by irrelevant information. A series of simple questions could reduce the processing involved in deriving remote inferences from text.

Prompting. An adjunct aid may prompt responses and higher-level skills. For example, a question such as "What can you deduce from points a and b?" may help the subject derive new information by prompting stimulus selection and a response which combines the selected stimuli. Memory for concepts and principles necessary for comprehending a difficult passage may be prompted by directions to recall those concepts and principles.

Pacing. A fifth function of adjunct aids may be to slow down the pace of reading. A question or statement may accomplish this function by requiring additional operations on the content, or by cueing the review of preceding portions of the text. In addition to slowing down the pace of reading, adjunct aids which cue review provide for rehearsal of prior material. Rehearsal may involve either overt or covert verbalization, and according to Wilder (1969), efficient rehearsal strategies involve overt speech, at least for young children. Wilder speculates that speaking may trigger other internal response-produced stimuli which uniquely affect memory and general information processing. Vocalization during rehearsal should aid young children (3 to 11 years) since their ability to engage in internal (i.e., silent) verbal rehearsal is not fully developed. Older children and adults in which internal verbalization is well developed may benefit less from overt verbalization during rehearsal.

Experiments in which adjunct aids (e.g., instructions) cue varying amounts of vocalization during rehearsal will be included in the proposed research.

Sequencing. Adjunct aids may also alter the sequence in which a reader encounters items of content or performs various cognitive activities. For instance, the learner may be directed to read certain paragraphs or chapters before others. He may be directed to learn the definitions of a set of terms before he is directed to associate those items with particular concepts.

Maintenance. Seventh, adjunct aids may also function to maintain active responding by continually arousing problem-solving activities. Given the goal of the ecological readers of imparting an understanding of the problem-solving or decision-making process as related to environmental problems, research on this function of adjunct aids would seem feasible and highly relevant.

Amplification. Adjunct aids might add new content in order to amplify the material that already exists. Amplification will be investigated in some detail in the proposed research. The processes included in amplification which are of major concern are imagery and hypostatization which can be induced either through the use of specially structured adjunct materials or through the use of instructions. For instance, slides picturing a marsh may be used to amplify the textual material related to the concept. Metaphorical or analogical pictures and statements inserted into text will also be studied. Imagery instructions and the use of pictures to amplify the text will be investigated also.

Training. The final function of adjunct aids, according to Frase, is that of training. Through contact with the adjunct aids, the learner may be gradually trained to take over their functions himself. This might be accomplished by a gradual elimination of the adjunct supports.

Earlier in this paper the distinction between induced and self-generated cognitive activities was noted. It is an important research question to determine the kinds of training procedures related to imagery and hypostatization that will allow children to become independent learners, engaging in these cognitive activities without specially structured material, instructions, or other types of adjunct supports.

To summarize, the use of adjunct aids to text will be studied in the proposed research. Briefly, some examples of adjunct aids to be investigated include: the use of nonassociative arousal events, preprose warm-up tasks, various kinds of rehearsal cues, and devices which evoke imagery and hypostatization. Other types of adjunct aids related to one or more of the functions outlined above may also be investigated during the course of the proposed research.

Learner Variables

In addition to variables related to representation of content and adjunct aids, a major focus of the research will be on learner variables which may influence or interact with the effects of experimental treatments.

A wide range of individual-difference variables will be investigated. For example, experimental treatments may be tried out with children of different ages, social classes, and IQ levels. Examples of other individual differences, perhaps more intrinsically related to the learning process, include modality preference, intrinsic arousal, curiosity, reading ability, concentration of attention, and distractibility. Some of these individual differences can be measured by means of standard psychometric procedures such as paper and pencil tests and self-report inventories (e.g., IQ, reading ability, social class). Others may require physiological or objective behavioral measures (e.g., modality preference, curiosity, intrinsic arousal, concentration of attention, and distractibility).

The goals of the research project related to individual differences are: (a) to discover which learner variables interact with experimental treatments, and (b) to specify underlying mechanisms (i.e., basic cognitive processes) which can account for those interactions.

Dependent Variables

The dependent variables measured will depend to some extent on the purpose of each experiment. That is, dependent variables will depend on both the variables manipulated and the processes investigated. Much thought must be given to the types of dependent measures as each experiment is designed. However, at least two classes of dependent measures which might be useful can be specified here.

One class of dependent variables is related to measuring the intended outcomes of instruction. This class may include measures of the acquisition and long-term retention of environmental facts, concepts, and principles taught. Tests for knowledge of concepts and, to some extent, principles can be generated by using the schema for testing levels of concept mastery developed by Frayer, Fredrick, and Klausmeier (1969). Test items derived from the schema may involve either recognition (e.g., multiple-choice items) or recall (i.e., production items). Learning of facts can be tested by multiple-choice items in which the subject must select the correct statement (in paraphrased form) from among distractors or by test items involving evaluation of factual assertions (i.e., true-false items) from the text.

