DOCUMENT RESUME

ED 187 698 SP 016 124

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TITLE Student Mediating Responses in Teaching Effectiveness. Final Report.
INSTITUTION North Texas State Univ., Denton.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE Mar 80
CONTRACT NIE-G-76-0099
NOTE 190p.

EDRS PRICE MF01/PC08 Plus Postage.
DESCRIPTORS *Academic Achievement; *Classroom Environment; *Cognitive Processes; Learning Processes; *Mediation Theory; Recall (Psychology); Retention (Psychology); Student Behavior; Student Reaction; *Task Analysis; *Teacher Effectiveness

ABSTRACT

A report is given on research exploring the theory that stimulation from the teacher does not directly initiate student learning but activates cognitive processes that result in learning. Combined research into classroom processes and student information processing was conducted. An analysis of treatment theories that operate in research on teaching is presented. A description is given of the essential features of a cognitive model of student mediation, as well as an analysis of different types of academic tasks and their relationship to outcomes of instruction. The meaning students attach to classroom events and the way knowledge is gained from accomplishing classroom tasks is analyzed. A model of classroom tasks is applied to teaching effectiveness research to interpret existing findings and suggest directions for further research. (JD)

STUDENT MEDIATING RESPONSES IN TEACHING EFFECTIVENESS

Final Report

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This work was supported by a grant from the National Institute of Education (Grant No. NIE-G-76-0099). However, the opinions expressed herein do not necessarily reflect the position or policy of the National Institute of Education and no official endorsement should be inferred.

March, 1980

ACKNOWLEDGEMENTS

The author is indebted to several people who provided assistance in the formulation and conduct of this project. Lee S. Shulman encouraged the initiation of the project and made available the intellectual resources of the Institute for Research on Teaching, Michigan State University. Jere Brophy, Christopher M. Clark, Joe Byers (all of the Institute for Research on Teaching) and Herbert J. Walberg (University of Illinois, Chicago Circle) provided advice during the early phases of the work.

Carolyn M. Evertson, Director of the Classroom Organization and Effective Teaching Project, R&D Center for Teacher Education, University of Texas at Austin, offered many comments and suggestions throughout the project and provided access to then-unpublished data from the Texas Junior High School Study.

Ian Westbury, University of Illinois, Urbana-Champaign, was willing to provide generous criticism and encouragement.

Charlotte Gelineau and Ruth Kurth assisted in locating and abstracting relevant documents.

Special appreciation goes to Sandy Behrens for her capable assistance in typing the many drafts and papers connected with the project, cataloguing the large number of documents that were acquired, and managing the daily operation of the office. Her help was invaluable.

The author accepts full responsibility for the opinions expressed in this report and for any errors or omissions.

ABSTRACT

This project was designed to identify student information-processing responses that mediate teaching effects in classroom environments. To achieve this purpose, a model was constructed from a comprehensive review of research on (a) human information processing and (b) classroom processes and teaching effectiveness. The model that emerged from the analysis was based on the concept of "task," i.e., a situational frame that defines a goal and a set of operations necessary to achieve that goal. The macrostructure of tasks provides instructions for building schemata that connect goals and cognitive operations designed to achieve these goals. These schemata, in turn, set the stage for monitoring classroom events and selecting content and instructional prompts to accomplish tasks. Pupil pursuits, in other words, are guided by the tasks they experience in classrooms. The task model has two important contributions. First, the model defines the cognitive operations that connect classroom events to outcomes. Second, the model connects teaching processes with content by defining the curriculum in use in the classrooms. The task model appears to be a useful foundation for building a theory of how teaching effects occur. Such a theory is necessary to interpret results of research on teaching effectiveness and formulate questions for further inquiry into classrooms.

Chapter 1

INTRODUCTION

Proposals for incorporating student variables into teaching effectiveness formulations have increased sharply in recent years (see, for instance, Bennett, 1978; Berliner, 1976; Harnischfeger & Wiley, 1976; Power, 1977; Walker, 1976; Winne & Marx, 1977). Most of these proposals have contained some form of a mediating process paradigm (see Doyle, 1977b, for more details). According to this paradigm, learning outcomes are a function of student processes, or what Harnischfeger & Wiley (1976) called "pupil pursuits." Teaching processes, in turn, are seen as factors which influence pupil pursuits. In this view, teaching does not affect achievement directly. Rather, teaching effects are mediated by what students do in instructional settings. Advocates of this paradigm argue that a mediational model will increase our understanding of process-product relationships and provide a guide for further inquiry.

As they now stand, most mediating process models are fairly primitive, often being little more than an assertion that student processes come between teaching processes and outcomes. The present project was designed to elaborate more fully the mediational framework by pulling together information from several sources to identify more specifically the student responses that are likely to mediate teaching effects in classroom settings. The major outcomes of the analysis are presented in this report.[1] As an introduction, the present chapter provides a description of the general nature of the project and the organization of the report.

The Nature of the Project

The project was structured around three broad areas of concern: (1) student information processing; (2) the characteristics of classroom environments; and (3) effective teaching. The central activity of the project, in bringing these three areas together, was the construction of a conceptual model of the student processes that connect classroom events to learning outcomes (of the value of models, see Cooley, 1978; Glass, 1976, Suppes, 1974). This section contains a description of how this model building was done.

Sources Consulted

A direct empirical approach to identifying student processes that mediate teaching effects in classrooms typically involves such techniques as stimulated recall or inserted questions. In stimulated recall, a recording of the class meeting is played back to students and they are asked to describe their thoughts at certain critical points (see Bloom, 1953; Siegel, Siegel, Capretta, Jones, & Berkowitz, 1963). In using inserted questions, the lesson itself is stopped and students are asked to describe their thoughts

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1 During the course of the project, several papers that dealt with aspects of the analysis of mediating responses were written (see Doyle, 1977b; 1978a, 1978b, 1979a, 1979b, 1979c). An interim report of the project was presented at the 1978 meeting of the American Educational Research Association in Toronto (Doyle, 1978c).

at the moment before the lesson was interrupted (see Hudgins, 1967; Olsen, 1979). Reports of student thoughts are then rated in terms of their relevance to the content of the lesson at the time the recording was stopped or the session was interrupted.

In most cases, these techniques have been used with college-age populations. At the elementary and secondary levels, inserted questions seem to be particularly disruptive, and stimulated recall seems to place heavy demands on student memory. In addition, using these techniques to go beyond a simple distinction between relevant and irrelevant thoughts to more specific aspects of information processing would seem to demand considerable analytical awareness of cognitive behavior by pupils. Such analytical awareness is likely to be uncommon (see Brown & Campione, 1977; Hymes, 1977; Mandler, 1975).

For the present project, an alternative route was chosen: viz., a review of available information that was likely to lead to hypotheses concerning student mediating responses in teaching effectiveness. The information was selected primarily from six domains: (1) prose learning research; (2) instructional psychology; (3) student behavior research; (4) student perception research; (5) classroom process studies; and (6) reading research.[2]

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[2] The review phase of the project was largely completed by August, 1978. General reviews of research relevant to the project which have appeared since that time (e.g., Brophy, 1979; Hoge & Luce, 1979; Good, 1979; Mayer, 1979) have been used for this report.

During the course of the project, these six domains were grouped into two broad areas: (1) research on prose comprehension and memory; and (2) research on classroom processes. The following comments are designed to clarify the character of each of these areas.

1. Research on prose comprehension and memory. As expected, the field of prose learning research was a rich source of data and conceptualizations for the project. From Rothkopf's (1970, 1976) studies of mathemagenic behaviors, Rohwer's (1972, 1973) work on elaboration in learning noun-pair lists, and R. C. Anderson's (1971) research on imaging, which were used when the project was being formulated, the field has expanded dramatically. The range of texts which have been studied has broadened from word lists to sentences, paragraphs, and stories (Frase, 1975; McConkie, 1977; Kintsch, 1977; Rumelhart, 1975; Stein, 1979). In addition, sophisticated models have been developed to describe the semantic structure of long-term memory ("schemata" or "scripts") and the operations in short-term and working memories that govern the reception, processing, and retrieval of information (see, e.g., J. R. Anderson, 1976; J. R. Anderson & Bower, 1973; R. C. Anderson, Spiro, & Montague, 1977; Bobrow & Collins, 1975; Bower, Black, & Turner, 1979; Clark & Clark, 1977; Craik, 1979; Estes, 1976, 1978; Gregg, 1974; Just & Carpenter, 1977; Kintsch, 1974; Klahr, 1976, Neisser, 1976; Newell & Simon, 1972; Norman & Rumelhart, 1975; Resnick, 1976; Schank & Abelson, 1977; Shaw & Bransford, 1977; Thorndyke & Hayes-Roth, 1979).

For purposes of the project, the domains of instructional psychology and reading were subsumed into the area of prose comprehension research. In both domains, models and research in cognitive psychology are being widely applied (see, e.g., Glaser, 1976; Greeno, 1978; Guthrie & Tyler, 1978; Rumelhart, 1977; Wittrock & Lumsdaine, 1977). One advantage of studies in the design fields of instructional psychology and reading is that they tend to focus on tasks which are closely related to those encountered in schools. These design fields also provide helpful examples of how to analyze the information-processing requirements of different learning tasks (see, e.g., Resnick, 1976).

2. <u>Research on classroom processes</u>. During the project, studies of student behavior and of teaching were combined into a general category of research on classroom processes. To an increasing degree, research on teaching has begun to include student variables (see Good, 1979; Rosenshine, 1976). As a result, the domains of student behavior research and teaching research have converged. Much of this work on student variables has focused on indicators of attention, compliance, and active participation (see Cartledge & Milburn, 1978; Hoge & Luce, 1979).

Two major sources of data on classroom processes were consulted. The first source was recent studies of teaching effectiveness (Anderson, Evertson, & Brophy, 1979; Bennett, 1976; Calfee & Calfee, 1976; Evertson, Anderson, & Brophy, 1978; Fisher, Filby, Marliave, Cahen, Dishaw, Moore, &

Berliner, 1978; Good & Grouws, 1975, 1979; Lambert & Hartsough, 1976; McDonald & Elias, 1976; Solomon & Kendall, 1979; Stallings, 1975; Tikunoff, Berliner, & Rist, 1975). With recent improvements in sample selection and observational methods, these studies have become an important resource for information about a wide range of classrooms.

The second source was classroom studies based on anthropological or participant observation methods (Bossert, 1977; Bremme & Erickson, 1977; Glandon, 1975; Gump, 1967; Hammersley & Woods, 1976; Jenkins, 1972; Lundgren, 1977; Mc Dermott, 1977; Mehan, 1979; Metz, 1979; Miran, 1975; Potter, 1974; Short, 1975; Sieber, 1976; Stodolsky, 1975; Stubbs & Delamont, 1976; Woods, 1979; Woods & Hammersley, 1977). Studies in this second area are often more difficult to locate, and the diversity of methods and theoretical approaches often complicates the tasks of comparison and interpretation. In addition, few of these studies focus explicitly on academic achievement or the relation between classroom processes and outcomes. Consistent with the disciplines within which most of these studies are conducted, attention is directed to language forms and social interaction or to socialization and enculturation rather than academic achievement. As a result, the application of such studies to issues of teaching effectiveness is not always obvious or direct. Nevertheless, studies in this tradition provide rich descriptions of the event structure of classroom environments.

Selectivity of the Review

As these brief descriptions suggest, information useful in understanding student mediating responses is scattered through a wide range of published and unpublished reports, not all of which are primarily concerned with classroom teaching. Therefore, a large number of documents were acquired and examined during the course of the project. Nevertheless, the review phase of the work was selective. It was simply not possible to review adequately all of the potentially relevant sources.

The selectivity of the literature review was guided in three major ways. First, special emphasis was placed on student behaviors related to academic learning in natural classroom settings at the elementary and secondary levels. This emphasis did not rule out studies in laboratories or in other nonschool settings. For a study to be considered, however, it had to contain subject matter at least analogous to academic content. In addition, studies in preschool settings or at the college level were considered only if they were especially relevant to the focus of the project. Finally, classroom studies which did not contain information about processes actually used in accomplishing academic tasks (e.g., studies of cognitive style) were not given primary attention.

Second, the conceptual model itself, as it evolved during the project, served as a device for sharpening and directing the search through the research domains. That is, the focus of the project was on the model of mediating processes in classrooms rather than on cataloguing available literature in each of the six domains. As the model began to take form, some areas of research were no longer consulted. For example, studies in the field of reading which focused on instantaneous signal detection, such as Gough's (1976) analysis of one second of reading or LaBerge and Samuels's (1976) studies of automaticity, were eventually seen as only indirectly related to the type of mediating model that was emerging from the project. (Such studies may be useful, however, for understanding teacher information processing in classrooms. See Doyle, 1979c.)

Finally, the broad definitions of Selected Area A in the NIE Basic Skills Research Grants Announcement oriented the project toward achievement in the basic academic skills. As a result, studies focusing primarily on nonacademic outcomes (e.g., peer group solidarity or self-concept) were not used extensively. (Further information about the specific focus of the project is provided in Chapter 2.)

Limitations

The review domains were initially selected to serve three general purposes. First, it was hoped that the domains would provide direct and indirect descriptions of how students process information under instructional conditions. They were viewed, in other words, as sources of "tracking" data about how students learn from instruction. Second, the domains were seen as likely sources of conceptual frameworks for thinking about student mediators in teaching effectiveness, i.e., alternative "paradigms" for interpreting the role of student mediating responses in teaching. Finally, the domains were expected to be sources of corroborative evidence for some of the propositions about student mediation that were derived speculatively from the model that was being developed. That is, they were to be searched for supporting data concerning the extent to which capabilities postulated as necessary for learning from classrooms did in fact operate in the manner proposed by the model.

These expectations were only partially borne out in the project. Despite the vast amount of information available concerning students--virtually the entire field of psychology--connecting this information to instructional treatments is a formidable task (Cronbach & Snow, 1977). This is especially true in attempting to account for teaching effects. Much of the experimental data about human information processing is derived in settings that are clearly remote from the conventional classroom with its complex treatment properties. At the same time, the available classroom data contain many substantive gaps. Aside, then, from the general problems of trying to build a theory of classroom effects using data from several sources, the project suffered from deficiencies within the data sources themselves. These limitations do not, of course, invalidate the project. The general purposes of the project were to see what could be done to extend the mediational framework with the available data and to identify areas that need to be studied. The limitations do mean, however, that the propositions about classrooms which emerged from the project cannot be interpreted as statements of fact. They are at best reasonable hypotheses which await empirical validation. In this sense, the orientation of this project differs fundamentally from that which has characterized recent reviews of research on teaching effectiveness (e.g., Dunkin & Biddle, 1974; Medley, 1977; Rosenshine, 1971, 1976).

A Note on Method

The conceptual work of the project was directed toward bringing together research on prose comprehension and research on classroom processes in order to trace the connection between classroom events and outcomes. A brief description of the orientation and methods of the conceptual phase of the project will explain how these two areas were combined.

Knowledge about human cognition or classroom processes has typically been applied to teaching in a prescriptive fashion (see Bruner, 1964). Information about the effects of passage structure or about encoding strategies such as imaging or elaboration has been used to plan instructional programs or train students to be more efficient learners (see, e.g., Forehand, 1974; Rohwer, 1972; Weinstein, 1977). In the field of writing, for example, a large amount of research is being done on the process of composing (see, e.g., Cooper & Odell, 1978). The justification for much of this work is that it will provide guidance in designing instruction to teaching composition. The emphasis, in other words, has been on mapping cognitive operations in order to design a better match between instructional conditions and the learner (Glaser, 1976; Snow, 1974). In a similar manner, descriptions of classroom practice have typically been gathered as part of investigations clearly focused on establishing prescriptions for teaching (see Gage, 1978).

The primary concern of the present project was the construction of an explanatory model to guide thinking and generate hypotheses about teaching effects in classrooms. That is, the intention was to describe how teaching effects occur rather than establish a set of rules for how to teach effectively. As a result, research on classroom processes and on human cognition were used for description and explanation rather than prescription.

To accomplish this explanatory purpose, research on classroom processes was used to describe the event structure of classroom environments and research on information-processing was used to define hypothetical mediators necessary to meet the demands embedded in classroom events. This model-building process was certainly not linear. Research on prose comprehension often provided new possibilities for interpreting classroom data. Similarly, classroom descriptions would signal possible areas of research on information-processing that needed to be explored. In actual practice, then, the two areas were examined simultaneously and connections were made as they became apparent.

The analytical focus of the project was on the interaction of environmental demands and information-processing capabilities. This emphasis on environment-behavior relationships was stimulated by the work in ecological psychology (see, e.g., Kounin, 1977; Gump, 1969, 1975; Shaw & Bransford, 1977; Willems, 1973, 1977). A fundamental premise of this ecological approach is that behavior, including thought, becomes turned to the demands and the resources of a particular setting. To understand behavior, therefore, an investigator must carefully analyze the environment in which the behavior occurred. From an ecological perspective, the classroom is seen as an ordered and bounded setting with demands unique to that environment. In addition, an ecological analysis of classrooms is oriented to group phenomena--to understanding how the classroom system works rather than to predicting the behavior of individuals. Finally, the ecological orientation to classrooms is fundamentally naturalistic, that is, the emphasis is on determining why naturally occurring practices persist rather than on how these practices can be changed. (For a similar approach to the analysis of environment-behavior regularities, see Tinbergen, 1972.)

Organization of the Report

The remainder of the report is organized into four chapters. A brief description of these chapters is given here to orient the reader to the report.

Chapter 2 contains an analysis of treatment theories that operate in research on teaching. These theories are often implicit, yet they guide thinking about how teaching effects occur. Such theories have consequences for selecting variables and interpreting findings in studies of teaching. An analysis of these theories serves to sharpen the focus of the present project.

