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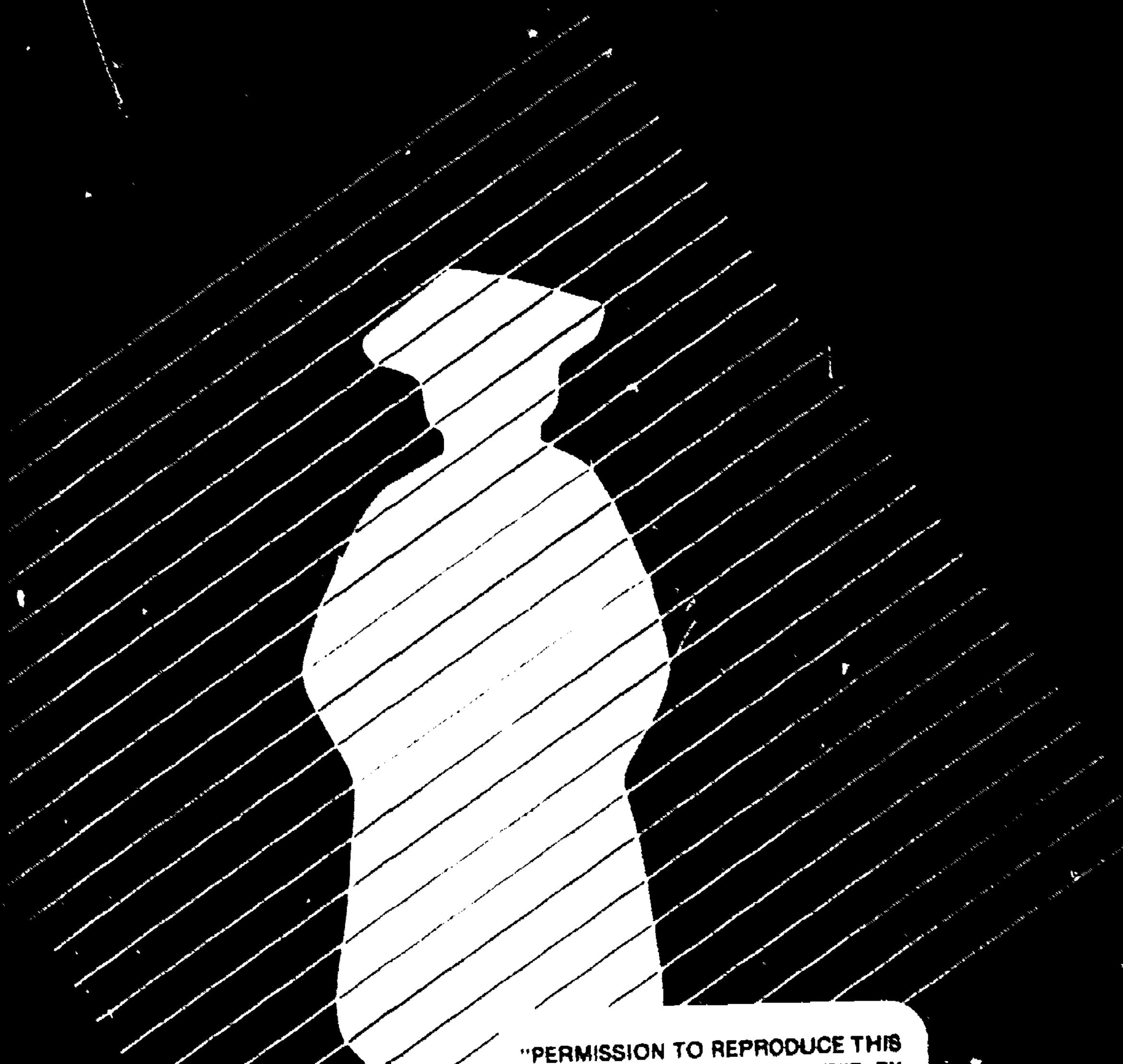
ABSTRACT

A review of the research literature on teaching and learning in the college classroom is presented. An introduction notes the role of research in identifying new goals for higher education and offers a conceptual framework based on a student mediation model and a focus on the process-product relationships between faculty teacher behavior and student outcomes. Individual sections then review the research in terms of: (1) student entry characteristics (intelligence, motivation and personality, and cognitive styles); (2) student cognition (knowledge structure, learning strategies, and thinking and problem solving); (3) student motivation (description of the expectancy path, description of the task-value path, antecedents of motivational constructs, interventions for motivation, and assessment); (4) instructional method (peer learning and teaching, the case method, lecture, class size, independent study, research on learning from reading, programmed instruction and Keller's Personalized System of Instruction, testing, and teaching methods); (5) academic tasks and activities; (6) attribute-treatment interactions; and (7) what effective teachers do. Tables and figures are included. Contains approximately 500 references. (SM)



Teaching and Learning in the College Classroom

A Review of the Research Literature

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I. Introduction

What can college and university teachers learn from the research on college learning and teaching? Not teaching methods that have previously been unknown. Not *the* best method of teaching. Not a magic elixir for motivating reluctant students. One should not expect to find broad generalizations that could not be found in the writing of Comenius, Dewey, William James, or other thoughtful students of education. Excellent teachers fit no single mold; they appear in all historical periods, in various cultures, and at all levels and areas of higher education.

What, then, can research contribute? One possibility is a more precise determination of the limits of generalizations; a second is disproof of faulty maxims; a third is a better understanding of how and why successful teaching strategies work. But research also has implications for teaching in a way that is less obvious; it affects conceptions of the goals of teaching. What we choose as goals depends upon our understanding of learning and of what teaching can produce. Thus a review of research on teaching cannot ignore broader trends in basic research.

A. New Goals for Higher Education

Advances in theoretical conceptions of cognition and motivation *should* make a difference in the ways we think about the objectives of undergraduate instruction. For example, college faculty members have traditionally placed heavy emphasis on the goal of communicating knowledge. But we now know that knowledge of facts and principles involves much more than memorization of isolated concepts, definitions, and facts. As Marton and Saljo (1976a), Dahlgren (1984) and other Gothenburg researchers have demonstrated, there are significant qualitative differences in students' understanding of reading assignments. Today cognitive psychologists emphasize the importance of conceptual structures within which facts and principles are organized. If students are to use their knowledge after completing their course examinations, they need to have elaborated the facts and principles in ways that organize the knowledge meaningfully.

Why is meaningful organization so important? The answer lies in a superordinate goal: *Students should continue to learn and to use their learning in more effective problem solving for the rest of their lives.* When one takes life-long learning and thinking as a major goal of education, knowledge becomes a means rather than an end, and other formerly implicit goals become more explicit. Surely one of the most important determinants of continued learning is interest in behavior and experience. A course that dulls the students' curiosity and interest must be a failure no matter how solid the content.

Just as we implicitly teach motivation for continued learning, we also implicitly teach certain cognitive skills and strategies. We lecture, give reading assignments, lead discussions, require papers and laboratory projects, carry out fieldwork, and give tests—all with the goal of influencing student learning. The kinds of assignments, tests, and classroom activities we use implicitly or explicitly affect the strategies and skills for learning that students develop. Too often both students and teachers carry out their roles routinely without attention to the ways by which the students' skills can be developed and without conscious awareness that different strategies may be appropriate for different situations. Similarly, lecturers and discussion teachers model ways of thinking without letting students in on the methods that are being used. Every course should help students *become aware* of strategies for learning and problem solving. An explicit goal of education throughout the curriculum should be to facilitate the development both of learning strategies and problem solving-skills and of effective strategies for their use.

To summarize, our goals now go beyond transmitting knowledge to helping students develop cognitive structures, skills, strategies, and motivation for continued learning and problem solving.

Effective teaching thus depends upon at least three kinds of knowledge:

1. Knowledge of the *subject matter*— the concepts, principles, and methods of thinking— to be taught. But it is not enough to know the subject matter as a scholar. To know the subject matter for teaching is to know the organization of the subject matter in ways that enable the teacher to pull out concepts at different levels of organization for differing purposes— to know how to build conceptual structures from the simple to the complex— to know how to derive specifics from generalizations and generalizations from specifics, in short, to be comfortable in simplifying while moving toward more complex, more probabilistic conceptual structures.

2. Knowledge of the *students*. Teaching involves building links between the knowledge we are trying to teach and the knowledge and concepts our students already have. We cannot effectively bridge the gap between our knowledge and the students' minds without an understanding of what they believe and know. The tools we use to make the bridge are metaphors, analogies, and examples that build on students' prior knowledge and experience so they can construct meaning out of the words and experiences we provide.

3. Knowledge of *teaching strategies* and skills that facilitate student motivation and learning of cognitive structures, skills, and strategies.

In this paper we review the research intended to enrich the college teacher's knowledge about learning and teaching in higher education— understanding student learning and what kinds of teaching affect learning.

B. Conceptual Framework and Plan of the Review

Our conceptual framework is displayed in Figure 1. This general model serves to organize our review of the literature on teaching and learning. There have been other conceptual models presented to organize research on teaching and learning. One of the best known is Dunkin and Biddle's (1974) presage, context, process, product, model (cf. Shulman, 1986). In Dunkin and Biddle's model, presage variables were defined as teacher characteristics (e.g., demographic variables, experience and training, as well as psychological aspects such as personality, intelligence and knowledge variables) that were assumed to influence the teachers' actual behavior in the classroom (the process variable in their model). For the most part, other programs in NCRIPTAL are integrating these presage variables; so they are not represented in our model. The context variables in Dunkin and Biddle's model included community, school, classroom, and student characteristics. Again, for the most part we will not be addressing the context-process relationships between institutional characteristics and faculty behavior. Although we realize the importance of these presage-process and context-process relationships, we are concentrating on the process-product relationships between faculty teaching behavior and student learning. Other programs in NCRIPTAL will be addressing the presage-process and context-process relationships. For a recent review of these relationships in higher education, see Dunkin (1986).

Although the focus will be on the process-product relationships between faculty teacher behavior and student outcomes, we have adopted a general student mediation model or paradigm for our research. As Shulman (1986) notes, the simple process-product model has gradually fallen out of favor in K-12 educational research, while a student mediation or student cognition model has gained ascendancy. Our model follows this trend and allows us to examine how different patterns of student motivation and cognition mediate the instructional activities that occur in the college classroom. In addition, this approach allows us to investigate context-process issues relating to student characteristics and instruction. Finally, the student mediation model is most appropriate for college students because so much of their learning and studying occurs outside the classroom. Given this fact, it is even more important to investigate how students' cognitive and motivational perceptions about academic work mediate their essential achievement.

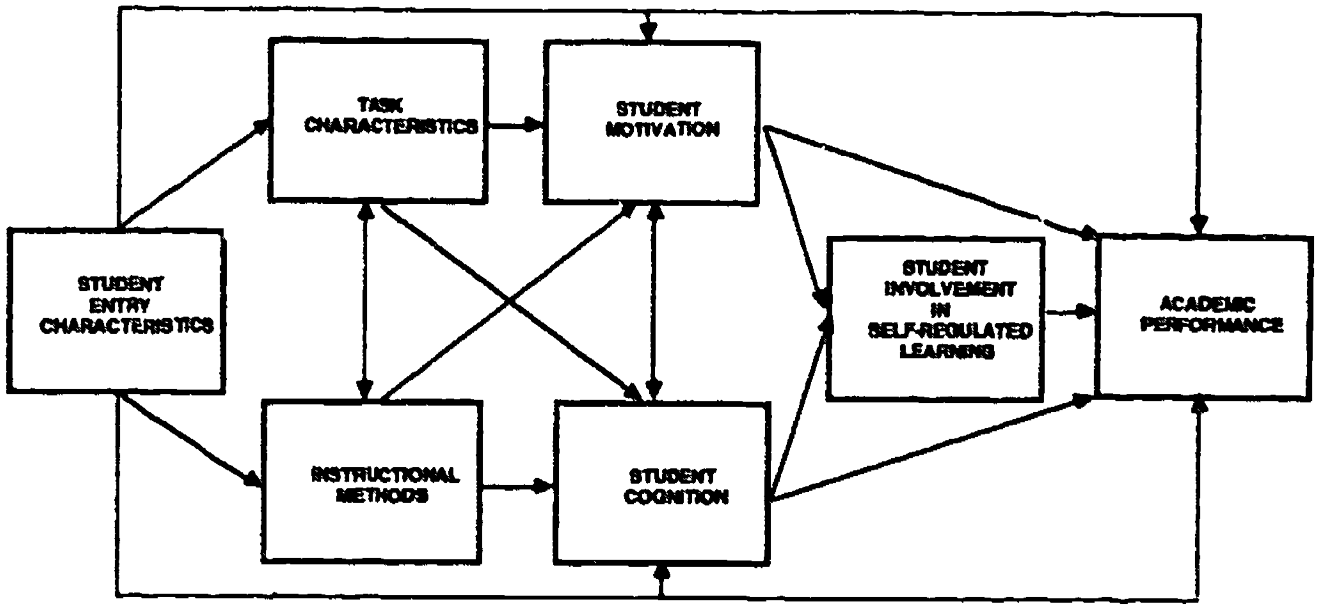

Figure 1. General model of college teaching and learning.

There are a variety of models for conceptualizing student cognitions and perceptions. Our model is based on a general cognitive information-processing and social-cognitive approach to teaching and learning rather than developmental or personality models of student learning. As such, the model integrates material from research in cognitive psychology, instructional psychology, and classroom-based educational research. An important aspect of the model is the assumption that the effects of instruction are mediated by students' cognitive and motivational characteristics. Our model assumes that students are active processors of information. Our emphasis on student perceptions as mediators of instructional activities parallels a variety of general cognitive psychological theories (e.g., Anderson, 1985; Ausubel, 1968; Brown, Bransford, Ferrara, & Campione, 1983; Bruner, 1964, 1965; Piaget, 1971) as well as current research on teaching (e.g., Shulman, 1986). A brief description of the major domains of the model follows.

Educational outcomes can be broadly construed as any of the potential outcomes of college (e.g., see Alexander & Stark, 1986). For our research in NCRIPTAL we will focus on students learning in college courses and our literature review will concentrate on these outcomes. *Student involvement in self-regulated learning* is similar to Astin's (1985) construct, although we take a more cognitive approach to student involvement than Astin's behavioral approach. Our construct of student involvement concerns the students' cognitive engagement (e.g., Corno & Mandinach, 1983) and commitment (e.g., Paris, Lipson, & Wixson, 1983) to the task at hand. We assume that the more a student is meaningfully engaged in the task, the more she or he will learn. Our conceptualization of student involvement in self-regulated learning assumes that the student is an active learner. Self-regulated learning is a combination of cognitive and metacognitive involvement with a task as well as motivated involvement with a task.

Student *motivation* and *cognition* are the two broad domains of student characteristics that influence student involvement. These two domains are reviewed in more detail below. Our conceptualization of student motivation is guided by a general expectancy-value model of motivation that is mostly cognitive in nature. Our cognitive approach to motivation allows us to link motivational constructs to cognitive constructs in an interactive fashion that is lacking in much current cognitive and instructional research. Student cognition, in our model, includes students' general learning strategies for processing information, their knowledge about content, and their general problem-solving and thinking skills.

The *instructional activities* and tasks that student engage in while in college influence their cognition and motivation. Instructional activities include the lectures, discussions, labs, and tutorials in which the students interact with their instructors and peers. The task construct is taken from various cognitive psychological models that stress the importance of the tasks that students are required to perform in school (e.g., Brown et al., 1983; Doyle, 1983; Jenkins, 1979; Mosenthal, 1983). In our model the tasks include the actual requirements of the course (e.g., the papers, quizzes, exams, presentations, lab reports, etc.). This academic "work" plays an important role in our model of student learning because it is through the preparation (i.e., studying), engagement, and completion of these tasks that various cognitive and motivational variables are evoked in the student. These cognitive and motivational variables then influence student involvement and, ultimately, their academic achievement.

Finally, *student entry characteristics* are in our model to represent the realization that students do not enter college (or any educational setting) as "blank slates." Students come to college and enter specific college courses with a variety of cognitive and motivational characteristics from previous educational experience. Obviously, these entry characteristics will influence and interact with the instructional and task activities the students confront, as well as the students' perceptions of the instruction and tasks.

Our review examines research on these constructs and their interrelationships in the college classroom. In some places, the review is quite detailed to allow for complete explication of the model and its complexity. In other places, we assume that the reader has a general familiarity with the literature and does not need detailed guidance. In addition, some aspects of the literature have recently been reviewed (e.g. Donald 1985) in these cases we point the reader to these other sources. Thus this review does not deal exhaustively with educational technology, student characteristics, student development, faculty characteristics of students upon entry and then aspects of cognitive structure, learning strategies, and problem-solving skills. Next we examine student motivation. Finally, we look at aspects of instruction and tasks affecting educational outcomes.

II. Student Entry Characteristics

As our model in Figure 1 shows, we assume that student entry characteristics influence the effects of instruction on student outcomes. This is not a new idea; the importance of individual differences in the ability to learn and benefit from instruction has been a long-standing theme in educational psychology (Corno & Snow, 1986; Pintrich, Cross, Kozma, & McKeachie, 1986; Snow & Lohman, 1984). As Corno and Snow (1986) pointed out, traditional approaches to individual differences in aptitude for learning have focused on three broad categories of individual difference constructs: (1) intellectual abilities, conceptualized as enabling cognitive abilities or skills; (2) personality characteristics, conceptualized as personal motivational and affective traits; and (3) cognitive styles, conceptualized as predispositions for processing information in particular ways. The traditional approach has tended to assume that these individual difference constructs are static, enduring traits of the student. However, current research based on modern cognitive psychology emphasizes a more dynamic process-oriented approach to learner characteristics (e.g., Brown et al., 1983; Corno & Snow, 1986; Pintrich et al., 1986; Snow & Lohman, 1984). Accordingly, our review (and more importantly, our research program) takes this more process-oriented approach to student characteristics.

We have organized our review of student entry characteristics using the three general categories (intelligence, motivation and personality, and cognitive style) of Corno and Snow (1986). Like Corno and Snow, we see these three categories as related in a complex and multivariate fashion, but we discuss them separately for ease of exposition.

A. Intelligence

The classic area of intelligence has probably shown more signs of change in the last decade than in any period since Thurstone and Spearman introduced factorial studies of intelligence. Recent research on intelligence has been revitalized by cognitive approaches. As Gagne and Dick (1983) point out, intelligence tests predict performance in conventional schools and intelligence interacts with instructional methods to affect educational outcomes. But what is intelligence? Undheim (1981a, 1981b, 1981c) has made a persuasive case for the proposition that intelligence is achievement– the result of past learning as well as a predictor of future learning.

The traditional, differential approach to intelligence is best represented by the psychometric paradigm. Psychometric theories of intelligence have attempted to define intelligence by focusing on the number and relationships of factors or latent traits of individuals that explain performance (particularly performance in school) (Sternberg, 1985). Psychometric theories represent individual differences between people in terms of a set of latent factors or traits. These factors are assumed to underlie the individual differences in performance on intelligence tests. Most psychometric theories differ only in the number of factors proposed as a source of variation (e.g., the general "g" factor vs. multiple factors). For example, Guilford (1982) proposed 150 factors underlying intelligence, while recent adaptations of general theories have focused on "crystallized" abilities, "fluid" or analytic abilities and, "spatial-visualization" abilities (Snow & Lohman, 1984).

Snow and Lohman (1984) suggest that crystallized abilities are evoked by familiar tasks and environments, and that noted tasks or unusual instructional techniques that require analysis or decontextualization demand fluid ability. Differences between familiar and noted tasks thus can result in attribute-treatment-interactions (ATIs) between instruction and learners.

In line with this task differentiation view, Gardner (1983) suggests that intelligence varies across different domains or symbol systems such as language, music, mathematics, or physical coordination (kinesthetic). He proposes examining the profile of a learner's intelligences in relation to educational goals and matching students with subject matter and teaching methods to develop further intellectual strength. This approach highlights the fact that the components measured in traditional intelligence tests emphasize the symbol systems used in schools, predominantly the verbal symbol system.

In contrast to traditional psychometric approaches, information processing approaches to intelligence have stressed the dynamic processes involved in intelligence rather than static traits of individuals. Such an approach guides our own research, and we have found Sternberg's model (1985) to be the most relevant. Sternberg has related four general information processing paradigms to intelligence. The *cognitive-correlates* approach has focused on performance of simple tasks, such as letter matching, in an attempt to uncover the basic cognitive processes involved, such as speed of response and speed of word recognition. In contrast, the *cognitive-components* approach has used more complex tasks, such as analogical reasoning, to explore the higher-level components involved in performance involving inference, application, and executive control. The *cognitive-training* approach demonstrates the existence and importance of cognitive functions by demonstrating the effects of training (e.g., Campione, Brown, Ferrara & Bryant, 1982). Finally, the *cognitive-content* approach has examined how differences in the structure and content of individuals' knowledge base influence performance. For example, Anderson (1983) has proposed that individual differences in performance are a function of the flow of information in the mind, with individuals differing in their declarative knowledge (knowing what something is) and their procedural knowledge (knowing how to do something).

Sternberg (1985) has proposed an ambitious triarchic theory of intelligence that attempts to integrate and synthesize most of the research on intelligence. The three subtheories in his overall theory are. the *componential*, the *contextual*, and the *experiential*. We find these three theories useful for our research and a brief description of each follows.

The componential subtheory represents Sternberg's (1985) attempt to specify the mechanisms or cognitive processes responsible for intelligent performance on tasks. The componential subtheory is closest to traditional psychometric and cognitive psychological approaches to intelligence. Sternberg defines a component as an "elementary information process that operates upon internal representations of objects or symbols" (Sternberg, 1985, p. 97). Components can be classified according to three general functions:

a. *Metacomponents* are higher-order cognitive processes used in planning, monitoring, and decision making
b. *Performance components* are cognitive processes used in the execution of a task, and
c. *Knowledge-acquisition components* are cognitive processes used to learn new information

Metacomponents are the control and executive processes that direct, maintain, monitor, and evaluate the two other general types of processes. As such, these processes are metacognitive in nature (cf. Brown et al., 1983). While the specification of these executive components raises the specter of the "homunculus" and issues about control of the executive processes and an infinite regression of homunculi, it is clear people engage in such processes quite easily and readily. Philosophers and experimental cognitive psychologists may argue about the theoretical efficacy of proposing control or executive processes, but they are clearly useful constructs in instructional psychology. Consequently, the following seven metacomponents from Sternberg (1985) are assumed to be relevant for performance in many task situations, albeit not for all tasks or all individuals.

1. *Decision as to just what the problem is that needs to be solved.* This metacomponent concerns the students' skill in figuring out the nature of the problem. Obviously, before any problem-solving skills can be retrieved, the students must understand the nature of the problem (cf., Newell & Simon, 1972). If students understand the nature of the problem, performance is enhanced; if they do not comprehend the task properly, performance is adversely influenced.

2. *Selection of lower-order components.* Students must select a set of lower-order processes to solve the problem. Difficulty in task performance can arise because of selection of non-optimal processes or because students do not have the optimal components available.

3. *Selection of one or more representations or organizations for information.* Students can select a variety of representations of information. Students have to select appropriate representations of the information to facilitate performance. For example, Bransford and and his colleagues (see Bransford, 1979) have shown that activation of the appropriate schema can facilitate memory performance.

4. *Selection of a strategy for combining lower-order components.* A collection of components or processes is not sufficient for good performance. The components must be integrated and controlled in a way that facilitates performance. Some processes need to be activated before others; in many cases processes need to be executed in parallel rather than serial fashion.

5. *Decision regarding allocation of attentional resources.* Students have limited attentional resources and decisions have to be made about how much time to allocate to each process and how the time restriction will influence the quality of performance.

6. *Solution monitoring.* Students must constantly check and evaluate their progress as they perform a task. These self-monitoring and self-regulation processes are important metacognitive skills that influence performance.

7. *Sensitivity to external feedback.* Students must be able to recognize and understand feedback on their performance and then be able to act on it to improve their performance.

These seven metacomponents control and regulate the *performance components.* Performance components in Sternberg's (1985) model are used to execute various strategies for task performance. There are many different performance components, but Sternberg finds a useful way to organize them by three stages of task solution: (1) encoding stimuli, (2) combination and comparison between stimuli, and (3) response. The encoding components involve the way the student perceives and stores new information. In Weinstein and Mayer's (1986) taxonomy these components would include their "selection" component or in Corno and Mandinach's (1983) model, these components would be labeled as "alertness" and "selectivity." The "combination" and "comparison" components include such processes as making inferences, mapping stimuli into other information, comparing stimuli, or applying stimuli. Weinstein and Mayer (1986) label these processes "construction" and "integration." Corno and Mandinach (1983) call these processes "connecting." The last stage of performance in Sternberg's (1985) model is the response component, which involves the students' actual response to the task.

The third type of components in Sternberg's model are the *knowledge-acquisition components.* These components are used in gaining new declarative and procedural knowledge. *Declarative knowledge* is knowledge of the content of a particular subject matter area. *Procedural knowledge* involves "how" to do something. Sternberg proposes three types of knowledge acquisition components that parallel performance components: (a) selective encoding (b) selective combination, and (c) selective comparison. In using encoding, the student distinguishes relevant from irrelevant information (Corno and Mandinach's selectivity). *Selective combination* involves the combination of selectively coded information into a coherent knowledge structure. Weinstein and Mayer (1986) label this process "construction." Finally, *selective comparison* involves relating new information to prior knowledge so that this new information is "assimilated" and understood in term of the old knowledge.

These three types of components (metacomponents, performance, and knowledge acquisition) are most closely related to intelligent performance on academic tasks and the type of tasks that appear on intelligence tests. In Sternberg's model, these components represent the students' *general analytic* ability. Students who score high on standardized intelligence tests and other aptitude measures such as the Scholastic Aptitude Test (SAT) or Graduate Record Exam are able to recruit, employ, and regulate the cognitive processes that are relevant to success on these tasks. As Sternberg notes, however, there are other aspects of the learner that are important for success in life that do not depend on the analytical aspects of the componential model. These other aspects are part of Sternberg's *experiential* and *contextual* subtheories.

The *experiential* component involves the student's ability to be creative and to synthesize disparate experiences in new, insightful ways. This involves being able to go beyond the information given. Specifically, the experiential component involves the student's ability to adapt to novel tasks and situational demands as well as the ability to automatize cognitive processes. An important aspect of intelligent performance is the student's ability to confront novel tasks and to use prior knowledge and present skills in successfully completing the tasks. For example, high school students with good analytical skills (e.g., high SAT scores) must be able to adapt to the new academic tasks of college to succeed. Or, in one of Sternberg's favorite examples, a graduate student in psychology with not very high GRE scores, but high experiential intelligence, performed much better at the creative research and writing tasks required of scholars than another student with much higher analytical skills (componential intelligence).

The other aspect of experiential intelligence concerns students' ability to automatize cognitive processes that are required on specific academic tasks as the students gain more experience with the tasks. For example, reading is a complicated task that requires a variety of cognitive processes. The more students are able to automatize some of the cognitive processes involved (e.g., word recognition), the more they will be able to devote attention to more complex cognitive aspects of reading, such as comprehension monitoring. Although the experiential intelligence subtheory is less well-defined than the componential subtheory, it seems clear that college students must be able to deal with a variety of novel tasks and also automatize various cognitive processes if they are to be successful.

The third and last subtheory, *contextual intelligence*, concerns students' ability to adapt to and manipulate the environment. In more colloquial terms, it involves the students' "street smarts" or practical intelligence. In Sternberg's view, adaptation to the environment is one aspect of the contextual subtheory. It also is important, however, for the student to be able to select and shape the environment to fit his or her needs. For example, a student may not be able to adapt the course requirements to a particular instructor's teaching style. One option for the student is to try to change the course requirements; a second is to change to a different section of the course with a different instructor and course requirements. The ability to understand and manipulate the system to achieve a better person-environment fit is an important skill for students. To accomplish this goal, students must not only have good problem-solving skills, but also social competence in terms of relating to others and understanding their needs and desires.

For this review our purpose in reviewing the research on intelligence is to identify general intellectual skills that both affect student learning and become goals for educational change. Identifying the components of intelligence would be of less value for our purposes if these components were basically determined by heredity and unaffected by education. Fortunately evidence of the impact of education on intelligence is accumulating (Balke-Aurell, 1982).