Problem-solving or decision-making skills related to environmental problems are another intended outcome of instruction. Items which measure this type of outcome may be derived from the specific behavioral objectives related to problem solving for the environmental readers. These objectives are listed on pages 10 and 11. An example of an objective related to problem solving included in the list is: Given a problem with environmental overtones, the student can produce two or more alternate solutions. For each solution specified, he can indicate the advantages (profit) and the disadvantages (cost, risk, limitations, and consequences).

Another intended outcome of instruction is a positive attitude toward preserving the environment and toward involving oneself in the solution of environmental problems. Attitude inventories could be devised to measure this type of outcome. A difficult to measure, but extremely interesting, outcome of instruction might be consistent changes in the student's behavior toward his environment. The question is, does the student's increased knowledge concerning environmental problems and his increased positive attitude toward preserving the environment lead to behavior consistent with his knowledge and attitude? Social-psychological studies could be designed in which children are placed in carefully planned situations (e.g., role playing in a mock supermarket) where their behavior related to the environment (e.g., the types of products they buy) can be observed. Other measures of behavior toward the environment (e.g., littering, attempting to tell others about environmental problems, volunteering services to help solve environmental problems) could also be obtained.

A second class of dependent variables is less useful for measuring practical outcomes of instruction in the sense of measuring achievement of instructional objectives. Rather, this class of dependent variables is useful for detecting the effects of independent variables on processes. One example of a dependent variable in this class is the use of word-association procedures to measure associative structure of concepts. From the word-association data, coefficients of relatedness (Garskoff & Houston, 1963) for the concepts can be calculated. This type of measure might be useful in determining the effects of such processes as hypostatization on the similarity of associative meaning of concepts.

Another example of a dependent measure related to processes is one intended to measure the effects of variables on the information processing activities of subjects. For example, the intent of adjunct questions and directions in text may be to induce subjects to select and relate information contained in two or more sentences in order to arrive at a correct inference. The extent to which adjunct aids are successful in stimulating the processing activities involved in drawing inferences could be measured by assessing the ability of subject to evaluate assertions involving inferences from the text. The inferences would come from portions of the text not containing adjunct questions or directions. In this way it is possible to separate the direct instructional effects of adjunct aids from their effects on the information processing activities of subjects (see Rothkopf, 1968).

A third example of a dependent measure related to the effects of variables on processes is the use of physiological measures of arousal and attention (e.g., heart rate, GSR). Here, the concern is not with outcome of instruction but with the effect of variables (e.g., novelty, uncertainty)on a process or state within the learner which may influence his learning and retention of the material.

The distinction made here between dependent variables related to instructional objectives and measures related to processes may seem somewhat artificial. However, the distinction may be fundamental in achieving the purposes of the research which are: (a) to provide new information concerning conditions of cognitive learning which can be applied to the development of instructional materials and procedures, and (b) to provide new information about the interrelations of processes and variables which will have implications for cognitive theory. To achieve the first purpose, measures of outcomes desired by curriculum developers and educational practitioners are needed. To achieve the second purpose, other outcome measures in addition to traditional ones may be needed in order to tap in on basic processes.

IV

REORGANIZATION OF PROGRAM 1

Subsequent to the writing of the present needs and specifications pater, the entire research program of the Center, Program 1, was reorganized. The need for integrating research efforts related to learning processes, conditions of learning and instruction, and individual differences outlined in the present paper provided a basis for this reorganization. Prior to the reorganization, Program 1 consisted of Projects 101, Variables and Processes in Cognitive Learning; 102, Motivation and Individual Differences in Learning and Retention; and 107, Role Theory Analysis of Peer Teaching Techniques. The various lines of research represented in these projects have now been reorganized into three components with three to four activities per component.

Component A, Operations and Processes of Learning, is concerned with investigation of basic processes in children's learning. Activities in Component A include research on motivation-attention processes in learning and retention; modes of cognitive representation; and cognitive operations and abilities in concept learning. Component B, Conditions of Learning and Instruction, is concerned with instructional research to determine how basic learning variables can be incorporated into materials in order to produce significant long-term effects on the outcomes of instruction. Activities in Component B include research on learning from text; instruction in learning strategies and skills; and effects of peer teaching. Component C is entitled Individual Differences among Learners and is concerned with identification of those learner differences which need to be taken into account during instruction. Within each component, principal investigators meet regularly in seminars to discuss ongoing research, possible integration of research, and plans for future research.

The new organization of Program 1 provides for integrated research on learning processes (Component A), individual differences (Component C), and the application of knowledge gained in these areas to research on conditions of instruction (Component B) which can be utilized by curriculum developers at the Center and elsewhere. Thus, integration of research efforts will be attained to a large degree by the reorganization of Program 1, eliminating the need for the special integrative research project outlined in earlier chapters of this paper.

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