Chapter 3 presents the essential features of a cognitive model of student mediation. The core of this model is built around the concept of task. It is argued that this environmental unit shapes the operations students use to process information and guide their interpretation of classroom events. A clear description of tasks provides, therefore, insight into the student processes that mediate teaching effects. The chapter also contains an analysis of different types of academic tasks and their relation to outcomes of instruction. This analysis provides a description of the basic elements of the treatment theory which emerged from the project.

Chapter 4 focuses on the transformation that takes place when academic tasks are embedded in a classroom environment. The analysis is directed especially to the consequences of classroom tasks for students. These consequences are defined in terms of the ambiguity and risk associated with different kinds of classroom tasks. The chapter also explores the semantic structure of classroom events and outcomes. The analysis is directed here to the factors influencing the meaning students attach to classroom events and to the way knowledge gained from accomplishing classroom tasks is integrated.

In the final chapter, the model of classroom tasks is applied to teaching effectiveness research to interpret existing findings and suggest directions for further inquiry. Particular emphasis is given to studies of the types of tasks students encounter in classrooms and the ways in which these tasks are administered.

Chapter 2

TREATMENT THEORY FOR RESEARCH ON TEACHING

In many respects students are mythical creatures in research on teaching. Although some early interest in recording student behavior was apparent in Jayne's (1945) study of effective teaching, the bulk of process research in classrooms has focused on teacher variables. As a result, little evidence is available concerning student processes in classrooms. Nevertheless, students are often lurking beneath the surface of research reports. It is known that measures of student entering abilities typically account for 60 percent or more of the variance in achievement (see, e.g., B. D. Anderson & Kaplan, 1974; Berliner, 1976; Stallings, 1975; Walberg, 1971). And, especially when interpreting findings, investigators often invoke student processes which presumably are elicited or shaped by particular patterns of teaching. Teacher enthusiasm, for instance, apparently inspires student enthusiasm which, in turn, makes subject matter more relevant and learning more enjoyable. Implicit assumptions about students are often used, in other words, to tie teaching variables to achievement.

Mediating assumptions form the core of a treatment theory, i.e., an explanation of why certain classroom conditions affect student learning outcomes in particular ways. A fully specified treatment theory does not exist for research on teaching, and it is probably premature to attempt to build one with the available data base (see Brophy, 1979). Nevertheless, a number of assumptions about how teaching treatments work operate in the field of research on teaching. The purpose of this chapter is to review these assumptions because of their direct relevance for understanding student mediating responses in teaching effectiveness. (Duke, 1978, has reviewed implicit process theories that purportedly explain school discipline problems.)

The Domain of a Treatment Theory

At the heart of teaching effectiveness research is the search for process-product relationships, i.e., relationships between teaching processes in the classroom and student achievement (usually in the form of academic achievement). Two steps are followed in identifying such relationships. First, classes are ranked on the basis of mean achievement adjusted for initial differences in entering ability. Second, differences among classes on teaching processes measures that are associated with achievement rank are then identified. In other words, process-product research seeks to "explain" between class differences in achievement by identifying between class differences in teaching processes. The result of this kind of analysis is a list of classroom conditions or characteristics (teaching process measures aggregated across observations) that correlate with mean achievement (usually academic achievement) for the class at the end of a school term.

The immediate empirical question in teaching effectiveness research is: Do process-product relationships exist? The available evidence supports the conclusion that process-product relationships do exist although their generality is probably less than was often anticipated when such research began (see Brophy, 1979; Good, 1979; Rosenshine, 1976; on early expectations in this field, see Doyle, 1978a). The theoretical question is: How can that be? The conceptual problem, in other words, is not whether process-product relationships exist but how teaching processes in classrooms affect learning outcomes in the direction specified by the empirical findings. The answer to this theoretical question requires a process model that connects teaching events with outcomes. It requires, that is, a treatment theory designed to explicate known relationships between processes and products. Such a theory should be useful in integrating separate process-product relationships into a larger framework, distinguishing between real and spurious process-product relationships, and guiding further research by predicting likely process-product relationships that have not been found by casting broad empirical nets.

There are two key points to remember in this discussion and throughout the present report. First, teaching effectiveness findings exist primarily at the class level. Some attempts have been made recently to move the analysis to within class differences and these attempts will be discussed later in this chapter. However, unless instruction is completely individualized, the theoretical problem is still one of explaining how conditions which characterize a class over several meetings can affect outcomes for a group of students at the end of that period. Second, theoretical research cannot be used to decide whether there are teaching effects. This is an empirical question answered by the procedures of process-product research. Theoretical work is directed, rather, to explicating how teaching effects occur.

Approaches to Theory in Research on Teaching

Theoretical work in the field of teaching, broadly conceived, generally takes two forms: (1) the construction of an ordered list of variables; and (2) the application of explanatory models derived from such disciplines as psychology, sociology, or philosophy. What follows is a brief discussion of these two approaches to provide a perspective on treatment theories in research on effective teaching.

Ordered Lists of Variables

The most common approach to organizing knowledge in the field of teaching is to construct a schematic diagram of the variables that presumably influence classroom processes and outcomes. The most ambitious attempt to construct such a diagram was made by Ryans (1965). Other versions of this approach have been produced by Dunkin and Biddle (1974) and by McDonald and Elias (1976).

These diagrams or "models" of teaching usually contain three broad categories of variables:

1. Presage variables - including teacher characteristics and training experiences.
2. Process variables - including the types and frequencies of teacher and student behaviors in classrooms.
3. Product variables - including measures of academic achievement, attitudes, and long-term accomplishments.

In their model, Dunkin and Biddle (1974) added another dimension:

4. Context variables - including attributes of students, the school, the community, and the classroom (class size, materials, etc.).

In the final form of the diagram, these classes of variables are arranged on a page and arrows are drawn to indicate probable associations among categories. In most cases presage and context variables are displayed as factors affecting classroom processes, and process variables are seen as factors influencing the outcomes or products of teaching. It is also known that student attributes (as a "context" variable) are strongly associated with achievement.

Such diagrams have led to better data by mapping the terrain of research on teaching and suggesting variables that have been included in teaching effectiveness studies

(Brophy, 1979). Such maps do not, of course, explain relationships or account for causality.

Derivative Models

A second common approach to theorizing in the field of teaching involves the use of models derived from social science disciplines, primarily psychology. Indeed, the value of these models is often claimed on the grounds that they are linked with systematic and presumably more basic research on human behavior.

Nuthall and Snook (1973) identified three broad classes of models of teaching: (1) a behavior control model based on the laboratory studies of learning by Skinner and others; (2) a discovery-learning model based on the more cognitive theories of Bruner and others; and (3) a rational model derived from more philosophically oriented analyses of cognition and learning. Along similar lines, Joyce and Weil (1972) catalogued 16 models of teaching ranging from social interaction models of Thelen, Massialas and Cox, and the National Training Laboratories; information processing models of Bruner, Ausubel, and Piaget; therapeutic models of Rogers, Glasser, and Schutz; and the behavior modification model of Skinner. Additional models have been developed by Easley (1977).

These derivative models are full of presuppositions about process-product relationships, but little supporting data are typically given. In most instances, the models are used prescriptively as rationales for particular ways of teaching or as arguments for the importance of particular kinds of learning goals. The models are used, therefore, as external criteria for judging the adequacy of existing practices or the legitimacy of existing goals for schooling. Much of the rhetoric, and even some of the research, surrounding the models is designed to persuade rather than describe or explain. In addition, training programs are often created to enable teachers to learn how to conform more closely to the dictates of the model. In an extreme form, the prescriptive attitude has prompted the recommendation that classrooms be redesigned to correspond more closely to the structure of the psychological experiment (Glaser, 1966).

Teaching effectiveness researchers seldom posit broad explanatory models that define a priori a set of teaching conditions or educational goals (Brophy, 1979). They rely, rather, on findings from classroom studies of process-product relationships to formulate prescriptions for teachers. Nevertheless, they often borrow empirical generalizations from psychology to account for a specific process-product correlations (see, e.g., Good & Brophy, 1978). The character of the propositions used to explain process-product relationships will be discussed in more detail shortly. But first it is necessary to examine some of the more general treatment assumptions that operate in teaching effectiveness research.

Treatment Assumptions

The field of research on effective teaching is characterized by several basic assumptions about causality in teaching (see Doyle, 1977b). These are the taken-for-granted notions that implicitly guide the framing of analyses and the interpretation of results. Three of these assumptions will be discussed here.

First, there is a presumption of treatment effects for process-product relationships. When a correlation is found between a process variable and achievement, it is often tacitly assumed that a treatment effect has been identified. Since process variables are usually narrowly defined categories of teacher behavior, such as clarity, praise, enthusiasm, criticism, etc., the treatment unit in classrooms is assumed to be relatively small and any one study may identify a large number of treatment "effects," i.e., significant process-product correlations. Presumably overall effects--i.e., between class differences in adjusted achievement--are the result of a summation of the small effects of each process variable unit.

Second, the search for criteria of effectiveness has predisposed investigators to assume that the direction causality in classrooms flows from teachers to students. For example, in McDonald and Elias's (1976) model of teaching, "teaching performances are conceptualized as antecedent events whose immediate effect is upon student behavior, and this behavior in turn is the antecedent event to the consequences of learning" (p. 73). As a result of this orientation in the field, correlations between teacher behaviors (such as enthusiasm or praise) are often interpreted--despite periodic admonitions--as evidence that these teacher behaviors cause students to learn more. Teacher behaviors, in other words, are seen primarily as treatment variables.

Finally, there has been a tendency in research on teaching to look for causes of student learning in the interpersonal arena of the classroom. There is a bias, in other words, toward interactive dimensions of teaching. Thus, studies have focused on the public behavior of teachers (lecturing, asking questions, praise, criticism), the types and frequency of teacher-student contacts, and various amounts of student participation in classroom activities. Treatment effects are assumed to occur during teacher-student interactions.

These treatment assumptions are reasonable; without them, process-product correlations are uninterpretable. For present purposes, however, it is necessary to understand that these assumptions are problematic. The following discussion focuses on three aspects of the problematic nature of general treatment assumptions in research on teaching.

First, process variables are intercorrelated. Some process variables may be consistently associated with achievement only because they are correlated with actual treatment variables. By themselves, they may have little or no effect on outcomes. Thus, to single out one predictor of achievement as if it had independent effects on outcomes can be misleading. For this reason, a list of discrete teaching variables associated with achievement is very difficult to interpret. What is clearly needed is some way to integrate separate process-product relationships into a unified treatment theory. There are two methodological approaches being taken to this problem. The first is to cluster variables prior to the analysis of process-product relationships (see Cooley & Leinhardt, 1978; Soar, 1979; Solomon & Kendall, 1979). The second is to run correlations on discrete teaching variables and then assemble variables that are significantly related to achievement into a pattern that appears to describe a composite treatment model (see Brophy & Evertson, 1976; Evertson, Anderson, & Brophy, 1978; Good & Grouws, 1975; Rosenshine, 1976).[1] Clearly both approaches have limitations. It is likely, however, that the second approach captures actual treatment variables better although it may not provide an accurate description of what the treatment was (Cf. Brophy, 1979).

Second, teaching treatments occur in an interpersonal setting. Investigators from several fields have pointed

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[1] Such a "model" is not a treatment theory, i.e., it does not explain how teaching effects occur. Rather, it organizes a set of discrete predictors of achievement.

out that causality in interpersonal relationships is reciprocal (Bell, 1968; Fiedler, 1975; Gleason, 1977; Klein, 1971; Lewis & Rosenblum, 1974; Loeber & Weisman, 1975). It is reasonable to argue, therefore, that there are independent student effects in classrooms. These effects are likely to operate in two ways. First, there is a student effect on outcomes: general ability is likely to have an effect on achievement that is independent of treatment. Second, there is a student effect on teachers: differences in general ability are likely to be associated with different patterns of student behavior in the classroom. These student effects complicate the interpretation of process-product relationships. For variables such as enthusiasm and praise, it is quite possible that teachers are more enthusiastic with groups of high achieving students or that students who score high on achievement tests also behave in classrooms in ways that elicit teacher praise or acceptance. Similarly, a negative correlation between management comments and achievement may simply mean that students who score low on achievement tests also behave in classrooms in ways that require that a teacher attend to management. It would be inappropriate to assume that management comments cause low achievement. Adjusting achievement for entering ability and matching classes on other student characteristics can reduce the influence of these student effects on process-product correlations. Nevertheless, it is still likely that the composition of a class influences both outcomes and teaching processes (Cf. Brophy, 1979).

Finally, teaching treatments are administered to a group, in contrast to the situation in psychological experiments. It is difficult, therefore, to know how the treatment was distributed to the class. Studies of teacher decision making (Clark & Yinger, 1979) indicate that teachers often intend to teach to a group. Yet, teachers also differentiate among students in the nature and quality of their contacts (Brophy & Good, 1974; Cooper, 1979). At the same time, teaching treatments in classrooms are not individualized. Furthermore, contacts between an individual student and the teacher are witnessed by others in the class, so there are likely to be vicarious treatment effects in classrooms. Ascertaining the distribution of a treatment to a class is complicated further by the fact that descriptions of treatment conditions available in process-product studies are based on an aggregation of process data across several observations. Such an approach may very well combine several different treatments into a composite description of a treatment that no one ever received in a given class.

This brief discussion suggests that describing treatments in classrooms is a formidable problem. Certainly more information about the internal sequence of class sessions is required before an adequate description of treatment conditions in teaching is possible. Until then, interpreting process-product correlations is a perilous business.

The complexity of the treatment setting means that an adequate treatment theory for classrooms will require constructs from several disciplines. In fact, there is evidence of increased attention to teaching in disciplines other than psychology. The fields of sociology, e.g., Schlechty, 1976) and linguistics (e.g., Cazden, Hymes, & John, 1972; Gumperz & Herasimchuk, 1975) are especially prominent in this movement. Several investigators have applied the concept of "work" to the analysis of classroom processes (see, e.g., Barr & Dreeben, 1977; Dreeben, 1973; LeCompte, 1978; Westbury, 1979). Several studies have also focused on the systematic analysis of discourse patterns and language competencies in classrooms, with particular attention to processes of negotiation (see, e.g., Edwards & Furlong, 1978; Kluwin, 1979; McDermott, 1976; Mehan, 1979; Miran, 1975; Shultz & Florio, 1979; Sinclair & Coulthard, 1975).

At the present time, much of this work is scattered across several different research questions which often have their origins in the parent disciplines. Moreover, these disciplines bring their own set of implicit treatment assumptions as well as constructs that were designed to explain processes in settings that are quite different from classrooms. For example, work goes on in classrooms, but a classroom is certainly not a factory. Whether these imported constructs will explain classroom phenomena remains to be seen. Nonetheless, research from sources other than psychology, will be necessary to unravel the complexities of classroom treatments.

Mediational Assumptions

Mediational assumptions in research on teaching effectiveness are usually implicit, reflecting the tacit commitments of researchers in the field (Cf. Dunkin & Biddle, 1974). Their most complete expression is found in attempts to account for the selection of variables or to explain specific findings from process-product studies. Because they are tied to specific findings, explanatory propositions about mediating processes are often isolated from each other and there is no necessary consistency across explanations. One investigator may use different theories to explain different relationships (see, e.g., Cooley & Leinhardt, 1978, pp. 47-72).

Two general mediational assumptions underlie thinking in research on effective teaching. The first emphasizes student motivation as a primary mediator of student achievement in classrooms. This assumption is widely used to explain teaching effects and to prescribe improvements in curriculum and instruction. The second assumption is based on the concept of practice as a necessary condition for learning. The focus on practice has become prominent recently as attention has turned to student behaviors in studies of teaching effectiveness. Teaching effects occur, in other words, because teaching processes either motivate students to learn or provide opportunities for appropriate practice.

Each of these mediational assumptions is described and evaluated in the following sections.

Assumption I: Motivation

Perhaps the oldest and certainly the most commonly used mediational assumption in effectiveness research is based on the concept of motivation. The logic of this assumption is reasonably straightforward. A desire to learn is a prerequisite for learning to take place. Therefore, instruction which is attractive, responsive to individual interests and preferences, and offers praise and support will be more effective. This assumption underlies the social interaction and therapeutic models identified by Joyce and Weil (1972). The assumption is also undergirded by a large amount of laboratory research on such constructs as reinforcement (Glaser, 1971; Leeper & Greene, 1975; Lipe & Jung, 1971), self-efficacy (Bandura, 1977); attributions (Weiner, 1976), and locus of control (Lefcourt, 1976).

Within research on teaching, the work associated with interaction analysis (Amidon & Hough, 1967; Flanders, 1970) is based on a generalized notion that motivation is a central mediator of teaching effects. The observational categories were constructed around the dimensions of dominative (or authoritarian) and integrative (or democratic) influence styles. It is assumed that integrative or indirect teacher influence motivates students to learn and elicits the kinds of information seeking and processing responses necessary for high levels of achievement. The teacher's use of indirect behaviors (accepting feelings, praise, accepting ideas, and perhaps questions) frees the student to initiate ideas and pursue independent and meaningful learning. On the other hand, direct teacher behaviors (lecturing, giving directions, criticizing) restrict independent action and thought, reduce personal motivation, and obstruct higher-order thinking and problem solving. The emphasis, in other words, is on removing constraints, increasing pupil initiation, and providing warmth and support (Flanders, 1969) in order to elicit unspecified cognitive and affective mediators of learning.

In many respects the model on which interaction analysis is based has been used to prescribe a way of teaching rather than to explain a set of process-product correlations. Much of the research on interaction analysis has been oriented to training teachers to be more indirect rather than verifying the effectiveness of indirect influence in classrooms.