Correlations between student cognitive variables and the cognitive outcomes of education are typically positive but not so high as to leave little room for the influence of other variables (Cronbach & Snow, 1977). In general both prior knowledge and general intellectual abilities contribute to cognitive outcomes, but teaching bright, naive students is not greatly different from teaching students with lower intelligence. Siegel and Siegel (1964) found that both intelligent students lacking in background and students with low intelligence learned more when taught by a highly structured method while intelligent students with good background knowledge did better with less structure.

As the Siegel and Siegel studies illustrate, prior knowledge and intelligence not only are general predictors but they also interact with teaching methods to affect learning. In general more highly structured methods, such as programmed instruction, work best for students with less prior knowledge or lower ability; less structured methods are likely to be preferable for students with more prior knowledge or ability (Goldberg 1969; Owen, et al., 1965).

B. Motivation and Personality

The student entry characteristics of motivation and personality have been investigated by many researchers for their interactions with instruction (Corno & Snow, 1986). Although many different personality variables have been studied, (e.g., authoritarianism, reflective-impulsive, rigid-flexible), few personality variables have been shown to have consistent relationships with instruction and achievement (Corno & Snow, 1986; Cronbach & Snow, 1977). In addition, modern personality theory and research has moved in the direction of conceptualizing personality variables in terms of process-oriented, dynamic characteristics of individuals rather than stable, enduring traits. This modern approach also emphasizes the importance of situational characteristics for determining an individual's behavior. While there is continuing controversy on the nature of traits and states and the situational and cross-situational stability of behavior (e.g., Allen & Potkay, 1981; Epstein & O'Brien, 1985; Epstein & Teraspulsky, 1986; Gangestad & Snyder, 1985; Mischel & Peake, 1982), we have adopted an intermediate position similar to that of Corno and Snow (1986). Basically, we recognize the importance of situational influences on student behavior, hence an emphasis on the classroom context and the types of classroom tasks. At the same time, we are interested in individual differences in reactions to these situations. Accordingly, we have adopted a general attribute-treatment interaction (ATI) model that is a special case of a person-environment or person-situation interaction psychology (cf. Corno & Snow, 1986).

Since our main interest is student learning and academic achievement, the main "personality" variable of interest to us is students' achievement motivation. Interactions between different motivational constructs and instruction have been investigated often. Constructs such as need for achievement, test anxiety, attributional patterns, self-efficacy, self-concept, and self-esteem have been used as interaction terms in Section IV, which details our model of motivation and the underlying constructs we will be studying. However, several general points can be made about student motivation as an entry characteristic.

First, as many studies of test anxiety have shown (cf. Sarason, 1980; Tobias, 1985), test anxiety often has a curvilinear relationship with achievement. The relationship is generally of the inverted-U form with students at medium anxiety levels performing better than students with very low or very high levels of anxiety (Corno & Snow, 1986). Other researchers have suggested that other motivational constructs show a similar curvilinear relationship to performance (e.g., Salomon 1983). In our own work (e.g., Pintrich, 1986), we have shown that motivational constructs influence students' performance by mediating the effects of learning strategies. Other researchers have shown linear effects of motivational variables (e.g., Bandura, 1982; Weiner, 1979) on performance. Obviously, more research is needed on how motivation interacts with students' cognition and with instruction. Recent reformations of motivation theory in cognitive terms make the examination of the interactions between cognition, motivation, and instructions easier. Our research agenda addresses the interaction of these three domains in line with current approaches to instructional psychology (Pintrich et al., 1986).

C. Cognitive Styles

The student entry characteristic of cognitive style has a long history in educational psychology as one of the most commonly investigated individual difference variables. The generally accepted definition of cognitive style is that cognitive styles are information processing regularities that are related to underlying personality traits. (Corno & Snow, 1986; Messick, 1984b). As Corno and Snow (1986) point out, cognitive styles are conceptually at the overlap between individual differences in intellectual abilities and personality characteristics. Kogan (1983) points out that cognitive styles are often measured in the same fashion as general intellectual abilities. For example, field independence-dependence is often measured by the Embedded-Figures test, which could also be used as a test of spatial ability. Given the same operational measure for field independence-dependence and spatial ability, the reasoning behind labeling an individual's performance as indicative of a cognitive style (field independence-dependence) or a general skill (spatial ability), obviously rests with the researcher's theoretical orientation (Kogan, 1983). A wide variety of cognitive styles have been investigated (e.g., field independence-dependence, cognitive complexity-simplicity, reflectivity-impulsivity, convergence-divergence, etc.). Reviews of cognitive style by Kogan (1983), Corno and Snow (1986), Messick (1976 and 1984b) and Witkin, Moore, Goodenough, and Cox (1977) suggest that some measures of cognitive style are relevant to student achievement, although in many cases they have not been differentiated from components of intelligence. Moreover, the notion of cognitive style as a fixed, unchanging personality attribute is giving way to theoretical conceptions of cognitive styles as preferred sets of strategies or approaches to learning and thinking. Thus our own research will focus on cognitive strategies rather than cognitive styles. Given our cognitive, process-oriented approach, we will be looking for general differences in the ways students process information. In line with this orientation, Marton and Saljo's (1976a, 1976b) work on learning styles is relevant.

Marton and Saljo's method involves observation and questioning of students reading textbook chapters. They found that students' approaches to the task differed. Some simply plunged in and plowed through the chapter, satisfied that they had gotten through it; others tried to find the aim of the author, looked for clues to organization, and thought about the meaning of the chapter. Marton called the former *surface processors* and the latter *deep processors*. This distinction is similar to Ausubel's distinction between rote and meaningful learning and to Entwistle, Hanley, and Hounsell's (1979) "identifying, "reproducing," and "understanding" learning. Many of Marton and Saljo's *deep* processors may simply be effective learning strategists. Marton and Saljo point to the fact that what students want to get out of studying often determines their approach; this in turn determines learning, retention, and use of the material learned. Thus students' processing strategies can be influenced by the types of test questions the teachers use. Some students, however, habitually use surface processing even in situations that require deeper processing. This learning style results in poor academic performance in many college and university courses. Other students are able to use either approach depending on their motivation and goals for the task.

The construct of student engagement and involvement is used in our research to tap these aspects of learning style. Student engagement in our model is a function of students' motivation and cognition.

III. Student Cognition

A. Knowledge Structure

In recent years, educational and instructional psychologists have emphasized the importance of meaningful learning (Ausubel, 1963, 1968; Greeno, 1978, 1980). The main focus is on the question of how students organize and represent knowledge and the role of students' cognitive structure in learning. At the same time, there is concern about subject matter structures in different disciplines (Schwab, 1962). The approach of curriculum development and curriculum evaluation based on Gagne's notion of a learning hierarchy (1970) emphasizes the importance of content structure in curriculum preparation (Shavelson, 1981). The work of these theorists suggests that, to understand student acquisition of knowledge and to improve instruction, it is necessary to investigate both the structure of subject matter and the student's internal representation of the structure of subject matter.

1. Definition of Constructs

a. Content Structure

Content structure, as a structure of subject matter, is defined as "the web of concepts (words, symbols) and their interrelationships in a body of instructional material." (Shavelson & Geeslin, 1975, p. 201). The content structure consists of the propositional structure with the meaning of concepts and operations and the procedural structure with a set of rules or heuristics that specify the step-by-step procedures for solving a problem or attaining a goal (Shavelson, 1981). Content structure is the structure of the subject matter (Phillips, 1983) and is therefore a kind of public knowledge. The content structure of a course may be derived from the instructional material, consisting of lectures, textbooks, syllabi, handouts, exams, etc. Shavelson and Geeslin (1975) and Geeslin and Shavelson (1975) employed the directed graph method (Harary, Norman, & Cartwright, 1965) to examine the content structure of physics and mathematics texts used in college or high school. They first identified 14 key concepts in a physics text and then identified the sentences and equations containing two or more of these key concepts. These sentences and equations were analyzed by the digraph method. The resulting digraph, considered a representation of content structure, has points (corresponding to concepts) and lines indicating the relationships between concepts. The distance between pairs of key concepts forms a distance matrix, which may be analyzed by multidimensional scaling and clustering techniques. Shavelson and Geeslin have used such content structures as criteria to measure the progress of students' learning in physics and mathematics.

Donald (1983) has studied the content structures in 16 university courses representing different disciplines. She asked professors to rate the key concepts in terms of salience, inclusiveness, and degree of abstractness. The professors then used these key concepts to construct a tree and described the relationships of each link in the tree structure. The tree structure illustrated the dominant relationships of key concepts in the course.

Donald found that the relationship most frequently found among the key concepts was the superordinate-subordinates relationship. She also found that natural science, humanities, and social sciences courses differed in the form of tree structures of key concepts. The natural science courses showed greater use of dependency or causal relationships between key concepts, whereas the social science and humanities courses showed greater use of similarity relationships.

Meyer (1975, 1977) used a method based on case grammar (Fillmore, 1968) and semantic grammar of propositions (Grimes, 1975) to identify the structure of a prose passage. The content structure was revealed as a hierarchically arranged tree structure that displayed the content of the passage. The nodes in the tree represented the content words; the lines among the nodes showed spatially how the content is organized; and the labels stated and classified the relationships among the content. She found that the ideas' positions and the pattern of specific relations in the content structure are important factors influencing learning and recall.

Stewart (1980, 1982, 1984) and Finley and Stewart (1982) have used conceptual maps and active structural networks to portray the knowledge of both concepts and propositions. In constructing a network one first lists all the important concepts, their meanings, and their important propositions. The most important proposition is selected from the list as a starting point and then additional concepts are added to the core. Labeled lines connecting the concepts describe the relationships among the concepts. A flowchart is used to represent the procedural knowledge in a series of steps of subgoals to be solved. A science curriculum represented in this way will enable the curricular developer (1) to survey the knowledge domain in a discipline, (2) to select appropriate subsets of knowledge for students to learn, (3) to sequence the curriculum content in a meaningful way, and (4) to suggest the appropriate teaching technique to present the information. The combination of conceptual and procedural knowledge would present a meaningful problem-solving model for science students (Stewart, 1892). Stewart (1982) and Finley and Stewart (1982) have applied these techniques to represent substantive structures in genetics and ecology.

These studies on the characteristics of content structure of instructional material may help educators in designing a curriculum and in adapting teaching strategies to different instructional materials.

b. Cognitive Structure (Knowledge Structure)

It is generally agreed that cognitive structure or knowledge structure may be considered as a mental structure of organized knowledge stored in a learner's memory (Ausubel, 1963; Ausubel, Novak, & Hanesian, 1978; Shavelson, 1974). As a hypothetical construct, cognitive structure refers to the organization of different kinds of knowledge and information in long-term memory (Shavelson, 1972). We will use the terms cognitive structure and knowledge structure interchangeably.

Although cognitive structure is "an internal representation of conceptual structure" or "a representation of subject matter structure" (Preece, 1978a), it is nevertheless a "student's public understanding of a discipline" (Shavelson, 1983). It is public in the sense that the cognitive structure can be inferred and described by objective measures and compared with some objective criteria.

Some theorists (e.g., Rumelhart & Ortony, 1977; Spiro, 1977) have considered cognitive structures to be schemata. "Cognitive structures (schemata) are cumulative, holistic, assimilative blends of information" (Spiro, 1977, p. 137). According to Mandler (1985), a schema is "a category of mental structures that stores and organizes past experience and guides our subsequent perception and experience" (p. 36). Cognitive structure, as prior knowledge, is viewed as one of the most important variables in determining meaningful learning and retention (Ausubel, 1968).

Different theories of memory have postulated different kinds of components and different representations for cognitive structures. *Declarative knowledge*, represented by concepts and propositional networks, and *procedural knowledge*, consisting of intellectual skills, production systems, and heuristic rules, are two closely related components of the cognitive structure (Anderson, 1980; E. Gagne, 1978; Greeno, 1978; Shavelson, 1981). Gagne and White (1978) and White (1985) also include images and episodes as components of cognitive structure. Anderson (1983) proposes spatial images as a kind of knowledge representation that preserves the configuration or pattern of elements. Episodes (recollections of events) are derived from personal experiences. Therefore, they have special meaningful connections and significance for the individual's knowledge structure.

2. Study of Knowledge Structure in Different Subject Domains

Most studies of knowledge structure have been exploratory approaches investigating the feasibility of different techniques to assess, infer, or represent knowledge structure. These studies have involved a variety of subject matter areas.

Several studies have investigated the development and change of knowledge structure as a result of instruction and learning. For example, Shavelson (1972) and Geeslin and Shavelson (1975) have studied the correspondence between content structure and the cognitive structures of students after being taught physics and mathematics. Such research tests the construct validity of the knowledge structure concept and at the same time provides evidence for the value of the techniques used for assessing knowledge structure.

Many studies were carried out in science education and used high school students as the subjects of investigation. Some of these studies are concerned with the methodological issues, and the results and findings are of value for postsecondary education. The studies, grouped by subject matter areas, are listed in the Table 1.

3. Assessment of Cognitive Structure

a. Techniques

The purpose of assessment is to reveal and infer a representation of the subject's cognitive structure. Based on the assessment procedure employed, the techniques can be classified into two categories: (i) indirect and (ii) direct. The indirect approaches require two procedures: data gathering and scaling. For data gathering these techniques first use key concepts to present a task to subjects for their responses; they then score or transform these responses into proximity or distance measures as an indication of the relationships between the stimuli or key concepts. Scaling methods are used to yield the representation of cognitive structures from the distance matrices.

In direct approaches subjects are asked to arrange key concepts and propositions and to construct some kind of spatial diagram or hierarchical structure to indicate the relationships among the key concepts and propositions as well as the overall framework or structure of the text material and passage. The spatial diagrams produced by the subjects may be considered representations of subjects' cognitive structures.

The data-gathering procedures for both the indirect and direct approaches should address these issues:

a. Defining a domain of stimuli or key concepts and propositions that represent the subject matter

b. The appropriateness of responses to be elicited by the stimuli

c. Clear instructions to inform the subject of the task to be performed

d. An adequate rule to score or transform the responses into indices

(1) Indirect Approach

Indirect approaches to assessment include word association, card sorting, ordered-tree techniques, and interviews, preference judgment, and similarity rating.

1. Word association. The use of word association to infer cognitive structure is based on Deese's work (1962, 1965), which provides a theoretical background for studying the structural relationships between concepts in a domain of subject matter.

In the word association task, subjects are presented a set (N) of key concepts chosen to represent a domain of topics, such as elementary probability in mathematics (Geeslin & Shavelson, 1975). Each key concept is printed at the top of sheet and also ten to twenty times down the side of page. The subjects are asked to write down as many connected words as they can think of when presented a key word; they are told that (a) the chaining response is to be avoided, (b) single words are to be used as responses, (c) repetition of a response on the same page is to be avoided, (d) there is no limit to the number of responses, (e) there is no right answer, and (f) subjects should not worry about spelling mistakes.

TABLE 1

Studies of Teaching and Learning

SUBJECT MATTER	SUBJECT LEVEL
Mathematics	
Mayer & Greeno (1972)	College
Geeslin (1973)	High School
Shavelson & Stanton (1975)	Teachers
Shavelson & Geeslin (1975)	Teachers
Geeslin & Shavelson (1975)	High School
Physics (Mechanics)	
Johnson (1967)	College
Johnson (1969)	High School
Johnson, Cox, & Curran (1970)	College
Johnson, Curran, & Cox (1971)	College
Shavelson (1972)	High School
Shavelson (1973)	High School
Shavelson & Geeslin (1975)	Teachers
Preece (1976a)	College
Preece (1976b)	High School & College
Nagy (1978)	High School
Thro (1978)	College
Moreira & Santos (1981)	College
Champagne, Hoz, & Klopfer (1984)	High School
Champagne, Gunston, & Klopfer (1985)	Teachers & High School
Chemistry	
Gorodetsky & Hoz (1985)	College
Psychology	
Fenker (1975)	College
Naveh-Benjamin et al. (1986)	College
Geology	
Campagne et al. (1981)	High School
Social Science	
Stasz et al. (1976)	High School
Science Program	
Hambleton & Sheelan (1977)	High School

For each subject, a response list to each of N stimulus words is obtained. The relationships between pairs of keys words is indexed by the relatedness coefficient (Garskof & Houston, 1963), which incorporates the response frequency to a given stimulus with the overlap between response distribution for pairs of stimulus words. The relatedness coefficient therefore represents the degree of associative similarity in meaning between pairs of words. An $N \times N$ symmetric similarity matrix of relatedness coefficients is constructed for each subject. A matrix of median relatedness coefficients is obtained by combining individual similarity matrices to represent a group similarity or proximity matrix.

A number of studies have applied different scaling methods to the proximity or distance matrices based on the word association data: multidimensional scaling methods (Geeslin & Shavelson, 1975; Shavelson, 1974; Thro, 1978; Champagne et al., 1984; Nagy, 1978; Johnson, Cox, and Curran, 1970; Johnson, Curran, & Cox, 1971); hierarchical clustering technique (Shavelson, 1974; Shavelson & Stanton, 1975; Thro, 1978; Champagne et al., 1984; Moreira & Santos, 1981); graphic technique (Preece, 1976a, 1976b); latent partition analysis (Champagne, Hoz, & Klopfer, 1984).

Shavelson (1972) has found that the cognitive structure of an experimental group based on 14 key-concept, word association data changed considerably during a short physics course and the students' cognitive structure corresponded more closely to the content structure at the end of instruction. Geeslin and Shavelson (1975) also found that the cognitive structure of students became more similar to the content structure during a probability course. Thro (1978) found that the greatest changes in the associative structure (cognitive structure) occurred in the first week of exposure to the course material and the students' cognitive structure showed significantly greater correlation with the instructor's cognitive structure after taking a general physics course than at the beginning. The establishment of related concepts in the students' cognitive structure was found to be a significant predictor for achievement in course.

2. Card sorting. In card sorting, the task is to sort a set of concepts into clusters based on the "similarity of meaning" of concepts (Miller, 1969). The chosen key concepts appear on 3 x 5 randomly ordered cards, with a different key concept typed on the center of each card. Subjects are asked to sort the key concepts into as many piles as they consider appropriate. They are asked to sort the concepts so that concepts within a pile will be more similar to each other than to concepts in other piles. An $N \times N$ proximity matrix is formed with 1 (one) in an entry (i, j) if concepts i and j are sorted in the same pile, and 0 (zero) otherwise. Miller (1969) has provided a theory of sorting for partitioning a set of concepts into clusters.

The cognitive structure from the group proximity matrix is revealed by latent partition analysis (LPA) (Wiley, 1967; Champagne et al. , 1984; Gorodetsky & Hoz, 1985; Hambleton & Sheelan, 1977); hierarchical clustering technique (Shavelson & Stanton, 1975; Champagne et al., 1984); and multidimensional scaling (Champagne et al., 1984). Gorodetsky and Hoz (1985) have shown that the students' group cognitive structure became more similar to the teacher's cognitive structure at the end of a course in chemistry.

De Jong and Ferguson-Hessler (1986) presented students with 65 elements each printed on a card to represent 12 problem types in physics. Each problem type consists of a set of knowledge elements that represent a problem situation, declarative knowledge, and procedural knowledge. The students sorted the 65 elements into piles. A hierarchical clustering analysis technique was used to analyze the sortings of the good and the poor problem solvers. The knowledge structures of the two groups differed. The sortings and clusters of the good problem solvers were essentially problem centered, whereas the sortings of the poor problem solvers were determined mainly by the surface characteristics of the elements.

3. Ordered tree technique. The ordered tree technique used to infer the representation of cognitive structure is a modification of a technique developed by Reitman and Rueter (1980) to investigate free recall data. The technique is based on a theory of mental organization (N. F. Johnson, 1972) that assumes that single concepts or sets of concepts are mentally organized into a hierarchy whose lowest level terminal nodes represent the single concepts and whose non-terminal nodes represent mental nodes that stand for their constituents. This technique capitalizes on the fact that people have a tendency to recall all items of one chunk of information before moving on to the next chunk. Cognitive structure is inferred from the way students order a set of concepts from the course material.

To construct an ordered tree, the subject is presented a matrix of key concepts in a course. The subject arranges the concepts in a linear fashion so that pairs of concepts that are closely related in terms of meaning in the course will be close to each other. In the first and fourth trials, students can start with any concept. In the second and third trials, students are told to start with a specific concept. The use of cued trials is intended to break stereotyping and encourage variety. Each trial takes about 7 minutes. There is an 8-minute break between trials, during which the instructor continues the normal course lecture. A computer algorithm finds a set of all chunks for each subject and represents this set as an ordered tree, which can be considered a representation of the student's cognitive structure.

Four measures of characteristics of the "ordered tree" have been produced by the method:

a. Grouping—the amount of organization of the structure

b. Depth or average hierarchical number of levels of the tree

c. Similarity, or semblance, to another tree

d. Directionality—the order information in the tree indicates the way in which students traverse the structure.

Naveh-Benjamin, McKeachie, Lin, and Tucker (1986) have used the ordered tree technique to infer students' cognitive structures and their development in a college course. McKeithen, Reitman, Rueter, and Hirtle (1981) used the ordered tree technique to study knowledge organization and skill differences between expert computer programmers and novices in a programming language. Hirtle and Jonides (1985) have found evidence of hierarchical organization of landmarks in cognitive maps of natural environments by using this technique.

4. Interview. Recently, some researchers have proposed using interviews to study students' cognitive structures. Pines (1977) employed a modified Piagetian clinical interview to investigate relevant existing cognitive structures prior to and subsequent to instruction. The interview transcriptions were transformed into relevant propositions by conceptual propositional analysis. The evidence found supports the hypothesis that an important relationship exists between prior knowledge and the resulting cognitive structure following instruction, and that relevant cognitive structure is an important factor affecting learning.

Gilbert, Watts, and Osborne (1985) used an "interview-about-instances" technique to elicit students' views about critical and noncritical attributes of the word and to identify the sources of valid and invalid use of the scientific concepts. The interview data were analyzed in five categories: personal, task, card, the concept, and the conceptual framework in order to understand students' knowledge and cognitive structures.

West, Fensham, and Garrard (1985) used free-definition type questions to obtain propositional statements from students. The procedure requires about one hour of group testing and one hour of individual interviews. The individual's cognitive structure is represented in the form of a "proposition skeleton" with boxes (nodes) as stated propositions and letters as stated relationships between boxes. An elaborated proposition skeleton could be a very complex structure showing the interrelationships of propositions and the depth of knowledge structure. The dimensions of integration of propositional knowledge, differentiation of propositional knowledge, differentiation of skills and examples knowledge, articulated propositional relatedness, and depth of propositional knowledge have been proposed for extracting information from the propositional skeleton.

White (1985) also used interview data for studying cognitive structure. Based on Gagne and White's model of memory (1978) White considers the cognitive structure to consist of four sorts of elements: propositions, intellectual skills (procedural knowledge), images, and episodes. He also proposes nine dimensions of cognitive structure: extent, precision, internal consistency, accord with reality, variety of types of elements, variety of topics, form of organization, ratio of internal to external associations, and availability of knowledge. The usefulness of these dimensions should be evaluated in terms of the criteria of (a) practicality, (b) robustness, and (c) creativity (White, 1985).

5. Preference judgment. In the preference judgment task, the method of triads ('order 2/3') is used. Three statements or propositions are presented as an item. Each subject is asked to indicate which statement he agrees with most (prefers) and which statement he agrees with least in each item. Obtaining the subject's preferences on all possible triad combinations, a scale can be derived describing the relationship between the statements. The individual's scale is called an "I" scale to represent this aspect of his or her cognitive structure.

Runkel (1956) has applied the method of triads with a set of five statements to assess both students' and instructors' cognitive structures in an introductory psychology course. The compatibility of student-teacher's cognitive structures is indicated when the two I-scales can be unfolded into or generated by the same qualitative J (Joint) scale. A qualitative J scale is an ordinal scale where "Each individual and each stimulus may be represented as a point on a common dimension." (Coombs, 1964, p. 80), in other words, it is a scale combining the scales of the individual students so that one can determine where each individual falls on the common underlying dimension along which the statements fall. Runkel labeled the compatible I-scales as the co-linear I-scales. Runkel (1956) found that for those students whose I-scales (cognitive structures) were compatible with their instructors both at the beginning and the end of semester grades were higher than for those students whose I-scales not compatible with their instructors. Runkel interpreted the compatibility (co-linearity) of I-scales as an indication of cognitive similarity which would facilitate the efficacy of communication between students and instructors on certain topics.

Lin, McKeachie, Wernander, and Hedegard (1970) tried to replicate Runkel's study (1956). They used the same set of statements and different sets of statements to assess the compatibility of cognitive structures between students and instructors in introductory psychology courses. They did not find the relationships between student-teacher compatibility of cognitive structures and students' performance that Runkel did. They suggested that the concept of compatibility of cognitive structures be expanded to include both the *degree* of compatibility located on a continuum instead of being all-or-none dichotomous category and the *pattern* of compatibility on a number of salient domains or dimensions of the cognitive structures.

6. **Similarity rating.** In the similarity rating task, all concepts or stimulus words are presented in pairs. Each pair of words is rated as similar or dissimilar on a 7-point scale. "These rating scales are designed to see how similar or dissimilar you feel the concepts represented by the words are to one another." (Johnson, 1967, p. 77). The median similarity ratings were correlated with the relatedness coefficients of the same concepts from the word association task as a means of validation (Johnson, 1967, 1969; Johnson, Curran, and Cox, 1971). The similarity judgments between pairs of words were also used as proximity measures for multidimensional scaling to generate psychological space or cognitive structure for the concepts (Johnson, Cox, and Curran, 1970).

(2) Direct Approach

Direct approaches to assessment include tree construction (graph building), concept mapping, concept structuring analysis technique (ConSAT), networking, mapping, schematizing, and concept structuring.

1. **Tree construction** (Graph building). In the tree construction task, the subjects receive a copy of written instructions and an alphabetical list of *N* key concepts.

Each subject is to produce a linear graph by connecting pairs of concepts with lines. The subject first picks from the list two words that seem the most related to each other. The subject writes these two words in the middle of the page and connects them with a line and labels the connecting line with a "1." Then the subject has two options. The first option involves selecting from the *N* - 2 remaining concepts one concept thought to be most similar to either of two concepts already selected. The subject writes this term down on the page, connects it to the similar word, and numbers the connecting line with a "2." The subject continues to select the remaining concepts and labels the lines with the next higher number until all concepts are connected in a linear graph.

The second option includes a new tree. After picking the two most similar words, the subject can start a new tree by picking two words that are more similar to each other from the *N*

- 2 remaining concepts and write these two words down and connect them with a line labeled "2." The subject continues to use option A or option B to connect words to the tree until all the words on the list are used. The subject then connects the separate trees. The nodes on the tree or graph are the *N* concepts, and the numbered lines on the tree represent the similarity between pairs of concepts. The smaller the numbers linking pairs of concepts, the more similar the concepts are in terms of subject's perception of the concepts. Rapoport (1967) has compared these two options of constructing a tree. He found that the formal structures of resulting graphs do not differ but option B has fewer constraints and is more flexible and thus to be preferred.

Donald (1983) used the tree construction technique to study content structures of 16 university courses in the natural sciences, humanities, and social sciences. Shavelson and Stanton (1975), Preece (1976a), and Champagne et al., (1984) used this technique as one method to yield representation of cognitive structures in their validation studies.

2. Concept mapping. In the concept mapping task, the students are asked to construct a concept map to represent a set of propositions in a lecture or instructional material (Novak & Gowin, 1984). The students are supplied with a list of related concepts, and then construct a map with the most inclusive or general concept at the top of map and less inclusive concepts at the lower levels of hierarchy. The students have to decide the way to construct a hierarchical map and choose the words to link the concepts. Another method is to ask students to identify the key concepts from instructional material and construct a hierarchical map. The students are also requested to link concepts with labels to indicate their relationships. The concept maps produced by students at the different stages of learning may be an expression of prior knowledge, misconceptions, learning outcomes, or creative thinking. A scoring system has been developed to provide quantitative assessment of concept maps (Novak & Gowin, 1984). Novak, Gowin, and Johansen (1983) have found that a high performance in concept mapping may require somewhat different abilities than those measured by standardized tests or typical classroom exams.

3. Concept structuring analysis technique (ConSAT). Concept structuring analysis technique (ConSAT) (Champagne, Klopfer, Desena, & Squires, 1981) is a combination of the free sorting and interview techniques. In ConSAT, each concept structuring task is administered on an individual basis. The student is given a set of cards with one concept (term) on each card in a given topic or subject matter. The student is asked to arrange these cards on a large sheet of paper to show how the student thinks about the words. While completing the arrangement, the researcher, guided by the student, connects the related words or groups of words with lines and labels the lines with the relationship that the student indicates. The resulting concept structure is a representation of knowledge structure. Champagne et al., (1981) compared students' structural representations before and after science instruction in geology and found that students' representations after the instruction became closer to the content structure of the subject matter. The ConSAT task may thus provide an useful technique for assessing understanding and the learning outcome of a discipline.

4. Networking. The networking technique as described by Holley and Dansereau (1984) is a kind of mapping technique using nodes to represent concepts and lines or arcs to represent relationships between concepts. Holley and Dansereau have used six kinds of links to indicate three types of structures, namely, hierarchy (part of and type of), chain (leads to), and cluster (analogy, characteristics, and evidence). Applying networking to text materials will result in a spatially organized hierarchical structure of the information in a passage. Originally, networking was designed as a learning strategy for reading comprehension and text analysis, but it can also be used to assess students' understanding of learning materials. The spatially hierarchical structures produced by students can thus be considered to represent their knowledge structures.

5. Mapping. Mapping is a way of "representing ideas in texts in the form of a diagram" (Armbruster & Anderson, 1984). In the mapping, text materials are represented in a hierarchically structured relational map (Schallert, Ulerick, & Tierney, 1984). The comparison relationships (similar, not similar, greater than, and less than), process relationships (temporal and causal relationships), and property relationships (characteristics, examples, and set relationships) of concepts and propositions are represented by different symbols in the map.

Mapping can be applied to the ideas in the text at the level of concepts and propositions, or at the level of larger text units such as "text frame" as "the structure of text that responds to questions about the generic concepts of a discipline" (Armbruster & Anderson, 1984, p. 202). Mapping can proceed either bottom-up or top-down, depending on the purpose and the prior knowledge of user. Mapping is useful not only for explicitly describing the text information, but also for helping students understand and structure what they read in the text. It may also be a useful tool for teaching writing. The student could use the organized information in mapped form as an outline and then translate the map into prose (Armbruster & Anderson, 1984).

6. Schematizing. Schematizing is a heuristic method for "creating a graphic representation of a study text" (Mirande, 1984, p. 150). It creates a two-dimensional representation with key terms as labels and with lines and arrows to indicate relationships between two labels. The relationship symbols represent static relationships, dynamic relationships, similarity, interaction, positive influence, negative influence, and negation. Mirande (1984) lists six major components of schematizing procedures as follows (pp. 155-156):

a. Surveying books and articles
b. Skimming chapters
c. Selecting labels and relationships
d. Arranging schematizations and subschematizations
e. Evaluating the schematizations
f. Specifying labels

Schematizing, originally designed as a spatial learning strategy, may also be used to depict the overall framework or macrostructure of text. The schematization produced by a student can be considered an indication of students' understanding of course materials and thus as a representation of their knowledge structures.

7. Concept structuring. The concept structuring technique described by Vaughan (1984) "involves the integration of varied readings of an expository text with the construction of a diagram that depicts the conceptual relationships as a reader perceives them" (p. 130). It is also a spatial learning strategy, but it can be used to assess the resulting cognitive structure following studying as well. The procedure requires the subject to read the expository text three times. In the first reading, the subject surveys the text and tries to identify the topics and the superordinate and the subordinate concepts. Once these concepts are identified, they are then depicted in a graphic overview. The second reading is an analytic reading seeking an understanding of the text and elaborating on the first stage of the graphic overview. The reader pays attention to the essential details for clarifying the major topics and inserts the clarified concepts into the graphic overview. The third reading requires the student to scan the nonessential detailed information and to insert it into the graphic overview. The complete graphic overview represents student's understanding of the concepts and their relationships in the text.

b. Reliability and Validity

1. Reliability. Reliability of the representation of cognitive structures is illustrated by the test-retest correlations and stability of similarity or proximity data generated by the different data-gathering techniques. For the word association technique, Preece (1978b) found a test-retest correlation of .49 for the relatedness coefficients over a three-year period. Nagy (1978) also found compatible results (r = .45 and .42) for a one-month interval. However, Champagne et al. (1984), in their study of response overlaps (relatedness coefficients) of the pre- and post-test word association to five key concepts in mechanics, found that mean relatedness coefficients range from .07 to .41 with a median of .22. They considered these low correlations evidence of lack of reliability of the word association technique. They found that card sorting and tree construction techniques yielded reasonably consistent group response data in a two-month interval.

The stability of the cognitive structures as represented by the ordered trees has been investigated by Hirtle (1982). The average similarity as measured by the McKeithen et al. index (1981) between the original trees and trees six weeks later was .68. Thus the trees are fairly reliable in the sense of being reasonably stable over time.

2. Validity. The validity of the representation of cognitive structures can be assessed in the following ways: illustrating convergent validity by investigating whether the representations of cognitive structures produced by different data-gathering techniques on a set of data are similar; and illustrating convergent validity by studying the relationships between changes in learning achievement and changes in cognitive structures after instruction. The links between learning outcomes and changes in cognitive structure can be viewed as some evidence for validity (Nagy, 1983).

In a study of some psychological aspects of 14 key concepts in physics, Johnson (1967) found a high rank order correlation between the median relatedness coefficients and the median similarity rating (r = .75). A rank order correlation of .85 was found between a free sort test and similarity rating and the rank order correlation between association tests and similarity ratings for nine key concepts in physics was .79 (Johnson, Curran, & Cox, 1971).

Shavelson and Stanton (1975) studied the similarity of cognitive structures from word association, card sorting, and graph building data generated by two experts and 12 teacher interns in mathematics. The hierarchical structures of 12 concepts in operation systems are quite similar among these three measures. Similar results were also obtained by Preece (1976a) and by Champagne et al. (1984). Champagne et al. have applied multidimensional scaling, hierarchical clustering, and latent partition analysis methods to data generated by free sorting, tree construction, and word association techniques. The representations yielded by latent partition analysis and hierarchical clustering solutions tend to be similar to each other, but are quite different from those representations produced by the multidimensional scaling method.

In theory, instruction should have effects on both the content and the structure of knowledge in students (Shavelson, Webb, & Burstein, 1986). The demonstration of effects of instruction and learning on both achievement and the representations of cognitive structures could provide some evidence for the construct validity of cognitive structure. The covariation links between learning achievement and resulting changes in cognitive structures have been the subject of research by many investigators.

A number of studies have shown that students' cognitive structures became more similar to content structure after instruction (Shavelson, 1972; Geeslin & Shavelson, 1975; Shavelson & Geeslin, 1975; Fenker, 1975; Stasz, Shavelson, Cox, & Moore, 1976), and more similar to the teacher's cognitive structure (Gorodetsky & Hoz, 1985; Naveh-Benjamin et al., 1986; Thro, 1978). In Moreira and Santos' study (1981), the contents of thermodynamics were taught in two different ways. One class studied the content in an Ausubelian approach, with all key concepts and basic laws introduced at the beginning of instruction. The other class was taught in a regular fashion with a linear sequence of concepts introduced one after another. The conceptual hierarchical clusterings of key concepts of the "Ausubelian group" was more coherent with the conceptual structure of the subject matter.

In the study by Naveh-Benjamin et al. (1986), students' cognitive structures became more organized and more similar to the instructor's structure at the end of course. The amount of organization of tree structures and the indices of similarity between students' structures and the instructor's structure correlated significantly with students' achievement in the course. Furthermore, it was found that the amount of organization of cognitive structure and the degree of similarity between students' structures and teacher's structure interacted to influence performance in multiple choice and essay portions of the final examination. Students with more highly organized structures do well if their structure was similar to that of the instructor, but they did not do well if their structure was not like that of the instructor. In a similar vein, significant correlations were found between percentages of variance representing the degree of similarity between students' cognitive structures and content structure and course grades in two psychology courses (Fenker, 1975).

c. *Limitations*

The present techniques for assessing and inferring representations of cognitive structures have some limitations which have to be taken into account for theoretical considerations and practical application.

1. The limits of the domain. The domain of the assessed cognitive structure or content structure is defined and restricted by a limited number of the key concepts (e.g., 14 or 16 concepts) in each of the methods used thus far. These concepts are usually only a subset of concepts in the whole area of a subject matter.

A related problem is what kind of concepts are used to describe cognitive structure. The criteria for selecting the key concepts to describe the cognitive structure have not been well defined in many studies. One criterion may be the centrality of concepts to the subject matter. The selection of the key concepts for defining the domain of cognitive structure and content structure is still a judgmental task that needs to be illuminated by further research.

2. Static versus dynamic models of cognitive structures. Most representations of cognitive structures describe the static aspects of the propositional structure of declarative knowledge. The representations of cognitive structure as shown by the multidimensional scaling and hierarchical clustering trees tell very little about the nature of relationships between concepts (Strike & Posner, 1976; Stewart, 1979) and the dynamic properties of the structure (Sutton, 1980). In response to these criticisms, the labels or links used in the concept mapping method (Novak & Gowin, 1984) or the representations generated by ConSAT (Champagne et al., 1981) are intended to describe the nature of relationships among concepts. The description of procedural knowledge in cognitive structure is lacking even though the use of concept profile analysis (Gorodetsky & Hoz, 1980) may be a method for tapping some dynamic aspects of cognitive structure.

Many representations of cognitive structure also lack diagnostic value for individual students or groups of students (Shavelson, 1981). This will limit the usefulness of cognitive structure for instructional purpose. The complexity and the dynamic aspects of cognitive structure have not yet been well dealt with.

3. The individual and group link issues. The content structure of a subject matter is a kind of public knowledge. It derives from the consensus of experts or scientists in a discipline. Therefore, content structure may be considered as "a group average cognitive structure" (Nagy, 1983). Nagy, however, has raised the question of interpreting "a group average cognitive structure" for an individual's cognitive structure. That cognitive structure is "an internal representation of subject matter" (Preece, 1978a) implies that it is an individual's knowledge structure. The description of cognitive structures for individual students seems to be more logical and more useful than group structures in understanding how cognitive structure develops and changes as a result of learning and instruction.

4. Multiple representations of cognitive structure. We should recognize that there may be more than one way to represent cognitive structure and content structure (Shavelson, 1981). The internal representations of subject matter structure may not be uniquely identified or constructed from behavioral data by any measurement technique (Phillips, 1983). The individual representation of cognitive structure constructed or inferred by any technique may be viewed as a representative structure or a dominant structure (Naveh-Benjamin et al., 1986). The multiple representations and the complexity and varieties of cognitive structure, therefore, cannot be adequately assessed or described by any single measure.

5. The problem of transformation of data. Many assessment techniques have to transform the elicited responses into some kinds of similarity or distance measures for constructing representations of cognitive structure. These transformations may miss or mask some potentially important characteristics of cognitive structures. Stewart (1979) has questioned the adequacy of using the digraph method for assessing the content structure of instructional material and in using proximity data to assess the truth value of relationships among concepts.

6. Practicality of assessment techniques. How easily can teachers employ these methodologies to study students' cognitive structure? Some assessment techniques involve rather complicated scaling methods to infer or construct cognitive structure. The impracticality of these methods may prevent the average teacher from using these methods to understand how students organize their knowledge and how students learn the subject matter.

Taking these limitations together, it appears that Nagy (1983) is reasonable in stating that "cognitive structuring as a measurement device is clearly in its infancy, and in its present state must be considered to be a 'blunt instrument'" (p. 32).

4. Development of Cognitive Structure

a. Teaching Knowledge Structures

The importance of organization and structure in the acquisition of knowledge and learning is revealed in the top-down approach of teaching, which is based on the notion of concept hierarchies in the conceptual structure of subject matter. Potentially, teachers could influence the development of students' knowledge structures by (1) presenting the structure and organization of instructional materials in a meaningful way, (2) requiring students to actively organize the learning material, and (3) activating the learner's cognitive structure and linking the instructional material to students' knowledge structures. The general goal is to develop and restructure students' knowledge structure.

1. Presenting organization in the instructional material. There is some evidence showing that comprehension, understanding, and recall are influenced by text structure and organization (Meyer, 1975, 1977; Kintsch & Yarbrough, 1982; Yekovich & Kulhavy, 1976; Brooks & Dansereau, 1983). Kintsch, Kozminsky, Streby, McKoon, & Keenan (1975) and Miller, Perry, & Cunningham (1977) found that superordinate propositions were recalled better than subordinate propositions. The encoding and retrieval of information are facilitated by organization of learning material (Glynn & Di Vesta, 1977).

2. Requiring students to actively organize the learning material. Teaching students how to organize the learning material trains them to pay close attention to the relationships among concepts and to the meaning of propositional networks. The construction of a concept map (Novak & Gowin, 1984) is not only a means to assess students' existing knowledge but also is a strategy to train students how to actively organize and integrate the learning material (Novak, 1985). Geva (1983) found that requiring students to pay close attention to the hierarchical coherent aspects of text and to construct text flowcharts significantly facilitated comprehension for less skillful readers.

Spatial learning strategies, such as networking, mapping, schematizing, and concept structuring, (Holley & Dansereau, 1984) require learners to organize and structure the learning materials in some systematic ways. Hence these learning strategies should improve learning and facilitate formation and development of adequate and meaningful knowledge structures.

3. Activating learners' cognitive structures and linking the instructional material to learners' relevant knowledge structure. According to Ausubel (1977), "the principal function of advance organizers is to bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand" (p. 168). Mayer's assimilation encoding theory (1979) tries to explain the function of advance organizers in terms of activation of anchoring knowledge in long-term memory. The interaction and integration with the incoming information results in meaningful learning. Teaching by analogies, models, metaphors, and examples are also ways to bring the receiving information in line with existing knowledge to generate meaningful learning.

b. Learning and Transfer of Learning

Rumelhart and Norman (1978) consider learning to be of three different forms: (a) accretion, (b) tuning, and (c) restructuring. These learnings all involve the encoding, organizing, and restructuring of information in terms of existing cognitive structure to create a new cognitive structure. The result of this learning is continuous development and creation of new cognitive structure.

Ausubel (1968) has clearly stated the importance of cognitive structure in learning and transfer:

> In meaningful learning, therefore, cognitive structure is always a relevant and crucial variable, even if it is not deliberately influenced or manipulated so as to ascertain its effect on new learning. (p.128)
>
> Thus a transfer situation exists whenever existing cognitive structure influences new cognitive functioning irrespective of whether it is in regard to reception learning or problem solving. (p.130)
>
> Royer (1979) using a schema theory, considers that "the transfer of learning involves the activation of a previously acquired schema when one encounters a new learning situation" (p. 65).

Royer and his associates found that acquired prior knowledge influences the storage location of prose materials (Royer, Perkins, & Konold, 1978) and the facilitative transfer in prose learning (Royer & Cable, 1976). They also showed that prose materials relating to existing knowledge structures were less prone to retroactive inhibition (Royer, Sefkow, & Kropf, 1977).

Several authors in the book *Cognitive Structure and Conceptual Change* (West & Pines, 1985) have advocated different ways of facilitating conceptual change and learning. Champagne, Gunstone, and Klopfer (1985) used confrontation strategy to produce conceptual change. Strike and Posner (1985) emphasize the relevance of the learners' current conceptions in generating new knowledge. In their view, learning is a process of transforming conceptions. All learning and teaching result in development and change of cognitive structure. Pines (1985) considers the study of development and the function of cognitive structure to be a psychological as well as an epistemological problem. These authors' approaches would undoubtedly add some additional dimensions and pose problems for the investigation of knowledge structure and its development. But at the same time, it would also broaden the investigators' horizons to enable them to study and analyze cognitive structure in a more subtle and insightful way.

B. Learning Strategies

The previous section stressed the role of prior knowledge in learning. Although the content and structure of knowledge are important, they may not be sufficient for all learning or problem solving (Pintrich et al. 1986). Educators at all levels have been increasingly concerned about generalizable cognitive skills such as those for learning, problem solving, and critical thinking. The next two sections focus on these generalizable cognitive skills.

1. Definition and Description of Learning Strategies

As Weinstein and Mayer (1986) point out, recent research on teaching and learning has focused on the active role of the learner in student achievement. Obviously, the subject matter content a student knows when taking on a new task will influence her performance. Accordingly, theories about prior knowledge and knowledge structure are important components of a theory of learning. Many of these knowledge-driven models, however, do not address how the student originally acquired that knowledge. Research on learning strategies deals with how students acquire and modify their knowledge and skills and skills(Weinstein & Mayer, 1986).

Weinstein & Mayer (1986) have proposed four main components of information processing, all of which can be influenced by the use of learning strategies. The four components are: (1) selection, (2) acquisition, (3) construction, and (4) integration. The *selection* component concerns the control of attention to certain stimuli or information in the environment and transfer of that information to working memory. Corno and Mandinach (1983) label this phase "alertness and selectivity." The *acquisition* phase involves the transfer of information from working memory to long-term memory for permanent storage. In the *construction* phase the student actively builds connections between ideas in working memory. Mayer (1982, 1984) and Bransford (1979) refer to this process of construction as schema development, which results in the new information being held together by a coherent outline or organization (Weinstein & Mayer, 1986). The *integration* phase involves connecting prior knowledge with incoming information (cf. Corno & Mandinach's "connection" component). In our own discussion of the different types of learning strategies we will refer to these different phases of information processing as *attention, encoding, organization,* and *retrieval.*

There are many different definitions of learning strategies. Weinstein and Mayer (1986) define learning strategies as thoughts and behaviors that a learner engages in during learning and that are intended to influence the encoding process. This includes basic memory processes as well as general problem solving. This is a very broad definition of learning strategies and encompasses almost all cognitive processes. In contrast, Tobias (1982) has distinguished between macrolevel learning strategies, such as reviewing, note taking and comprehension monitoring, that complement the more microlevel basic cognitive processes, such as attention and encoding. These macroprocesses concern the students' processing of instructional input, whether this input is from a teacher, a textbook, or another medium. The focus on macroprocesses is more molar than molecular, and parallels Sternberg's (1985) distinction between metacomponents and cognitive processes. As Tobias (1982) sees it, these macroprocesses are at the nexus of research on the psychology of learning performed by cognitive psychologists and research on the psychology of instruction performed by educational psychologists. In this paper and in our research program, we will concentrate on the macrolevel cognitive strategies rather than on the basic microlevel processes.

The choice of this focus is made on theoretical, methodological, and practical grounds. First, a number of researchers (e.g., Paris et al., 1983) have limited the definition of learning strategies to cognitive processes that are intentional and under the control of the learner. Some of the more basic memory processes and microlevel processes of intelligence (see Sternberg, 1985) are not really under the control of the student; they are part of every individual's basic information-processing equipment and are elicited automatically by various tasks.

Second, the basic cognitive microprocesses are difficult to measure unless the researcher uses an experimental design with highly specified experimental tasks and collects reaction times. This is neither practical nor ecologically valid in our research program. Our research will be field-based and we will often rely on students' self-reports. Although there are problems with self-report data (e.g., Nisbett & Wilson, 1977), it can be used if treated as just one source of data on the phenomena of interest (Ericsson & Simon, 1984). Accordingly, we will use other performance measures to triangulate on the cognitive macroprocesses of interest. In using self-report measures rather than experimental tasks there is a trade-off between decreased construct validity (Cook & Campbell, 1979) and increased external validity.

Our focus on global or macrolevel learning strategies includes both students' *use* of them as well as their *knowledge* about them. Paris et al. (1983) have discussed three types of knowledge about learning strategies that are important to informed use: declarative, procedural, and conditional knowledge. Declarative knowledge is defined as propositional knowledge about task characteristics, strategies, and personal abilities (cf. Anderson, 1985; Brown et al. 1983; Flavell, 1979). *Declarative knowledge* concerns the content or *what* about tasks, strategies, and the self. For example, students can know that reviewing notes before an exam is a good strategy. They also may know something about themselves in terms of their skill in reviewing notes. However, this declarative knowledge is not enough for good performance. *Procedural knowledge* involves students knowing how to execute various cognitive strategies. That is, it is not enough for students to know about the strategies, they must know how to use them properly and efficiently.

The final type of knowledge, *conditional knowledge*, is a term coined by Paris et al. (1983) to describe the knowledge about *when* and *why* to use strategies. It is not enough just to know about various strategies and how to use them, but students must be able to use them in a flexible and strategic manner. For example, students might know about the efficacy of skimming a chapter in a reading assignment (declarative knowledge) and even how to skim (procedural knowledge), but not know when skimming is best used or why it might be used in different situations depending on the students' goals (conditional knowledge). Given these three types of knowledge about strategies and their differential implications for performance, it is important to assess students' level of knowledge in all three areas.

There are many learning strategies and different taxonomies for classifying them (e.g., Dansereau, 1985; Pressley, 1986; Weinstein & Mayer, 1986). We have adopted a rather general framework that groups strategies into three broad categories: *cognitive, metacognitive*, and *resource management* (see Table 2). The cognitive category includes strategies related to the students' learning or encoding of material as well as strategies to facilitate retrieval of information. The metacognitive strategies involve strategies related to planning, regulating, monitoring, and modifying cognitive processes. The resource management strategies concern the students' strategies to control the resources (i.e., time, effort, outside support) that influence the quality and quantity of their involvement in the task.

a. Cognitive Strategies

The basic cognitive learning strategies are outlined by Weinstein & Mayer (1986) as rehearsal, elaboration, and organizational strategies. Each of these three types of strategies also has a basic and complex version, depending on the complexity of the task. Basic rehearsal strategies involve reciting or naming items from a list to be learned. This strategy is related to the attention and encoding components as the learner brings information into working memory (Weinstein & Mayer, 1986). Basic rehearsal strategies are best used for simple tasks and activation of information in working memory rather than acquisition of new information in long-term memory. Rehearsal strategies for complex tasks such as learning material from a text include strategies most college students use in their day-to-day studying. For example, saying the material aloud as one reads (shadowing), copying the material over into a notebook, taking notes as one reads, and underlining or highlighting sections of the text.

As Weinstein and Mayer (1986) point out, these strategies are assumed to influence the attention and encoding processes, but they do not appear to help students construct internal connections among the information or integrate the information with prior knowledge. For example, Mayer and Cook (1980) found that students who were asked to shadow a text passage remembered more of the details and facts about the passage than a control group who did not repeat the words to themselves. However, the control group remembered more of the conceptual information and performed better on a creative problem-solving task that required use of the text material. Weinstein and Mayer (1986) conclude that rehearsal strategies need to be supplemented with other learning strategies that help the student organize and integrate the information in long-term memory, not just bring it into working memory.

Elaboration strategies help students store information into long-term memory by building internal connections between items to be learned (Weinstein & Mayer, 1986). Basic learning tasks that can be performed more efficiently with elaboration strategies include learning foreign language vocabulary (paired-associate learning) and free recall list learning like learning to name all the parts of the brain (Weinstein and Mayer, 1986). Research has shown that the mnemonic keyword method (Pressley, Levin, & Delany, 1982) is one of the best techniques for learning vocabulary.

The keyword method essentially involves the building of two types of links between the foreign word and its English counterpart. First, a verbal acoustic link is formed between the words by choosing an English word that sounds similar to the foreign word. Second, this new word (the keyword) that sounds like the foreign word is paired with the English definition of the foreign word in a mental image that helps the reader remember the links between all three words. There has been a great deal of research on the keyword method

TABLE 2

A Taxonomy of Learning Strategies

I. Cognitive Strategies	*Basic Tasks (e.g., memory for lists)*	*Complex Tasks (e.g., test learning)*
A. Rehearsal Strategies	Reciting list	Shadowing Copy material Verbatim note taking Underlining text
B. Elaboration Strategies	Keywork method Imagery Method of loci	Paraphrasing Summarizing Creating analogies Generative note taking Question answering
C. Organizational Strategies	Clustering Mnemonics	Selecting main idea Outlining Networking Diagramming
II. Metacognitive Strategies	*All Tasks*	
A. Planning Strategies	Setting goals Skimming Generating questions	
B. Monitoring Strategies	Self-testing Attention-focus Test-taking strategies	
C. Regulating Strategies	Adjusting reading rate Re-reading Reviewing Test-taking strategies	
III. Resource Management Strategies		
A. Time Management	Scheduling Goal setting	
B. Study Environment Management	Defined area Quiet area Organized area	
C. Effort Management	Attributions to effort Mood Self-talk Persistence Self-reinforcement	
D. Support of Others	Seeking help from teacher Seeking help from peers Peer/group learning Tutoring	

(see review by Pressley et al., 1982) that suggests students are not very adept at building their own keyword links. If instructors are going to use the keyword method, better performance usually results if the links are provided by the teacher or the textbook.

Other elaboration strategies for basic tasks include simple imagery, which is useful for learning lists. This strategy involves the creation of an image that helps the learner remember the list. The "method of loci" is one example of this strategy. The method of loci involves the use of the image of the learner's house and its layout (e.g., hallway, living room, dining room, etc.). To learn a list of words in order (serial list learning), the learner pairs the first word with an object in the first room of the house and constructs an image of that word in the object in the first room. The second word and image of it is paired with a second object in the room or in the next room. When the learner wants to remember the list, he or she imagines walking through the house and recalling each image on entering a room. Of course, this method works best when the list to be remembered is made up of concrete words (i.e., a shopping list). The task is more difficult when the list includes abstract words or concepts that do not readily lend themselves to images.

Weinstein and Mayer (1986) classify complex tasks as learning from text or prose learning. Elaboration strategies that assist the learner on these tasks include paraphrasing, summarizing, creating analogies, generative note taking, explaining, and question asking and answering (Weinstein & Mayer, 1986). These strategies help the learner integrate and connect the new information with prior knowledge. For example, by paraphrasing what they are reading, learners actively connect the new text information with prior knowledge and organizational framework for that subject matter area. In the same fashion, generative note taking where students do not take notes verbatim but try to write notes in their own words and connect them to prior knowledge should result in better storage and retrieval of the information.

The third type of general cognitive strategy is organizational. An organizational strategy helps the learner select appropriate information and also construct connections among the information to be learned. For basic memory tasks, the most common organizational strategy is clustering (Weinstein & Mayer, 1986). Clustering involves the grouping of the words to be learned into taxonomic categories that reflect some shared characteristics or attributes. This grouping process results in the learner being actively involved in the task and should result in better performance (Weinstein & Mayer, 1986).

The more interesting and useful organizational strategies for college students involve the complex task of learning from texts. Weinstein and Mayer (1986) have identified selecting the main idea as an important cognitive goal. There have been a variety of techniques developed to help learners identify the main ideas in a text. Weinstein and Mayer (1986) summarize several of these techniques. One technique, networking, helps students identify the connections among the ideas in a passage by having them classify the types of links among the ideas (see Dansereau et al., 1978; Dansereau, et al., 1979; Holley et al., 1979; for more details). Another type of outlining procedure was developed by Meyer (1975, 1981) it trains students to recognize five types of structures found in expository texts. A third type of outlining procedure (Cook, 1982) helps students identify prose structures. All these techniques help the students select the main ideas from a text by analysis of the text structure. It is assumed that through this analysis, students will come to understand the material better and be able to integrate it with prior knowledge.

b. Metacognitive Strategies

The term metacognition is a popular term used by a variety of researchers in cognitive, educational, and instructional psychology. As Brown et al. (1983) point out, the term has a number of definitions, making it a "fuzzy" concept. It is most often used to refer to two aspects of cognitive life: (1) the awareness of and knowledge about cognition and (2) the control and regulation of cognition (Brown et al., 1983; Flavell, 1979). The awareness aspect of metacognition refers to the learners' knowledge of person, task, and strategy variables that influence performance. According to Flavell (1979), awareness of person variables refers to knowledge about the self in terms of cognitive performance (e.g., knowing that you are a fast reader, a poor writer, etc.). This aspect of metacognition is closely related to motivational constructs such as perceived competence and self-concept. Task-variable knowledge includes information about the difficulty of various tasks and the different demands of academic tasks. Strategy-variable knowledge concerns the learner's knowledge about different strategies and how to use them (i.e., declarative and procedural knowledge; cf. Flavell, 1979; Paris et al., 1983). Although this knowledge about person, task, and strategy variables is important, metacognitive learning strategies involve the control and regulation aspect of metacognition more than the knowledge aspect. Accordingly, in this section we concentrate on the control and regulation aspect of metacognition as it relates to learning strategies.