There is a curious connection between interaction analysis and reinforcement theories. Strict contingency management or behavior modification formulations were never explicitly used by the primary authors of the approach. Nevertheless, the emphasis on praise and acceptance of student responses often led to informal "reinforcement" interpretations. Indirect teacher behaviors presumably reward student responses and thus strengthen them. Hence, classrooms which score high on indirect teaching can be viewed as classrooms in which there is a large amount of reinforcement available to students. Unfortunately, the observation system recorded only the total amount of teacher praise and acceptance. For a full reinforcement interpretation it is necessary to know when praise and acceptance are given and what responses are being reinforced.

There are at least four other traditions in research on curriculum and instruction which are based on motivational assumptions. First, an emphasis on the beneficial effects of freedom and pupil initiation is found among advocates of open education and informal classrooms (Barth, 1972; Walberg & Thomas, 1974). Descriptions of such programs indicate that there can be much less teacher direction of activity and much more reliance on pupil choice and initiative than in more traditional programs (Resnick, 1971). Second, the concepts of interpersonal affiliation, motivation, and rewards are often used to explain the potential benefits of cooperative learning teams (Aronson, Blaney, Stephen, Sikes, & Snapp, 1978; Johnson & Johnson, 1975; Slavin, 1978). Third a reliance on motivation as a central mediator is also clearly evident in the analysis of differences in achievement between whites and blacks (Banks, McQuarter, & Hubbard, 1978). Understandably, then, motivation is often posited as a key mediator of the effects of desegregation (Bradley & Bradley, 1977). Finally, the extensive work on student perceptions of learning environments relies heavily on motivational constructs (see Walberg, 1976).

Assumption II: Practice

The second mediational theory in research on teaching is based on the concept of practice. The logic is that students must actually work with the content they are expected to learn. Teaching processes which expose students to the content and provide sustained opportunities to practice will, according to this model, influence achievement.

The simplest form of the practice model is focused on the way information is presented to students. Studies in this tradition have been directed to the qualities of teacher explanations, the frequency and types of teacher questions, and several indices of content coverage, including opportunity to learn the criterion material, overlap between curriculum and the content of the achievement test, time allocated to different content, and the pace of instruction (see Armbruster, Stevens, & Rosenshine, 1977; Belgard, Rosenshine, & Gage, 1971; Gall, 1970; Gall, Ward, Berliner, Cahen, Winne, Elashoff, & Stanton, 1978; Good, Grouws, & Beckerman, 1978; Program on Teaching

Effectiveness, 1976; Rosenshine, 1979; Walker & Schaffarzick, 1974). The premise underlying this work is that students must be exposed to the content if they are to learn it.

A more elaborate form of the practice model incorporates a direct measure of student behavior in classrooms, such as attention, time on task, or engagement see Fisher, Filby, Marliave, Cahen, Dishaw, Moore, & Berliner, 1978; Lomax & Cooley, 1979; Rosenshine, 1979). In this form of the practice model, mediational assumptions are more explicit. Learning results from what students do, from "pupil pursuits" (Harnischfeger & Wiley, 1976). Operationally, what students do is usually measured by some indicator of the time spent "on task." Teaching processes, in turn, are seen as one of the factors that affects the amount of time on task. Teaching effects, then, are mediated by engaged time.

Engaged time can be measured globally as a class average of attention for an observational period. A more refined approach to measuring engagement also records the circumstances under which attention occurs. Such an approach includes a consideration of the quality of student engagement. In the study of "academic learning time" (Fisher et al., 1978), for instance, three dimensions were measured: engagement, the content being studied, and the difficulty level of the material for the student. Academic learning time is recorded as the time spent working at a high level of success with content covered on the criterion test. The more units of this kind of engagement that are accumulated, the more the student learns.

The concept of practice is also used to explain the differential effects of teacher expectations on student achievement (Brophy & Good, 1974; Cooper, 1979; Good & Brophy, 1978). In this case, both motivational and practice dimensions are combined. The basic argument is that teacher expectations for a student's performance affect the quality of teacher-pupil contacts. The quality of these contacts is defined by such dimensions as the content and frequency of contacts, the type of questions directed to a student, the amount of time a teacher waits for an answer, and the type of feedback a student receives. (Weinstein and Middlestadt, 1979, found that students are aware that differences in teacher behavior along these dimensions are associated with different achievement levels.) The nature of teacher-pupil contacts clearly determines the number and quality of the opportunities to participate that a student receives. In the case of low expectations, a student may not be given a chance to practice relevant skills. The quality of teacher-pupil contacts also affects a student's self-concept, aspirations, and beliefs about effort-outcome relationships. These factors, in turn, affect a student's willingness to participate in academic work by volunteering in a discussion or trying to work an assignment. In other words, motivational effects on achievement are mediated by practice. From this perspective, effective teachers presumably provide students with the opportunities to participate, encourage them to use these opportunities, and give them clear and explicit instructions and feedback so that correct responses are learned.

Support for Mediational Assumptions

In this section, the empirical support for mediational assumptions based on motivation and practice is assessed.

Despite the clear appeal of motivation, the evidence for this mediational assumption is not especially impressive from the perspectives of process-product research. Motivation variables clearly differentiate between high and low achievers (see, e.g., Bar-Tal, 1978). Nevertheless, teaching process variables that appear to be associated with motivational constructs have not consistently predicted learning outcomes. Few of the interaction analysis variables, for instance, were found to be correlated with academic achievement, especially in the early elementary grades. The data suggest, rather, that direct and structured teaching of content is related to higher achievement in these basic subjects (see Brophy, 1979; Good, 1979; Medley, 1977; Rosenshine, 1971, 1976, 1979). Indeed, in Cooley and Leinhardt's (1978) study, the "motivators construct," which contained measures of curriculum adaptability and attractiveness as well as indicators of interpersonal support, was only weakly associated with achievement, whereas the amount of content overlap between the curriculum and the achievement test "was the important predictor of gain" (p. 32).

A similar pattern is evident in the other areas in which instructional programs are built on the assumption that motivation is a primary mediator. Most of the evaluative data suggest that informal programs and open classrooms, which presumably engender higher motivation to learn, do not enhance academic achievement. On the other hand formal, structured programs appear to have positive effects (R. B. Anderson, 1977; Becker, 1977, 1978; Bennett, 1976; Horwitz, 1979; Traub, Weiss, & Fisher, 1976; Wright, 1975). The research on cooperative teams and individualized programs also indicates that academic achievement is enhanced to the extent that academic tasks are clearly structured and accountability is high (Cohen, Intili, & Robbins, 1979; Slavin, 1978). Motivational conditions by themselves do not appear to be sufficient for academic achievement in classrooms. These results may reflect the fact that a large amount of pupil choice leads to the decision by some students not to participate in the treatment at all. The treatment may not, therefore, apply uniformly to all participants in informal or high option settings (see Stodolsky, 1972, 1975). In addition, Good and Beckerman (1978b) found that student engagement was higher on work the teacher assigned than on work the students chose.

In many instances, advocates of the motivational hypothesis point to nonacademic outcomes, such as improvements in self-concept, attitudes, and interpersonal affiliation, as the major effects of their programs. Here the evidence for positive treatment effects is stronger: programs designed to motivate appear to affect motivation variables (see Peterson, 1979). This pattern of findings raises some questions about the motivational hypothesis, however. If motivation is an independent outcome, then it is difficult to argue that it is a mediator of achievement in classrooms.

Regardless of the validity of this argument, the evidence suggests that motivation alone is not a central mediator of process-product relationships. This is not to say that motivation is not involved in school learning. Certainly motivation accounts for students' decisions to participate in classroom tasks and their persistence at these tasks. But motivation has not been a very useful construct for generating teaching variables that are good predictors of academic achievement. The motivational qualities of classrooms, defined in terms of attractiveness, responsiveness to interests and preferences, and the amount of pupil freedom, do not appear to be independent causes of student achievement.

A better empirical case can be made for mediational assumptions based on the concept of practice. Teacher clarity appears to be consistently related to student achievement (Rosenshine, 1971). Recent studies have also found that several measures of content coverage, such as the opportunity to learn criterion material, overlap between curriculum and the content of the achievement test, time actually allocated to instruction in specific content, and the pace of instruction, are positively related to learning outcomes (Good, Grouws, & Beckerman, 1978; Rosenshine, 1976, 1979). Presumably such classroom conditions provide for more and better practice.

Empirical support for the variable of engagement--a more direct measure of practice--is also available. There is fairly consistent evidence that students who pay attention, comply with rules and procedures, and actively participate in academic activities also learn more than students who do not exhibit these qualities (Cartledge & Milburn, 1978; Hoge & Luce, 1979; Lambert, 1977). Similarly, students who accumulate more academic learning time tend to learn more than those who do not (Fisher et al., 1978). In other words, students who practice more appear to achieve more. The evidence for behavior-achievement relationships is not, of course, conclusive. Neither attention (Hall, Huppertz, & Levi, 1977) nor participation (Power, 1977b) are always related to achievement, and the "time-on-task" variable needs to be carefully interpreted (Lomax & Cooley, 1979). Hoge and Luce (1979) conclude from their comprehensive review that, "at best, only moderate degrees of association have been established between classroom behaviors and academic achievement" (p. 493). They further argue that "there remains considerable uncertainty regarding factors which mediate the behavior-achievement relations and considerable uncertainty regarding the nature of these relations" (p. 493).

Although practice would seem to be necessary for achievement, there is less direct evidence that practice mediates teaching effects in classrooms. There are two reasons for this state of affairs. First, engagement, as a measure of practice, is confounded with student ability and inclination to engage in academic activities (see Campbell, 1974; Metz, 1978). Students who score high on achievement tests are also likely to pay attention, comply with rules, participate in classroom activities, make fewer errors on assignments, and give fewer wrong answers to teacher questions. This confounding is important because in analyses of the relationship between engagement and achievement, the pupil rather than the classroom is often the unit of analysis. As a result it is often difficult to disentangle teaching effects from student effects when attempting to identify causes of achievement. Along these lines it is interesting to note that in the study of academic learning time (Fisher et al., 1978), allocated time (a measure of content covered) and engagement rate (a measure of student behavior) were, as separate variables, more strongly correlated with achievement than engaged time, which was the product of these two variables and thus a more specific measure of time spent practicing content.

Second, it has been easier to connect student behaviors with outcomes than it has been to connect teaching processes to student behaviors. There is some evidence from process-process studies that engagement varies with different classroom formats: student involvement appears to be higher, for example, in teacher-led whole class activities than in self-paced seatwork (see Good & Beckerman, 1978b; Gump, 1967; Kounin & Gump, 1974). In turn, there is evidence that in basic skill subjects the use of whole-class formats is correlated with achievement (see Evertson, Anderson, & Brophy, 1978; Rosenshine, 1976, 1979). This is suggestive but not conclusive evidence that engagement mediates the effects of whole-class instruction, assuming other selection decisions are not operating--e.g., that teachers use more whole-group instruction with high ability classes. More direct observation of this connection in a single study is needed to verify whether engagement mediates the relationship between whole-class instruction and achievement.

In the BTES study of academic learning time (Fisher et al., 1978), the interrelationships among teaching process variables, academic learning time, and achievement did not clearly support a mediational interpretation. The strongest results were for teacher self-report or rating variables; the observed teaching process variables were less consistently related to the full academic learning time variable. Some of the process variables related to achievement were associated with only segments of academic learning time. Similarly some process variables were related to engagement or error rate but not to achievement. The authors concluded that "ALT (academic learning time) and teaching process variables contributed relatively independently to the prediction of achievement" (pp. 7-37 to 7-38). Partly for this reason, the authors argued that "Both ALT and achievement are incomplete but useful measures of student learning" (p. 7-34). It would seem, then, that academic learning time is an outcome of teaching rather than a mediator of teaching effects.

Finally, research on teacher questions is even more problematic for the practice theory of mediating processes. Studies in this area have not shown that exposure to higher-cognitive questions is correlated with higher-cognitive achievement (see Dunkin & Biddle, 1974; Gall, 1970; Program on Teaching Effectiveness, 1976; Rosenshine, 1976; Soar, 1979; Winne, 1975). One recent experiment found, for instance, that students who received 25% and 75% higher cognitive questions learned more than students who received 50% higher cognitive questions. Moreover, "students in the 25% HCQ treatment outperformed students in the 75% HCQ treatment both on the knowledge acquisition and higher cognitive measures. . ." (Gall et al., 1978, p. 196). In the case of teacher questions it would seem that opportunities for practice do not lead to the type of achievement that might be expected.

In summary, the available data only partially support the premise that practice mediates teaching effects in classroom environments. The construct is certainly a plausible mediator but an understanding of how practice operates in classrooms awaits more detailed observation and analysis.

An interesting pattern seems to have emerged in the review of mediational models in this chapter. Many of the variables around which explanatory models are built--motivation and engagement-differentiate reliably between high and low achieving students. A similar pattern is evident in studies of more specific levels of information processing: successful learners extract information efficiently from stimulus displays, encode and rehearse the information appropriately, are less easily distracted, and are flexible in adapting to the changing demands of learning tasks (see, e.g., Battig, 1975; Edfeldt, 1975; Maccoby & Hagen, 1965; Silver, 1977; Smith, 1967; Willows, 1974; Wirtenberg & Faw, 1975). Moreover, successful learners appear to use these learning strategies spontaneously, with little special prompting from a teacher or an instructional program (Brown & Campione, 1977).

In a mediational approach to effective teaching, information about processes that differentiate between high and low achievers is often used to explain process-product correlations. Thus, teaching variables that correlate with achievement are presumed to do so through processes and differentiate between high and low achievers. In this way engagement, for example, is used to explain the effects of direct instruction. Since engagement correlates with achievement, direct instruction must be effective because it increases engagement.

This form of thinking in which student attributes are used to explain teaching effects is very close to an aptitude-treatment interaction (ATI) model. The research on aptitude-treatment interactions has been extensively reviewed by Cronbach and Snow, (1977), and such a review need not be repeated here. Nevertheless, the ATI model needs to be discussed because of its close association with a mediating process paradigm and because, on the surface, it appears to offer a way to identify processes that mediate teaching effects.

Aptitude-Treatment Interactions

The idea that characteristics of students interact with teaching methods has a long history in education (see Hunt, 1975; Mitchell, 1969). The logic of this work is that aptitudes of students--including ability, attitudes, and personality dimensions such as self-concept, anxiety, and conceptual style--interact with characteristics of instructional treatments to determine outcomes. Achievement will be greater for types of students, presumably, if students are matched to treatments which are compatible with their aptitudes. It might be hypothesized, for instance, that students with high anxiety or low initial ability will achieve more from instructional procedures that provide structure and guidance than they will from procedures that rely primarily on self-direction.

One popular matching model focuses on a personality dimension known as cognitive style or conceptual tempo (Kogan, 1976; Witkin, Moore, Goodenough, & Cox, 1977). In this area, tests have been developed which differentiate among students on such dimensions as field dependence-independence or reflective-impulsive tempos. These dimensions appear to represent relatively stable preferences for perceiving and processing information. Reflective thinkers, for instance, take longer to respond and are more analytical when identifying ambiguous figures than impulsive thinkers who respond rapidly and frequently guess. Along similar lines, field independent persons tend to perceive their environment analytically: items are experienced as more or less separate from the surrounding field. In contrast, field dependent persons tend to see items as embedded in the field in which they are experienced. It seems to follow that such information about student differences has important implications for teaching.

Information about student aptitudes can be used in three ways (see Cronbach & Snow, 1977). First, in the case of such dimensions as cognitive style, instruction can be adapted to <u>capitalize</u> on information-processing preferences. Second, information about specific processes such as encoding or rehearsal strategies (e.g., elaboration) can be used to train low achieving students to use the strategies employed spontaneously by high achieving students--a <u>remedial</u> matching (see Cartledge & Milburn, 1978; Weinstein, 1977). Finally, information about specific information processing strategies can be used to design learning environments which make up for the deficiencies in low achieving students by prompting achievement-producing responses--a <u>compensatory</u> matching (see Rohwer, 1972; Wang, 1976).

How viable is the ATI assumption? Cronbach and Snow (1977) conclude that aptitude-treatment interactions exist. At the same time, many interactions are not easy to replicate and some are difficult to interpret. The clearest interactions seem to appear for the dimension of general ability:

> When one treatment is fully elaborated, whereas the other leaves much of the burden of organization and interpretation to the learner, the regression slope in the former tends to be less steep. That is, Highs profit from the opportunity to process the information in their own way; Lows tend to be handicapped (Cronbach & Snow, 1977, p. 500).

Cronbach and Snow (1977, p. 504) also point out that the effects of general ability on achievement depend upon the degree of intellectual work that is required to learn. "Procedures that reduce the intellectual demand often reduce the differences between Highs and Lows" (p. 504).

Instruction can, it appears, compensate in specific circumstances for abilities the learner may not have.

A recent study by Brown and Campione (1977; see also Brown, Campione, & Murphy, 1977) provides some interesting insights into the long term effects of matching instruction to aptitudes. They used a remedial approach focusing on teaching young, slow learners to use memorization strategies. The evidence from their study and others they reviewed suggests that such learners have a production rather than a capacity deficiency: they are able to use mnemonic strategies but do not use them spontaneously. As a result, prompting can yield improvement in performance. Nonetheless, such improvement is not typically durable: it lasts only while prompting conditions are in effect. Moreover, there is little flexibility in that the skills are not used on memorizing tasks other than the one in which prompts were given. They found that durability could be increased through training, although the amount of training required was much greater than expected. In addition, training to achieve durability <u>reduced</u> flexibility. The skills became welded to the tasks used in training. Faced with these findings, they turned to a higher level of operation, viz., the level of metamemory in which students were trained to monitor their own processing. Studies at this level showed some promise. Little durability was achieved for younger learners, but some transferability was evident among older learners.