Brown et al. (1983) note that there are three general processes that make up metacognitive activities: planning, monitoring, and self-regulation. These activities are closely related to metacognitive knowledge, although they can be distinguished theoretically. In addition, the distinction between what is cognitive and what is metacognitive is often difficult to make. We use this distinction, however, because of its theoretical and heuristic value (Brown et al., 1983). Therefore, in our description of the various metacognitive strategies, there may be some aspects that other researchers would classify as cognitive, not metacognitive, activities.

Planning activities include setting goals for studying, skimming, generating questions before reading the text, and doing a task analysis of the problem. All these activities help the learner plan the use of strategies and the processing of information. In addition, they help to activate, or to prime, relevant aspects of prior knowledge that make organizing and comprehending the material easier. Brown et al. (1983) summarize various planning models that have been suggested by cognitive psychologists. Much of the research on planning, and metacognition in general, suggests that good learners engage in more planning and more metacognitive activities than poor learners (cf., Pressley, 1986).

Monitoring activities are an essential aspect of metacognition. Weinstein and Mayer (1986) see all metacognitive activities as partly comprehension monitoring. We take a broad view of monitoring to include self-monitoring during any cognitive activity. Monitoring activities include tracking of attention as one reads, self-testing while reading a text to insure comprehension of the material, use of certain kinds of test-taking strategies (i.e., monitoring speed and adjusting to time available), and monitoring comprehension of a lecture. These various monitoring activities assist the learner in understanding the material and integrating it with prior knowledge.

Self-regulation activities are related to monitoring activities. For example, as learners monitor the comprehension of a text, they can regulate their reading speed to adjust for the difficulty of the material. This continuous adjustment and fine-tuning of cognition is an important component of metacognition (Brown et al., 1983). Other forms of self-regulation behavior include re-reading portions of a text to increase comprehension, reviewing material, and using test-taking strategies (i.e., skipping questions and coming back to them later in the exam). These self-regulating activities are assumed to improve performance by assisting learners in checking and correcting their behavior as they proceed on a task.

c. Resource Management Strategies

Resource management strategies include a variety of strategies that assist students in managing the environment and the resources available. These resources include the time available for studying, the actual study environment, others such as teachers and peers, as well as learners themselves (in terms of effort, mood, and persistence). These strategies could be seen as both cognitive and metacognitive in nature, but they are different enough to warrant a separate category. These strategies help students adapt to the environment as well as change the environment to fit their needs (cf., Sternberg, 1985).

Time management is a classic area included in most traditional study programs (e.g., Deese & Deese, 1979; Johnson, Springer, & Sternglanz, 1982). Thomas and Rohwer (1986) note that time management is an important self-management activity in studying. There are different levels of time management varying from monthly and weekly scheduling to managing an evening of studying. Of course, this kind of scheduling involves planning and regulation activities that are metacognitive in nature. It is probably useful for students to have a weekly schedule for studying that helps organize their time, but this schedule also needs to be flexible enough to allow for adaptations in light of course demands (e.g., midterms, finals). At a more microlevel, students also need to manage time while actually studying. For example, if a student has set aside three hours one evening for studying, he or she must be able to schedule the use of those three hours efficiently. This involves setting realistic goals.

Another resource that must be managed by the student is the study environment. As Deese and Deese (1979) point out, students' study environments are an important aspect of their studying. It is probably useful for students to have a defined area for studying. This area can be in a variety of settings (e.g., library, study hall in dormitory, individual dorm room, or kitchen table). The nature of the setting is not as important as the fact that the student recognizes that this particular location is set aside for studying. It should be relatively free of distractions, both visual and auditory. Accordingly, it should be organized and quiet. It is probably not possible to have quality engagement in studying when there are many distractions (e.g., other students talking, loud music or television on, children in the room, etc.). The student needs to organize the study environment in such a way as to increase attention.

Another aspect of the environment that the student must learn to manage is the support of others. The student needs to know when and how to seek and obtain help. The source of this help can be teacher or peers. This aspect of resource management is related to Sternberg's (1985) notion of practical intelligence in that good students know when they don't know something and are able to identify someone to provide some assistance. There is a large body of research that shows that peer help or peer tutoring can facilitate student achievement (e.g., Webb, 1982). In addition, the work on reciprocal teaching (e.g., Palinscar, 1986; Palinscar & Brown, 1984) demonstrates the power of individual teacher help. However, many students do not seek help appropriately or at all. Many college instructors can probably testify to the lack of student attendance at review sessions even after the session was set-up at students' requests.

A study by Ames and Lau (1982) found that students' actual use of a review session was related to their attributional pattern and past performance. Students who did poorly on earlier exams, but attributed their poor performance to low effort and a lack of course specific knowledge rather than a general ability deficit were much more likely to seek help than students who attributed their poor performance to lack of interest, the difficulty of the exam, or the instructor. This study demonstrates that motivational patterns are related to students help-seeking behavior and need to be considered in examining students' general learning strategies. More research is needed on how students with different motivational patterns seek and use help from both teachers and peers.

The last resource management strategy is directly related to students' motivational patterns. This strategy concerns students' general self-management in terms of effort, mood, self-talk, and self-reinforcement. Dansereau (1985) has discussed this aspect of learning strategies in terms of support strategies that help the student develop and maintain a good internal state. For Dansereau (1985), one of the most important strategies is mood-setting or mood maintenance. This is the *M* in Dansereau's "MURDER" scheme for learning strategies. Weinstein and Mayer (1986) term strategies for managing effort and mood, affective learning strategies. Effort management may be one of the most important learning strategies. A good student knows when to increase efforts and persist on the task as well as when maximal effort is not required for success. Corno and Rohrkemper (1986) discuss the importance of students' regulating their cognitive learning strategies in combination with their effort management. Students who are able to regulate both cognitive and motivational aspects of their behavior are termed self-regulating learners (Corno & Rohrkemper, 1985).

Another aspect of effort management concerns the students' attributions for success and failure (discussed in more detail in the motivation section of this paper). Attributing failure to lack of effort suggest that success may come by trying harder. This attribution leads to a higher expectancy for success and should help the student maintain commitment to the task. Other internal perceptions of the student are important to involvement besides attributions. Meichanbaum and Asaranow (1978) have shown that positive self-talk or self-coaching (similar to general cognitive therapy techniques) can help students succeed at difficult tasks.

Students need to have instruction, including modeling, in how to use these self-coaching techniques. (Dansereau, 1985). Positive self-talk can help students halt the debilitating "self-perturbing ideations" that Bandura (1982) has focused on in his work on self efficacy.

Another aspect of this self-management category that is related to the cognitive-behavior modification model is self-reinforcement. If students are able to set-up simple plans to reward themselves for accomplishing their goals, this can help them maintain their involvement in the task. For example, a student may decide that every hour spent studying merits a "reward" of a five-minute break. This kind of self-management can help the student maintain attention and involvement, which results in better performance.

2. Teaching Learning Strategies

The preceding description of the different types of learning strategies documents the wide variety of strategies available to students. Although some students seem to be able to acquire and use these strategies on their own, most students do not acquire them or at least do not use the strategies in the most effective manner. Accordingly, there is a need to teach students how to use learning strategies. This may sound easy to do, but there are a number of problems associated with teaching learning strategies. There are issues related to training and also to the transfer and generalizability of the strategies.

Much research shows that learning strategies can be taught (e.g., Chipman, Segal & Glaser 1985; Segal, Chipman & Glaser, 1985; Weinstein & Mayer, 1986). There are, however, disagreements about what strategies should be taught and how to teach these strategies. Levin (1986) has suggested that there are four important principles to follow in learning strategy instruction. They are:

1. The instructor should teach different learning strategies for different tasks. As Levin notes, this is just a restatement of the old cliche, "Different tools for different jobs." However, it is an important principle to remember in training learning strategies. There is no one best learning strategy. Strategies have to be adapted to the task demands as well as the learners' knowledge (Levin's third principle).

2. Strategies should have identifiable components. Here Levin (1986) suggests that strategies should be able to be decomposed into multiple components related to particular information processing variables and operations. This multiple component approach has several advantages. Students can learn the components and then adapt and combine them in different ways depending on the task. Second, research on multiple component strategies programs will help us avoid the somewhat simplistic evaluations of strategy programs that result in a "works/does not work" outcome. We need to know how and why different strategies work in different contexts, not just whether some global program works.

3. Learning strategies must be considered in relation to students' knowledge and skills. This third principle of Levin's is simply that there must be a "match" between the student and the strategy. Students must have the prerequisite skills to master certain strategies. Levin (1986) notes that processing capacity differences between children of different ages and adults may result in some strategies being useful for older children and adults but not for younger children. In our own work (e.g., McKeachie Pintrich, and Lin, 1985a, 1985b), we have found that the efficacy of a general learning strategy course for college students was related to the students' basic skill and aptitude levels. Students who had very poor reading skills and low general aptitude levels did not benefit from the program as much as other students. Some minimum level of competency seemed to be required to be able to use the strategies effectively. For example, if students cannot decode words, then it is useless to teach them sophisticated reading comprehension strategies.

4. Learning strategies that are assumed to be effective must be empirically validated. This principle of Levin is similar to comments made by Sternberg (1983). There must be empirical data on the effectiveness of various strategies and general strategy programs if we are to learn more about how to teach learning strategies. This includes evaluating techniques that are very effective in laboratory settings but may not be effective when moved into the ecologically valid setting of the classroom. As many

researchers and program developers know, the leap between research and practice is a large one. If empirical data is not collected on the effectiveness of these programs, we will not progress in our understanding of learning strategies and how to teach them.

These principles are general issues to consider in learning strategy instruction. At a more practical level, there are several other principles that should be considered. First, a variety of researchers have noted that direct instruction in strategies is not only useful for students, but almost required. (McKeachie, et al., 1985a, 1985b; Pressley, 1986). Students need to be taught both task specific strategies as well as general cognitive and metacognitive strategies (e.g., Paris et al., 1983; Pressley, 1986). Another important aspect of teaching strategies is modeling the strategies for students and providing guided practice in the use of strategies (Corno & Snow, 1986; Paris et al., 1983; Pressley, 1986). This suggestion on direct instruction of strategies follows the general model of direct instruction in any content domain (e.g., Rosenshine & Stevens, 1986).

This content-domain issue brings us to the issue of transfer and generalizability. There is a long and continuing controversy on the domain-specificity of problem-solving skills (Campione & Armbruster, 1985; Glaser, 1984). As Campione and Armbruster (1985) point out, the issue revolves around the training of general cognitive strategies versus specific knowledge-based strategies. Most of the learning-strategy training programs would be placed on the general cognitive strategy side of this dichotomy.

There is evidence that learning strategies can be taught and generalized beyond the original instructional context. For example, courses designed to enhance study skills have long been successful (e.g., Kulik, Kulik, & Schwalb, 1983). Dansereau (1985) and Weinstein and Underwood (1985) provide descriptions of two successful programs to improve learning strategies. Weinstein and Mayer (1986) review the research on learning strategies performance and the success of different programs in teaching strategies. Learning strategy training programs should show transfer not only of the original strategies taught, but also that achievement in other areas is influenced (cf. Sternberg, 1983).

One aspect of the transfer problem in teaching learning strategies is learning with awareness (Campione & Armbruster, 1985). Most learning strategies programs attempt to make students aware of the various strategies available to them. However, as we have noted, there are two aspects of awareness or metacognition that need to be considered in the teaching of learning strategies: knowledge about cognition and regulation of cognition. (Brown et al., 1983).

Most learning strategy training programs teach both of these aspects of metacognition. Knowledge about cognition includes knowledge about the person, task, and strategy variables that influence performance (Flavell, 1979). These person, task, and strategy variables parallel the factors of the tetrahedral model: criterial task, materials, learner, and activities (Brown et al., 1983). Students need to know how task characteristics (i.e., recall vs. recognition) and the nature of materials (i.e., visual vs. linguistic) influence their learning. In the same manner, knowledge about their own abilities and characteristics (e.g., knowing they are better at recognition tasks such as multiple choice tests) will help students adapt their learning to the task. Finally, knowledge about various cognitive strategies or activities should improve learning. Most strategy training programs focus on the latter aspect of the tetrahedral model (Brown et al., 1983) by teaching students about the various memory strategies (i.e., rehearsal, imagery, elaboration) and other strategies for attention, problem solving, and comprehension.

Knowledge about cognition, however, does not necessarily lead to improved cognition. Students need to learn how to regulate their cognition through executive control of their resources (e.g., attention, memory, effort, and time). Teaching about self-regulation of cognition is easier than fostering actual regulation of cognition. Most learning strategy programs teach students about the importance of planning their study activities, regulating their attention, and monitoring their comprehension of readings and lectures. There is no guarantee, however, that students will internalize these strategies and become self-regulating. The problem of getting students to actually use the strategies and become self-regulating in other situations besides the training program is one all learning strategy programs must confront.

Motivational factors play a role in the transfer of learning strategies to other situations. Paris et al. (1983) have proposed three types of knowledge important for strategic learning: declarative, procedural, and conditional knowledge. They define *declarative knowledge* as propositional knowledge of task characteristics and personal abilities (cf. Brown et al., 1983; Flavell, 1979). *Procedural knowledge* is defined as knowing about how to execute various cognitive processes and skills (i.e., how to use elaboration, how to skim). The new term, *conditional knowledge*, introduced by Paris et al. (1983), is defined as knowing when and why to use strategies. Paris et al. argue that it is not enough just to know how to use strategies, but that students must be motivated to use them in a flexible and strategic manner. If they have the conditional knowledge of why a particular strategy works, they will be more likely to use it in an appropriate situation.

The transfer issue is not an easy one to resolve. Strategy training programs can attempt to increase transfer by directly teaching students how to apply the strategies to different tasks. In addition, it is important to combine cognitive, metacognitive, resource management, and motivational strategies in a program in such a way that the student can use them to become a self-regulating learner. In the end analysis, it is individual students' responsibility to become active learners and take control of their own learning.

Various programs and models have been used to teach learning strategies. Glaser, et al. (1985) and Segal, Chipman, and Glaser (1985) describe a variety of programs to teach thinking and learning skills. Chance (1986) and Nickerson et al. (1985) also summarize a variety of programs. These one programs can range from general training programs (e.g., Sternberg, 1986) to rather specific learning strategy programs (e.g., training in the keyword method (Pressley, Levin, & Delaney, 1982). In between are several programs to teach general learning strategies and study skills (e.g., Dansereau, 1985; McKeachie et al., 1985a, 1985b; Pintrich et al., in press; Weinstein & Underwood, 1985). These programs are too diverse and varied to describe here, but they all focus on teaching college students (or high school students) general learning strategies to improve their school performance.

3. Assessment of Learning Strategies

The issue of assessing students' learning strategies is an important one for our research as well as an issue in evaluating all strategy instruction programs (cf., Levin, 1986; Sternberg, 1983). Weinstein and Underwood (1985) provide a good review of currently available instruments and problems that need to be considered in the measurement of learning strategies. The measurement of learning strategies is not a new problem. Carter (1958), Brown and Holtzman (1967), Brown (1964), Christensen (1968) and Goldman and Warren (1973) all developed different study skills inventories or instruments. However, as Weinstein and Underwood (1985) point out, there are problems with these instruments.

First, there is no underlying theoretical or conceptual framework for the instruments. Items are included concerning traditional areas of study skills such as note taking, time management, work habits, and attitudes, but there are few items on how students actually learn or process material (Weinstein & Underwood, 1985). To cope with this difficulty, Weinstein and her colleagues at the University of Texas have developed an instrument to measure how students actually process their course material. Items are included on how students learn new material, their use of elaboration and organizational memory strategies, their use of comprehension monitoring and other metacognitive activities and their resource management skills. As Weinstein and Underwood (1985) report, initial results with the instrument, the Learning Activities and Study Skills Inventory (LASSI), are promising. The instrument can be used by researchers to collect data on the effectiveness of their programs, and teachers and students can use it for diagnostic purposes. The LASSI framework is in line with our process-oriented approach to learning strategies and we have used it successfully in our own research (e.g., McKeachie et al., 1985). We plan to use a similar instrument in our research for NCRIPTAL.

C. Thinking and Problem Solving

While we treat "thinking and problem solving" as a separate topic, let us make it clear that there is a continuum running from what is usually termed "learning" to "problem solving" and "creativity." We usually say that someone has *learned* when they display the effects of training or experience in a context similar to that in which the learning occurred. We talk about "transfer of learning" when the learning is displayed in a situation somewhat different from that in which the original learning occurred. If the transfer situation is so different that the use of the learning encounters some barrier or difficulty, we speak of "problem solving." When the situation is greatly different and the distance of transfer needed is greater still, we speak of "creativity." But even a simple learning task, such as reading a textbook assignment, requires thinking. Selecting an approach to maximize one's learning is a problem solving activity quite comparable to that involved in designing an experiment or solving a puzzle.

1. Definition of Construct

Current cognitive and instructional research stresses the role of prior knowledge in learning (Glaser, 1984; Pintrich, et al., 1986). For example, it is obvious that college students' previous knowledge in chemistry or mathematics will have an important influence on their performance in these courses in college. However, even though content knowledge is critical, it may not be sufficient for effective problem solving. The problem of teaching generalizable cognitive skills is particularly crucial for higher education, since for most college students, life after college will not draw so much upon specific content knowledge of chemistry, mathematics, history, psychology, etc., as upon their abilities to learn effectively, solve problems, reason, evaluate, and make decisions.

When faculty members talk about teaching critical thinking, problem solving, or reasoning, they typically are referring to teaching students to use their learning in new situations to solve problems, reach decisions, or make evaluations with respect to standards of excellence.

The faculty at Alverno College (Mentkowski & Strait, 1983), who have spent over a decade developing a curriculum to teach critical thinking, describe their educational goal of achieving cognitive skills and integrative abilities in terms of "complex systems of intellectual development rather than quantifiable sets of skills" (Loacker, Cromwell, Fey, & Rutherford, 1984, p. 1). This definition temporarily bypasses some of the difficult problems of analysis and measurement by pointing to holistic, global, qualitative methods of assessing the outcomes of education. Nonetheless, one would like to be somewhat more specific about the outcomes of a specific course or curriculum. While the systems of intellectual development are undoubtedly intertwined in complex ways, we should be able to tease out the components of thinking taught in different subject matter domains as well as differentiable cognitive skills generalizable across two or more domains.

Much highly skilled intellectual performance does not require thinking. One may learn to apply standard methods of solution so automatically that no thinking is necessary. In mathematics or science, for example, the student may solve many problems by automatically applying a standard algorithm. Elshout (1985) describes a "zone of problematicity" as that area lying between the area where problems are so difficult and complex that the problem solver cannot solve them and the area where the problem solver can automatically apply the correct procedure to arrive at a solution. The zone of problematicity thus is different for problem solvers of differing degrees of expertness. From this perspective the task of higher education becomes that of increasing the area in which thinking is not required as well as to develop strategies and skills for dealing with problems in the zone of problematicity.

Research on problem-solving and general thinking skills has a long history in psychology. Recent volumes edited by Chipman, Segal, and Glaser (1985) and Segal, Chipman, and Glaser (1985) highlight both the theoretical and practical work being conducted in this area. The entire winter 1984 issue of Review of Educational Research deals with problems in the teaching and learning of reasoning skills. Fredericksen (1984) demonstrates the applicability of cognitive theories to instruction in problem solving. Glaser (1984) provides an excellent overview of the critical issues involved in attempting to teach generalizable cognitive skills. Essentially, the research suggests that there are five critical issues that must be addressed in future research. They are:

1. Can general cognitive skills be taught?

2. How can current knowledge-based structural cognitive theories be applied to the teaching of general problem-solving skills?

3. How can instruction best be designed to foster these skills?

4. How can cognitive skills learned in one domain of knowledge be transferred to another domain?

5. How can we assess the effectiveness of teaching critical thinking?

2. Teaching Critical Thinking

Support for a positive answer to the first question above— that of the teachability of general intellectual skills— comes from studies of the impact of education on intelligence. Balke-Aurell (1982) has shown that general, or "fluid," intelligence increases with increased education. Verbal, or "crystallized," intelligence is also enhanced by education in general while spatial/technical ability is particularly enhanced by education in such fields as engineering and science. Individuals involved in work demanding verbal functioning develop increased verbal ability, while participation in activities demanding spatial/visual functioning results in greater development of this somewhat more specialized ability.

A number of scholars have applied current theories of cognitive psychology to programs for teaching thinking. Four book-length programs have been developed by major figures in cognitive psychology— Hayes (1981), Bransford and Stein (1984), Sternberg (1986), and Nickerson, Perkins, and Smith (1985).

Problem Solving and Discussion. Studies such as Balke-Aurell's encourage hope about the potential value of education for educational development, but we now need to determine what kinds of education are most facilitative. Most of the programs to teach intelligence have been targeted at children. Evidence of their success is less than one would desire but still somewhat encouraging. All of these programs involve a component of active discussion or dialogue.

Similarly, at the level of higher education, Smith (1977) observed twelve college classrooms in different disciplines and found that student participation, teacher encouragement, and student-to-student interaction were positively related to critical thinking outcomes. This fits well with both the pre-college research and with the results of other research on college teaching methods, which found discussion to be superior to lecture in experiments using measures of thinking or problem solving (McKeachie, 1986).

Supporting the conclusion that discussion is likely to increase opportunities for students to practice critical thinking is the finding by Fischer and Grant (1983) that in small classes student responses showed greater use of analysis, synthesis, and evaluation than in large classes.

Problem Solving in Content Courses. Turning to research on teaching problem solving in particular courses, we get some additional hints of possible answers to the "how to teach" question. The typical teacher— teaching problem solving in a discipline such as mathematics— assumes that th way to do it is to have students solve lots of problems. This is not a bad assumption, bu eachers can probably do better by being more explicit about the specific methods and strategies to be used and by noting differences in the approaches useful for novices as compared with those used by experts. Working in thermodynamics, Konst, Wielenga, Elshout, and Jansweijer, (1982) have found that beginners need to go through an orientation phase involving: (1) bringing order out of chaos; (2) discovering uncovered ideas; (3) developing strategies; (4) and avoiding jumping to conclusions. In studies of medical problem solving Elstein, Shulman & Sprafka, (1978) found that, in areas of no prior knowledge, conservative focusing strategies should be preferred; with more knowledge, simultaneous multiple-hypothesis testing is efficient. Thus problem solving instruction for beginners needs to differ from that for students with more experience. Problem representation is a key task for all problem solving but particularly so for beginners dealing with ill-defined problems.

Standard courses in logic apparently are not very successful in teaching practical skills in reasoning beyond the formal settings of problems used in logic courses. In a study of student development during logic courses, Cheng, Holyoak, Nisbett, and Oliver (in press) found that abstract teaching needed to be coupled with examples of concrete instances to be effective. In contrast to the difficulty in teaching thinking using formal logic training, instruction using a pragmatic reasoning schema did generalize to reasoning on other problems for which the schema was relevant. These results support these researchers' claim, that neither of the two dominant views of reasoning is sufficient. One is the view that people use syntactic rules of logic that transcend subject matter; the other is that reasoning depends upon domain-specific knowledge. Cheng et al. propose that people often use "pragmatic reasoning schemas"—general rules defined with respect to classes of goals and types of relationships.

In contrast to the lack of generalizability of courses in logic, training in statistics does generalize to everyday problems involving inferences about events perceived to be subject to random variability. Even brief training in the law of large members results in generalization, probably because subjects have intuitive schemas approximating the statistical abstraction (Fong, Krantz, & Nisbett, in press; Nisbett, Krantz, Jepson, & Kunda, 1983).

Mettes, Pilot, and Roossink (1981) describe a successful attempt to integrate subject matter and problem-solving in a thermodynamics course. Heuristics and problem-solving methods were presented with content in a step-by-step "Programme of Actions and Methods." General problem-solving strategies, such as working backwards, making sketches, and taking extensive notes to reduce the load on working memory, were tied directly to solving problems in the subject matter.

Guided Design. "Guided Design" is a method of course organization and teaching developed by Wales (Wales & Stager, 1977) to teach engineering students problem solving and decision making. Guided design courses involve textbook and problem-solving assignments out of class and small-group decision making in class. The class time is spent on a sequence of open-ended problem-solving projects (perhaps three to five projects in a term). In one of Wales' classes, they were:

1. Developing Better Housing in a Rain Forest
2. Making University Campus Buildings Accessible
3. Providing Water and Power to a Mountain Cabin

Each guided design project involves use of subject matter from the text and is guided by printed material prepared by the teacher. The first printed instruction describes the situation and specifies the students' roles (e.g., Peace Corps workers). Student groups then identify the problem and set a goal for their work. After completing this step they are given a printed sheet showing how other groups have responded. Students are not asked to agree with other groups but to consider the other viewpoints. Similar feedback and directions are given at each step of the problem-solving process; e.g.,

1. Situation
2. Goal
3. Gathering information
   What information is needed?
   Where can it be obtained?
   Who will get what?

4. Possible solutions
   List 3 or more ways to attain the goal
5. Constraints
   List limiting factors
6. Choose a solution
   Test solutions for positive and negative consequences before choosing
7. Analysis
   Identify important factors to be considered in working out the details of the solution
8. Synthesis
   Produce a detailed solution
9. Evaluation
   How can the solution be evaluated?

Students who took the guided design course showed better achievement in advanced courses and were less likely to drop out of engineering than comparable previous students.

Laboratory Teaching. Laboratories are believed to be important in teaching problem solving in the sciences but there is some evidence that they only achieve problem-solving goals if taught with a special emphasis on problem solving. While reviews of research on laboratory teaching find that laboratory courses are effective in improving skills in handling apparatus of visual-motor skills, laboratories generally are not very effective in teaching scientific method or problem solving (Shulman & Tamir, 1973; Bligh et al., 1980).

Lawrenz (1985), however, taught an inquiry oriented physical science lab using a three-phase learning cycle of (1) exploration, (2) invention, and (3) application. In all three phases students interacted in small groups. Significant gains were found on a pre-test/post-test measure of formal reasoning (Lawson, 1978).

Bainter (1955) found that a problem-solving method was superior to traditional laboratory manual methods in teaching students to apply principles of physics in interpreting phenomena. Lahti (1956) also found a problem-solving method to be superior to more conventional procedures in developing students' abilities to design an experiment.

All of these studies point to the importance of developing understanding, rather than teaching problem solutions by going through a routine series of steps. Whether the laboratory is superior to the lecture-demonstration in developing understanding and problem-solving skills probably depends on the extent to which understanding of concepts and general problem-solving procedures are emphasized as opposed to "cookbook" methods.

Verbalization. One of the critical elements in learning, retention, and transfer of problem-solving skills is verbalization. Ahlum-Heather and Di Vesta (1986) showed in a controlled experiment that practice with verbalizing the reason for taking a step before the step was taken resulted in improved performance. Verbalization was most helpful during the initial stages of learning.

The Alverno College Experience. Explicit verbalization is an important element of the Alverno College program. In teaching critical thinking throughout the college, the Alverno College faculty (Loacker, Cromwell, Fey, & Rutherford, 1984) stress *explicitness, multiple opportunities to practice in differing contexts*, and *emphasis on developing student self-awareness* and *self-assessment*. Growth in critical thinking abilities occurred over four years of college as demonstrated both on locally developed measures and on Stewart's *Analysis of Argument*, the *Watson-Glaser Critical Thinking Appraisal*, and the Kolb *Learning Styles Inventory*.

Summary. In summary, problem solving can be taught, but most success in teaching has come when the problem-solving skills have been explicitly developed in the context of existing subject matter, courses, or modules. Evidence for transfer to other subject matter domains is generally lacking.

Overall, the research on teaching problem solving, or other skills in thinking, is less conclusive than one would like. McMillan (1986) summarizes his review of critical thinking research as follows, "The results failed to support the use of specific instructional or course conditions to enhance critical thinking but did support the conclusion that college in general appears to improve critical thinking. Table 3 summarizes the studies reviewed by McMillan (1986). McMillan accepts the null hypothesis when results fail to reach the .05 level of significance. If one takes a more Bayesian view, a somewhat more hopeful, conclusion from these and other studies is that at least three elements of teaching seem to make a difference:

1. Student discussion
2. Explicit emphasis on problem-solving procedures and methods
3. Verbalization of methods and strategies to encourage development of metacognition

3. Assessing Critical Thinking

As indicated above, the Alverno researchers used a number of measures, including the *Watson-Glaser Critical Thinking Appraisal* (probably the most widely used outcome measure in this area), Stewart's *Analysis of Argument*, Kolb's *Learning Styles Inventory*, and a variety of locally derived measures.

The *Watson-Glaser Critical Thinking Appraisal* (1980) includes subtests to measure (1) inference, (2) recognition, of assumptions, (3) deduction, (4) interpretation, and (5) evaluation of arguments. Most studies using the Watson-Glaser to assess efforts to teach critical thinking have been disappointing. As McMillan (1986) points out, this may be because the Watson-Glaser is such a generalized measure that it is unlikely to be greatly affected by a single course in a specific content area.

The *Cornell Critical Thinking Test*, Level Z, (Ennis & Millman, 1985) includes sections on induction, credibility, prediction and experimental planning, fallacies, deduction, and identification of assumptions and is broader in its definition of the domain of critical thinking. It, too, is machine scored, which results in a loss of ability to assess aspects of thinking in which a variety of outcomes are possible or in assessing the processes involved in arriving at a solution.

Chickering's *Critical Thinking Behaviors* inventory is similar to the learning strategies inventories discussed earlier in relying on students' self-reports. It asks students to report the percentage of study time spent on each of six activities: (1) memorizing, (2) interpreting, (3) applying, (4) analyzing, (5) synthesizing, (6) and evaluating.

The Watson-Glaser, Cornell and Chickering inventories represent the two major types of objective measures used in assessing problem solving and critical thinking: (1) tests of ability to solve problems that do not require specialized knowledge and (2) self-reports of activities or preferences presumed to be related to critical thinking. Since critical thinking is so intimately related to knowledge, it is likely that most educational purposes will be better served by assessment devices tied to particular subject matter areas. Within a subject matter domain it is still possible to test for both "near transfer" (ability to solve problems similar to those on which training has occurred), and "far transfer" (ability to solve problems going beyond the specific training).

However, the major problem in testing is that the test may measure different aspects of cognition for different students. Most attempts to use the *Taxonomy of Educational Objectives* (Bloom, 1956) to generate items at different levels of their hierarchy failed because of inadequate equating of the knowledge required. Thus students might fail items intended to measure analytic or evaluative skills not because of lack of relevant skill but because of lack of knowledge. On the other hand, a test intended to measure high level problem solving may simply be a test of rote memory if the problems have been worked out by the instructor in class.

The American College Testing Program (Steele, 1986) has developed a measure of reasoning as part of its College Outcome Measures Program (COMP). COMP uses written and audio-

TABLE 3

Studies Investigating Changes in College Students' Critical Thinking

STUDY	PROBLEM	DESIGN	SUBJECTS	INSTRUMENTS	RESULTS
Bailey (1979)	To study the effect of a special instructional paradigm emphasizing problem-solving on critical thinking	True experimental pretest-posttest control group	University students randomly assigned to either a zoology course or botany course	Watson-Glaser Critical Thinking Appraisal	Significant gains in critical thinking were obtained for the treatment group; no significant differences were reported in comparing the two classes.
Beckman (1956)	To study the extent to which courses in argumentation and discussion improve critical thinking	Non-equivalent pretest-posttest control group	303 students in 8 colleges and universities	Watson-Glaser Critical Thinking Appraisal	No significant difference between the experimental and control classes. The differences in mean gain between colleges was significant.
Coscarelli and Schwen (1979)	To ascertain the effects of three representation modes on critical thinking	Non-equivalent pretest-posttest control group	190 introductory chemistry students in 10 lab classes at a large university	Watson-Glaser Critical Thinking Appraisal	No significant differences among the three groups.
Dressel and Mayhew (1954)	a.) To assess the gain in critical thinking of freshmen students enrolled in social science courses	Pretest-posttest	1,752 freshmen students attending 11 colleges	Test of Critical Thinking in Social Science developed by a team of experts for a comprehensive evaluation of general education.	Students from all institutions showed a significant gain; students scoring lower on the pretest showed the greatest gain.
	b.) To assess the gain in critical thinking of upper-class students	Repeated measures (three times)	236 students from several institutions	Test of Critical Thinking in Social Science	Student's scores continued to increase for three groups of students and remained constant for one group.
	c.) To evaluate the effect of different course materials or instructors on critical thinking	Non-equivalent pretest-posttest comparison group	approximately 680 students in 14 different groups	Test of Critical Thinking in Social Science	There was no significant difference among classes that used different instructional methods; significant differences were found among sections of the same course taught by different instructors.
	d.) To assess the gain in science reasoning over a one year period for freshmen taking general education courses	Pretest-posttest	990 freshmen from 7 colleges	Test of Science Reasoning and Understanding. Developed for this study to assess science problems and conclusions	Significant gains were reported for six colleges, with significant variations between the colleges. Large gains were found for initially low students; small or significant gains reported for initially high scoring students.

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TABLE 3—*Continued*

Dressel and Mayhew (1954)	e.) To assess the relationship between gain in science reasoning over a one year period and type and amount of science taken for freshmen and sophomore students	Non-equivalent pretest-posttest control goup	Approximately 470 students from 7 colleges	Test of Science Reasoning and Understanding	Two colleges reported no significant differences when comparing students taking science with students not taking science. One college reported gains of students taking science equal to gains of students taking a logic course. Three colleges showed significantly higher gain scores for students taking specific science courses such as biology or physical science than students taking general science or no science.
	f.) To assess the effect of science classes emphasizing critical thinking objectives as compared to science classes not stressing these objectives on gain scores of science reasoning	Non-equivalent pretest-posttest control group	1075 students from 3 colleges	Test of Science Reasoning and Understanding	No significant differences were found comparing posttest scores of non-randomized groups.
	g.) To assess change in critical thinking of college freshmen after one year of general education coursework	Pretest-posttest	1002 students from 7 colleges	A Test of Critical Thinking. Prepared to assess the abilities of defining a problem, selecting pertinent information, recognizing assumptions, formulating hypotheses, and drawing conclusions.	Significant gains reported for all colleges. Students scoring low initially showed the greatest gain. Students scoring high initially showed little or no gain.
Fishbein (1975)	To determine the effect of three methods of grouping students on critical thinking	Non-equivalent pretest-posttest control group	359 community college students in six classes	Watson-Glaser Critical Thinking Appraisal	Students grouped complimentarily, in which they were alike on all four personality functions, or heterogeneously, with wide variations of personality variables, scored significantly higher than students grouped randomly.
Gressler (1976)	To investigate the effect of a foundations research course on critical thinking	Matched two group posttest only design	62 graduate students	Watson-Glaser Critical Thinking Appraisal	No significant differences between students who had taken the research course and students who had taken a similar number of graduate hours, but not the research [illegible]
Hancock (1981)	To study the effect of Guided Design in the development of critical thinking by comparing a class taught with Guided Design to a traditionally taught class	Non-equivalent pretest-posttest control group	236 in two sections of the same class	Watson-Glaser Critical Thinking Appraisal	No significant differences between the two classes.

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TABLE 3—Continued

Hardin, L.D. (1977)	To test the effect of a self paced system of instruction compared to a lecture approach to instruction	Non-equivalent pretest-posttest control group	62 university students enrolled in two physics classes	Logical Reasoning Test Watson-Glaser Critical Thinking Appraisal	No significant differences were obtained between the pretest and posttest of both groups, and no significant differences were obtained between the self-paced and lecture groups.
Hayden (1978)	To compare critical thinking abilities of students taking BSCS mini-courses to students taking traditional mini-courses	Two group posttest-only	74 university non-science majors enrolled in a biology course	Watson-Glaser Critical Thinking Appraisal	No significant differences were obtained in comparing the two groups.
Jackson (1961)	To compare gains on critical thinking of college debaters to comparable control groups	Non-equivalent pretest-posttest matched control group	Students from 9 colleges	Watson-Glaser Critical Thinking Appraisal	In five colleges, debate students scored significantly higher gains than controls. In four colleges the controls outgained the debaters.
Jones (1974)	To study the differences in critical thinking between traditional and values clarification methods of teaching two interdisciplinary general education courses	Non-equivalent pretest-posttest control group	161 university freshmen	Watson-Glaser Critical Thinking Appraisal	Traditional social science course had significantly lower posttest scores than either experimental group. No significant pretest-posttest differences were reported for the experimental groups.
[illegible]gan (1976)	[illegible] investigate the relationship between amount of sociology and critical thinking	Eight cohort groups compared	874 students ranging from freshmen to graduate level	Locally de[illegible] test to assess the inclination and ability of students to, without prompting or directions, think critically about statements on contemporary social issues	[illegible] all levels scored very low on both inclination toward and competence in critical thinking. Graduate students scored slightly higher than undergraduates. Undergraduates taking a course specifically designed to develop habits of critical thinking showed significantly higher scores for both inclination toward and ability to think critically than did a comparable group just beginning the course.
Lyle (1958)	To study the effect of a special psychology course designed to enhance critical thinking compared to a traditionally taught psychology course	Non-equivalent pretest-posttest control group	55 students in two sections taught by the same instructor	A Test of Critical Thinking developed by Dressel and Mayhew (1954)	No significant differences between the classes or between matched students.
Mentkowski and Strait (1983)	To assess changes in critical thinking of students taking a curriculum structured to enhance critical thinking and other cognitive achievement outcomes of college	Longitudinal repeated measures over 3 1/2 years; cross sectional, freshmen and senior cohort groups compared	350 college students	Test of Thematic Analysis Analysis of Argument Watson-Glaser Critical Thinking Appraisal	No significant differences were found on any of the instruments comparing freshmen and senior cohort groups; the repeated measures showed significant positive gains on the Watson-Glaser; no significant differences for the Test of Thematic Analysis or the Analysis of Argument.

TABLE 3—*Continued*

Shuch (1975)	To compare achievement in critical thinking of students using electronic calculations to students using paper and pencil calculations	Two group posttest-only	112 community college students in four classes	Watson-Glaser Critical Thinking Appraisal	Contrary to the research hypothesis, students using paper and pencil calculations achieved significantly greater scores than students using electronic calculations.
Smith (1977)	To study the relationship between specific classroom behaviors and critical thinking	Single group pretest-posttest	138 undergraduate students in 12 classes in a small, liberal arts college	Modified Flanders Interaction Analysis Watson-Glaser Critical Thinking Appraisal Chickering Critical Thinking Behaviors	No change in scores on the Watson-Glaser. Significant positive relationship between change in critical thinking scores (Watson-Glaser) and and reported critical thinking behavior (Chickering), and student participation, faculty encouragement, and use of student ideas, and peer-to-peer interaction.
Suksringarm (1976)	To study the effect of BSCS (emphasizing inquiry and higher order thinking) compared to traditional biology and instruction on critical thinking	True experimental Solomon Four Group	152 university students in four classes	Watson-Glaser Critical Thinking Appraisal (translated)	Students taught with BSCS instructional materials scored significantly better than students taught using traditional methods.
Tomlinson-Keasey and Eisert (1977)	To evaluate the impact of the second year of a comprehensive program to enhance critical thinking of freshman	Non-equivalent pretest-posttest control group	104 university freshmen	Watson-Glaser Critical Thinking Appraisal	Treatment group showed statistically significant gains while no gain was reported for control groups.
Tomlinson-Keasey, Williams and Eisert (1977)	To evaluate the impact of the first year of a comprehensive college program to enhance critical thinking of freshmen	Non-equivalent pretest-posttest matched control group	184 university freshmen	Locally developed test of logical operations, including drawing conclusions and probability	No significant difference between the treatment and two comparison groups.
Whitla (1977)	To assess changes in cognitive abilities during the undergraduate college years	Nine cohort groups compared	182 freshmen in 3 cohorts; 142 seniors in 2 cohorts; 43 sophomores; 1192 alumni in 6 cohorts	Test of Logic and Rhetoric Analysis of Argument Test of Thematic Analysis Thematic Apperception Test (cognitive maturity section)	With the exception of natural science seniors, upperclass students composed more forceful and logical essays than freshmen. Upperclass students are significantly more able to compose more effective and logical arguments, use analysis skills and use causal explanations than freshmen.
Williams (1951)	To compare gains on initial thinking of college debaters to comparable control groups	Non-equivalent pretest-posttest matched control group	Debate students and control students from one university	Watson-Glaser Critical Thinking Appraisal	No significant differences between the treatment and control groups

Source: McMillan, 1986

taped stimuli to which subjects respond by writing letters (e.g., to a legislator) or by role playing and speaking to a friend or group. To assess reasoning, trained judges assess the subjects' identification and clarification of principal issues, costs and benefits, potential problems, and potential solutions. Two major components of the scale are called "Solving Problems" and "Clarifying Values." Validity studies were encouraging, and seniors scored higher than freshman.

Many locally designed measures of critical thinking present cases or simulations that are then validated by the use of experts providing ideal answers to which students' answers are compared. Sometimes the simulations are presented by computers. For example Diserns, Schwartz, Guenin, and Taylor (1986) presented computer simulations of three patient cases to faculty, residents, and third-year medical students. They concluded that nine cases would be necessary to achieve adequate reliability for individual assessment.

Perry's (1970) theory of intellectual development during college has stimulated the development of a number of assessment techniques. Knefelkamp (1974) and Widick (1975) created the "Measure of Intellectual Development," an essay test involving decision making, careers, and classroom learning. Trained raters using a three-digit number mark the students' development in the Perry stages (which roughly go from dualism through relativism to commitment). Experimental attempts to facilitate development showed expected pre-to-post course changes (Widick, 1975; Stephenson & Hunt, 1977; Touchston, Wertheimer, Cornfeld, & Harrison, 1977).

Kitchener and King (1981) have developed the Reflective Judgment Interview, in which an interviewer asks questions about a dilemma presented orally and in writing. Tape recordings of the interview are scored in terms of a theory of intellectual development similar in some respect to that of Perry.

Fredericksen (1986) describes in-basket and other types of measures that suggest ways of developing better measures of educational outcomes. Ennis (1962, 1986) reviewed critical thinking tests and suggested logical, criterial, and pragmatic dimensions for improvement of evaluation procedures. He distinguishes between tests and other evaluation procedures as well as comparing critical thinking with reasoning and creativity.

Clearly much research work remains in the development of effective, evaluation tools for use by college faculty members to assess the achievement of educational goals having to do with thinking, particularly with respect to the ill-structured problems faced in real-life situations.

For our own research program, some combinations of measures are likely to be selected from tests measuring generalized cognitive skills to those specific to a particular course and from standardized tests to Flanagan's critical incidents method (Flanagan, 1954) used to identify the characteristics believed by our participating faculty members to reveal critical thinking.

IV. Student Motivation

Although there are many models of motivation that may be relevant to college student learning (see Weiner, 1980b, for a review of general motivational models), we have chosen to use a general expectancy-value model to organize our review. Expectancy-value models are essentially cognitive models of motivation, in contrast to psychodynamic models (e.g., models based on Freudian or psychoanalytic theory), ego-psychology models (e.g., models based on Erikson's theory), learning theory or drive models (models based on Spence's or Hull's theories), or humanistic models (models based on Maslow's or Rogers' theories). Since we are primarily concerned with student cognitive development in our research program, rather than personality or social development, a cognitive model of motivation fits nicely with this focus. In addition, cognitive approaches to motivational theory, such as attribution theory (Weiner, 1979, 1985, 1986), suggest many productive relationships between motivation and cognition (Pintrich et al., 1986). Although the sections of this literature review may treat cognition and motivation separately, one of the hallmarks of our research program is the examination of various cognitive and motivational constructs taken together in the context of the college classroom.

Expectancy-value models are derived from Atkinson's (1964) model of achievement motivation. However, recent cognitive reformulations of Atkinson's model have made the role of students' perceptions or cognitions central to achievement dynamics (e.g., Dweck & Elliott, 1983; Eccles, 1983; Nicholls, 1984; Weiner, 1985, 1986). For example, in Atkinson's (1964) model, the students' probability of success was defined objectively in terms of task difficulty. Several researchers (e.g., Eccles 1983; Weiner, 1985, 1986) have pointed out that it is not the actual task difficulty that determines the students' expectancy for success but the students' perceived probability of success, given their perception of the task difficulty and their perceived ability. Accordingly, in these newer cognitive models of motivation, students' perceptions about themselves and the task are the most important components of motivation.

Figure 2 displays the general relationships between the expectancy and task value components and their relationship to achievement. Figure 2 is based on Eccles' (1983) expectancy-value model with additions and refinements added to integrate the various motivational constructs of other researchers. The six general constructs in the middle of the figure (i.e., student goal orientation, task value, student efficacy, control and outcome beliefs, perceptions of task difficulty, perceived competence, test anxiety and affect, and expectancy for success are all student perception constructs assumed to mediate the relationship between the college classroom environment and student involvement and achievement. This is not to say that certain environmental characteristics may not have direct effects on student involvement or achievement, but that our predictive model will be stronger and more complete if the student perception constructs are included. Very little research in higher education has addressed motivational constructs using an expectancy-value model. Accordingly, our review focuses on the relevant higher education literature when available, but also includes literature from developmental and educational psychology. Our goal is to provide a framework for organizing motivational constructs that will be useful both for theory and in guiding research on motivation in higher education.

A. Description of the Expectancy Path

The expectancy path in Figure 2 is at the bottom of the figure and flows from students' efficacy, control, and outcome beliefs to their perceptions of the task, and from their perceived self-competence to expectancy. Expectancy, in combination with task value, is assumed to lead to task involvement and subsequent achievement. The relationships among the expectancy components are described below.

1. Expectancy

The expectancy component is generally more familiar and more researched than the value component (Parsons & Goff, 1980). The expectancy component is defined as the student's belief about his or her probability of success (or failure) on a particular task. As Eccles (1983) has pointed out, there is a long history in motivational research documenting the &

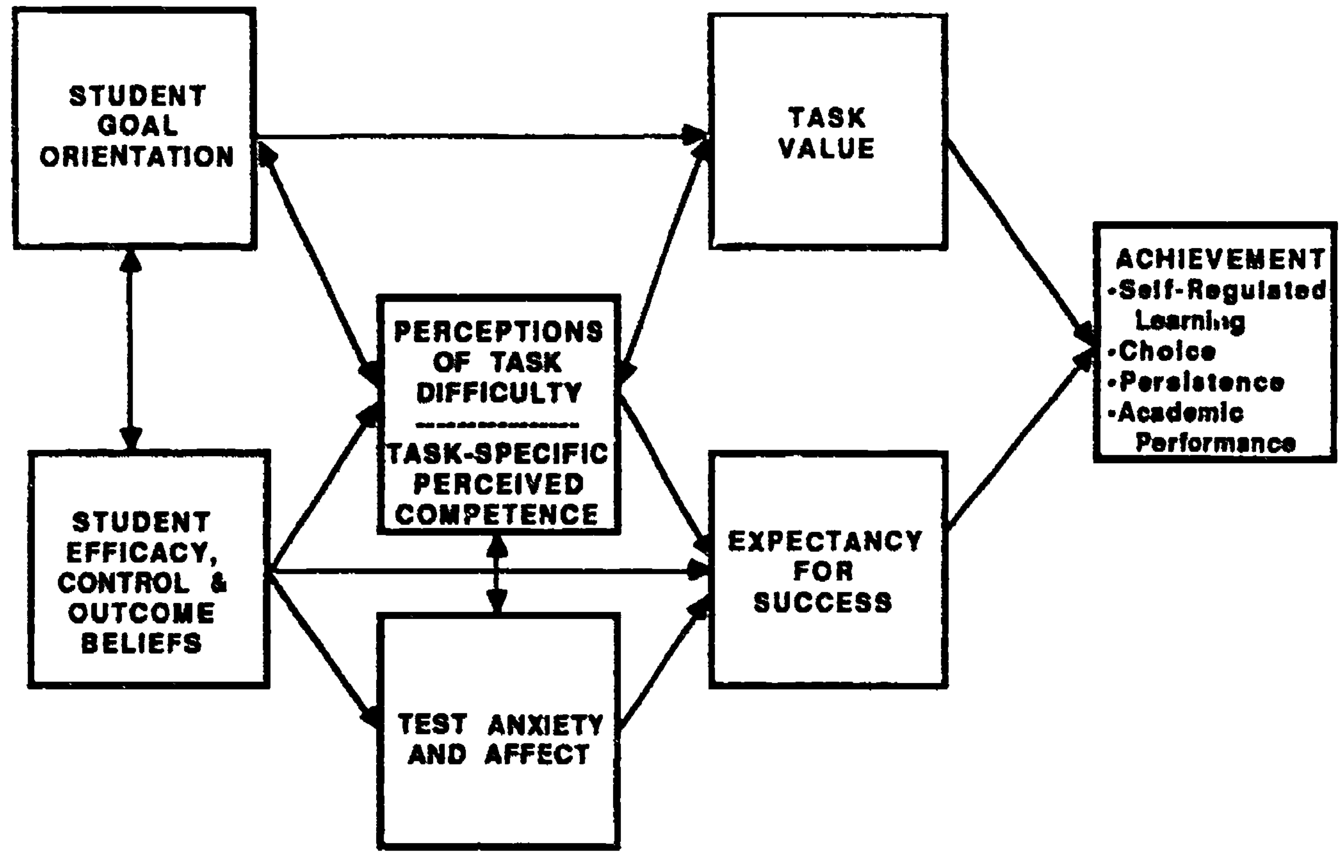

Figure 2. Components of motivation

importance of expectancies for academic performance, task persistence, and task choice (e.g., Atkinson, 1964; Covington & Omelich, 1979a, 1979b; Crandall, 1969; Dweck & Elliott, 1983; Feather, 1969; Lewin, 1938; Veroff, 1969). Expectancies can be specific or general. For example, students can believe they will fail a midterm exam in chemistry course because they did not study (a specific short-term expectancy). A more generalized expectancy would be students' beliefs about their potential for receiving an A in the chemistry course, while an even more generalized expectancy would be the perception that they will do well in all future science courses or in college in general.

2. Perceived Self-Competence, Self-Concept

As Figure 2 demonstrates, there are two other types of student perceptions that play a direct role in expectancy formation: perceived self-competence and perceptions of task difficulty. Perceived self-competence is not the same as expectancy for success or actual ability. Self-competence is defined as students' *perceptions* of their ability to accomplish a particular task. As such, it should be isomorphic to actual ability, but it is not necessarily identical to actual ability. It differs from expectancy for success in that a student can have a high perceived competence for a task, but, under certain conditions (i.e., stress, an extremely difficult or boring task, a biased teacher), not have a high expectancy for success. It is the interaction of the student's perception of task difficulty and perceived competence that is assumed to produce the student's expectancy (Dweck & Elliott, 1983; Eccles, 1983). In addition, perceived competence can vary along the specific to global dimension as does expectancy, however, it is generally assumed to be more stable than expectancy (Harter, 1983).

The construct of perceived self-competence is related to the self-concept literature (e.g., Harter, 1983; Shavelson & Bolus, 1982; Marsh et al., 1984) as well as the self-efficacy literature (e.g., Bandura, 1982). There is a long history of research that demonstrates that self-concept is correlated with achievement, with positive self-concepts related to higher achievement (see reviews by Harter, 1983; Purkey, 1970; Rosenberg, 1979; Wylie, 1974, 1979). Although there is a continuing controversy on the causal predominance of self-concept over achievement (cf., Caslyn & Kenny 1977; Dweck, 1975; Eccles, 1983; Scheirer

& Kraut, 1979; Shavelson & Bolus, 1982), we do not plan to enter into this debate. Rather we believe that self-concept and achievement are inextricably linked in a synergistic fashion. Our goal is to examine how students' perceived competence is related to their use of cognitive strategies and task involvement and subsequent achievement, not whether past achievement or self-concept is causally predominant in predicting future achievement.

Recent work in the self-concept literature (e.g., Marsh & Shavelson, 1985; Shavelson & Bolus, 1982) suggests that self-concept is best characterized as being both task specific and hierarchical and global in nature. That is, students have both fairly domain-specific self-concepts (e.g., a self-concept for mathematics, science, English, sports or physical activity, social skills, etc.) and more global self-concepts that are made up of the domain-specific self-concepts. This distinction parallels the discussion between domain-specific cognitive skills and more global, generalizable cognitive skills in the cognitive literature (Pintrich et al., 1986). In keeping with the general social-cognitive perspective of this paper, emphasizing the active learner and the dynamic relationships among students' self-perceptions, the term "perceived self-competence" is used rather than the static term "self-concept" to refer to students' self-perceptions of their ability for academic tasks. In addition, given results in both the motivational (e.g., Eccles, 1983) and cognitive domains (e.g., Stevenson & Newman, 1986) that domain-specific perceptions and cognitions are better predictors of academic achievement than global self-perceptions, we will be focusing on fairly specific self-perceptions.

3. Perceptions of Task Difficulty

Our model assumes that students' perceptions of task difficulty are important mediators of achievement behavior in contrast to "objective" task difficulty. This is not to say that objective task difficulty is not important; obviously, students' achievement (if measured by GPA) will be related to the difficulty of the types of courses they elect. Rather, our model suggests that student perceptions of task difficulty may modulate and change the relationship of task difficulty to students' expectancy for success and their subsequent achievement behavior (including choice of courses). For example, an introductory psychology course may not be as "objectively" difficult as an organic chemistry course in terms of complexity of the material covered, yet it may be perceived by some students to be more difficult due to differing requirements. Some students majoring in science may be used to taking objective type exams that stress factual knowledge of formulas and chemicals and not be very skilled at writing essays that require integration of different abstract psychological theories. Consequently, these students may perceive the writing of a psychology paper to be more "difficult" than taking an exam in chemistry. In contrast, other students may perceive the chemistry course as much more difficult. These differing perceptions of task difficulty should lead to different expectancies for success.

The exact relationship of perceived task difficulty to expectancy is not clear. As Eccles (1983) points out, perceptions of task difficulty should be inversely related to expectancy. However, in her review of this construct, Eccles suggests that the literature on the relationship between perceived task difficulty and expectancy is not straightforward. First, Eccles notes that many experimental studies (e.g., Atkinson & Birch, 1970; Kukla, 1978; Meyer, Folkes, & Weiner, 1976; Weiner, 1972, 1974) show that students' persistence and choice of tasks is a curvilinear function of perceived task difficulty; tasks of moderate difficulty seem to elicit the most choice and persistence, while easy and very difficult tasks result in lower levels of choice or persistence. However, since many of these laboratory studies use tasks with low ecological validity (e.g., anagrams, ring toss games), it is not clear that the curvilinear function generalizes to actual college student achievement behavior (Eccles, 1983).

While Eccles suggests that there might be a simple negative relationship between task difficulty and choice of courses (courses perceived to be harder should be chosen less), task difficulty also interacts with task value to produce choice. For example, pre-med courses might be perceived as being very difficult, but because these courses have high task-value for some students (e.g., they have a high utility value for students who have a goal of becoming a doctor), these courses may be selected by pre-med students, even if their expectancy for success in these courses is low. Accordingly, there is not a simple relationship between task difficulty, expectancy for success and achievement behavior. Research needs to be done to clarify these relationships in ecologically valid settings with ecologically valid tasks. Our research represents one attempt to address this gap in the literature.

4. Test Anxiety and Affect

In our model, test anxiety is placed near the perceived-competence construct. We are not proposing that it is the same construct as perceived competence, as others have (e.g., see Nicholls, 1976), but that it is closely tied to perceived competence. Generally, test anxiety is assumed to have two components, a worry (or cognitive) component and an emotionality component. Given previous research demonstrating that the cognitive component is most closely associated with performance decrements (Tobias, 1985), we will focus on the cognitive component in our research, although we will include emotionality. Our model also assumes that student beliefs influence test anxiety and that test anxiety is negatively related to expectancy for success (see Figure 2). As will become clear in the following discussion, we also link test anxiety to students' cognitions as well as to task characteristics.