These findings are important in that they suggest some useful questions that can be asked about the nature of effects. How durable are the effects of instructional procedures that remediate or compensate? Are the effects of these kinds of instructional procedures transferable to situations in which the remedial or compensatory conditions are not present? Brown and Campione's findings suggest that attention be given to the possibility of a "heart pacer" effect in which performance levels are maintained only because the instructional program is doing most of the work. One way to check this possibility is to obtain follow-up data on students after they leave remedial or compensatory programs.

With respect to personality and style variables, Cronbach and Snow (1977) concluded that while many interactions frequently appear, few are consistent across studies. Part of the problem here may well be that general measures of personal traits or preferences do not take into account the effects of specific situations (see Jones, 1979; Mischel, 1977). The clearest results in this area appear for "constructive" motivation: confident, self-starting, assertive students seem to do better if left on their own to work through assigned content.

Two messages emerged from the work on aptitude-treatment interactions. First, consistent interactions are likely to appear only under very specific conditions in which an instructional treatment is designed precisely for a particular aptitude. Interactions under more generalized conditions of aptitude and treatment definitions are less replicable or informative. Second, knowing that a general aptitude interacts with a broadly defined treatment does not explain how the aptitude and the treatment are connected. For these reasons, considerable attention has turned recently to the study of what Cronbach and Snow (1977) called "aptitude processes," i.e., the processes which are actually tapped by measures of aptitude dimensions (see Carroll, 1976; Hunt, 1974; Pellegrino & Glaser, 1979; Snow, 1978). The premise for this work is that a better understanding of aptitude processes will enable instructional designers to construct treatments that will interact with aptitudes. Cronbach and Snow (1977) also call for more extensive descriptions of instructional treatments in natural settings such as classrooms so that interactions appearing in such settings can be understood and reasonable prescriptions for practice can be made.

ATI and Research on Teaching Effectiveness

Do aptitude-treatment interactions explain how teaching effects in classrooms occur? Probably not. The reasons for this conclusion are explored in this section.

A compensatory model is often invoked to explain the effects of direct instruction. The logic seems clear. Direct instruction is characterized by structured, whole-class activities orchestrated by the teacher, an academic focus, clear accountability, a rapid pace, a high success rate for students on questions and assignments, and a supportive teacher manner. This model seems to be especially effective for basic skill subjects in the early elementary grades (see Brophy, 1979; Good, 1979; Rosenshine, 1976, 1979). This pattern of results suggests that direct instruction gets it effects because it makes up for likely deficiencies in ability on the part of pupils.

Does this effect occur because of an aptitude-treatment interaction? If one examines data for the effectiveness of formal vs. informal programs, especially those for low ability students in the early elementary grades, a compensatory interaction seems plausible. Such students seem to do better in formal, structured programs (Rosenshine, 1976, 1979; Stallings, 1975). Yet the effects for direct instruction seem to apply to both high and low ability students and across grade levels from primary to junior high school (at least in mathematics) (see Bennett, 1976; Brophy & Evertson, 1976; Evertson, Anderson, & Brophy, 1978; Good & Grouws, 1975; Solomon & Kendall, 1979). Moreover, it appears that treatment effects, at least for effective teachers, are fairly uniform across ability levels within a class (see Bennett, 1976; Good & Beckerman, 1978a; McDonald & Elias, 1976). The fact that direct instruction is effective across ability and grade levels raises questions about whether a compensatory interaction for general ability occurs in direct instruction classrooms.

These findings also cast some doubt on the entire premise that compensation is the primary mechanism through which direct instruction gets its effects, except in the very general sense that all instruction is compensatory when compared to learning totally on your own.

This is not to say that aptitude-treatment interactions do not occur in classrooms. Indeed, many such interactions have been identified (Ebmeier & Good, 1979; Evertson, Anderson, & Brophy, 1978; Solomon & Kendall, 1979). Nevertheless, main effects are consistently strong in teaching effectiveness studies in basic skill subjects. Moreover, many of the interactions that have been identified are not consistent across studies or are very difficult to interpret.

In two studies at the Texas R&D Center, ability-treatment interactions were found at the class level. In the third-grade study (Brophy & Evertson, 1976), an analysis was done for possible differences in process-product relationships between high and low SES classes. In the junior high study (Evertson, Anderson, & Brophy, 1978), differences for high and low entering ability classes were analyzed. In both studies the data suggest that effective teachers in low ability classes were generally more supportive and tolerated more student comments that were not specifically focused on the lesson than effective teachers in high ability classes.

"It is apparently especially important for teachers in high ability classes to maintain a narrow academic focus, even at the expense of discouraging student initiative. In the low ability classes, on the other hand, the more successful teachers were those who allowed students to express their ideas, even if they were not directly relevant to the academic task at hand".(Evertson, Anderson, & Brophy, 1978, p. 109).

These findings can be attributed to possible differences in motivation between the two ability levels. Nevertheless, the findings are not consistent with ATI results in laboratory studies in which "constructive" motivation (confidence and assertiveness) is associated with greater achievement in autonomous rather than restricted treatments and lower ability learners do better with focus and guidance (Cronbach & Snow, 1977). It is also likely that the classroom interactions are in part a reflection of the different classroom conditions that are associated with differences in student ability levels (Campbell, 1974; Metz, 1978).

It is not particularly surprising that ATIs in classrooms are not consistent with those in laboratories. Classrooms differ from laboratories on several dimensions, including the group nature of the setting, the duration of the group's life, and the range of learning tasks. Similarly, it is unreasonable to expect that ATIs in classrooms would be strong and replicable given the general level at which both aptitudes and treatments are typically defined.

The existing evidence does not support an ATI interpretation for existing process-product relationships. At the same time, complex interactions are likely to operate in classrooms in ways that attenuate process-product associations. The identification of these interactions awaits a better understanding of how treatment effects occur in classrooms. At present, the available work on aptitude-treatment interactions in either laboratories or classrooms does not cast much light on the processes that connect teaching conditions with outcomes.

Conclusion

The treatment theories underlying teaching effectiveness inquiry provide little specific information about the processes that mediate teaching effects in classroom environments. Motivational constructs are useful for predicting the general persistence of individual students in classroom events and, through the instrumentality of practice, their likely level of achievement. Such constructs do not, however, specify what content is being presented or how the student is expected to process that content. The academic substance of instruction, in other words, is left out of the analysis.

The construct of practice certainly moves closer to academic substance. The construct is typically associated with such variables as content covered or academic engagement. Nevertheless, a treatment theory based on practice still has limitations. Part of the problem is that the most direct measure of practice--viz., engagement--is imperfect. Appearing to be engaged in the presence of academic stimuli does not necessarily mean that one is actually engaged on academic content (Hudgins, 1967). Moreover, a measure of engagement does not tell how the person is engaged; i.e., how the person is processing the available information. As Gage (1978) has observed: "Academic learning time, in the form of allocated and engaged time, is, in a sense, a psychologically empty quantitative concept. We need better analyses of how that time is filled, of what learning processes go on during academic learning time" (p. 75).

In sum, the treatment assumptions in research on teaching are based primarily on a reception theory of student mediating responses. This theory "is a one-stage model that posits that test performance is a function of the amount of information that is received by the learner. . . . The amount received. . .is a function of such instructional factors as the amount and speed of presentation and of such internal factors as the motivation of the learner" (Mayer, 1979, pp. 373-374). Such a theory provides little insight into the cognitive operations that occur when learning takes place.

The next logical step in attempting to understand how teaching effects occur is to construct a process model that connects classroom events to outcomes. As the above analysis of aptitude-treatment interaction research suggests, an approach which focused on information processing responses primarily as attributes of good and poor learners is not an especially fruitful route to such a process model. What is needed is a framework that explains how classroom events influence student information processes for all students. The next two chapters report the results of an attempt to construct such a framework.

Chapter 3

A TASK MODEL OF STUDENT MEDIATION

The central problem of the project was to add to our understanding of how teaching effects occur by identifying the cognitive processes that connect classroom events to outcomes. To address this problem it was necessary to focus on the substance of instruction, on the information that is processed in classrooms rather than simply the overt behavior of teachers and students. This shift to content was also consistent with the findings from process-product research that content variables--opportunity to learn, content covered, and curriculum pace--are correlated with achievement (Rosenshine, 1976, 1979). The intention was not, however, to abandon the teacher and focus exclusively on the effects of curriculum. Rather, an attempt was made to study the curriculum in use in classrooms and to view teaching variables as information resources that guide students in their processing of content (see Carroll, 1976a; Gibson, 1960; and Frase, 1972 for an information interpretation of instructional stimuli).

Cognitive psychology was used as a basis for conceptualizing how content is processed in classrooms. There are, of course, limitations inherent in this approach. Many of the constructs in cognitive psychology are based on artificial or simplified tasks performed under heavily controlled conditions. Nevertheless, the field has recently shown considerable promise for unraveling some of the problems and mysteries in the field of school learning (see Anderson, 1977; Davis, Jockusch, & McKnight, 1978; Glaser, 1979; Posner, 1978).

The literature in cognitive psychology is large, highly technical, and diverse. No attempt is made here to review all of this literature (for useful collection and reviews see Anderson, Spiro, & Montague, 1977; Bobrow & Collins, 1975; Clark & Clark, 1977; Cotton, 1976; Craik, 1979; Estes, 1978; Gagne, 1978; Gallagher, 1979; Glaser, 1979; Hagen, Jongeward, & Kail, 1975; Klahr, 1976; McConkie, 1977; Resnick, 1976; Rumelhart, 1977a; Simon, 1979; Wittrock & Lumsdaine, 1977). The focus, rather, is on the core concepts of cognitive psychology that appear to have relevance to the problem of understanding processes that connect classroom events to outcomes.

The chapter is organized around the concepts of schema and task. Each of the concepts is defined and illustrated with special reference to the process of comprehension. To begin, however, it is necessary to provide a general overview of the human information processing system.

Human Information Processing

Most contemporary models of human information processing posit three interconnected units or components: (1) a sensory register; (2) a short-term store or working memory; and (3) a long-term store or semantic memory (see Atkinson & Shiffrin, 1968; Rumelhart, 1977a).

The sensory register is the level at which sensory data from the environment impinges upon the information-processing system. The capacity of the sensory register is large but information is retained for very short intervals unless it is transferred to the short-term store for conscious processing. Research in such areas as visual perception, signal detection, and letter discrimination is oriented to this level of sensory registration (see Gregg, 1974; Haber, 1978; LaBerge, 1975; LaBerge & Samuels, 1976; Posner & Snyder, 1975).

The short-term store or working memory component is a limited-capacity processor within which conscious processing of information takes place. Information at this level is received selectively from the sensory register and is often combined with information from long-term memory to construct meanings and make decisions. Working memory has a limited storage capacity: information is typically retained only as long as it is needed for conscious processing.

Semantic memory receives information from working memory (and perhaps some from the sensory register) for long-term retention. At the same time, long-term memory contributes information for conscious processing and influences the selection of information from the sensory register. Semantic memory is the repository for a person's knowledge about the world. Information at this level is organized into associational networks. The capacity of semantic memory is virtually unlimited, but information is not always accessible because of inadequate retrieval cues or inappropriate search strategies.

These three components define the structural features of the information-processing system. The system also contains a set of control processes that direct attention, rehearsal, elaboration, and search, (see Craik, 1979; Craik & Lockhart, 1972; Morris, Bransford, & Franks, 1977). These are the operations carried out on information during encoding, processing, storage, and retrieval.

A central premise of modern cognitive psychology is that comprehension is a constructive process (Bransford & Franks, 1976; Dooling & Christiaansen, 1977b; Greeno, 1974; Hunt, 1973; Kintsch & van Dijk, 1978; Paris, 1975; Schank & Abelson, 1977; Smith, 1975). According to this premise, meaning does not result from passive reception of information from the environment. Rather, understanding involves construction of a cognitive representation of events or concepts and their relationships in a specific context.

The process of constructing a cognitive representation of a situation to be comprehended is interactive and sequential, involving information from both the environment and from semantic memory (see Estes, 1975; Levy, 1977; Rumelhart, 1977b; Rumelhart & Ortony, 1977). In comprehending prose, for example, a reader gradually builds a model of the semantic structure of the passage. Information from the environment makes contact with information from semantic memory to suggest a likely interpretation. This interpretation establishes expectations about what subsequent events will mean. These expectations, in turn, guide processing of new information in working memory (see Chafe, 1970, on the process of foregrounding). They restrict, in other words, the options for interpreting incoming information. Thus, the interpretation of the word "saw" depends upon whether the information already available to the reader suggests that the passage at that point is about looking or cutting a board. Finally, new information is used to update the initial interpretation as the reader progresses through the passage.

This interaction between knowledge of the world and passage information can be illustrated in the following example. If the first sentence in a passage is: "Michael took the keys from Steven," several interpretations are possible. All that is known at this point is that the possession of the keys has passed from Steven to Michael, but the circumstances are not clear. If the next sentence is "Steven called the police," the information about the circumstances surrounding the change in possession is clarified by the inference that Steven's actions are contingent upon having discovered that his keys were missing. As will be emphasized later, constructing a cognitive representation of a passage involves not only the explicit information in the sentences but also the inferences that are made to complete the full picture of the episode or event to be comprehended.

Passages and situations differ, of course, in terms of the amount of prior knowledge and the number of inferences required for comprehension. That is, some passages are more familiar and more redundant than others (see Haber, 1978). If the information in a passage and the person's knowledge of the world do not permit the construction of a cognitive representation, then comprehension will not be achieved.

In the following section, the interactive process of constructing a cognitive representation of an event is explained more fully. The discussion in this section focused on the concept of schema, which is basic to modern cognitive theory, and to the way the macrostructure of events guides information processing.

Schemata and the Macrostructure of Texts

One of the underlying propositions in cognitive psychology is that knowledge in semantic or long-term memory is organized into associational networks or schemata (Anderson & Bower, 1973; Bobrow & Norman, 1975; Frederiksen, 1975b; Hunt, 1973; Kintsch, 1974; Meyer & Schraneveldt, 1976; Norman, Gentner, & Stevens, 1976; Rumelhart & Norman, 1978; Rumelhart & Ortony, 1977; Thorndyke & Hayes-Roth, 1979). Several different approaches have been taken to notation for representing knowledge structures, but in general they consist of a diagram of concepts and propositions about the relationships among these concepts. Kintsch (1974), in particular, emphasizes that the structure of knowledge is a propositional network. Much of the work in this field has concentrated on schemata for prose. Recently, however, the basic concept has been extended to representations of pictures (Mandler & Ritchey, 1977), stories (Kintsch, 1977; Rumelhart, 1975), episodes (Bower, Black, & Turner, 1979; Schank, 1975), and social situations (Schank & Abelson, 1977; Stein & Goldman, 1978).

This organizational view of knowledge calls attention to the multiple associations that are brought to bear on a piece of information. The word "apple," for instance, is embedded in a network of associations referring to shape, color, texture, use, and relation to other foods. In contrast, the word "brick" elicits a different set of associations. Similarly, the concept "drugstore" evokes a range of associated objects and events. Finally, verbs, such as "take," "run," or "carry," specify actions that are performed on or with objects.

These meanings associated with objects, episodes, actions, or situations are utilized in constructing a representation of the semantic content of a passage or event. A schema is a relatively abstract representation acquired from past experiences with exemplars (see Bransford & Franks, 1976; Bransford, Nitsch, & Franks, 1977). It contains slots or variables into which specific objects, actions, or events can be instantiated (Anderson, Pichert, Goetz, Schallert, Stevens, & Trollip, 1976; Anderson, Stevens, Shifrin, & Osborn, 1977). Once a schema has been selected and the variables instantiated, comprehension takes place. In other words, "comprehension can be considered to consist of selecting schemata and variable bindings that will 'account for' the material to be comprehended, and then verifying that those schemata do indeed account for it. We say that a schema 'accounts for' a situation whenever that situation can be interpreted as an instance of the concept of the schema represents" (Rumelhart & Ortony, 1977, p. 111).

Schemata play an especially important role in accounting for ambiguities in passages or situations and in making inferences. Passages or episodes are seldom fully specified. In building a cognitive representation, therefore, a person must make inferences to interpret association and causality among concepts or events. Thus, in the sentence "George entered the restaurant," the restaurant schema or script permits inferences about how he will be assigned a table (Schank & Abelson, 1977). Similarly, in the example used earlier, the sentences "Michael took the keys from Steven. Steven called the police" permit the inference, based on knowledge of why people call the police, that Michael stole the keys.

This process of inference making in building a cognitive representation is called "semantic integration" (see Bransford & Franks, 1971; Brown, 1976; Brown, Smiley, Day, Townsend, & Lawton, 1977; Paris, 1975; Paris & Carter, 1973;

Paris & Lindauer, 1976). In studies of semantic integration, subjects read simple stories or descriptions. These stories are constructed so that several inferences are possible. Subjects are then given a list of sentences, some of which are verbatim from the story and some of which are statements of inferences that could easily be made, and they are asked to tell which sentences appeared in the original story. Both children and adults consistently recognize true inference statements--i.e., sentences which express a logical inference from the sentences in the story--as having appeared in the original text when in fact these statements did not appear. Paris and Carter (1973), for example, read three sentence stories to second and fifth grade students. A typical story would be: "The bird is inside the cage. The cage is under the table. The bird is yellow." When tested for recognition memory of verbatim, true inference, and false inference sentences, the students consistently claimed to have already heard true inference sentences such as "The bird is under the table."

The operation of schema in comprehension can be demonstrated with two examples taken from experiments in this field. In the first example, Bransford and Johnson (1972) demonstrated that when a passage does not permit the construction of a cognitive representation comprehension and recall are difficult to achieve. To demonstrate this effect, they wrote an ambiguous passage:

If the balloons popped, the sound wouldn't be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying, since most buildings tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face to face contact, the least number of things could go wrong (Bransford & Johnson, 1972, p. 719).

Comprehension ratings and recall for this passage were low unless subjects were given a context within which to interpret the passage. The appropriate context in this case was a drawing depicting a modern-day Romeo attempting to serenade his girlfriend. In the drawing, the balloons are used to lift a speaker to the girl's window at the top of the building so that the sound of the singing, accompanied by a guitar, could be heard.

The second example demonstrates that the knowledge of the world subjects bring with them to a passage influences the semantic representation that is constructed. In this example, Anderson, Reynolds, Schallert, and Goetz (1977) gave college students the following passage:

Every Saturday night, four good friends get together. When Jerry, Mike, and Pat arrived, Karen was sitting in her living room writing some notes. She quickly gathered the cards and stood up to greet her friends at the door. They followed her into the living room but as usual they couldn't agree on exactly what to play. Jerry eventually took a stand and set things up. Finally, they began to play. Karen's recorder filled the room with soft and pleasant music. Early in the evening, Mike noticed Pat's hand and the many diamonds. As the night progressed the tempo of play increased. Finally a lull in the activities occurred. Taking advantage of this, Jerry pondered the arrangement in front of him. Mike interpreted Jerry's reverie and said, 'Let's hear the score.' They listened carefully and commented on their performance. When the comments were all heard, exhausted but happy, Karen's friends went home (p. 372).

Evidence from tests indicate that physical education students tended to interpret the passage as a description of a group of friends playing cards. Music students, on the other hand, interpreted the passage as a rehearsal session for a woodwind ensemble. A second passage which could be interpreted as either a prison escape or a wrestling match produced consistent findings: music students tended to adopt the prison interpretation but physical education students saw it as a wrestling match. Similar results are reported by Dooling and Christiaansen (1977a, 1977b) in which passages are attributed to famous authors (e.g., Hitler). They found that subjects used their general knowledge about such authors to encode the passage and, when the author identity was delayed until recall, to reconstruct the passage at retrieval.

To this point the discussion has focused on how schemata operate in constructing an interpretation of a passage or event. But the selection of a schema and the instantiation of variables is constrained by the passage or event itself. Some insight into how context--i.e., the event or passage to be comprehended--constrains information processing can be gained from studies of the macrostructure of texts. The major work in this area is that of Meyer (1975, 1977; Meyer, Brandt, & Bluth, 1978), but others have reported similar results (see Coke & Koether, 1977; Johnson, 1970; Johnson & Scheidt, 1977; Just & Carpenter, 1976; Thorndyke, 1977). The main finding of these studies is that concepts high in the organizational structure or hierarchy of a passage are recalled better than concepts lower in the hierarchy. These findings suggest that readers adopt the semantic structure of the passage to guide the selection and processing of information. Propositions high in the passage hierarchy are used to organize large chunks of information lower in the structure of the passage. Indeed, Cirilo and Foss (1980) found that processing propositions high in a text hierarchy actually takes longer than those lower in the hierarchy. Along similar lines, Shavelson (1972, 1974; see also Geeslin & Shavelson, 1975) found that students who learn more about a subject (in this case physics and mathematics) also acquire a cognitive representation that corresponds more closely to the structure of the content. Of course, if content is not structured, subjects will impose a structure of their own (i.e., they will rely on their own schemata) or they will benefit greatly from experimenter-provided structures in the form of advance organizers (see Mayer, 1977).

Comprehension, then, is an interactive process (Kintsch & van Dijk, 1978). Schemata play an important role in interpreting sentences or events and making inferences necessary to construct a cognitive representation of a passage or episode. But such representations are not solely personal. Passages and episodes carry instructions for constructing meaning and people use these instructions to guide their processing. To understand comprehension, then, it is necessary to understand the structure of knowledge in both people and situations (see Bransford, McCarrell, Franks, & Nitsch, 1977).

Tasks

A description of the use of schemata in comprehension gives insight into how the information processing system works. But the discussion leaves out an important dimension: people process information for a purpose. A passage which is read purely for personal interest is likely to be represented differently from a passage which is read in preparation for a test. Similarly, instructions to summarize the gist of a passage will result in a representation that differs from the representation produced by instructions to report the number of words beginning the the letter "S."

Purposes are introduced into the construction of cognitive representations by the task conditions under which people process information (see Frederiksen, 1975a; McConkie, 1977; Morris, Bransford, & Franks, 1977; Rothkopf, 1976). A task is a set of explicit or implicit instructions about what a person will be expected to do after reading a passage or witnessing/participating in an episode. In informal situations, such as cocktail parties or parks, instructions are likely to be broadly construed so that personal choice defines the substance of tasks. In formal situations, such as classrooms, expectations are more likely to be specific and explicit.

In essence a task consists of two elements: (a) a goal and (b) a set of operations necessary to achieve the goal (see Simon & Hayes, 1976). A full specification of a task, therefore, gives insight into the cognitive processes that can be used to accomplish the task. As Dawes (1975, p. 121) has observed: "The model of the task enables us to understand the task requirements--i.e., to answer questions of how the task is successfully completed. Understanding these task requirements, in turn, yields an understanding of the subject who performs in a more or less successful manner." Clearly the study of tasks is especially appropriate for the present project because a task bridges the region between environmental conditions and information processing.

A central problem in defining tasks is that a single goal can be accomplished in several ways. It is therefore not always possible to specify a unique set of operations necessary to reach a given goal. Subjects may use a variety of idiosyncratic processes to successfully memorize a list of noun pairs and, indeed, the same individual may use different strategies for memorizing different lists (see Battig, 1975). But it is possible to demonstrate that different goals require different operations for their accomplishment. Different tasks, therefore, are associated with different processes.

The effect of different tasks is clearly seen in the contrast between semantic and nonsemantic processing, i.e., the processing of words for meaning vs. the processing of words for lexical features (see Bransford, Nitsch, & Franks, 1977; Morris, Bransford, & Franks, 1977; Postman & Kruesi, 1977). Thus, if subjects are required to count the number of X's appearing in a set of photographs, they are unlikely to remember much about the scenes or faces depicted. Similarly, if subjects are asked to identify the words that rhyme in a passage they will remember less about the gist of the passage than those who are instructed to summarize the main ideas.

But task effects are evident at a more refined level. These effects are especially clear in experiments in which expectations for testing are manipulated (see Balch, 1964; Frase, 1975; Frederiksen, 1975a; Hunt, 1973; Naus, Ornstein, & Kreshtool, 1977; see McConkie, 1977, for a review). Such studies indicate that subjects adjust information processing to fit the type of test they expect. Different strategies of selecting and processing information are used, therefore, depending on whether subjects expected to be tested for recall, recognition, or inferences. There is even evidence that different tasks influence the microprocesses of selecting different features of words in reading a passage (Gibson & Levin, 1975, pp. 360-372, 466-474). In other words, "the nature of exploratory behavior with respect to any stimulus configuration is modulated by the task in which the subject is involved at the time of encounter" (Nunnally & Lemond, 1973).

Barr's (1975) study of the substitution errors first-grade pupils made when trying to identify unfamiliar words in a text provides a more naturalistic example of how task differences affect processing. She found that pupils taught by a sight-word method substituted words from the sample of reading words contained in the instructional materials, made few non-word responses, and showed little letter-sound correspondence in attempts to identify unfamiliar words. Pupils taught by a phonics method, on the other hand, made more non-word or partial-word responses, showed high letter-sound correspondence in making substitutions, and substituted words not contained in the instructional materials. It is clear in these results that pupils used operations in reading that were consistent with the way in which each method defines the reading task. Barr also found that students who entered instruction with a strategy inconsistent with that required by the method soon adapted to task demands.

Schemata and the Macrostructure of Tasks

The evidence reviewed above clearly indicates that a task provides context which regulates the selection of information and the choice of strategies for processing that information. Thus, "changing a subject's task changes the kind of event the subject experiences" (Jenkins, 1977, p. 425).

The effects of a task on selective attending and processing depends on at least two factors: (1) familiarity with the task; and (2) the developmental level of the person attempting to accomplish the task (see Bransford, Nitsch, & Franks, 1977; Day, 1975; Estes, 1975; Gibson & Levin, 1975; Goodnow, 1972; Haber, 1978; Hagen, 1975; Nunnally & Lemond, 1973; Siegel & White, 1975; Vernon, 1966). Mature subjects are much more selective and efficient in using available cues to extract information relevant to accomplishing a task, and this efficiency increases as they become more familiar with the task. Less mature subjects, on the other hand, attend to a broader range of stimuli and are less likely to select and process information to fit the demands of a particular task (see Pick, Frankel, & Hess, 1975; Wright & Vlietstra, 1975). This is not to say that young children are incapable of understanding a task or adjusting strategies to meet task demands. Investigators in the field of sociolinguistics have found that children as young as four years old adjust language patterns to match demands of different communication tasks, such as giving an explanation to an adult vs. giving an explanation to a younger child (Pickert & Sgan, 1977; Shatz & Gelman, 1973, 1977). Nevertheless, young children often require a "well-formed" task in order to understand task demands (see Simon & Hayes, 1976). Moreover, they often exhibit a "production deficiency" (see Brown, 1975; Brown & Campione, 1978; Brown & Smiley, 1977; Brown et al., 1977; Chi, 1977; Hagen, Jongeward, & Kail, 1975; Kreutzer, Leonard, & Flavell, 1975). This means that children are capable of using information processing strategies but typically do not use them spontaneously and flexibly to match specific task requirements. Knowledge of the task alone is not always sufficient. They depend, rather, on instructions and prompts to activate appropriate strategies.

There are two important implications of these data on factors which influence task effects. First, as McConkie (1977) has observed, the effect of a task increases with the number of times it is experienced. Experience with a task probably increases the clarity of task demands. Instructions for a task often do not communicate in any complete sense the nature of the goal that is to be accomplished, i.e., the nature of the test subjects will receive. But once the test has been taken and feedback received, the task is more fully specified. As will be emphasized later in this report, task effects are likely to be especially strong in classrooms because tasks are experienced repeatedly over a fairly long period of time.

Second, the data on selectivity provide insight into the consequences of instructional conditions on task performance. In learning from prose, for example, students may be given lists of objectives, instructions to look for specific types of information, or questions inserted at intervals in the passage. These conditions do not change the task itself, although they may clarify the nature of the task or affect the likelihood that it will be accomplished. (It is possible, of course, to understand a task but not be able to accomplish it.) Research on these conditions (see Andre, 1979; Frase, 1972, 1975; Mayer, 1977, 1979; McConkie, 1977) is consistent with results of studies for selective attending and processing: the effects of instructional conditions depend upon their specificity and their connection to the task being accomplished. Very general prompts or adjunct aids that do not either add to the information already supplied by understanding the task itself or activate processes necessary to accomplish the task, do not contribute to performance. Indeed, such prompts are probably ignored. In addition, prompts are more likely to affect the performance of subjects who do not have the necessary schemata for understanding the task or the maturity to select the appropriate strategies. Whether the effects of prompts on the performance of less mature subjects are permanent is questionable (Brown & Campione, 1977).

From the perspective being developed here, comprehension of prose is a task. Indeed, in most comprehension studies, subjects are either told they will be tested or can reasonably assume that a test will be given. Thus a task context exists for the passage. Under general instructions to read and understand the passage, subjects appear to make use of the macrostructure of the text to construct a cognitive representation for comprehension. Specific task instructions can, however, override the effect of text structure (see Pichert & Anderson, 1976). If the task requires processing of information low in the text hierarchy, then such information will be attended to. Furthermore, comprehension may not be the task in a particular situation. A reader might be required to remember proper names or technical terms rather than comprehend the passage itself. In such a case, the syntactic and semantic characteristics of the passage will have little effect on task accomplishment.

Constructing a cognitive representation of a passage or an episode is guided, then, by the task a person is working on. This view broadens the context of comprehension from the macrostructure of texts and episodes to the macrostructure of situations (see Mischel, 1977; Schank & Abelson, 1977). To understand a task it is necessary to construct a cognitive representation that encompasses a goal and a set of operations likely to achieve that goal (see Simon & Hayes, 1976). Since tasks are typically set by people, especially in classroom situations, representing a task involves social cognition, i.e., a representation of how another person views the world (see Hayes, 1972; Shantz, 1975). In addition, under certain circumstances constructing a task representation may require the integration of events taking place over several days. Inference and problem-solving are central, therefore, to understanding task demands. Finally, over time knowledge structures or schemata are built around tasks. A head waiter's restaurant schema is likely to be different in fundamental ways from a customer's schema.

Conclusion

At this level of abstraction the task model would appear to be a promising approach to understanding how teaching effects occur for at least two reasons. First, the concept of task connects information processing with environmental conditions. Knowing the task gives access to the kinds of cognitive processes that are likely to be necessary to accomplish the task. Second, a task is more than just content. It also includes the situation in which content is embedded. It is still possible, therefore, to incorporate teaching variables into the conceptualization of classroom conditions that effect achievement. At the same time, teaching variables are not isolated from the substance of instruction.

To clarify these potential contributions of the task model, it is necessary to turn to an analysis of the types of academic tasks that are likely to appear in classrooms and to describe the way such tasks function as frameworks to guide student information processing in classroom environments.

Chapter 4

ACADEMIC TASKS IN CLASSROOM ENVIRONMENTS

The purpose of this chapter is to construct a bridge between the information processing model based on the concept of task and the field of research on effective teaching. This purpose will be served by relating the general task model more specifically to the subject-matter tasks students are likely to encounter in classroom environments. The chapter is divided into two sections. In the first section, different types of academic tasks are identified and their effects on information processing and learning are described. In the second section, attention turns to the consequences of embedding academic tasks in classroom environments. In this section the analysis centers on how tasks are affected by the conditions under which they are experienced in classrooms.

Academic Tasks

In Chapter 3, the focus was on comprehension because it provided a convenient way to illustrate how tasks influence information processing. In addition, comprehension is essential if one is to navigate the demands of a complex environment with any degree of functional achievement. In this chapter, however, it is necessary to introduce the concept of "learning" since classrooms are officially designated as settings in which learning is to take place. To deal with learning it is necessary to view tasks as treatments.

Adopting this view does not involve a radical shift from the previous analysis because the task model readily lends itself to a treatment interpretation. Accomplishing a task can have two consequences. First, a person will acquire information--facts, concepts, principles, solutions--relevant to the demands of the particular task that is accomplished. Second, a person will practice operations--memorizing, classifying, inferring, analyzing--used to obtain or produce the information demanded by the task. (For a discussion of the distinction between information and operations, see Merrill & Boutwell, 1973.) Students will learn what a task leads them to do, i.e., they will acquire information and operations which are necessary to accomplish a task (see Frase, 1972, 1975; Markle, 1969). Different tasks, then, will have different effects depending upon the goals and the operations which are defined by the tasks. This, in essence, is the foundation of a treatment theory based on the task model.

An important distinction must be kept in mind throughout this chapter. Understanding is always required at the task level. A person must understand a task--i.e., comprehend the goal and the operations that are necessary to achieve the goal--in order to accomplish the task. But the task to be accomplished may not require understanding of the subject matter which is embedded in the task. To accomplish a task which requires identifying in a passage all words which contain the letter "S," a person must first understand that identifying such words is the task. The task itself requires no understanding of the content of the passage.

Memory vs. Comprehension Tasks

The analysis of academic tasks will begin with basic distinction between tasks which can be accomplished by verbatim reproduction of content previously encountered (memory tasks) and tasks which can be accomplished by understanding the gist of the material previously encountered (comprehension tasks). The first issue is to clarify this distinction. The discussion then turns to the way each of these tasks affects information processing.

The distinction between memory and comprehension tasks is based on a distinction between the surface structure and the conceptual structure of text (see Chafe, 1970). Memory tasks direct attention to the surface structure of the text and to the verbatim reproduction of that information; comprehension tasks direct attention to the conceptual structure of the text and to the learning of the gist of the information at that level. In other words, "verbatim information consists of propositions about the physical sentences, whereas gist information consists of propositions about the referents of the sentences" (J. R. Anderson & Paulson, 1977).

R. C. Anderson (1972) approaches the distinction from the perspective of test items. Verbatim items, i.e., items which contain examples previously encountered in instruction or which contain language that is congruent with that used in instruction, measure recall but not necessarily comprehension. Paraphrase items, i.e., items which contain examples not used previously in instruction or which contain a transformed version of the language used in instruction, allow a more confident inference that a subject comprehended the information. To this list can be added inference items, i.e., items which ask for information not explicitly stated in the text but available through inference or those which require application of the information in the text for formulate new propositions or relationships (see Entwistle, 1978; Gagné & White, 1978).

One of the essential differences between memory and comprehension tasks is that they require different strategies of information processing (see Brown, 1975; Craik, 1977, 1979; Craik & Lockhart, 1972). In comprehension tasks, the ideas (concepts and propositions) embedded in the surface structure of text are decontextualized and organized into a high-level propositional network or schema (see Bransford & Franks, 1976; Kintsch, 1975). Such a network contains little of the original surface structure of the text or examples from which the abstract propositions were formed. Schema are generative, however (Shaw & Wilson, 1976). That is, schema can be used with great flexibility to handle unencountered instances with ease or to generate inferences about the application of concepts and propositions to new situations. In other words, it is possible to answer paraphrase and inference items using a schema which serves as a generator set for such answers.