There are many different theoretical explanations for the well-documented finding that test anxiety interferes with performance. Two general theoretical models have been suggested: a cognitive skills deficit model and an attentional-interference model (Tobias, 1985).

1. Cognitive skills deficit model. The cognitive skills deficit model generally includes two components: a learning strategies or skills deficit and a test-taking skills deficit (Tobias, 1985). The research, as reviewed by Tobias, shows that the learning skills deficit component is consistently related to anxiety and performance, while the research is somewhat contradictory on the test-taking skills deficit component. The learning skills deficit component of the cognitive deficit model (e.g., Benjamin, McKeachie, Lin, & Holinger, 1981; Culler & Holahan, 1980) includes study skills such as active reading, reviewing material, comprehension monitoring, and metacognition that can be called macrolevel cognitive processes (e.g., Tobias, 1982) as well as microlevel cognitive processes that make up basic information processing activities (e.g., elaboration, rehearsal, and imagery techniques for memory, see Weinstein & Mayer, 1986). As Tobias (1985) has pointed out, a variety of researchers have shown that students high in test anxiety often have less effective study skills, which leads to less effective processing of information in the encoding and acquisition phase of learning (in other words, poor preparation) and a subsequent decrement in performance. In line with this research, the cognitive learning skills deficit component of our general model is proposed as a mediator of anxiety's influence on performance (see Figure 2.)

In contrast to the learning skills deficit, which is assumed to operate before the student takes the exam, the test-taking skills deficit is assumed to operate at the time of the exam. Students who do not have good test-taking strategies might do poorly on the exam even if they are well-prepared (i.e., have good learning strategies). Tobias (1985) suggests that students with low test-taking strategies (e.g., lack of knowledge about differences in how to answer multiple choice vs. essay questions) become aware that they are doing poorly on the exam. This awareness results in students' becoming anxious and the onset of attentional-interference problems. Test-taking skills are not synonymous with the attentional-interference effects of anxiety, however. Paulman and Kennelly (1984) have shown that test anxiety and test-taking skills have separate effects on performance.

2. Attentional-interference model. The attentional-interference model suggests that anxious students' drop in performance (Wine, 1971) is due to the occurrence of interfering and distracting thoughts (e.g., "I'm really failing this exam; I don't know what to do.") that divide the students' attention between these "self-perturbing ideations" (see Bandura, 1982) or task-irrelevant thoughts and the task-relevant thoughts about the actual exam. Given this divided attention, it is no surprise that the high-anxious student does poorly on the exam, even if well prepared. The attentional-interference model assumes that most of the effect of test anxiety occurs at the time of testing. The divided attention problem results in the students not being able to retrieve the relevant information.

3. Cognitive capacity synthesis of deficit and interference models. A recent cognitive capacity formulation by Tobias (1985) has suggested that the deficit and interference models should not be seen as mutually exclusive but rather as inversely complementary. The model assumes that students have a limited cognitive capacity to process information at any one time. The model also proposes that the cognitive components of learning strategies and test-taking skills tend to increase the amount of cognitive capacity available to the student for any one task, while, in a complementary but inverse fashion, the interference components decrease the cognitive capacity available. If this is so, then good learning strategies and test-taking skills should reduce the cognitive demands on the student when the student is taking the exam while interfering thoughts increase cognitive demands. For example, if the student is well prepared (because of good study skills) and has good test-taking strategies (allowing him or her to activate the appropriate schema for the type of test questions), then his or her cognitive capacity is free to deal with any interfering anxious thoughts that may arise in the testing situation. Accordingly, the model predicts a disordinal interaction between cognitive skills and the interference aspect of test anxiety. Students high in cognitive skills and low in the interference aspect of test anxiety should perform at the highest level, while students low in cognitive skills but high in interfering thoughts should suffer the largest performance decrement. Students with low skills and low amounts of interference and high skills and high interference should be at intermediate levels of performance in Tobias' (1985) model.

This model represents an important integration of the cognitive and interference models of anxiety based on a general information-processing model. However, it does not include a cognitive-motivational component. Recent reviews (e.g., Pintrich et al., 1986) have suggested the need to integrate cognitive-motivational constructs with cognitive constructs. It is becoming clear to various researchers that cognitive strategies (e.g., learning strategies and test-taking strategies) are not recruited and employed in isolation from motivational components. Accordingly, there is a need for the addition of motivational components, such as ability and effort attributions and expectancies for success, to the cognitive capacity model. Covington (1985) has begun to explore the interactions between anxiety and students' attributional patterns. He has found that students' attributions of success or failure to their own lack or adequacy of ability mediate some of the effects of anxiety. He also found that effort attributions did not mediate anxiety effects, mainly because high-anxious students reported that they tried as hard as other students. Pintrich (1986) also found that high and low-anxious students did not differ in their effort, but that high-anxious students had lower levels of cognitive skills than low-anxious students. However, Pintrich did find that the relationship of these cognitive skills to student performance was mediated through effort. That is, having high levels of cognitive skills did not lead directly to improved performance, it was only the motivated and effortful use of these strategies that led to improved performance.

Although test anxiety includes affect, there are other types of emotions that can be generated in achievement contexts that are related to students' motivation and achievement. The model displayed in Figure 2 suggests that students affect is influenced by students beliefs about efficacy, control and outcome. This is in line with a general attributional approach to the cognition-emotion link (e.g., Weiner, 1986). Weiner proposes that more complex emotions like pity, guilt, shame, pride, or self-esteem are a function of students' attributional patterns. For example, attributing success to internal factors (e.g., ability) can lead to feelings of pride and self-esteem. In contrast, attributing a failure to an internal cause such as ability may lead to feelings of shame. The attributional dimension of controllability can also lead to different types of emotions. For example, attributing success to effort can lead to feelings of pride but attributing a failure to effort can lead to feelings of guilt (Weiner, 1986). It should be noted that Weiner's (1986) theory also assumes that some simple emotions like happiness or sadness are basically outcome-dependent (i.e., whether you succeeded or failed) and do not require cognitive interpretations (cf. Zajonc, 1980).

5. Student Efficacy, Control and Outcome Beliefs

The fifth component of the expectancy path in our model is the individual's beliefs about efficacy, control and outcome. There have been a number of constructs and theories proposed about the role of these beliefs in student achievement. For example, early work on locus of control (e.g., Rotter, 1966) found that students who believed that they were in control of their behavior and could influence the environment tended to achieve at higher levels. Although this general idea of internality is still represented in current motivational theories, newer models stress that these perceptions of control may be more situationally specific in contract to stable personality traits and that locus of causality is a separate construct from controllability (Weiner, 1985, 1986). Accordingly, our approach is to to conceptualize these beliefs about efficacy, control and outcome in a more dynamic, social cognitive perspective. We have incorporated the ideas from several different theories in this section, but a good starting point is attributional theory.

Attributional theory proposes that students' causal attributions for success and failure, not actual success or failure, mediate future expectancies. A large number of studies (see reviews by Weiner, 1985; 1986) have shown that students who tend to attribute success to ability (e.g., "I did well on that exam because I'm smart") will expect to do well on future exams because ability is assumed to be stable over time. In contrast, students who tend to attribute their success to other causes (e.g., task difficulty, an easy exam, or extra effort) will not have as high expectancies because the task or effort can change over time. In failure situations, stable attributions to ability have detrimental effects on expectancy. That is, students who attribute their poor performance to ability (e.g., "I did poorly because I'm not very smart") will tend to have lower expectancies for future exams. Just the opposite is true of unstable attributions for failure. Students who attribute failure to effort tend to have higher expectancies because they can change their level of effort for the next exam or in the case of attributing failure to a difficult exam, expect that the next exam will be less difficult. Many attributions can be provided for most achievement situations (e.g., ability, skill, sustained effort, unstable effort, luck, task difficulty, mood, illness, fatigue, other people, interest, knowledge, and attention; see Weiner, 1980b, 1985, 1986 for reviews). However, it is not the actual attributions per se that seem to determine consequences but their common causal dimensions (Weiner, 1985, 1986). The three main dimensions on which attributions can be placed include *locus*, *stability*, and *controllability*, although intentionality and globality are other dimensions that have appeared in some analyses (Weiner, 1985, 1986). It is the causal properties of the dimensions that relate to future expectancy and behavior.

The *locus* dimension refers to the internal or external nature of the cause in relation to the individual. For example, ability and effort are internal causes, while task difficulty and luck are external causes. Generally, it is assumed that having an internal locus-of-causality is positive. This is the basic distinction inherent in the general social learning construct of locus of control (Rotter, 1966). However, this one-dimensional locus-of-control formulation has proven too simplistic and inadequate to account for the data (Weiner, 1986). The other dimensions of stability and controllability also need to be included in the model.

The *stability* of an attribution refers to the manner in which the cause may fluctuate over time. For example, ability (or, more appropriately, aptitude) is an internal cause that is assumed to be stable over time, while effort (also an internal cause) is assumed to be changeable over time. Luck and task difficulty are both external causes that are assumed to be unstable. Weiner (1986) has suggested that the stability dimension is most closely related to changes in expectancy for success in the achievement context. According to Weiner's expectancy principle, attributions to stable causes (e.g., ability) should result in more positive expectancies for the outcome in future situations, while attributions to unstable causes may result in a different expectancy or an unchanged expectancy for the outcome.

The *controllability* dimension refers to the individual's ability to control the cause. For example, mood, fatigue, and effort are all internal and unstable causes, yet effort is generally under the individual's volitional control while mood and fatigue are not (Weiner, 1986). In the same manner, aptitude (an internal and stable cause) is not considered to be under the individual's control, while skill (an internal and unstable cause) can be brought under the individual's control. While stability is assumed to relate to expectancy change, controllability and locus are assumed to relate to students' affective reactions in Weiner's (1986) model.

Attributional theory, as originally proposed, was a theory of individuals' situation-specific reasoning about events. As such, individuals could make attributions to any cause for almost any outcome in any situation. However, other researchers have shown that individuals tend to show consistent patterns in their attributional reasoning over time and across different achievement tasks. These patterns have been shown to be related to achievement behavior. These different patterns can be grouped according to which of the three dimensions of causality they concern most.

1. Students' beliefs about the stability of achievement. A few attributions seem to predominate in most achievement contexts. Weiner (1986) suggests that the two most important attributions in the achievement domain are effort and ability. Although these two attributions are understood intuitively by most people, recent theory and research by Nicholls (1984) and Dweck and Elliott (1983) suggest that individuals can differ in their conceptions of ability and that there is a developmental progression in individuals' conceptions. The main thrust of this work has been to show that conceptions of ability change from a skill-based model to an aptitude or capacity model. In addition, Blumenfeld, Pintrich, and Hamilton (1986) have shown that children's criteria for judging ability change with age.

In the skill-based model individuals assume they can improve with effort and that skill rises with increased mastery of the task. Dweck and Elliott (1983) term this an "incremental" approach to ability, while Nicholls (1984) labels it the "undifferentiated conception of ability." In contrast, in the aptitude model, ability is seen as capacity (Nicholls, 1984), setting a limit on improvement of performance as well as on the efficacy of effort for improvement. Dweck and Elliott (1983) term this an "entity" approach to ability while Nicholls (1984) labels it as the "differentiated conception of ability."

These conceptions of ability should be related to students' expectancy and perceived competence. Students who have a skill-based or incremental model of ability will assume that effortful behavior will help them improve, resulting in a higher expectancy for success. In addition, they will tend to judge their competence in terms of their own self-mastery of a task, rather than in relation to others' performance. In contrast, students with an entity or aptitude theory will tend to see their past performance as limiting their future performance, which is not debilitating if one perceives oneself as having high aptitude and has had success in the past, but it can be debilitating if one does not have a pattern of past success and high perceived competence. These constructs are relatively new and have been investigated with younger children but have not been explored in great detail with college students. In our work we will examine these constructs and their relationships to perceived competence, expectancy, and performance.

2. Students' beliefs about the internal or external locus of achievement. The locus of causality dimension has generated a variety of models concerning the individuals' pattern of intrinsic or extr[illegible] control (e.g., Lefcourt, 1976; Rotter, 1966). The general message of all these models is [illegible] a general pattern of perception of internal control results in positive outcomes (i.e., higher achievement, high self-esteem), while sustained perceptions of external control result in negative outcomes. For example, Deci (1975) and de Charms (1968) have discussed perceptions of control in terms of the students' belief in self-determination. de Charms (1968) coined the terms "origins" and "pawns" to describe students who believed they were able to control their actions and students who believed others controlled their behavior.

More recently, Connell (in press) has suggested that there are three aspects of control beliefs: an internal source, an external source or powerful others, and an unknown source. Students who believe in internal sources of control are assumed to perform better than students who believe powerful others (e.g., teachers, parents) are responsible for their success or failure and better than those students who don't know who or what is responsible for the outcomes.

These models generally assume that perception of internal control is a positive condition and external or unknown control is negative. Reviews of research in this area are somewhat conflicting, however. For example, Siptek and Weisz (1981) in a review of research on perceived control and academic achievement conclude that there is little relationship between perceptions of control and elementary students' academic achievement. In contrast, Findley and Cooper (1983), in a larger review that included studies of college students and adults, found a small but significant positive relationship between perception of internal control and academic achievement. Findley and Cooper also found evidence for a curvilinear relationship between perceptions of internal control and achievement. They found that the relationship was strongest for young adolescents (e.g., junior high school students) and weakest for elementary students (first through third grade) and college students. This curvilinear relationship by age may be responsible for the conflicting findings of previous reviews if the review did not sample or analyze by age of subject. In addition, Findley and Cooper found that the positive relationship was stronger for males than females. These findings suggest that for college students, the relationship between perceptions of internal control and achievement may not be straightforward.

Almost all the models concerned with internal orientation automatically assume that higher levels of internal control result in positive outcomes. However, this may not necessarily be the case. There may be times when perceptions of internal control may be debilitating (e.g., Covington & Beery, 1976). Harter (1985) has proposed a refinement of the general internal-external orientation with her construct of beneffectance. The neologism, beneffectance, is formed by combining effectance motivation (White, 1959) and beneficence, meaning good outcomes (see Greenwald, 1980). Harter proposes that beneffectance involves the individual's tendency to attribute successful outcomes to internal causes and attribute failure outcomes to external causes. This hedonic bias should result in more positive outcomes. As expected, students who tend to have a high level of beneffectance, tend to perform better on academic tasks and have higher expectancies for future success (Harter, 1985).

3. **Students' beliefs about the controllability of achievement.** As Weiner (1986) points out, the controllability dimension is related to the internal dimension as well as the intentionality dimension, but they can be separated on conceptual grounds. In fact, most of the early social learning research on locus of control confounded the internality and controllability dimensions (Weiner, 1986). The controllability dimension concerns the individual's perception that events are controllable. The most common attributional pattern related to this dimension is one that has been labeled "learned helplessness" (e.g., Seligman, 1975). The negative aspect of this pattern has been the focus of much of the research, hence the negative label. The basic pattern is that individuals perceive no association or contingency between their own behavior and the environment in terms of outcomes, other's behavior (i.e., the teacher's), rewards, and punishments. This lack of perceived contingency can lead to passivity, anxiety, lack of effort, and lower achievement levels (Weiner, 1980b; Wortman & Brehm, 1975). This attributional pattern is related to students efficacy beliefs.

Students' self-efficacy has been defined as individuals' beliefs about their performance capabilities in a particular domain (Bandura, 1982; Schunk, 1985). The construct of self-efficacy includes students' judgments about their ability to accomplish certain goals or tasks by their actions in specific situations (Schunk, 1985). This approach implies a relatively situational or domain specific construct rather than a global personality trait. In an achievement context, it includes students' confidence in their cognitive skills to perform the academic task. In terms of our model these beliefs about self-efficacy should be related to task difficulty perceptions as well as expectancy for success. In addition, it is important to distinguish these perceptions of efficacy from students' beliefs about outcome. As Schunk (1985) has pointed out, outcome expectations refer to persons beliefs concerning their ability to influence outcomes, that is, their belief that the environment is responsive to their actions. This belief that outcomes are contingent on their behavior leads individuals to have higher expectations for success and should lead to more persistence. These beliefs are distinct from students self-appraisals of their ability to master task (Schunk, 1985). Accordingly, beliefs about self-efficacy and outcome can vary. For example, a student may believe that she has the capability to perform well on exams, but at the same time, expect a poor grade because of a tight grading curve in the class or a belief that the instructor's criteria for evaluating the exam are arbitrary. These beliefs about the grading system would lead the student to expect a lower outcome than her self-efficacy beliefs would predict. It is important, therefore, to assess not only students self-perceptions of efficacy but also their beliefs about the responsiveness of the environment to their actions.

In addition to the notion of controllability, a number of researchers have suggested that intentionality is an important dimension of achievement beliefs. For example, an effort attribution for success or failure can be seen as intentional. A student must purposively exert effort in an intentional manner. In contrast, a study strategy attribution for success or failure generally would not be considered intentional. Students do not usually use a poor study strategy that leads to failure intentionally (Weiner, 1985). They usually don't use a particular strategy because they don't have the knowledge of the strategy (declarative knowledge), how to use it (procedural knowledge) or don't recognize the situation as appropriate for the strategy (conditional knowledge). Of course, intentionality is not orthogonal to control. It seems likely that any attribution that can be considered intentional would also be controllable. In addition, as Weiner (1985, 1986) points out, logically, intention is not a characteristic of an attribution, it is a characteristic of an action or individual and best describes a motivational orientation. As such, Weiner (1985) leaves intentionality out of his general attributional model and classification of attributions along causal dimensions. The concept of intentionality as a motivational orientation, however, has important implications for our research on student learning. Recent work by Kuhl (1983, 1985), Corno (1986) and Skinner (1985) has addressed the relationship between intentionality and the individual's control of their actions and their cognition and learning. Basically, this research shows that students who believe they have control over their behavior and act accordingly (with volition) perform better than students who do not have this type of motivational orientation. Since much of college learning takes place outside the classroom and is under the control of the student, these concepts of control, volition and intention are important aspects of students' motivational orientations. Accordingly, we have included these beliefs in our model of motivation.

B. Description of the Task-Value Path

The task-value path in the model has been less researched and developed than the expectancy path (Eccles, 1983; Parsons & Goff, 1980). In our formulation, we have followed Eccles' conceptualization of task value and student goals. The general flow of the model is from students' goal orientation to task values. A simple example of the flow follows. A young woman decides that she would like to become a doctor. She may then adopt this career goal as one of her life goals. This goal adoption then influences her value for certain kinds of tasks in college (e.g., choosing pre-med courses over other types of courses). The causal flow and definitions of the constructs are explored in more detail below.

1. Task Value Component

The task-value component was originally conceived as the value an individual attached to success or failure on a task. This value, like probability for success, was defined in objective task terms by Atkinson (1964) in his achievement motivation theory. However, as Eccles (1983) points out, task value can be conceived of in more subjective, broader, and individualistic terms (cf., Parsons & Goff, 1978, 1980; Raynor, 1974; Spenner & Featherman, 1978). This more subjective focus includes the characteristics of the task as well as the needs and goals of the student. Three components of task value have been proposed by Eccles (1983) as important in achievement dynamics: the attainment value of the task, the intrinsic value or the intrinsic interest value of the task, and the utility value of the task for future goals. There has been very little research on these components of task value.

a. Attainment Value

This component of task value refers to the students' perception of the task's ability to provide a challenge, fulfill certain achievement needs, and to confirm a salient aspect of the self (e.g., competence). For example, students who think of themselves as "smart" and perceive a certain course as both a challenge and a confirmation of "smartness" (e.g., organic chemistry), would have a high attainment value for this course (Eccles, 1983). High attainment value should lead to more involvement in the task.

b. Intrinsic, or Interest, Value

The intrinsic, or interest, value of a task refers to the individual's inherent enjoyment of the task. Intrinsic interest is assumed to influence students' involvement in the task and their future achievement. Interest in the task is partially a function of the individuals' preferences as well as aspects of the task (e.g., Malone, 1981).

c. Utility Value

In contrast to the "means" or "process" motivational dynamic of intrinsic task value, utility value refers to the "ends" or instrumental motivation of the student (Eccles, 1983). Utility value is determined by the importance of the task in facilitating the student's goals. For example, organic chemistry may not be an inherently interesting task or have high attainment value for a student, but because the student has a goal of becoming a doctor, the course has a high utility value for the student. This instrumental aspect of college students' motivational dynamics may play an important role in their choice of classes and their ultimate involvement in the course.

2. Motivational Views of Student Goal Orientation

Student goals are assumed to influence their value for certain tasks as the last example of the pre-med student demonstrates. Student goals can be conceptualized along a continuum from the global level (in terms of career goals and life goals) to the more specific level referring to the students' approach to a particular task, exam, or course. Our program will take a fairly task specific approach to student goals, in keeping with our general model of examining cognition and motivation in relationship to the instructional and task environment that students confront in college. Although a number of researchers have discussed student goals, there are three general perspectives, an intrinsic motivation model, a self-worth model, and a cognitive goal formation model. They range, in order, from more to less general views of student goal structure. However, these models are not intended to subsume one another. Rather, they represent relatively distinct ways of thinking about a student's motivation to learn.

a. Intrinsic Motivation Model

Research and theory in intrinsic motivation has a long and varied history. This very general perspective on human motivation began as an effort to make sense of our propensity to actively seek engagement with the surrounding environment, and was only recently reconceptualized as an inherent part of a student's motivation to learn in the classroom. Examples of this early perspective are provided by the work of Woodworth, McDougal, Allport, White and others. Woodworth (1918, 1958) argued that only when an activity is energized through some inherent aspect of its process or substance will it be performed freely and effectively. McDougal (1908) viewed intrinsic motivation as an innate human propensity while Allport's (1937) work indicates that it is an essential dimension of functional autonomy. This early work received support from research on the reinforcing qualities of exploratory behavior among nonhumans (Dashilell, 1925; Nissen, 1930; Montgomery and Segall, 1955), which demonstrated that the exploration of novel environmental stimuli is both an intrinsically rewarding activity (Harlow et al., 1950; Harlow & Meyer, 1950; Premack, 1959, 1963), and a secondary reinforcer of other responses (Butler & Harlow, 1957).

Research focusing on the functional properties and goals of intrinsic motivation, including the reduction of psychological incongruity (cf. Hunt, 1971; McClelland et al., 1953; Berlyne, 1971), cognitive dissonance (Festinger, 1957), and the reduction of uncertainty (Kagan, 1972), suggests that intrinsic motivation may be most fruitfully conceptualized as serving the needs of humans to deal effectively with their environments (White, 1959). In this way, intrinsic motivation is related to control beliefs and perceived competence from the expectancy side of the model. This concept encompasses the motivation to engage in activities including exploration, manipulation, attention, thought, and communication (Deci, 1975).

The intrinsic motivation to effectively interact with the environment may be quite undifferentiated in children (White, 1959; Deci and Ryan, 1985), while becoming progressively differentiated into more specific motives like mastery, cognizance, and achievement among adolescents and adults. Particular motives become more salient to a person's make-up through experiences as different aspects of environments call for different types of effective functioning (de Charms, 1968).

While we question, with White (1959), the correctness of conceptualizing this propensity among humans in terms of simple drive states, two points seem well established. Humans, as well as other animals, appear to readily engage in the exploration and manipulation of stimulus objects within their environments, and the intrinsic incentives inherent in these activities appear to be important motivators of behavior (cf., Deci, 1975).

The intrinsic motivation to learn has been conceptualized in a somewhat different way. In large part, this differentiation is due to the need of educational researchers to capture important aspects of the classroom environment and characteristics of the student that are relevant to classroom learning. Consequently, we find that the basic propensity to pursue a sense of personal causality and competence is often joined with a learned facility which enables the student to sustain the desire to learn (Corno and Rohrkemper, 1985). This learned facility reflects the development of cognitive and other academically related skills that include abilities to pursue achievement through one's own efforts, the ability to delay immediate gratification for less proximal but highly valued rewards, and a gradual reduction in fear of failure (Weiner, 1979; Corno and Rohrekemper, 1985). Harter and her colleagues (1985) have developed an instrument designed to assess a student's present capacity for intrinsically motivated learning.

She has proposed five student-centered dimensions of the intrinsic motivation to learn in the classroom. They are: challenge, curiosity, mastery, independent judgment, and internal evaluative criteria. These dimensions parallel some of the aspects of the models of Dweck and Elliott's (1983) and Nicholls' (1984). Each dimension can be conceptualized as a continuum along which individuals can vary. The challenge dimension refers to the individual's preference for challenging tasks or easy tasks. The curiosity dimension is anchored at one end by the student's tendency to work to satisfy his own interests and curiosity rather than working to please others (parents, instructors) or to obtain good grades. The student's preference for working out problems alone in contrast to relying on the instructor for assistance makes up the mastery dimension. A related dimension is the student's belief that she is capable of making judgments about what to do versus being dependent on the instructor for guidance. The last dimension concerns the student's reliance on internal criteria for judging success and failure versus reliance on external criteria (e.g., grades, social comparison) for judging performance.

This description of intrinsic motivation joins together, then, descriptors of person and social environment. It suggests that humans have a need to seek optimal levels of stimulation and sense of competence. By implication, it also suggests that the environment must provide students with appropriate opportunities and resources for such activities. Finally, our conceptualization of an intrinsic motivation to learn indicates that the individual must come to possess what Weiner (1979) has termed "personal responsibility factors". These factors or capacities enable the individual to effectively pursue involvement with intrinsically interesting education tasks.

b. Self-Worth Model

Covington and Beery (1976) have proposed a self-worth model of motivation that assumes that one of the driving forces of students' motivational dynamics is the maintenance of self-worth. In this model, students are not necessarily intrinsically motivated for challenge or mastery, but rather are motivated to increase their feelings of self-worth and self-esteem or at least protect their self-worth. In this model, the classroom context is seen as a competitive system with an inordinate emphasis on student ability (Covington, 1976). This classroom context encourages students to prefer to be seen by others as succeeding through ability rather than effort (Covington & Omelich, 1979a; 1979b). In addition, the model assumes that the nature of the classroom system produces more failure experiences than success experiences for most students. This system also distributes grades (or other rewards) on a fixed basis in an unequal distribution (e.g., grading on a curve). Under this system, with a scarcity of rewards and an emphasis on ability, students will tend to have a motivational orientation or goal to avoid failure rather than strive for success (Covington, 1974).

This failure-avoidant goal will result in a variety of strategies to avoid failure. The key attributional mechanism for failure-avoiding strategies concerns the nature of effort and ability. If students try hard at an academic task (a paper, an exam) and fail or do poorly, they often have no other attribution to make for poor performance except lack of ability. This lack-of-ability attribution is very damaging to the individual's sense of self-worth and individuals will try to avoid this event. In contrast, if they do not try hard and then do poorly, they can avoid the lack-of-ability attribution by noting that they did not try hard enough. Hence, effort is a double-edged sword. Effort increases the probability of success, but it also increases the potential for lack of ability attributions if failure occurs (Covington & Omelich, 1979a; 1979b). There are many different strategies to avoid effort. For example, students may not exert any effort by choosing not to participate in a variety of educational activities, by skipping classes, sleeping in class, etc. (cf., Astin, 1985). A more sophisticated strategy involves setting extremely difficult goals, such as electing an overload of difficult courses for a semester. This strategy (if it results in failure) allows the student to make a task-difficulty attribution for poor performance and avoid the lack-of-ability attribution.

Another popular effort-avoiding strategy involves procrastination, such as cramming for an exam and writing papers the night before the due date. These strategies allow the individual to avoid lack-of-ability attributions because, if poor performance results from these activities, students always can say that they would have done better if they had studied more or started the paper earlier. In addition, the procrastination strategy presents students with a "bonus" if they do well on the exam or paper. In this case, they can conclude that they must be smart (an ability attribution) because they did so well with so little studying or preparation. Of course, another strategy to avoid failure is to structure the situation so that the probability of achieving success is quite high. In experimental studies this results in students choosing easy tasks (Covington, 1976). The college analog of this behavior is the election of extremely easy courses, solely on the basis of ease of obtaining a high grade without consideration of the students' overall curriculum plans or career goals.

c. Cognitive Goal Formation Model

Dweck and Elliott (1983) and Nicholls (1984) have proposed two basic types of goals students can adopt as they engage in a task: performance goals (or an ego-involved orientation) and learning goals (or a mastery orientation). Essentially, students who adopt a performance goal will focus on their own ability to do the task, their performance in relation to some normative, rigid, or immediate standard, and on their obtained outcome, and they will tend to see errors as examples of failure. This is similar to the self-worth goal orientation model. In contrast, students who approach a task with a learning goal will focus on the process of how to do the task, their performance in relationship to their past performance or a personal standard that is flexible, and their involvement in the task in contrast to the outcome, and they will tend to see errors as useful (Dweck & Elliott, 1983). This is similar to the intrinsic goal orientation model.