In comprehension tasks, remembering is an involuntary or incidental product of comprehension (Brown, 1975). "If I fail to understand, then I will also fail to remember" (Norman, 1975, p. 531). Memory for information acquired by comprehension is more durable, but there is a leveling and sharpening of the original text so that reproduction of the surface structure of a particular text becomes difficult (J. R. Anderson & Paulson, 1977; Brown, 1975; Kreutzer, Leonard, & Flavell, 1975). In other words, semantic integration takes place so that memory is for the gist of the original text rather than for the precise form of the text or the examples used originally (see Bransford & Franks, 1971; Brown, 1976; Paris, 1975; Paris & Lindauer, 1976). Indeed, a person who has acquired a generator set may not be able to distinguish between encountered and unencountered examples (Shaw & Wilson, 1976).

To accomplish comprehension tasks, then, a student must build a high-level semantic structure or schema that can be instantiated in several ways as particular circumstances demand. The construction of such a schema for academic content is likely to be difficult and require extended experience with the content (see Bransford & Franks, 1976; Nelson, 1977; Norman, 1975). Before such a schema is constructed, involuntary remembering is not likely to operate efficiently (Shaw & Wilson, 1976). Some evidence for the difficulty involved in comprehension tasks is found in the studies which indicate that scores on paraphrase items are typically lower than scores on verbatim items (Anderson & Biddle, 1975; Armbruster, 1976). These data may also mean that subjects tend to process information for memory rather than comprehension.

Memory tasks come into existence under three conditions. First, a task may require an exact replica or a very close approximation of the original form of the information, such as dates, quantities, names, terms, or other facts. Many laboratory tasks in memory studies have this requirement. Second, a task may be heavily recall-dependent, i.e., to make an inference or an application a person may first have to remember a large number of facts. Finally, a task may require a person to know information that cannot be understood (i.e., assimilated into a schema) and therefore is acquired by rote. For example, the sentence "Groundwater returns to the ocean during the hydrologic cycle" might well be learned by memorizing rather than understanding. Rote learning of inherently meaningful material is likely to happen when a person does not have sufficient background to assimilate the new information into an existing schema or sufficient time to construct a new schema.

In any one of these circumstances, deliberate memorizing is required so that a person can at least reproduce the original information (Brown, 1975). Deliberate memorizing requires at least two processes. First, a person must restrict semantic integration, i.e., cut off the new information from what is already known, in order to preserve the surface structure of the information that is to be reproduced (see Dooling & Christiaansen, 1977b; Mosenthal, 1979; Spiro, 1977). Second, a person must use mnemonic strategies to generate a rich encoding of the original information to make it more durable in memory (see Craik, 1977; Levin, Shriberg, Miller, McCormick, & Levin, 1980; Rohwer, 1973). The use of mnemonic strategies represents a form of episodic encoding of information (see Brown, 1975; Nelson, 1977; Tulving, 1972). Episodic encoding involves the construction of a concrete-level schema which contains much of the temporal, spatial, and autobiographical stimuli that were present when the information to be remembered was experienced. Information might, for instance, be coded by its location in the sequence of a passage or its place on a page (see Just & Carpenter, 1976; Murray, 1977; Rothkopf, 1971; Schulman, 1973; Zechmeister, McKillip, Pasko, & Bespalec, 1975). Retrieval of information that has been learned in this manner is often dependent upon a high degree of similarity between the encoding cues and the retrieval cues (Bjork, 1975; Peterson, Peterson, & Ward-Hull, 1977; Tulving, 1970). The information, in other words, cannot be used flexibly.

The distinction between memory and comprehension tasks must be viewed as a matter of degree. Some tasks are weighted more heavily on verbatim reproduction or slight transformations of the language of instruction. Other tasks are weighted in the direction of paraphrased language or inferences. In addition, some comprehension items may be answerable by recall, thus allowing memory to be a route to accomplishing what is nominally a comprehension task. If, for instance, an item that requires a person to give an example of a concept can be answered by reproducing an example used in instruction, then the item can be answered by memory. In such a case it is not necessarily legitimate to infer comprehension from the correct answer.

Procedural vs. Comprehension Tasks

A second distinction between procedural tasks and comprehension tasks elaborates further the types of academic tasks students can encounter in classroom environments. This distinction is especially clear in the field of mathematics where it is formulated as a difference between (1) knowing an algorithm (i.e., a sequence of computational steps for adding a column of number, multiplying two-digit numbers, dividing by whole number, etc.) that enables one to produce an answer and (2) understanding why the procedure works and when it should be used (see Davis, 1975; Davis & McKnight, 1976, 1979; Glaser, 1979; Greeno, 1978). Procedural tasks, then, are tasks which are accomplished by using a routine that produces answers. There is typically little unpredictability in such cases because the routines or algorithms are very reliable, i.e. they consistently produce correct answers if no computational errors are made. Comprehension tasks, with respect to procedures, are tasks which are accomplished by knowing why a procedure works or when to use a particular procedure in a particular situation.

Procedural tasks are especially evident in mathematics, but they exist in any academic area when rules are used to produce answers. Grammar, for example, is defined largely by a set of procedures. Similarly reading and composition involve procedures which are applied to content in order to generate answers. Indeed, in the sense used in this report, achieving comprehension is a procedure of building a semantic representation of a text or episode. In this very broad sense, all thought is algorithmic (see Davis & McKnight, 1976).

Nevertheless, there are levels of specificity that must be considered in the distinction between procedural and understanding tasks. A procedural task is one which can be accomplished without understanding by simply knowing how to follow the computational steps to produce an acceptable answer. This limits procedural tasks to content for which algorithms can be constructed. In some areas, such a composition, predictable formulas for producing answers may not exist. Even here, however, procedural tasks can be created. In composition, for example, a sentence-combining task can be used in which two simple sentences are given with an algorithm for combining them into a compound or complex sentence (see O'Hare, 1973).

A comprehension task related to procedures involves the basic processes of comprehension that have been outlined previously in Chapter 3 and this chapter. To accomplish a comprehension task a student must be able to construct a cognitive representation of the ideas embedded in the surface structure of the algorithm or conceptualize a problem in terms of procedures that are likely to apply (see Davis, 1975; Greeno, 1978). Tests for understanding a procedure generally operate at one of two levels (see Gagne & White, 1978). The first level requires the student to apply the procedure to problems that differ in surface features from those used in instruction. This level corresponds to the paraphrase test discussed in conjunction with memory tasks. The second level requires that a student decide which of several procedures is applicable to a particular problem. Such a test corresponds to the inference level discussed earlier and is commonly referred to in mathematics as a word problem (see Heller, 1979). As was true with comprehension of information, constructing a high-level schema necessary for understanding a procedure and the circumstances under which it applies is a more lengthy and difficult process than learning to follow a largely invariant sequence of steps to produce an answer to a specific problem (Davis, 1975; Davis & McKnight, 1976; Greeno, 1978).

The Relationship Among Tasks

Several issues surround the relationship among memory, procedural, and comprehension tasks. In this section, two issues will be considered: (1) the effects of different tasks; and (2) the possibility of interference among tasks.

In a series of interrelated studies, Greeno and Mayer (see Greeno, 1972, 1974; 1976, 1978; Mayer, 1975, 1979;

Mayer & Greeno, 1972) have established that different instructional methods produce structurally different learning outcomes. Methods which focus on comprehension of information or procedures appear to result in superior performance on "far transfer" tests which require application of concepts and principles to novel problems or situations. Methods which focus on acquiring specific information or on learning how to use a procedure result in superior performance on "near transfer" tests which require reproduction of information or computational skill. The investigators argue that these performance differences reflect structural differences in the representation of knowledge produced by different methods.

These findings and their interpretation are consistent with the present analysis of task differences. Accomplishing memory tasks is likely to require episodic encoding of information to preserve surface structure. Episodic encoding is not generative, however, i.e., it is not likely to result in knowledge that is readily applicable to new situations. A similar case can be made for the effects of procedural tasks. Using a procedure without understanding is not likely to result in flexibility or in the ability to know when to use the procedure. With both memory and procedural tasks, then, it is reasonable to expect near rather than far transfer. Comprehension tasks, on the other hand, require the construction of high-level generative schemata which are broadly applicable to novel situations and to decision making.

This analysis emphasizes the importance of considering qualitative differences in outcomes when studying the effects of instruction (see Marton & Saljo, 1976). Teaching methods can affect <u>what</u> is learned rather than simply the <u>amount</u> that is learned. Indeed studies of cognitive preferences (S. A. Brown, 1975; Tamir, 1975), the effects of different curricula (Walker & Schaffarzick, 1974), and the effects of different strategies of teaching reading (Barr, 1975) all point to the importance of qualitative differences in outcomes produced by different approaches to instruction.

Is it possible that different tasks are incompatible? A comparison of memory and comprehension tasks suggests that preparation suitable for one task can interfere with preparation for the other (see Bransford & Franks, 1976; Kintsch, 1975). Accomplishing a comprehension task can, because of the effects of semantic integration, interfere with the ability to reproduce specific facts or the surface structure of the original text. On the other hand, accomplishing a memory task can produce knowledge in a form that is not easily applied to recognizing new instances or making inferences to new situations. Advanced knowledge of the task, therefore, is essential for task accomplishment. For some tasks, reading for comprehension may be inappropriate. This perspective explains why subjects typically adjust information processing strategies to fit the nature of the task they are working on (Gibson & Levin, 1975; McConkie, 1977).

A comparison of procedural and comprehension tasks produces a parallel argument. Learning to use an algorithm does not necessarily enable one to understand why the algorithm works or when to use it. Similarly, learning to understand why an algorithm works or when it should be used does not necessarily lead to computational proficiency. This distinction is especially clear in a recent analysis, by Greeno (1976). Using a logical task analysis, Greeno mapped alternative representations of problems involving fractions. Such problems were represented in set-theoretic terms, geometric or spatial terms, or purely numerical terms. Each representation produces the same answer, but representations differed in terms of the number of steps and the type of cognitive activity required to generate a solution. Indeed, representations could be compared in terms of their instructional efficience (which representation could be learned faster), their application efficiency (which could be applied more readily to "real world" problems), their transfer efficiency (which representation made it easier to learn other concepts related to fractions), and their production efficiency (which representation generated answers faster). The numerical representation, for example, could be used with little understanding of the nature of fractions. Such a representation was high on production efficiency but low on transfer to new concepts related to fractions. If the task to be accomplished is procedural, i.e., if the student is judged on his or her ability to solve correctly a large set of problems, the most useful representation would be the numerical one. The other representations are simply too cumbersome to use as routine solution strategies.

It can be argued that extensive drill and practice with computation procedures is a prerequisite for acquiring high-level generative schemata (Davis, 1975; Davis & McKnight, 1976; Greeno, 1978) or that students must know the facts before they can understand the material. This analysis suggests, however, that accomplishing one task does not necessarily or automatically lead to the outcomes of the other. Indeed, at the level of accomplishing a single task, memory, procedural, and comprehension processing may interfere with each other.

Two final aspects of academic tasks and their effects need to be addressed before considering how these tasks are experienced in the classroom. First, there is an important developmental effect on task accomplishment. A reasonably large body of evidence suggests that comprehension (i.e., assimilation to schemata) and the involuntary remembering that is a product of comprehension are achieved "naturally" by very young children. That is, they are able to understand tasks in their world and remember a considerable amount about these tasks and their accomplishment. Developmental differences are clear, however, when a task involves deliberate memorizing or the deliberate acquisition of a new schema in order to achieve comprehension of academic content (see Brown, 1975; Hagen, Jongeward, & Kail, 1975).

As pointed out in Chapter 3, developmentally young children often have a production deficiency, i.e., they lack the ability to select and organize strategies to accomplish a specific situationally-imposed goal. For present purposes, this means that young children are capable of comprehending a task but not necessarily of accomplishing it if it involves deliberate memorizing or the development of new schema. To accomplish academic tasks, whether memory, procedural, or comprehension, such children require substantial prompting from the instructional environment.

Second, there is some evidence available which suggests that students acquire procedures for generating answers by experience with accomplishing tasks rather than through direct instruction in these procedures. Resnick and her associates (Resnick, 1976; Groen & Resnick, 1977), for example, found that pupils transformed instructional routines which were easy to articulate, represented the structure of the subject matter, but were cumbersome for generating answers, into production routines which were difficult to articulate but more efficient in producing answers. For example, after completing several problem sets, students learned to add smaller numbers to larger numbers even though they had not been taught to follow this procedure (and in all probability did not know this algorithm prior to instruction in addition). The solution strategy was devised, in other words, from direct and repeated experience with the content. Other studies have also found that students devise their own strategies for producing answers, but the strategies are not always appropriate. Erlwanger (1975), for example, discovered students who were very successful in producing answers but who had fundamentally erroneous conceptions of mathematics. Their procedures typically worked for only a very limited range of problems, violated basic assumptions in mathematics, reflected little understanding of mathematical principles, and were resistant to being changed. Similar findings have been reported by Peck and Jencks (1979; Peck, Jencks, & Chatterley, 1980). These results indicate a need for careful analysis of what is learned when students accomplish academic tasks.

<u>Summary</u>

For purposes of the present analysis, three types of academic tasks have been identified: memory, procedural, and comprehension. For memory tasks, the goal is to be able to reproduce information previously encountered. The operations on academic content that enable a person to accomplish a memory task include episodic encoding using various mnemonic strategies. For procedural tasks, the goal is to be able to use a rule or algorithm to produce a predictable answer to a computational problem. To acquire this ability, a person must learn the sequence of steps that define the algorithm and practice these steps to gain mastery. In the case of both memory and procedural tasks, performance is dependent on congruence between practice and testing contexts. The knowledge and skills acquired in memory and procedural tasks, in other words, are relatively inflexible. Finally, for comprehension tasks, the goal is to be able to generate answers to unencountered instances or situations. With respect to a body of knowledge, comprehension is demonstrated by being able to recognize or construct transformed versions of the original content or to make inferences within the passage or from the passage to new situations. With respect to procedures, comprehension is demonstrated by being able to tell why a procedure works or decide when one of several procedures is applicable. To acquire such abilities, a person must construct a high-level semantic structure or generative schema that can be applied flexibly to a wide range of circumstances.

Classroom Tasks

The discussion has now come full circle back to the classroom. In this section the focus is on what happens to academic tasks when they are inserted into a classroom environment. The analysis of this issue is organized around three features of the classroom environment: (1) the evaluative climate of the classroom; (2) the group setting and instructional materials characteristic of classrooms; and (3) the history of classroom groups.

The Evaluative Climate in Classrooms

Academic tasks in classrooms are embedded in an accountability structure defined by Becker, Geer, and Hughes (1968) as an exchange of performance for grades. In this report, the term "grades" does not refer simply to marks on report cards. The reference is, rather, to the various forms of public recognition for appropriate performance that occur in classrooms. Students are required to display knowledge and skills on different occasions: they take tests, complete assignments, answer questions in discussions, and so forth. These answers are labeled by the teacher and these labels are usually available to an audience in the classroom and, when labels are formally recorded, to parents, school officials, and others who have not witnessed the performance at all.

Classroom studies (e.g., Jackson, 1968; Potter, 1974; Smith & Geoffrey, 1968) indicate that judgments about student answers and their classroom conduct are made frequently. In a study of first and fifth grade classes, Sieber (1979) reported that teachers evaluated conduct publically on the average of 15.89 times per hour, or 87 times a day, or an estimatedly 16,000 times a year. By being either a recipient or a witness to these evaluations, students can build an evaluative map of a classroom environment (see White, 1971). Students thus appear to be very aware of the evaluative dimensions of classrooms (Morine-Dershimer, 1976) and able to adapt to different modes of evaluative feedback. Hill (1976) reported that students were able to interpret nonreaction as a mode of evaluative feedback. Similarly, Gelman (1972) reported that students would interpret a question coming after an answer as a signal to change their answer, especially if they were working on material they did not understand. Finally, there is some evidence that the evaluations students receive affect their status in the school at large. In a recent study of the social organization in high schools it was reported that "a student 'sorted' as a 'good student' is differentially allowed to negotiate both territorial rights and his adherence to the formal and informal rules of the school " (Ianni, 1975).

The evaluative climate in classrooms connects academic tasks to a reward structure. Answers, therefore, are not just evidence of having accomplished an academic task. They also count as points earned in an accountability system. The function of answers in a reward system adds important dimensions to the accomplishment of academic tasks. Three consequences of these dimensions are explored briefly in the following discussion.

First, the answers a teacher actually accepts and rewards define the real task in classrooms. The announced goal of an art lesson, for example, may be to learn how to analyze the effects of color on emotions, a task potentially involving comprehension. If, however, the teacher rewards verbatim reproduction of definitions presented in the textbook, the task can be accomplished by memorizing definitions.

Second, the allowable routes to answers affect the nature of the task that is accomplished. If, for example, a student can produce an acceptable answer by copying the work of another student, then the student will learn to copy an answer rather than the operations intended by the academic task. Mehan (1974) has described an instance in which first-grade pupils in a discussion used various delaying tactics when called upon to recite. The result of these tactics was that other students or the teacher would provide the answer for the student who was called on. Similar examples of students circumventing tasks demands in recitations have been reported by MacKay (1978) at the secondary level. From a teacher perspective Lundgren (1977) has described this phenomenon as "piloting," a technique in which the teacher uses a sequence of increasingly explicit prompts to enable a student--usually a low achiever--to produce an answer. As prompts become more explicit, a student can give an answer without using the operations required by the task itself.

Finally, the strictness of the criteria a teacher uses to judge answers has consequences for task accomplishment. MacLure and French (1978) have described an incident in which a primary school teacher accepts a broad range of answers, many of which are factually incorrect, in a discussion of birds that are native to the students' home region. Other investigators have also reported that teachers sometimes praise "wrong" answers (Belleck, Kliebard, Hyman, & Smith, 1966; Mehan, 1974; Rowe, 1974), so the phenomenon may be common. In such instances it appears that answering, rather than giving the correct answer, is the task. If the criteria for correctness are loose enough, the task system itself is suspended.

The embedding of academic tasks in a reward structure would seem to affect the character of student performance. Several studies of language use in classrooms have reported that student talk is constricted, vague, and indeterminant (see Edwards & Furlong, 1978; Harrod, 1977; Sinclair & Coulthard, 1975). Searle (1975), for example, examined the spoken language of high school students in English, social studies, and physics classes and found qualitative differences between academic and non-academic episodes.

> The talk which resulted from their activities as participants in school work was usually a series of short exchanges (and) was not in itself complete but required either reference to texts or movement.... It would seem that the students understood that there was one kind of talk to be used among themselves and another kind which was suitable for school work (p. 280).

Along similar lines, Graves (1975), in a study of writing in the second grade, found that texts for assigned writing were shorter than those for unassigned writing. This effect was observed under both traditional and open forms of classroom organization. Finally, Rosswork (1977), in a laboratory study in which sixth-grade students were required to generate as many sentences as possible from words in a spelling list, found that students improved performance to meet specific output goals by reducing the number of words per sentence to the minimum established by the experimenter. Rosswork comments that "In some cases, specific goals might lead to inappropriate short cutting, particularly when poor conceived goals are set for conplex situations" (1977, p. 715).

One final aspect of the reward structure in classrooms merits consideration in the context of this project. It would seem that embedding academic tasks in an accountability system generates pressure on both teachers and students to use memory or procedural tasks. Comprehension tasks provide high option answering occasions. In other words, a correct answer in a comprehension task can take several different surface forms and, indeed, different answers may be equally correct. This situation requires a considerable amount of interpretation by both teachers and students in order to judge the correctness of answers. Teachers would appear, on accasion at least, to reduce this interpretive load by defining a single answer as acceptable when several answers would be legitimate (see Barnes, 1971; Keddie, 1971; Nash, 1973). Aside from reducing the interpretive load, specificity would also seem to increase student involvement, even more perhaps than extrinsic incentives (Rosswork, 1977). From a student perspective, Davis and McKnight (1976) have described a case in which students strongly resisted an attempt to shift information-processing demands in a mathematics class from procedural to comprehension tasks. The students argued that they had a right to be told what to do and demanded explicit instructions on how to solve problems. (A similar situation has been described by Wilson, 1976.)

One possible reason for this demand is that understanding well-formed explicit problems, in contrast to ill-formed problems, requires less knowledge of the world by the student (see Simon & Hayes, 1976). From the perspective of both the teacher and the student, then, the pressure is toward specificity and explicitness. As these two dimensions increase, academic tasks can be accomplished by memory rather than comprehension. As Davis and McKnight (1976, p. 282) have observed: "it is no longer a mystery why so many teachers and so many textbooks present ninth-grade algebra as a rote algorithmic subject. The pressure on you to do exactly that is formidable!"

This issue of student pressure toward memory tasks would seem to have implications for two areas of classroom inquiry. First, it provides a perspective for examining the question of reciprocal influence in classrooms, a question raised in Chapter 2 of this report. Second, it gives a framework for examining research on student attitudes toward teachers. From a student perspective, a "fair" teacher is likely to be one who explicitly teaches reliable formulas for getting answers.

In summary, it would appear that the reward structure in classrooms drives the task system. The accountability system within which an academic task is embedded can change the nature of the task. Moreover, if accountability is not present, i.e., if answers are not required or any answer is acceptable, then the task system itself is suspended. To the extent that the task system is the primary treatment unit in classrooms, the reward structure affects outcomes through its effect on tasks.

Classroom Conditions: The Group Setting

In contrast to laboratory settings in which most learning research is conducted, academic tasks in classrooms are accomplished in an environment of considerable inherent complexity. In this section, two aspects of the classroom as a task environment are considered: (1) the group circumstances under which tasks are accomplished; and (2) the instructional materials students use in accomplishing academic tasks.

A classroom embodies a very complex information system (for more details on this description, see Doyle, 1977b). There is a rich array of printed materials and media as well as comments from a teacher and twenty to thirty students. Any one of these resources can assume significance for a task depending on particular circumstances. In addition, many formal instructional cues are unreliable. Instructions from teachers are not always complete and feedback is sometimes inaccurate. Finally, the classroom is a mass processing system that is not always adaptive to the needs and interests of an individual student. It may be difficult, therefore, for an individual to get the information needed at a particular moment. To learn in classrooms, therefore, a student must develop considerable <u>interpretive competence</u> to identify relevant instructional cues and utilize them to help define academic tasks and gain information necessary to accomplish those tasks (see Cicourel, 1974; Dweck, Hill, Redd, Steinman, & Parke, 1976; Mehan, 1979). Students who have problems focusing on the central material of academic tasks are not likely to learn from classrooms (see Mondani & Tutko, 1969).

The fact that academic tasks in classrooms are accomplished in a group setting has at least three consequences. First, answers are often public. This publicness may discourage some students from participating in classroom activities for fear of criticism from peers (Potter, 1974). Indeed, it is likely that public performances, such as presenting reports in class, have considerable accountability press that engenders a high degree of task involvement. Second, the group nature of classrooms means that other students are potential resources for task accomplishment. This effect can be both direct and indirect. That is, a student might directly consult another student for answers or for clarification of task requirements (see Weisstein & Wang, 1978). Or a student can learn from the questions other students ask the teacher what the task is and how it can be accomplished. Tasks, in other words, may be negotiated publically to the benefit of all students in the class.

The way in which classmates become resources depends upon the way in which instruction is organized in a classroom. Studies indicate that student-to-student interaction is higher in open or team structured classrooms than in traditional teacher-led classrooms (see Hallinan, 1976; Slavin, 1978). In part, this student orientation results from the fact that in open structures the teacher typically has a less direct role in providing information to the whole class. In teacher-led classrooms, students appear to focus attention on the teacher as a primary resource; in student-centered classrooms, students rely more on each other as resources (see Johannesson, 1967, p. 20; Short, 1975). In fifth-grade science, Shymansky and Matthews (1974) found, for example, that in contrast to student-structured classrooms, students in teacher-led classrooms:

1. spend more class time observing the teacher;
2. spend more class time following teacher directions regarding what activity to do and/or how the activity should be done;
3. spend less class time doing activities in which no specific teacher directions are followed, i.e., doing an activity of their own design;
4. spend less class time responding to teacher questions;
5. spend more class time initiating (or attempting to initiate) interaction with the teacher and continuing self-initiated interaction with the teacher;
6. spend less class time receiving ideas from another student (who is not demonstrating for the teacher), and
7. spend less class time giving ideas to another student (not at the request of the teacher)(p. 164).

Some insight into the dynamics of how students use each other as resources is available in Pepitone's (1972) report of experiments in which third-grade students were given a puzzle to assemble under different instructional conditions. The experiments were conducted by randomly drawing five students at a time from the same classroom and having them assemble the puzzle in separate experimental room in which the students could talk to each other and view each other's work. In the first experiment, all students assembled the same puzzle, but in one condition a model of the completed puzzle was present and in the other the model was not available during assembly. Pepitone found that when the model was absent students looked to each other, but when the model was present they attended to the model. In the second experiment, the model was not provided during assembly, but students in one condition worked on the same puzzle and in the other condition they worked on different puzzles. In this experiment, more social comparisons were made in the identical task condition. Pepitone also found that in the model-absent conditions, there was more evaluative interactions, more negative social acts, and more "besting" behavior, i.e., attempts to do better than the other students, than in the model-present condition. In addition, students also compared work even when they were working on different tasks. What seems to be happening here is that in the model-absent, identical-task condition, the investigator created a "test-like" event. As a result, students became competitive and took advantage of the opportunity to talk and view each other's work. The frequency of evaluative interactions would seem to be one way of arriving at a standard for acceptable performance in the absence of a model by which they could easily assume they would be judged. Finally, the comparisons made while working on different tasks probably reflected an attempt to adjust the pace of work output by reference to the pace of the other members of the group. Such monitoring for pacing purposes in likely to be a common phenomenon in classrooms.

The third consequence of the group nature of classrooms is related to task accountability. Because tasks are administered to a group and performance on these tasks must often be evaluated publically, a teacher would be under pressure to adjust standards and pace to the level at which most students can accomplish tasks (see Arlin & Westbury, 1976). This again may limit the utility of comprehension tasks which typically require considerable skill to accomplish (see Greeno, 1972). Moreover, prompts which are given to lower ability students to assist them in accomplishing tasks are also available to other students who may not need such prompts. As a result, some students may end up working on a task at a level that is considerably below their ability. Finally, it would seem to be difficult to maintain individual accountability in a group setting. It is always possible that a student can copy answers from others or slip through the accountability system in other ways. The problems of maintaining a tasks system in classrooms would seem to be formidable.

The group setting in which academic tasks are accomplished in classrooms provides, then, a rich array of potentially supporting and interferring resources. Students appear to be able to shift attention to those resources which are optimal for a particular set of circumstances. In the absence of a direct teacher role in providing information about tasks and their accomplishment, students will turn to each other for assistance.. The availability of classmates also means that some students can circumvent the task accountability system and many students will probably be working on tasks at a level below what they are capable.

Classroom Conditions: Materials

Descriptive studies indicate that a large amount of classroom time is structured around printed materials (see EPIE Institute, 1977; Nash, 1973; Rosenshine, 1976, 1979). Over 60% of classroom time is typically spent in seatwork and even other activities such as teacher lectures and discussions are often based on the textbook or other materials. Clearly, materials are an important resource in accomplishing classroom tasks. In this section, two aspects of instructional materials will be briefly considered: (1) the nature of these materials; and (2) their match to learner abilities.

Careful analysis of the discourse properties of school texts indicate that they often present students with complex logical and inferential tasks (see Frederiksen, Frederiksen, Humphrey, & Ottesen, 1978; Gammon, 1973; MacGinitie, 1976). In an extensive analysis of the suitability of eight beginning reading programs for compensatory education students, Beck and McCaslin (1978) concluded that many programs present material to students in ways that are likely to cause confusion and contained recommendations to teachers for instructional procedures that are often convoluted and demanding from the student perspective. In many instances, then, it would appear that a significant portion of students would have a difficult time learning from textbooks.

Jorgenson (1978) has provided some naturalistic data on the match between textbooks and students reading ability, and the consequences of this match for classroom behavior. The study focused on reading and social studies at the third and fifth grade levels in an urban elementary school. In third-grade reading, the teachers were able to match students to textbooks written at several reading levels. In fifth grade social studies, there was a single text for all students. In the reading classes in which teachers could match students to texts, 61% of the students were assigned to material easier than their ability level. In social studies classes in which only one text was available, 85% of the students were required to learn from material that was beyond their reading ability. Jorgenson also found that students who were assigned to material below their ability levels were rated by teachers as better behaved. In addition, when students were assigned to material that exceeded their ability they tended to spend more time relying on the teacher and other students for assistance.

Finally, Armbruster, Stevens, and Rosenshine (1977) studied the content covered and emphasis in three reading curricula and two common standardized tests, focusing on the second half of third grade. They found that the overlap between the texts and the standardized tests was low. The reading curricula tended to emphasize "comprehension skills that appear to require inference, interpretation, identification or relationships, and synthesis" (p. 8). The tests, on the other hand, tended to focus on "factual items entailing locating information in the presented text" (p. 8).

Clearly more research is needed on the cognitive demands of instructional materials, given the large amount of classroom time that is structured around this resource. The evidence reviewed here suggests that many students would have difficulty learning with comprehension from the instructional materials they encounter in classrooms. It would be important to know, therefore, how teacher maintain task systems in classrooms when such materials are used. One suspects that a considerable amount of explicit prompting by the teacher is necessary for students to accomplish tasks that are based on printed material. In addition, if the tasks cannot be accomplished with comprehension, then memory or the learning of algorithms is likely to be the operations most students use in attempting to accomplish academic tasks.

History

One of the distinctive characteristics of classrooms is their history. A classroom group convenes regularly for a period of three to nine months, depending on the grade level and the schedule of the school system. As a result, a class has a history. In this section, the consequences of this history for task accomplishment and outcomes are explored.

As mentioned in Chapter 3, the task effects increase with repeated experience. The fact that classrooms have a history means that task effects should be particularly robust in these settings. That is, tasks should serve as the primary stimulus sorting mechanisms for students in classroom environments.

Over the course of the year there is likely to be a tuning to task demands. At the beginning of the year students face the initial problem of constructing a cognitive representation of the task or tasks that the teacher is establishing. That is, they must understand the goal, and the operations that are allowed by the teacher to achieve that goal. It is necessary, therefore, for students to gather data about task requirements. Indeed, students seem to be especially sensitive to task information when encountering a classroom for the first time, even more so than teachers (Morine-Dershimer, 1976). Reliable information about task demands may not be available to students during the first few days. They may have to wait, for instance, until the first formal test to determine what the teacher expects and allows.

During the initial phase of the year, student monitoring of instructional stimuli is likely to be broad. Once a cognitive representation of the task system is constructed, however, students can predict performance expectations and select more efficiently from the array of stimulus information available in a classroom (see Bransford, Nitsch, & Franks, 1977; Schank & Abelson, 1977). Attention can, in other words, become tuned to the demands of tasks and students can tag relevant information which may not be specifically tagged by the teacher as important to learn. For instance, the sentence "Groundwater returns to the ocean during the hydrologic cycle" can easily be coded as a likely candidate for a test item regardless of whether the teacher explicitly underscores the sentence as one that needs to be learned. All the students need to know now is whether the item will be verbatim or paraphrase in order to select an appropriate rehearsal strategy.

Experienced students have an advantage in the opening of the year since they are likely to have acquired classroom task schema or scripts from previous attempts to solve the problem of understanding task demands (see Reed & Johnsen, 1977; Schank & Abelson, 1977). For such students, the initial problem may simply be one of determining whether an existing script can be instantiated in a particular situation. If an existing script fits the situation, the problem of understanding the task system can be resolved early. If existing scripts are not applicable, then the students must engage in the more difficult process of formulating a plan, i.e., constructing a new representation to meet the specific demands of the task (see Schank & Abelson, 1977).

Some indirect evidence concerning how tasks serve as sorting mechanisms for students is available in studies of attention or notetaking in lectures. In a stimulated recall study, Siegel and his associates (1963) found that an individual's attention to content varied widely across the "critical moments" when the experimenter stopped the tape. Since the lecture was embedded in a classroom task system, it is possible that task demands were being used to selectively attend to lecture content. Locke (1977) studied lecture notes taken by college students in twelve different classes. Compared to a set of "ideal" notes, Locke found that student notes were seldom inaccurate but the average student had only 60% of the content in the notes. If, however, information was written on the board, 88% of the content was in the notes. In addition, new material was more completely represented than review of previous material or information that was also in the book. Again, there appears to be a selectivity factor operating which may be related to the macrostructure of tasks operating in these classrooms. Unfortunately, in neither study were tasks described.

One of the most interesting investigations of classroom lectures was reported by Kintsch and Bates (1977). The investigators attempts to determine whether the macrostructure of the lecture content, i.e., the semantic organization of knowledge in the lecture, would predict what students remembered from the lecture. The lectures were carefully designed and given as part of a course in psychology. Students were tested for recognition of verbatim and paraphrased sentences as well as sentences not appearing in the lectures. The tests focused on both the content of the lectures and extraneous comments, such as announcements or jokes. The results indicated that students were able to discriminate spoken sentences or paraphrased sentences from those that did not appear in the lectures. Scores for verbatim sentences were also higher initially than scores for paraphrased sentences and verbatim memory for sentences tended to remain high in a delayed test. In addition, memory for extraneous sentences--announcements and jokes--was better than memory for descriptive statements. The investigators attribute this effect to the distinctiveness of these statements in the lectures. It could also be evidence for a form of episodic encoding similar to memory for locations in a sequence of a passage or place on the page. The investigators did not find, however, that students remembered sentences higher in the content hierarchy of the lectures better than sentences about details. These results differ sharply from those for text memory (see Meyer, 1975). Unfortunately no analysis was reported for the task demands in the course. It is possible that the task system would account more completely for the selective attention of the students than the content structure of the lectures.

In Chapter 3 the argument was developed that when task effects are strong, the effects of prompts and adjunct questions will depend upon their relevance to accomplishing the task. Because of history, this argument should certainly apply to the use of instructional prompts in classrooms. Whether students pay attention to teacher questions or participate in a classroom discussion would seem to depend upon the relationship between the discussion and task accomplishment. If, for example, the discussion focuses on discovering the solution to a problem, but the test requires that the students remember the solution arrived at in class, then it is likely that students will attend to the solution rather than to the processes of obtaining a solution. Similarly, if the presentation of a procedure in class focuses on understanding how the procedure was derived and why it works, but the assignment is to solve 25 computational problems, then attention is likely to focus on learning the computational steps necessary to produce answers efficiently.

Duchastel (1977) has reported an interesting study concerning how instructional prompts are used. In this study, high school students were given four trials in which they received objectives, read a passage, and took a test. The objectives were specific statements concerning what they would be tested for. In one condition, students received objectives which were congruent with the test; in a second condition, students received objectives which were incongruent with the these, i.e., the content specified by the objectives consistently did not appear on the test. The results of a free recall test on the fourth trial indicated that students who received the congruent objectives remembered nearly all of the content relevant to the objectives but very little of the content not relevant to the objectives. In other words, students used the objectives to select information for processing during reading. In the incongruent condition in which objectives never predicted test items, students remembered slightly more content not relevant to the objectives than content relevant to the objectives. In fact their performance was not substantially different from that of a control group who did not receive objectives at all. It appears that the students in the incongruent condition did not use the objectives to guide their processing of the passage since they did not help task accomplishment. Indeed, then did not even use them in a negative sense, i.e., as indicators of content that does not need to be processed. In part these results suggest that negative instructions are hard to use: knowing what not to learn does not tell someone what to learn. In addition, however, these results may reflect the fact that incongruent objectives represent an anomalous classroom condition which probably cannot be trusted. Knowledge of classroom tasks suggests that the most useful strategy in such a condition would be to ignore the objectives and process as much of the content of the passage as possible to be able to adapt to whatever test might be given.