This cognitive goal formation model encompasses aspects of the intrinsic motivation model as well as the self-worth model. It is a fairly recent formulation and has not been researched as much as the other two models. It represents a synthesis of the two approaches, and we will be using it in our research on motivation. In addition, the cognitive goal model is more process-oriented and predicts that students will have different orientations for different tasks. For some tasks, students may be driven by a performance goal. They may just want to get a good grade. In other cases, they may adopt a learning goal to strive to master the task.

It is obvious from these examples that students' motivational orientations are an important component of any motivational model of student behavior. Motivational orientation influences students' level of involvement in a task, their value for the task, and their expectancy and perceived competence for the task. The question for researchers remains whether students are intrinsically motivated for mastery, challenge, and learning, or are motivated to enhance their self-worth and ability perceptions, or some combination of both, depending on the situation and their past experience and history. Our research will attempt to address this question by examining students' motivational orientation in relation to other motivational variables, cognition, and instruction.

C. Antecedents of Motivational Constructs

Students' motivation is influenced by a variety of environmental antecedents. There is very little ecologically valid research on the general expectancy-value model we have proposed here in the college setting. Consequently, we not only summarize existing literature but also point out potential research areas that need to be investigated. Many of the possible environmental antecedents are aspects of other research programs in NCRIPTAL and will not be discussed here. These include school-wide variables, such as institutional climate (Peterson, Cameron, Mets, Jones, & Ettington, 1986) or curriculum variables (Stark & Lowther, 1986). Of most concern to our research program are environmental variables at the course level, such as instructor characteristics, format and structure of the class, grading practices,and types of exams.

1. Instructor Characteristics

While another program in the Center is doing research on the individual faculty member, (Blackburn et al., 1986), our interest concerns instructors' general instructional styles and teaching strategies. Section V discusses the cognitive outcomes of different teaching methods; here we are concerned with how different teaching strategies affect motivational constructs.

Dunkin's (1986) review of teaching in higher education mainly focuses on cognitive outcomes, but he notes several findings related to motivation. First, in his summary of the Michigan meta-analysis (e.g., Kulik, Kulik, & Cohen, 1979), Dunkin (1986) notes that the Keller Plan does result in more student satisfaction than conventional instruction. The general mechanism assumed to be operative here is that students' choice and control over the pace of their learning results in more satisfaction. This notion of student choice and control has been promulgated by intrinsic motivation researchers for all grade levels (e.g., Deci, 1975).

Other faculty characteristics that Dunkin reviewed included socio-emotional qualities and lecturing characteristics. Again, Dunkin focused mainly on the cognitive outcomes of these characteristics. The motivational outcomes have seldom been evaluated, except for general student attitudes. It would seem likely that positive faculty characteristics, such as praise and encouragement, would be related to student's motivation, but Dunkin notes that the results are equivocal in the few studies that have addressed this issue. Clearly, there is a need for more research in this area.

In terms of lecturer characteristics, Baumgart (1976) found six types of faculty roles (i.e., reflexive judge, data input, stage setter, elaborator, probe, and cognitive engineer). Baumgart found that students engaged in more higher level thought and expressed more positive evaluations when the instructor performed the role of reflexive judge. Dunkin notes that this type of research is valuable by demonstrating the differential effects of different aspects of teaching behavior. Again, there is a need for more research that examines students' cognition and motivation as conceptualized in our review.

2. Other Course Variables

Many other course variables can influence motivational variables. These include the format of the class (e.g., lecture, discussion, lab section, etc.), grading practices, and types of tasks assigned for the course. In Section V of this paper there is a review of many of these aspects of the class environment. However, one aspect that has been investigated from a motivational perspective is the nature of the reward system in the classroom. In particular, researchers who have investigated intrinsic motivation have focused on this aspect of the classroom environment.

As students of this area well know, controversy over the value of intrinsic motivation to learn is not new. Over four decades ago Dewey (1938) wrote of the continuing debate over whether education is best oriented toward fostering development of the students from within or whether it is better oriented toward formation from without. A microcosm of this debate presen y focuses on whether intrinsic incentives versus extrinsic rewards are the more effective motivators of learning and whether intrinsic motivation is undermined by extrinsic rewards. We now turn to a brief review of some of the major points in this ongoing debate.

An instructive way of addressing the relationship between intrinsic motivation to learn and extrinsic rewards is to disaggregate the process into components including initial engagement with the activity, the actual process of working the activity through to its conclusion, disengagement from the task, and subsequent reengagement (Condry & Chambers, 1981). This procedure focuses our attention on the learning process rather than simply on intrinsic interest, enabling us to avoid intellectually interesting, but pedagogically inconsequential distinctions between intrinsic and extrinsic rewards.

a. Engagement

The impetus for much of the research on the "hidden costs" to learning of extrinsic rewards is based on a single, important set of observations. In sum, the observations are: there is an inverse relationship between an individual's attitude toward an activity and the salience of extrinsic justification for engaging in it (Lepper & Greene, 1975). In situations where salient external incentives are expected at the outset, the findings from over-justification research suggest that students tend to engage in that activity for the reward rather than for any inherent challenge or the possibility of learning it may provide (Lepper et al., 1973; Smith, 1976; Deci, 1971).

Further, some evidence indicates that subjects who anticipated being judged by an external source (Maehr & Stallings, 1972) or who were persuaded that they would be paid for undertaking learning problems (Condry & Chambers, 1981) took on significantly easier tasks than those working under intrinsically oriented conditions. This finding is especially salient because the potential for students to be "distracted" from seeking out optimal challenge appears to be most pronounced when an activity is first being learned (Bruner, 1974; Condry & Chambers, 1978; Harter, 1981).

Finally, it is argued that extrinsic rewards tend to curtail free choice in the engagement phase of any activity (Corno & Rorhkemper, 1985; Condry & Chambers, 1978; Harter, 1981). One implication of this finding is that the level of active self-involvement will also tend to be less under conditions of extrinsic incentives. The finding that the motivators of initial engagement are crucial to what is eventually learned will not come as a surprise to most astute practitioners. The upshot of such work is that the nature of the motivators of initial engagement with any learning activity will almost certainly have direct implications for how a student defines optimal levels of personal investment and challenge vis a vis that activity, and in turn, on whether a student is oriented toward learning new material or simple performance.

b. Process

The problematic relationship between extrinsic rewards and learning continues during the learning stage, with the possibility that the foregoing effects may be generalized to actual performance. Lepper and his colleagues (1973) have noted that, as compared with children expecting no reward, children expecting a reward for pictures drawn during an experimental session tended to draw more pictures, but of lower quality. In a study of concept-attainment, Condry and Chambers (1978) introduced subjects to a learning task and then asked them to work through one on their own. They found that participants who were paid to do the problems proceeded in a way that was more "answer oriented." This is similar to the ego-involved motivational orientation. Members of this group sought less information, made more premature guesses, made more redundant choices, and in the end, needed as much or more information before achieving the correct solution (see also Garbarino, 1975). Their conclusion is instructive:

> Learning requires that one develop some skills and habits such as attention to specific aspects of the informational array, formation of meaningful questions, perception of relationships, and integration of information. Our research suggests that these skills, what we prefer to call strategies of learning, are different under the two motivational contexts we have described. Intrinsically motivated subjects attend to and utilize a wider array of information; they are focused on the way to solve the problem rather than the solution. They are, in general, more careful,logical, and coherent in their problem-solving strategies than comparable subjects offered a reward to solve the same problems. (p. 69)

Such findings strongly advise against uncritically basing classroom teaching on systems of extrinsic reward. However, we agree with Deci's distinction between feedback originating from the environment that is informational rather than controlling in nature (Deci, 1975). Information, in whatever form, that is intended or experienced as pressure to perform, think, and feel in a particular way will tend to facilitate an extrinsic orientation toward learning. Information experienced as providing effective relevant feedback in a context of relative choice or autonomy will tend to enhance intrinsic engagement in an activity (Deci, 1975; Ryan, Connell, & Deci, 1985). Consequently, we advise against the wholesale categorization of extrinsic rewards as detrimental to the learning process in general, and intrinsic motivation to learn in particular. Rather, we suggest the need for careful consideration of the intent of the application of extrinsic rewards to this stage of the learning process, with great restraint advised in using incentives of this type to simply control student learning behaviors.

c. Disengagement and Reengagement

Disengagement refers to the point at which a student terminates his or her involvement with a task, while reengagement refers to a willingness to persist or return to a task later (Condry & Chambers, 1978). Disengagement may occur under conditions of choice, wherein a student decides that he or she is willing to leave a task. Such situations are subsumed by intrinsic motivational contexts. We would expect termination to occur when the questions leading to initial engagement with the activity have been resolved, a sense of mastery has been developed, one's curiosity has been satisfied, or other tasks or interests draw one away from the activity (Condry & Chambers, 1978). The opposite of this learning situation is one in which some other party decides when the demands associated with an activity have been met or its incentive value has been exhausted.

While the requirements of mass education may seem to call for employing extrinsically determined termination of involvement with particular learning activities (e.g., term paper deadlines, time limits on work in laboratory courses, exam dates), this is largely incons tent with requirements of intrinsically oriented learning. For example, in studies of m vation among children, (Condry & Chambers, 1978), Condry notes that when asked to w out problems without offering answers until they were certain of their soundne significantly more of those in the extrinsic context guessed before they "logically had sufficient information."

The largely behavioral literature on token economies argues convincingly that in the presence of valued forms of extrinsic reward, students can be induced to engage in an activity to secure such rewards. However, research demonstrates that in the presence of such rewards subjects are much less likely to seek reengagement in a given activity relative to those working under intrinsic reward conditions (Lepper, Greene, & Nisbett, 1973). Replication of these findings involving substantial variations in the nature of the contingency imposed, the target activity, and the rewards employed have substantiated these initial findings (Greene & Lepper, 1974; Lepper & Greene, 1975). Further, variation in task performance does not confound these effects (cf., Amabile, DeJong, & Lepper 1976; Deci & Ryan, 1985; Ross, 1975). We conclude that extrinsically based learning situations suffer in attractiveness to students because they tend to emphasize the fact that the activity is simply a means to an extrinsic end (Lepper & Greene, 1978; McKeachie, 1986), and that the locus of causality for involvement with the task lies outside oneself (Deci, 1975; Ryan, Connell, & Deci, 1985).

In an earlier section we indicated that the intrinsic motivation to learn was based on the propensity of humans to seek optimal levels of stimulation and to move toward both the mastery of challenging situations and the reduction of uncertainty. Further, we suggested that sustaining an intrinsic motivation to learn also depends on a student's ability to actively and successfully engage in the learning process. Interacting with the properties of the individual are characteristics of the instructional environment that together influence achievement. In the following section we will review some of the attributes of classroom environments supportive of intrinsic motivation.

d. Structural and Evaluative Components of the Classroom

While we caution against generalizing too quickly from the results of research examining developmentally dissimilar groups, Corno and Rohrkemper's (1985) analysis of primary school classrooms does identify several influential environmental characteristics. They identify four general dimensions of settings in which academic training usually occurs. These dimensions will both foster and impede the intrinsic motivation to learn.

Task *flexibility* is linked to learning options and academic goals that are explicitly stated or implicitly expressed in a particular lesson or task. Higher levels of flexibility tend to be more supportive of intrinsic motivation in such cases. As was discussed earlier, the *reward structure* of a course is an important classroom attribute, with more informational forms of incentives tending to support intrinsic motivation and intrinsically motivated performance. The form of *evaluation* employed is also important, with privately rendered, relatively specific forms of feedback especially effective (Corno & Rohrkemper, 1985). McKeachie (1986) also notes that the calculus used to evaluate students has implications for their interpersonal relationships, with "grading on the curve" often disrupting the development of cooperative and mutually supportive orientations to learning among students.

Finally, the *timing and emphasis* of feedback on performance should be (1) frequent, immediate, contingent, and informative in terms of pinpointing the probable source of student errors, (2) encouraging, and (3) provided in a natural context that displays performance recognition by a source student respects (Corno & Rorhkemper, 1985, p. 81; see also Brophy, 1981; McKeachie, 1986, Chaps. 8 and 9). Under such conditions argue these researchers, a sense of growing competence and self-worth tend to support intrinsic engagement with learning.

In our view, a universally optimal configuration of assignments, exercises, lectures, and discussions for all subject areas does not exist. Whether an instructor is employing term papers, programmed learning, computers as instructional tools, audiovisual techniques, laboratory teaching, or instructional games and simulations (McKeachie, 1986, Chaps. 10-17); the motivational principles for intrinsic motivation are the same. They continue to involve enhancing a student's sense of self determination as a result of engaging in activities (Ryan, Connell, & Deci, 1985), and supporting a student's pursuit of optimal levels of academic stimulation. Teachers must weigh the familiarity of their students with these techniques, the set of aptitudes associated with a particular group of students, and the resources they have at their disposal, in conjunction with these principles, while developing appropriate vehicles for teaching certain subjects (McKeachie, 1986; Corno & Rohrkemper, 1985).

e. The Teacher as Focal Point and Model

One of the most important forms of influence on a student's intrinsic motivation to learn in the classroom may simply be the instructor. Beyond determining the substantive content and organizational structure of the course, the instructor may embody those characteristics that help his or her students develop intrinsic appreciation for course material.

In their continuing study of the development of self-regulation skills among grade and high school students, Corno and her colleagues (1983, 1985) indicate that the teacher who is able to promote intrinsically motivated engagement in learning does not simply display mastery of correct procedure. The instructor must also develop and display the capacity to discuss difficult aspects of task performance and indicate how they might be managed or overcome. In effect, a coping model of activity should be periodically presented along with suggestions of how students can learn from the task. McKeachie and his associates' (1985a, 1985b) work on the development of a course intended to teach undergraduates at the University of Michigan how to learn more effectively, points up the motivational importance of an instructor's efforts to go beyond simple presentation of information. He or she must also learn to foster the development of general cognitive learning strategies that may be flexibly brought to bear on questions of importance in their discipline.

Moreover, the lecturer's own attitudes and enthusiasm may have an important effect on students' intrinsic motivation to learn. McKeachie (1986) indicates that:

> Research on student ratings of teaching as well as on student learning indicates that the enthusiasm of the lecturer is an important fr or in affecting student learning and motivation. Not only is the lecturer a model in terms of motivation and curiosity, the lecturer also models ways of approaching problems, portraying a scholar in action in ways that are difficult for other media or methods of instruction to achieve. In fact there is some evidence suggesting that one of the advantages of live professors is the tendency of people to model themselves after individuals whom they perceive as living, breathing human beings with characteristics that can be admired and emulated. (p. 71)

D. Interventions for Motivation

Programs designed to change students' motivational patterns often focus on the task or classroom context. For example, Hill and Wigfield (1984) describe a variety of ways that public school classrooms can be structured to reduce test anxiety. Covington and Beery (1976) have suggested that college classrooms organized in more cooperative ways can increase student motivation and lessen anxiety.

In contrast to these context-based approaches, attributional retraining programs focus on individuals and their motivational patterns. This section concerns these programs that attempt to change students' motivational patterns by directly changing the student attributional style.

As Forsterling (1985) has pointed out, there are two basic paradigms used in attributional retraining, misattribution procedures and attributional retraining procedures. Misattribution programs address causal cognitions about internal states such as arousal, depression, and insomnia and follow from the Schacter and Singer (1962) two-factor theory of emotion arousal. These programs focus on the locus of the problem as being either internal or external to the individual. The basic strategy of these programs is to have the individual attribute the problem to something external rather than internal. For example, a program to help with insomnia would have the individual attribute the problem to a pill or medication, rather than some aspect of the individual's personality (Forsterling, 1985).

In contrast, attributional retraining models, based on the work of Bandura (1982), Seligman (1975), and Weiner (1979, 1985), do not make use of the arousal component and focus on causal cognitions about success and failure (Forsterling, 1985). Since many of these programs concentrate on students' success and failure in achievement situations rather than clinical problems, these attributional retraining programs are more relevant to student learning than misattribution programs. In addition, attributional retraining programs work with all three dimensions of causal attributions (i.e., locus, stability, and controllability) not just the locus dimension. Accordingly, we will focus on attributional retraining programs in our review.

In his review of attributional retraining programs, Forsterling (1985) concludes that these programs generally produce the desired cognitive and behavioral changes. The cognitive changes generally include having the individuals make attributions to lack of effort (an unstable, controllable, and internal cause) for failure and high ability (a stable, uncontrollable, and internal cause) or high effort for success. The behavioral changes include increased persistence at difficult tasks and improved performance. However, of the 16 attributional retraining studies review by Forsterling (1985), only three of them concern actual academic achievement of college students. Others (e.g., Dweck 1975; Schunk, 1981, 1983, 1984) used elementary students or tasks such as anagrams (e.g., Andrews & Debus, 1978), which have low ecological validity. Consequently, it is difficult to generalize from many of these studies to the college environment.

The three studies that did focus on college student achievement deserve further attention. Wilson and Linville (1982, 1985) provided their freshman subjects with information that the causes of low grades in the first year of college are unstable. Basically, they presented material (both written and videotaped) to their subjects that stated many students have problems adjusting to college the first year and that most students' grades increase in the sophomore year. Control subjects did not receive this information. Their outcome measures were students' self-reports of attitudes, expectancies, and mood as well as their performance on some items from the Graduate Record Exam (GRE), grade point average (GPA) a year later, and dropout rate. In both studies (the two 1985 studies were a replication of the 1982 study) the results showed little change on the self-report measures, but significant improvement in GRE performance, increased GPA, and a lower dropout rate for their experimental subjects.

Although these results are encouraging, several caveats must be noted. First, across all three studies, only 66 students from Duke University and the University of Virginia were involved in the experimental treatment. This rather small number and sample selectivity raises a problem of external validity in terms of the sample's generalizability to other college students. Second, it is not clear that the attributional aspect of the treatment can be linked to the positive behavioral outcomes since the cognitive self-report measures showed little change. There may be other factors (e.g., courses taken, outside help received, etc.) that may be more strongly related to the positive results. Although students were randomly assigned to the experimental and control groups, this does not insure that actual course selection or other aspects of college life were actually equivalent. Block & Lanning (1984) showed that, in fact, randomization in this case did not result in equality of the samples. The treatment group had lower GPAs at the outset and their positive change might be due to regression-to-the-mean effects. Data on treatment fidelity (Cook & Campbell, 1978) would improve the causal inferences that can be made from these studies.

More generally, attributional retraining programs that focus on student achievement and only provide attributional information may be misleading and possibly detrimental to the student in the long run (Blumenfeld, Pintrich, Meece, & Wessels, 1982). For example, training students to attribute all failure to lack of effort may not be helpful if the student does not actually possess the skill needed to complete the task. In this case, the students could go on failing because they do not have the skill, yet attribute it to lack of effort and keep on trying harder without securing the necessary help. The students really need instruction in the skill to complement the attributional retraining in this example. Accordingly, the focus of attributional retraining programs should not be on changing the general attributional style of the student but on helping the student make *accurate* attributions for performance. In cases where the student has the skill to do the task, yet does not believe it and won't attempt the task, then effort reattribution training would be indicated. In contrast, if the student does not have the skill, attribution retraining programs need to help the student realize this and seek the proper assistance. In this latter case, an important component of the attributional retaining program is helping the student see that academic performance in college is made up of many skills, most of which are learnable. This change from attributing academic performance to a given trait of ability to a learnable skill would be useful to many students.

E. Assessment

Assessing motivational patterns of students has been a longstanding problem in instructional psychology. In general, there have been three methods used: self-report, observation, and projective techniques. Projective techniques (e.g., the Thematic Apperception

Test, or TAT) were used by many of the early motivational researchers (e.g., Atkinson, McClelland) to measure students' motives for achievement, power, or affiliation. These techniques involved presenting students with pictures and asking them to interpret the portrayed situation (e.g., two people in a work setting). The individuals' responses were analyzed and scored according to an elaborate coding scheme designed to classify the open-ended responses. These projective measures were similar to other projective measures such as the Rorshach used by clinical psychologists in that they were supposed to provide the researcher with a measure of the individuals' motives (both conscious and unconscious). There are many difficulties with these projective measures (cf. Weiner, 1980a) and most motivational researchers now use self-report measures.

Behavioral measures have often been used in experimental studies of motivation. For example, researchers investigating the effects of reward on intrinsic motivation (e.g., Lepper & Green, 1975) often use the student's choice of an activity as a measure of motivation. In a typical experiment, students are provided with a variety of activities to choose from and observers code their choice of and persistence in activities. Other researchers (e.g., Feather, 1961) also have examined students' persistence as a measure of motivation. These behavioral measures can be useful indicators of students' motivation, but the use of observers is expensive and time consuming. In addition, these behavioral measures do not measure the cognitive aspects of *why* students engage in certain behaviors.

Self-report measures, although they have problems (e.g., Nisbett & Wilson, 1977), can be used to tap students' perceived reasons for their behavior as well as their interests, values, expectancies, and perceptions of competence. Survey researches have long relied on self-report measures and most motivational researchers today also use self-report measures. There are two general types of self-report methodologies: interviews and questionnaires. Interview methods are used to collect more in-depth information from students but can be expensive and time consuming. Self-report questionnaires are the most commonly used measures of motivation.

There are standardized measures of motivational constructs, such as self-concept and intrinsic motivation, as well as unique questionnaires developed by individual researchers to measure motivational constructs of interest to them. There are too many instruments to review here but in our research program we will be adapting various questionnaires used by different motivational researchers. For example, Harter (1981) has developed an intrinsic motivation scale that we will adapt for our research.

Five intrinsic motivation factors, represented by five multi-item subscales were developed by Harter (1981). They include: (1) learning motivated by curiosity versus learning in order to please the teacher, (2) incentive to work for one's own satisfaction versus working to please the teacher and get good grades, (3) preference for challenging work versus preference for easy work, (4) desire to work independently versus dependence on the teacher for help, and (5) internal criteria for success or failure versus external criteria. Future piloting and testing of our measures of these items will help determine which of these factors are useful in assessing the motivational orientations to learning among college students.

A number of noteworthy problems may arise in the straightforward application of this instrument to college populations. For example, Deci (1975) and others have noted that as the most basic of non-drive based motivators, intrinsic motivation is differentiated into a number of more distinctive orientations as humans develop and are differentially socialized by their environments. Consequently, it may become difficult, among young adults, to identify simple distinctions between intrinsic and extrinsic orientations to learning that are necessarily indicative of functional and disfunctional orientations to learning (particularly across all learning situations).

A second, related issue concerns the possibility of the introduction of social desirability biases into the measurement of constructs like independence, challenge, mastery, and independent judgment in a culture that strongly favors these attributes among young adults. Part of this problem may be obviated by employing Harter's (1981) scaling method for assessing intrinsic motivation. However, this issue deserves careful consideration.

A third issue is aligned with the developmental differences between children and young adults, and what we might think of as changes in optimal mixes of responsiveness to internal and external incentives in different age groups. While we suggest that an intrinsic orientation to learning is discernible in all age groups, there may be compelling reasons to be responsive to external incentives among older age groups as they are confronted with adjustment to adult roles in relatively complex or competitive environments (e.g., the pursuit of course-grades that will make possible admission to top graduate training programs).

This should not be interpreted as an argument for the necessity or desireability of a primarily extrinsic orientation to learning among older age groups of students. Rather, it is simply a call for careful consideration of the possibility that the optimal configuration of intrinsic and extrinsic motivational orientations may change somewhat with the developmental challenges people are faced with at different points in their lives. Consequently, our assessment of its form and function should reflect these age-related changes.

Our measures of other motivational constructs also will take these issues into consideration. We will be adapting questions used by Eccles (1983) and her colleagues at Michigan to examine junior and senior high school students' motivational patterns. We will be adapting their task value and expectancy items to the college context, taking care to represent the underlying constructs in an ecologically valid manner. Through the construction and piloting of scales based on these items, we hope to develop a useful motivational instrument for use by faculty and higher education researchers.

V. Instructional Methods

As noted in earlier reviews on research on teaching (McKeachie, 1986), most research on teaching has used as the primary outcome measure, scores on a teacher-made final examination measuring simple knowledge and understanding. All in all, the results suggest that differences in teaching make little difference in examination scores. Large and small classes, lectures and discussions, and other comparisons of teaching methods show few significant and consistent differences. The conclusion that teaching doesn't make a difference is, however, erroneous. Teaching does make a difference in achieving more important long-range goals. Even for knowledge outcomes, the null hypothesis should not be taken as a conclusion. The problem is that final examinations are not very good criteria of differential effects of teaching for a number of reasons:

1. Final examinations are primarily based on textbook material. Thus they are not likely to be good measures of learning in classroom or other non-textbook learning activities.

2. Motivation for grades is so great that students try to compensate for ineffective teaching by increased effort. When this motivation is coupled with a criterion measure based on a textbook that the student can study regardless of the teaching method used, the result is a washing out of teaching-produced differences in learning.

3. In comparing different methods of teaching one would like to sample adequately all of the learning produced by either method of teaching, but to assign grades fairly teachers typically construct the final examination only on materials taught in common by the methods compared. Thus comparison of a modular, self-paced course with a standard lecture course may assess only that content contained in the modules that is also in the standard course. Material in the lectures is typically not included in the examination since it would be unfair to students who did not attend the lectures; similarly any material in the modules not included in the standard course will be excluded from the exam.

Despite the weakness of final examinations as criterion measures, we have learned a good deal about what makes for effective teaching. Because degree of structure is an important dimension interacting with student characteristics, we use as one characterization of each method its typical degree of structure as compared with other methods. Generally speaking explicit organization of content is a good thing (Kallison, 1986) for learning subject matter content, but as we shall see, a high degree of organization or structure is not effective for higher level goals or for students with good background and ability.

A. Peer Learning and Teaching

The best answer to the question, "What is the most effective method of teaching?," is that it depends on the goal, the student, the content, and the teacher. But the next best answer is, "Students teaching other students." There is a wealth of evidence that peer teaching is extremely effective for a wide range of goals, content, and students of different levels and personalities (Johnson & Johnson, 1975; Johnson, Maruyama, Johnson, Nelson, & Skon 1981).

In experiments in educational psychology and general psychology, Gruber and Weitman (1962) found that students taught in small discussion groups without a teacher not only did at least as well on a final examination as students who heard the teacher lecture, but they were also superior in curiosity (as measured by question-asking behavior) and in interest in educational psychology. The discussion students reported a larger number of readings during the term, whereas the lecture students reported more attempts at applying their learning. In an experiment in a physical optics course, the lecture students were superior to student-led discussion students on a test of facts and simple problems but inferior on a test containing complex problems and learning new material. The superiority of student-led discussions was particularly marked for students below the median in ability. Romig (1972) and Beach (1960, 1968) report similar results in English and psychology classes.

Webb and Grib (1967) reported six studies in which student-led discussions were compared with instructor-led discussions or lectures. Significant differences in achievement tests favored the student-led discussions. Both students and instructors reported that the student-led discussions increased student motivation; and students who had been exposed to student-led discussions tended to favor them over instructor-led discussions as a supplement to lectures. Webb and Grib note that students report that the sense of freedom to ask questions and express their own opinions is a major advantage of the student-led discussions. This may explain Gruber and Weitman's (1962) finding that the poorer students benefited most from the student-led discussions. It makes theoretical sense that this opportunity to expose individual conceptions and misconceptions and compare ideas with those of others should contribute to learning if the group contains sufficient resources of knowledge and higher level thinking to explain things in ways that help the less knowledgeable students restructure their understanding. A student-led group would most likely not be effective in areas in which students simply reinforced each other's biases.

"Pay to be a tutor, not to be tutored" is the message from studies of peer tutoring. For example, Annis (1983) compared learning under five conditions:

1. Students read a textbook passage.
2. Students read the passage and were taught by a peer.
3. Students did not read the passage but were taught by a peer.
4. Students read the passage and prepared to teach it to other students.
5. Students read the passage and taught it to another student.