One final comment about classroom history is in order. Given the amount of work involved in constructing or instantiating a cognitive representation of classroom tasks and the advantages of cognitive tuning for monitoring the classroom system, there is likely to be pressure from students to maintain stability in the task system throughout the semester or year. That is, students are likely to want a teacher to maintain the same type of academic task, whether memory, procedural, or comprehension, across different segments of content in the course of subject matter area. Such stability leads to predictability which, in turn, simplifies the task of identifying appropriate stimuli. When tasks change, predictability is lost and students must construct new plans in order to select and process information efficiently for task accomplishment. This suggestion of a functional value for task stability has implications for understanding the problems of changing a curriculum. It is also likely to have been a factor in the student resistance Davis and McKnight (1976) reported for an attempt to change a mathematics course from procedural tasks to comprehension tasks.

Classroom Knowledge Structures

The foregoing analysis suggests that student knowledge structures are built around classroom tasks. Thus, the knowledge students have of subject matter is embedded in their cognitive representations of the tasks they encounter in classrooms. To conclude this chapter, two implications of this embedding are discussed.

The first implication of embedding is that the semantic integration of content is likely to take place with reference to classroom tasks rather than the structure of the subject-matter field. White (1971) argues that a student's cognitive map of content is essentially a map of school experience.

> His experiences in school are the organizers of his knowledge, until high school or later, before he makes connections within that knowledge. Until then, the schema that serves him is his school life. That schema, in turn, is organized by the way in which school life itself is organized, that is by grade level, by "subjects," by teachers, and by the daily schedule.... Particular knowledge and skills are

considered by the pupils to be important, depending upon the workload assigned to them, and the frequency of evaluation.... The converse is also true. Anything the teacher mentions once, but does not repeat, does not assign work in, and does not test for, is dismissed as unimportant. This might well include the following: Why we study this subject, what this topic has to do with some other topic, how this piece of knowledge fits into that piece from last year, how this operation relates to another in a different subject, how we can generalize from this instance to other instances..." (White, 1971, pp. 340-341).

The central point is that accomplishing classroom tasks will not necessarily lead to the construction of high-level schemata within an academic discipline that will enable a student to use subject matter knowledge flexibly to deal with novel instances or inferences within the discipline. This type of effect will result only if such academic schemata are necessary for accomplishing classroom tasks, i.e., if all academic tasks in classrooms are comprehension tasks.

The second implication of embedding has to do with the nature of the tasks students are likely to encounter in classrooms. There is probably a wide variety of academic tasks across classrooms. McCutcheon (1976), for instance, described a science lesson in three different fourth-grade classrooms. In one class, the emphasis was on isolated facts. In the second class, there were many unresolved questions and an emphasis on personal interpretation. In the third class, the emphasis was on problem-solving under strong guidance from the teacher. Despite these possible differences, there is considerable evidence that most classrooms are dominated by memory and procedural tasks rather than comprehension tasks (see Durkin, 1979; Hoetker & Ahlbrand, 1969; Power, 1977; Rappaport, 1974). Students are often required, in other words, to reproduce information encountered in textbooks or teacher presentations. Or they are required to learn procedures in order to achieve the computational accuracy or the production efficiency necessary to complete assignments.

Even when comprehension tasks are used by teachers, many students may lack the background or the time required to construct knowledge schemata necessary to accomplish these tasks through comprehension (see Bransford & Franks, 1976; Greeno, 1976; Norman, 1975 on the processes necessary to achieve comprehension). In such cases, students are likely to use memory or a variety of idiosyncratic procedures to accomplish tasks which are beyond their ability to understand (see Gelman, 1972).

The prevalence of memory and procedural tasks means that students are likely to rely on episodic encoding of subject matter to accomplish classroom tasks. Under such circumstances, students are not using subject matter information to update their knowledge of the world but rather are contextualizing such knowledge as separate from their own schemata (see Anderson, 1977; Spiro, 1977). As was pointed out in Chapter 3, knowledge which is stored in an episodic form cannot be adapted flexibly to novel instances or to the making of inferences. Indeed, recall for such information is dependent upon congruence between encoding cues and retrieval cues. From this perspective, Duke's (1977; Duke, Muzio, & Wagner, 1978) finding that students had a difficult time telling an outside interviewer what they had learned in a social studies course is understandable. The retrieval cues may simply not have been sufficient for recall.

The central point of the present analysis is, however, that classroom tasks provide a context for learning subject matter. As a student gains knowledge of classroom tasks and how they are accomplished, this knowledge can be used to select and encode academic content. In this way, the macrostructure of tasks provide a semantic context within which memory and procedural tasks are meaningful.

Summary

In this chapter, an attempt was made to connect the general task model more closely to the concerns of teaching effectiveness research by examining academic tasks in classroom environments. Academic tasks were viewed as the central treatment mechanisms in classrooms, and the effects of different tasks--memory, procedural, and comprehension--

were identified. When academic tasks are embedded in classroom environments, certain transformations of these tasks occur because of the evaluative climate, group setting and materials, and history that characterize these settings. The final point is that student knowledge of academic content is integrated into the cognitive representations of the tasks they accomplish in classrooms. The macrostructure of tasks provides, therefore, the context in which classroom events are meaningful.

Chapter 5

IMPLICATIONS FOR RESEARCH ON EFFECTIVE TEACHING

The present project began as an attempt to elaborate more fully the mediating process paradigm for research on teaching effectiveness. It is necessary in this final chapter, therefore, to relate the model-building aspect of the project to central issues in the study of effective teaching. The chapter is organized into three sections. In the first section, the essential features of the task model and the advantages of this model as a treatment theory for research on teaching are summarized. In the second section, the implications of the task model for interpreting available findings from research on teaching effectiveness are considered. In the final section, questions for further research are identified.

A Treatment Theory for Research on Teaching

To interpret process-product relationships it is necessary to have a model of the cognitive processes that connect classroom events to outcomes. In other words, it is necessary to have a treatment theory that specifies the conditions which activate subject matter processing in classroom environments. The present project was directed to the construction of such a model, using as a major resource the recent work in cognitive psychology. The model which emerged from this analysis was based on the fundamental concept of task. A task is a situational frame defined by a goal and the operations necessary to achieve that goal. A fully specified model of a task delineates the information-processing responses necessary to accomplish the task. Especially in formal situations such as classrooms, tasks organize and direct experience.

As an approach to teaching effectiveness research, the task model has at least two major advantages. First, the model successfully connects features of the classroom environment with student information processing and outcomes. The macrostructure of tasks provides instructions for building schemata that connect goals and cognitive operations designed to achieve these goals. These schemata, in turn, set the stage for monitoring classroom events and selecting from the array of environmental stimuli those dimensions of content and instructional prompts which are relevant to task accomplishment. "Pupil pursuits," in other words, are guided by the tasks they encounter in classrooms. As tasks are accomplished, students acquire capabilities that are reflected in scores on outcome measures. Moreover, the connection between events and outcomes is made at the class level rather than at the level of individual student aptitudes or the interactive contacts between a teacher and a student. That is, the task model does not simply focus on how certain individuals are likely to process information in classrooms or how these individuals interact with a teacher. Rather, the model directs attention to the class-level structures that organize and direct cognition for all students within a class.

Second, the task model deals directly with content, a dimension of classrooms which, according to recent process-product findings, is consistently associated with achievement. However, the task model deals with content in a way that includes teaching variables. In other words, there is room in the task model for teacher effects. The study of tasks is not simply the study of curriculum effects or subject matter effects. A task defines the curriculum-in-use and the context within which subject matter is experienced. Teachers play an important role in shaping how the curriculum is used by the way they structure academic tasks in classrooms.

It would seem, then, that the task model provides a suitable foundation for building a treatment theory for research on effective teaching. The model is certainly incomplete at this stage. Nonetheless, it provides a place to begin understanding the processes that mediate teaching effects in classroom environments. In addition, the model supplies a framework for relating research from several disciplines to the distinctive features of teaching in classrooms. To illustrate in part this utility, an attempt is made in the following sections to apply the model to interpreting teaching effectiveness studies and to formulating questions for further inquiry.

Interpreting Teaching Effectiveness Research

According to the task model, learning outcomes from classroom teaching are the result of the tasks students accomplish. Tasks, in other words, are the certain treatment units in classrooms. If a task is accomplished, there will be effects. Furthermore, if the same task is accomplished in separate settings, the effects are likely to be similar despite differences in process variables between settings.

Teaching effects will differ, of course, depending on what task is accomplished. In addition, how many students successfully accomplish a task depends upon the conditions under which the task is administered in the classroom. For memory and procedural tasks, gains are likely to occur for all ability levels as resources are maximized, i.e., as the teacher provides cues concerning the nature of the task and clear guidelines for accomplishing the task. Student attitudes toward the teacher are also likely to be positive. As pace increases--i.e., as less time is spent on each segment of content or on each task--then within-group variance is likely to increase (see Arlin & Westbury, 1976; Barr, 1974), unless the ability levels within the group are fairly uniform. A rapid pace under heterogeneous conditions is likely to result in gains primarily at the top end of the distribution of ability. If this happens, mean achievement for the class is still likely to be high (see Atkinson, 1976). Student attitudes, however, will probably be lower than those in classrooms with a slower pace. Comprehension tasks are likely to be most suitable for middle to high ability students (see Greeno, 1972).

Low to middle ability students will probably attempt to accomplish such tasks by using memory or surface algorithms and will probably have negative attitudes. As prompts become more explicit in order to increase the potential for task accomplishment for lower ability students, the task is likely to become a memory or procedural task.

From this perspective, no teaching effects will occur under three conditions. First, if no task is accomplished, then no effects will occur. This condition can arise if no task has been established in the classroom or the task that has been established cannot be accomplished by the students with the resources the teacher has made available. Second, no effects will be obtained if the task accomplished does not involve learning, i.e., if the students already know how to accomplish the task. Finally, no effects will be detectable if the "wrong" task is accomplished, i.e., if the operations necessary to accomplish the classroom task are not measured by the criterion test.

Within the task model, teaching effects can occur at three levels. First, teaching effects occur at the level of accountability. As indicated in Chapter 4, accountability drives the task system in classrooms. If there is no accountability, then there is no task, and whatever effects are obtained will depend upon the personal interests and motivations of students. Accountability is likely to be a very important area of teaching effects. In Good and Grouws (1979) experiment, for instance, variables related to accountability for work were clearly related to outcomes. Accountability is also likely to be closely related to the effectiveness of classroom management (see Emmer, Evertson, & Anderson, 1980; Evertson & Anderson, 1979). Second, teaching effects occur in the definition of task requirements. If task requirements are not clearly defined and maintained, then outcomes will be affected. Similarly, if the task that is defined and maintained is not congruent with the criterion test, then outcomes will not be detectable. Finally, teaching effects occur as prompts and resources for task accomplishment. As pointed out in previous chapters, effects at this level interact with the nature of the task and the nature of the learners. Teacher prompts will have effects to the extent that they provide information required to accomplish tasks. If such prompts are not information resources students can use to accomplish tasks, then they are likely to be ignored. To study prompts, therefore, it is necessary to take into account the task environment.

In this context, teaching behaviors are viewed as task maintenance variables rather than as motivators or reinforcers. As task maintenance variables, teaching behavior cannot be interpreted outside the framework of the tasks within which they occur. If process variables are aggregated across classes in which different tasks were operating (as was often done in early studies of teaching effectiveness), then few clear process-product relationships will be found and those that are found will be difficult to interpret accurately.

Results in the teaching effectiveness field would seem to support this argument. In many recent studies the focus has been on basic skills in the early elementary grades. In such contexts, tasks are likely to be clearly defined and uniform across classes. The process-product findings from such studies have been clear and replicable (see Brophy, 1979; Good, 1979; Rosenshine, 1976, 1979). The results of the Texas Junior High School Study are especially instructive in this regard (Evertson, Anderson, & Brophy, 1978). In the math data, where task conditions appear to have been more uniform, the results were internally consistent and clear. In the English data, where the content label was probably less descriptive of learning tasks, the results were less consistent and less interpretable.

Pooling process data across tasks, then, is likely to mask process-product relationships. In addition, this practice is likely to lead to false interpretations. Differences between classrooms that are attributable to tasks are likely to be attributed to teaching variables. Thus, teaching practices that are in fact effective for a particular task will be labeled ineffective because they are not associated with gains for another task. To locate teaching effects it is necessary to hold task variables constant. Moreover, improving instruction in some situations may involve changing tasks to conform to expected outcomes rather than simply changing teaching practices.

The task model would seem to be a useful framework to account for specific results of recent process-product studies. In direct instruction, for example, task requirements are likely to be clear, accountability high, and treatment effects uniform across the group. It is reasonable to expect gains under such conditions, especially for memory and procedural tasks which depend upon directed practice for their effects. As indicated in previous chapters, however, questions can be raised about the durability and transferability of effects achieved under direct instruction. Performance may be highly dependent upon the strong prompts available in direct instruction classrooms. High structured teaching might produce, in other words, a "heart pacer effect" in which performance is sustained by the instructional system rather than by the learner. This possibility calls attention to the need to examine the nature of teaching effects and their long-term consequences.

In individualized or open-structure classrooms, management is likely to be difficult and accountability hard to maintain for all students. The possibility is high, therefore, that some students will slip through the tasks system in such classrooms by having other students do the work or by otherwise avoiding accountability. This possibility merits attention since it might explain the findings which indicate that achievement is lower in individualized and informal classes (see Bennett, 1976; Brophy, 1979; Rosenshine, 1976, 1979).

Finally, the effects for types of questions might eventually be explained in terms of task variables (see Gall et al., 1978; Program on Teaching Effectiveness, 1976). Lower cognitive questions may simply signify more specific accountability than the more general and indeterminant higher cognitive questions. If so, such questions would activate more specific and thorough processing of subject matter. In this case, outcomes would be attributable to accountability rather than to direct treatment effects of the questions.

The task model would seem, then, to be a useful tool for interpreting the results of teaching effectiveness research and a framework for examining some of the troublesome questions that have arisen in the field. Indeed, the task model would seem to have captured one of the central elements that structures experience in classroom environments. As such, the model becomes an important tool for any study of classroom processes.

Questions for Further Research

The final section of the report focuses on questions for further research that flow from the task model of how teaching effects occur in classroom environments. The discussion of these questions is divided into four broad areas.

First, there is a critical need for more research on what tasks are used in classrooms. In the present project an attempt was made to map classroom tasks with the available evidence. In many instances this evidence was precariously thin. More descriptions of the nature of classroom tasks and how they are scheduled throughout the year would provide a better foundation for understanding how teaching effects occur in classrooms.

These descriptions should include attention to the process variables associated with different types of classroom tasks. For example, process questions may be more appropriate for comprehension rather than memory or procedural tasks. Certainly the match between classroom processes and task characteristics is likely to be imperfect. Nevertheless, it would be helpful to know more about the process variables that are associated with different types of classroom tasks in order to interpret process-product findings more accurately.

Second, there is a need for research on how the task system is realized in classroom environments. Such research should focus on the way tasks are established and maintained and how tasks are adjusted to meet the many contingencies of life in classrooms. It is certainly reasonable to expect that different tasks require very different configurations of classroom management. Until more is known about these configurations, it will be difficult to understand how conditions associated with effective teaching are brought into being in classrooms. Such an understanding is essential if the findings of teaching effectiveness research are to be put into practice.

Third, there is a need for more research on the task-relevant schemata of teachers and students. From a student perspective, task schemata are the primary mediators of teaching effects. For some students, the problems of learning from classrooms may originate in their understanding of the classroom system. The more that is known about how children understand classrooms the greater the possibility of helping students to be more effective learners. From a teacher perspective, the tasks which are established in classrooms are the primary means of influencing student achievement. It is important, therefore, to know more about how teachers think about academic tasks and how task variables play a part in teacher planning and decision making. Certainly a significant part of learning to be a teacher involves translating knowledge of subject matter into tasks that can be accomplished by students in classroom environments.

Finally, more attention needs to be given to the qualitative, rather than simply quantitative, dimensions of outcomes. More needs to be known, that is, about what is learned in classrooms rather than simply how much is learned. Indeed, most of the arguments about curriculum reform center around differences in the quality of learning outcomes. This focus on quality is especially important in view of the recent studies which indicate that students can successfully accomplish classroom tasks with very little understanding of the academic content which they are supposed to be learning (see Erlwanger, 1975).

Conclusion

In sum, the present project was an attempt to push the mediating process paradigm as far as it would to to see what light it casts on teaching effectiveness research. One outcome of this attempt was the realization that mediational models are inherently problematic. Certainly such models seem to have no end point: mediators at one level can be explained by mediators at a "deeper" level. In addition, it is easy to assume too much about the relationship between teaching variables and student variables in classrooms. Student behavior has many causes that are independent of specific teacher behaviors and the connections between teacher variables and student variables may often be indirect. Finally, mediational thinking readily falls into a presumption of aptitude-treatment interactions. This is an attractive and, indeed, widespread mediational framework, especially since it offers the promise of being able to design learning environments that are more productive for more people. Nevertheless, such interactions are difficult to interpret without an understanding of how treatment effects occur in a complex environment such as a classroom. Moreover, it is naive to assume that classrooms are easy to change or that any change will have intended consequences. There is no substitute for understanding how classroom environments work. As Neisser (1976) has observed: "no change can have 'controlling,' or predictable, results unless the relevant sector of the world is well understood" (p. 183).

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