The results demonstrated that teaching resulted in better learning than being taught. A similar study by Bargh and Schul (1980) also found positive results, with the largest part of the gain in retention being attributable to deeper studying of material when preparing to teach. These results fit well with contemporary theories of learning and memory. Preparing to teach and teaching involve active thought about the material, analysis and selection of main ideas, and processing the concepts into one's own thoughts and words.

Looking at peer teaching with respect to our structure dimension, we would place peer teaching methods toward the unstructured end of the scale. Nonetheless, peer teaching methods vary substantially in degree of structure and the Learning Cell which we next describe, is one of the more highly structured peer teaching methods.

1. Learning in Pairs: The Learning Cell

While instructors sometimes assume that the ideal learning situation would be one where students might work individually, at their own pace, with their own equipment, and with individual help, the common practice in laboratory instruction of having students work in pairs has good educational justification as well as the economic one of saving equipment. At the Third International Conference on Improving University Teaching (1977), both Fukuda of Japan and Elton of England (oral communications) reported that in computerized instruction students learned more effectively when two students shared a computer terminal rather than when they used separate terminals. This fits with other research and experience showing that working and studying in pairs can facilitate student learning.

One of the best-developed systems for helping pairs of students learn more effectively is the "Learning Cell" developed by Marcel Goldschmid of the Swiss Federal Institute of Technology in Lausanne (Goldschmid, 1971). The learning cell, or student dyad, refers to a cooperative form of learning in pairs, in which students alternate asking and answering questions on commonly read materials.

1. To prepare for the learning cell, students read an assignment and write questions dealing with the major points raised in the reading proper or other related materials.

2. At the beginning of each class meeting, students are randomly assigned to pairs and one partner, A, begins by asking the first question.

3. After having answered and perhaps having been corrected or given additional information, the second student, B, puts a question to A, and so on.

4. During this time, the instructor goes from dyad to dyad, giving feedback and asking and answering questions.

A variation of this procedure has each student read (or prepare) different materials. In this case, A "teaches" B the essentials of his or her readings, then asks B prepared questions, whereupon they switch roles.

The effectiveness of the learning cell method was first explored in a large (250 students) psychology course (Goldschmid, 1970) where four learning options were compared: seminar, discussion, independent study (essay), and learning cell. Students in the learning-cell option performed significantly better on an unannounced examination and rated their ongoing learning experience significantly higher. A more extensive field test in a number of other disciplines at the university level (Goldschmid & Shore, 1974) demonstrated the learning cell's effectiveness regardless of the size of the class, its level, or the nature of the subject matter. A third investigation evaluated the learning cell across three age groups (Schirmerhorn, Goldschmid, & Shore, 1975). Fifth- and ninth-grade pupils as well as university students studied probability at their respective intellectual levels for two class periods using the learning cell. All age groups showed significant learning after reading and formulating questions and after the discussions between partners (Goldschmid, 1975).

Learning cells work better for some students than others. Leith (1974a) found that introverts did about as well studying alone as in learning cells; extroverts did better in learning cells if their partners were also extroverts. A learning cell composed of an extrovert paired with an introvert was no more effective than individual learning. In summary, learning cells increase learning for some students and do not hurt the learning of any students.

Why does peer learning work? One reason might be that the learning cell has both motivational and cognitive assets. Motivationally the method has the advantages of interaction with a peer—an opportunity for mutual support and stimulation. (One piece of evidence for the motivational value of peer learning (Schomberg, 1986) is that it reduces absenteeism.) Cognitively it provides an opportunity for elaboration—putting material into one's own words—and for stimulating students to look for main points and for monitoring their own learning.

The task of the successful student in peer learning is to question, explain, express opinions, admit confusion, and reveal misconception, but at the same time the student must listen to peers, respond to their questions, question their opinions, and share information or concepts that will clear up their confusion. Accomplishing these tasks requires interpersonal as well as cognitive skills—being able to give feedback in non-threatening, supportive ways, maintaining a focus on group goals, developing orderly task-oriented procedures, and developing and sustaining mutual task. It is little wonder that peer learning sometimes fails; the wonder is that it so frequently works.

2. Student Centered Teaching

Many different teaching methods are described by the labels "student-centered," "nondirective," "group-centered," or "democratic" discussion. Proponents of these various methods have had in common the desire to break away from the traditional instructor-dominated classroom and to encourage greater student participation and responsibility. Table 4 lists some of the ways in which student-centered methods differ from the traditional "instructor-centered" class.

Student-centered classes also give greater attention to effective aspects of classroom interaction. Mann et al. (1970) considered classroom interactions as involving both cognitive and affective elements. The primary of classroom activities focus is cognitive, but

TABLE 4

Dimensions upon Which Student-Centered and Instructor-Centered Methods May Differ

STUDENT-CENTERED	INSTRUCTOR-CENTERED
Goals	
Determined by group (Faw, 1949)	Determined by instructor
Emphasis upon affective and attitudinal changes (Faw, 1949)	Emphasis upon intellectual changes
Attempts to develop group cohesiveness (Bovard, 1951a, 1951b)	No attempt to develop group cohesiveness
Classroom Activities	
Much student participation (Faw, 1949)	Much instructor participation
Stutdent-student interaction (McKeachie, 1951)	Instructor-student interaction
Instructor accepts erroneous or irrelevant student contributions (Faw, 1949)	Instructor corrects, criticizes, or rejects erroneous or irrelevant student contributions
Group decides its own activities (McKeacnie, 1951)	Instructor determines activities
Discussion of students' personal experiences encouraged (Faw, 1949)	Discussion kept on course materials
De-emphasis of tests and grades (Asch, 1951)	Traditional use of tests and grades
Students share responsibility for evaluation (Ashmus and Haigh, 1952)	Instructor evaluates
Instructor interprets feelings and ideas of class member when necessary for class progress (Axelrod, 1955)	Instructor avoids interpretation of feelings
Reaction reports (Asch, 1951)	No reaction reports

Source: *Teaching Tips*, (McKeachie, 1986, p. 47)

at times progress on cognitive work is impeded by underlying affective interactions. In their book, *The College Classroom*, Mann and his collaborators present a detailed analysis of the affective elements of student and teacher interactions in four classes.

The advocates of student-centered or group-centered teaching also introduced another category of objectives, not usually considered in traditional classes— the goal of developing skills in group membership and leadership. The group-centered teacher might argue that even if group-centered teaching were no more effective than traditional methods in achieving the usual course objectives, it is so important that students learn to work effectively in groups that it may even be worth sacrificing some other objectives to promote this kind of growth.

From the standpoint of theory, student-centered teaching in its more extreme forms might be expected to have some serious weaknesses, at least in achieving lower-level cognitive goals. With the instructor giving little information, feedback, or structure, it is apparent that a heavy burden falls on the group members to carry out any of these functions. Thus their task, as in peer learning, goes beyond content learning to interpersonal, leadership, and group-membership skills.

This may be related to the fact that some researchers report student enthusiasm for student-centered teaching while others report hostility. Since teachers sometimes become frustrated by the failure of the class to assume responsibilities, they may reach the end of their patience and take an authoritarian role (e.g., see Mann et al., 1970). Horwitz (1958) found that aggression toward the teacher increased when the teacher exercised authority arbitrarily; for example, when the teacher refused to abide by the students' decision about teaching methods after telling them that their vote would count. The same method was not resented when the instructors indicated that they would make the final decision.

Since student-centered teachers often stress group cohesiveness, a possible explanation for the contradictory results in some experiments may be found in the studies of group cohesiveness and productivity in industry (e.g., Seashore, 1954). These studies indicate that it is not safe to assume that a cohesive group will be a productive one. Cohesive groups are effective in maintaining group standards, but may set either high or low standards of productivity. Since more cohesive groups feel less threatened by management than less cohesive groups, it may be difficult to change their standards. Thus, in creating "groupy" classes instructors may sometimes be helping their students develop strength to set low standards of achievement and maintain them against instructor pressures, or at least to develop group goals different from their normal academic goals.

While scores on objective final examinations seem to be little affected by teaching method, student-centered methods were superior in student adjustment as reported by Asch (1951), Faw (1949), and Zeleny (1940). Classes compared by Bovard (1951a, 1951b) and McKeachie (1954) differed in the degree to which interaction between students was encouraged and in the degree to which the class made decisions about assignments, examinations, and other matters of classroom procedures. Like other experimenters, Bovard and McKeachie found that the groups did not differ in achievement as measured by the final examination. However, two clinical psychologists evaluated recordings of the class discussions that followed the showing of the film, "The Feeling of Rejection." Both clinicians reported that the "group-centered" class showed much more insight and understanding of the problems of the girl in the film. Similarly, Wieder (1954) found that nondirectively taught psychology classes tended to produce more reduction in prejudice that conventional classes. Like Bovard and McKeachie, Andrews (1969) encouraged self-revelation and personal involvement in a freshman writing course. His results were also positive with respect to a variety of student self-report measures.

Patton (1955) felt that an important variable in group-centered classes was the students' acceptance of responsibility for learning. He compared traditional classes to two classes in which there were no examinations, no lectures, and no assigned readings. Students in the experimental classes decided what reading they would do, what class procedures would be used, what they would hand in, and how they would be graded, so that they had even more power than had previous experimental groups. At the end of the course, these classes, as compared with the control group, (1) felt the course was more valuable, (2) showed greater interest in psychology, and (3) tended to give more dynamic, motivational analyses of a problem of behavior.

But giving students power can't work if students will not accept responsibility; so Patton also obtained individual measures of acceptance of responsibility within the experimental classes. As hypothesized, he found that the degree to which the student accepted responsibility was positively correlated with gain in psychological knowledge, gain in ability to apply psychology, interest in it, and rating of the value of the course.
Gibb and Gibb (1952) reported that students who were taught by their "participative-action" method were significantly superior in role flexibility and self-insight to students taught by traditional lecture-discussion methods. In the participative-action method class, activities centered on "sub-grouping methods designed to increase effective group participation." The instructor, who played a constantly diminishing role in the decisions and activities of the group, gave training in role playing, group goal setting, problem centering, distributive leadership, evaluation of individual performance by intragroup ratings, process observing and group selection, and evaluation and revision of class activities.

Gibb and Gibb also provide support for the assumption that group-centered teaching can facilitate development of group membership skills. They found that in nonclassroom groups the participative-action students were rated higher than other students in leadership, likeableness, and group membership skills. Di Vesta's (1954), results tend to support this conclusion, and Anderson and Kelly (1954) report that members of student-centered groups are characterized by positive attitudes toward themselves as participants.

Another bit of support for less directive teaching is Thistlethwaite's (1959) finding that there is a significant negative correlation between a college's productivity of Ph.D.s in natural science and the directiveness of teaching methods used. His finding (1960, p. 67) of a positive correlation between National Merit Scholars' desire to learn and the flexibility and permissiveness of their teachers lends additional support to student-centered teaching.

In one of our own studies (McKeachie, Lin, Moffett, & Daugherty, 1978), instructors whose students did best on achievement tests of critical thinking (with intelligence controlled) tended to be described as follows: "He listened attentively to what class members had to say." "He was friendly." "He was permissive and flexible." "He explained the reason for criticism." "Things are explained clearly." "He is skillful in observing student reactions." Both the Thistlethwaite results and these results support the value of student-centered teaching for motivation and critical thinking.

The results of the spate of research on student-centered teaching methods support the theory with which this discussion began. We had suggested that student-centered teaching might be ineffective in achieving lower-order cognitive objectives. There seem to be few instances of such a loss. Students apparently can get information from textbooks as well as from the instructor. But we also predicted that any superiority of student-centered discussion methods would be revealed in higher-level outcomes. As Table 5 indicates, differences in ability to apply concepts, in attitudes, in motivation, or in group membership skills have been found in comparisons of discussion classes emphasizing freer student participation with classes involving greater instructor dominance. The differences favored student-centered methods.

B. The Case Method

One of the paradoxes of peer learning and student-centered approaches is that if the teacher is effective, the student may not recognize the teacher's effectiveness. Ideally the student-centered teacher creates a learning situation in which students develop stronger intrinsic motivation for learning and take greater control of their own learning activities. Students and teachers alike are all too prone to think of the effective teacher as one who lectures brilliantly and provides a clear structure of assignments and course content. Thus the student-centered teacher takes the risk that students will attribute lack of success to lack of good teaching and attribute success to their own motivation and skills.

The case method is widely used in business and law courses and is frequently incorporated for one or more class sessions in other disciplines. Generally case method discussions produce good student involvement. Case methods, like games and simulations, are intended to develop student ability to solve problems using knowledge, concepts, and skills relevant to a course. The students are also expected to be motivated by the case to learn from readings, lectures, or other resources. The case method, like other discussion methods, falls toward the unstructured end of our continuum of methods.

The teacher's role in the case method is primarily to facilitate discussion-- questioning, listening, challenging, encouraging analysis and problem solving, and proposing hypothetical situations to test the validity of generalizations. The student's task involves analysis of the case, distinguishing relevant from irrelevant details, and arriving at reasonable hypotheses or conclusions.

Typically the case method involves a series of cases, but in some case method courses the cases are not well chosen to represent properly sequenced levels of difficulty. Often, to make cases realistic, so many details are included that beginning students lose the principles or points the case was intended to demonstrate. As in classic studies of discrimination learning in the laboratory, teachers attempting to help students learn complex discriminations and principles of problem solving need to choose initial cases in which the differences are clear and extreme before moving to more subtle, complex cases. Typically, one of the goals of the case method is to teach students to select important factors from a tangle of less important ones that may, nevertheless, form a context to be considered. One does not learn such skills by being in perpetual confusion but rather by success in solving more and more difficult problems. For a more detailed exposition see Hunt (1951) and Maier (1971).

Watson (1975) compared classes taught by the case method with a class taught by the lecture method. Students in one of the two case study classes scored better in knowledge and understanding than the lecture class. The other case study class and the lecture class were roughly equal. Both case study classes were superior to the lecture in ability to apply

TABLE 5

Student-Centered Teaching Effects

REFERENCE	COURSE	STUDENT-CENTERED VS. INSTRUCTOR-CENTERED CRITERIA		
		Factual Exam	Higher Exam Cognitive	Attitude, Motivation
Faw (1949)	Psychology	*S		S
Asch (1951)	Psychology	*I		S
Deignan (1956)	Psychology			S
Bovard (1951a & b)	Psychology		S	S
McKeachie (1951)	Psychology		S	S&I
Patton (1955)	Psychology		S	*S
Carpenter (1959) & Davage (1958; 1959)	Psychology	*S	*S	*S
Anderson & Kelly (1954)	Psychology			S
McKeachie (1954)	Psychology			S
Wieder (1954)	Psychology			S
Guetzkow, Kelly & McKeachie (1954)	Gen. Psych.	I		S
Bills (1952)	Gen. Psych.	I		*S
Lyle (1958)	Gen. Psych.	ATI	ATI'	
Perkins (1950)				S
Gibb & Gibb (1952)	Gen. Psych.			*S
Johnson & Smith (1953)	Intro. Psych.			(2 classes)
Smith (1954)	Intro. Psych.			
Maloney (1956)	Educ. Psych.			S
Rasmussen (1956)	Educ. Psych.			S
Moore & Popham (1959)	Educ. Psych.			S
Landsman (1950)	Human Development			S
Di Vesta (1954)	Human Relations			S
Slomowitz (1955)	Graduate Counseling			S
Krumboltz & Farquahar (1957)	"How to Study Course"			
Burke (1956)	College Freshman Orientation	I		
Jenkins (1952)	English			
Wispe (1951)	Social Relations	ATI		
Ashmus & Haigh (1952); Haigh & Schmidt (1956)	Child and Adolescent Psychology			S
Zeleny (1940)	Sociology			

Source: *Teaching Tips* (McKeachie, 1986, pp. 50-51)
I = Instructor-Centered Superior
S = Student-Centered Superior
ATI = Attribute-Treatment Interaction
ATI' = Higher ability students benefited from the more student-centered course. Lower ability students benefited from the teacher-centered coruse
* = Difference significant at .05 level or better. All other results are the actual direction of the difference in the experiment.

concepts. In view of the continuing popularity of the case method, it is surprising that so little research has been done on its effectiveness.

Cases, simulations, and games involve getting, recalling, and using information to solve problems. This involves the kind of restructuring that should be likely to result in better retention, recall, and use of learning outside the classroom.

C. Lectures

Both students and faculty are likely to perceive the student's task in lectures as simply that of understanding and retaining the knowledge presented by the lecturer. In fact, however, good students do much more. They analyze the content of the lecture, seeking organizational cues, looking for key concepts, and attempting to follow the instructor's mode of thinking. Typically students take notes, both as a method of providing an external memory and as a device for maintaining attention and active thought during lectures. In general, lectures hold down the structured end of the scale ranging from unstructured to structured teaching methods.

Hartley has reviewed research on student note taking and finds support for the value of note taking. Of 39 studies of note taking during lectures, 21 found that note taking helped learning, 3 found negative effects, and 15 not find statistically significant differences (Hartley, 1986; Hartley & Davies, 1978). As might be expected, note taking is ineffective when the notes are inaccurate and disorganized. Verbatim notes are also likely to be unhelpful. Moreover, attempting to take notes on complex, difficult material overloads the students' cognitive capacity so that they miss much of the lecture.

A large number of studies have compared the effectiveness of lectures with other teaching methods. Table 6 shows that when measures of knowledge are used, the lecture proves to be as efficient as other methods. However, in those experiments involving measures of retention of information after the end of a course, measures of transfer of knowledge to new situations, or measures of problem solving, thinking, attitude change, or motivation for further learning, the results tend to show differences favoring discussion methods over lecture.

D. Class Size

The question of class size was probably the first problem of college teaching approached by research. Are small classes really more effective for teaching than large classes? The professor's answer has generally been "Yes." But the refreshing empiricism of the 1920s looked hard at many "self-evident truths" about human behavior; among them was the assumption that class size had something to do with educational effectiveness. Large classes are likely to be more highly structured and teachers of large classes are likely to spend more time lecturing as compared with small classes.

Among the first investigators were Edmondson and Mulder (1924), who compared the performance of students enrolled in a 109-student class with students enrolled in a 43-student class of the same course in education. Achievement of the two groups was approximately equal, with a slight edge for the small class on an essay and the mid-semester tests, and for the large class on quizzes and the final examination. Students reported a preference for small classes. Mueller (1924) compared classes 20 and 40 students and found better results on a final examination for the smaller class.

The Edmondson and Mulder results encouraged the Committee of Research at the University of Minnesota to begin a classic series of studies of class size. In 59 experiments, which involved such widely varying subjects as psychology, physics, accounting, law, and education, the results of 46 favored the large classes (Hudelson, 1928).

Support for small classes, however, came from studies in the teaching of French conducted by Cheydleur (1945) at the University of Wisconsin between 1919 and 1943. With hundreds of classes ranging in size from 9 to 33, Cheydleur found a consistent superiority on objective departmental examinations for the smaller classes.

Post-World War II experiments are also favorable to small classes. Nachman and Opochinsky (1958) found a small class to be superior to a large one on surprise quizzes, but the two classes were not significantly different on the final examination for which students prepared. Differences were also revealed in the more subtle and persisting results of Feldhusen's (1963) study showing that a small class in educational psychology produced more change in attitudes toward teaching than a large class did.

The Macomber and Siegel experiments at Miami University (1957a, 1957b, 1960) are particularly important because their measures included, in addition to conventional achievement tests, measures of critical thinking and problem solving, scales measuring stereotypic attitudes, and tests of student attitudes toward instruction. Statistically significant differences favored the smaller classes (particularly for high ability students). When retention of knowledge was measured one to two years after completion of the courses, small differences favored the smaller classes in eight of the nine courses compared (Siegel, Adams, & Macomber, 1960).

TABLE 6

Lecture vs. Discussion

REFERENCE	COURSE	CRITERIA Factual Exam	 Higher Level Cognitive	 Attitude Motivation
Spence (1928)	Educ. Psych.	*L		
Remmers (1933)	Elem. Psych.	L		
Husband (1951)	Gen. Psych.	L (5 classes)		
Lifson et al. (1956)	Gen. Psych.	L = D		*D
Ruja (1954)	Gen. Psych. Philosophy	*L (4 classes) D (2 classes)		
Elliott (1951)	Elem. Psych.			D
Casey & Weaver (1956)	Human Devel. & Behavior			D
Beach (1960)	Social Psych.	D		*D
Hill (1960)	Anthropology (15 classes)	D		
Bane (1925)	Education	L(3)D(2)	*D(5)	
Solomon et al. (1964)	Government (24 classes)	L	D	
Gerberich & Warner	(1936)	Government	L	
Barnard (1942)	Science	L (6 classes)	*D	*D
Barnard (19[illegible])	(2 classes)	L = D		
Dawson (1956)	Elem. Soil Sci.	L (6 classes)	D	
Lancaster et al. (1961)	Physics	D		
Warren (1954)	Physics	D		

Source: *Teaching Tips* (McKeachie, 1986, p. 40)
L = Lecture Superior
D = Discussion Superior
* = Difference significant at .05 level or better. All other results indicate only the direction of difference in the experiment.

Few instructors are satisfied with the achievement of knowledge if it is not remembered, if the students are unable to use it in solving problems where the knowledge is relevant, or if the students fail to relate the knowledge to relevant attitudes. If one takes these more basic outcomes of retention, problem solving, and attitude differentiation as criteria of learning, the weight of the evidence clearly favors small classes.

How can we account for these results? Let us briefly return to theory. Insofar as information communication is a one-way process, size of group should be limited only by the audibility of the lecturer's voice. In fact, as Hudelson suggests, a large class may have sufficient motivational value for instructors to cause them to spend more time in preparation of their lectures, resulting, one would hope, in better teaching and in greater student achievement.

But usually we have goals going beyond communication of knowledge. If educators are to make wise decisions about when and where small classes are most important, we need to analyze more carefully the changes in educationally relevant variables associated with changes in size. One lead comes from social psychologists Thomas and Fink (1963) who reviewed research on face-to-face groups—not only classroom groups, but laboratory, business, and other groups also. They suggest that two types of input increase with increasing group size—resource input (skills, knowledge, and so on) and demand input (needs). It is clear that the larger the number of group members, the greater the likelihood that some members will have needed resources of knowledge, intelligence, or other skills needed for the educational purposes of the group. However, since there is often a limited amount of *relevant* knowledge and skills, beyond some point additional students contribute little that is not already part of the group's resources of knowledge. A group's utilization of resources is constrained by the simple facts that, (1) in large groups a smaller proportion of group members can participate orally, and (2) the larger the group, the less likely it is that a given person will feel free to volunteer. Because active thinking is so important to learning and retention of learning, constraints on oral participation are likely not only to induce passivity but also to be educationally harmful.

E. Independent Study

With the support of the Fund for Advancement of Education, a number of colleges experimented with large programs of independent study. As with other comparisons of teaching methods, few large differences were found between achievement of students working independently and those taught in conventional classes. Moreover, the expected gains in independence also often failed to materialize. Students taught by independent study did not always develop greater ability or motivation for learning independently. Nevertheless, a number of encouraging results emerged.

1. Small Group Independent Study

A number of the studies of independent study exemplify the strengths of peer learning discussed earlier. One of the most comprehensive research programs on independent study was carried out by Antioch College (Churchill, 1957; Churchill & Baskin, 1958). The Antioch experiment involved courses in humanities, social science, and science. Periods of independent study were varied, and a serious attempt was made not only to measure cognitive and affective achievement, but also to evaluate the effect of independent study on "learning resourcefulness." As in most experiments on teaching methods, the predominant results were "no significant difference." An exception to this may be found in various indices of students' satisfaction in which several significant differences favored lecture-discussion over independent study and especially over independent small groups.

Much more favorable results on independent study were obtained in the experiments carried out at the University of Colorado by Gruber and Weitman (1960). In a course in freshman English in which the group met only about 90 percent of the regularly scheduled hours and had little formal training in grammar, the self-directed study group was significantly superior to control groups on a test of grammar. In a course in physical optics, groups of students who attended class without the instructor, but were free to consult him, learned fewer facts and simple applications, but were superior to students in conventional classes in difficult applications and learning new material. Moreover, the areas of superiority were maintained in a retest three months later when the difference in factual knowledge had disappeared. In educational psychology an experimental class of five or six students without the instructor was equal to a conventional three-lecture-a-week class in mastery of content, and it tended to be superior on measures of curiosity.

2. Variations in Amount of Classro a ? me

Independent study experiments have varied greatly in the amount of assistance given students and in the patterning of instructional vs. independent periods. For example, merely excusing students from attending class is one method of stimulating independent study. The results of such a procedure are not uniform but suggest that classroom experience is not essential for learning. However, different kinds of learning may take place out of class than in class.

The experiment reported by McKeachie, Forrin, Lin, and Teevan (1960) involved a fairly high de ee of student-instructor contact. In this experiment students normally met with the instructor in small groups weekly or biweekly, but students were free to consult the instructor whenever they wished. The results of the experiment suggest that the "tutorial" students did not learn as much from the textbook as students taught in conventional lecture periods and discussion sections meeting four times a week, but they did develop stronger motivation both for course work and for continued learning after the course. This was indicated not only by responses to a questionnaire administered at the end of the course, but also by the number of advanced psychology courses later elected.

The results of the studies in a child development course by Parsons (1957) and Parsons, Ketcham, and Beach (1958) were, in a sense, more favorable to independent study. In the latter experiment four teaching methods were compared—lecture, instructor-led discussions, autonomous groups that did not come to class, and individual independent study in which each student was sent home with the syllabus, returning for the final examination. In both experiments, students working independently made the best scores on the final examination, which measured retention of factual material in the textbook. The instructor-led discussion groups were the lowest in performance on the final examination. There were no significant differences between groups on a measure of attitudes toward working with children. The authors explain their results in terms of the independent group's freedom from distraction by interesting examples, possible applications, or opposing points of view from those presented in the text.

Although the Parsons, Ketcham, and Beach results were favorable to independent study, they are not very satisfying to advocates of this method, for they lead to the conclusion that if students know that they are going to be tested on the factual content of a particular book, it is more advantageous for them to read that book than to participate in other educational activities. In fact even better results might be obtained if the desired facts could be identified by giving the student test questions in advance (as in Keller's Personalized System of Instruction). But knowledge of specific facts is not the typical major objective of an independent study program. What instructors are hoping for is greater integration, increased purposefulness, and more intense motivation for further study. That independent study can achieve these ends is indicated by the Colorado and Michigan experiments. But the paucity of positive results suggests that we need more research on methods of selecting and training students for independent study, arranging the independent study experience, and measuring outcomes. Note that the Colorado and Michigan results came in courses in which a good deal of contact with the instructor was retained. While independent study methods tend to be less structured than conventional classes, it appears that in these studies independent study was more successful if there was some structure.

3. Time in Class

The independent study experiments demonstrate that education is not simply a function of time spent in a class with a teacher. Well-planned activities outside teacher-controlled classrooms can be at least as educational as conventional classes. But merely reducing time in class is not independent study. Generally speaking, the more time spent on learning, the greater the learning. Wakely, Marr, Plath, and Wilkins (1960) compared performance in a traditional four-hour-a-week lecture class with that in a class meeting only once a week to clear up questions on the textbook. In this experiment the traditional classes proved to be superior. Similarly Paul (1932) found 55 minute class periods to be superior to 30-minute periods, as measured by student achievement. Shortening class periods, reducing the number of classes, cutting the length of the academic term may be advisable as part of a planned educational change, but they should not be undertaken with the blithe assumption that the same educational outcomes will be achieved. Only if student active cognitive engagement with the learning materials is increased, will educational outcomes be improved.

F. Research on Learning from Reading

An early study (Greene, 1928) found that students learned as well from reading material as from listening to the same material read aloud. The better students, moreover, profited more from reading than from listening. A number of other studies have compared printed materials with lectures, and the results—at least with difficult materials—favor print (Hartman, 1961). In fact Reder and Anderson (1982) found that students who studied textbook summaries scored better on achievement tests that those who read the entire text. The details in the text were distracting rather than supportive.

Thus in learning from reading, as in learning from other media, the learners' task is to analyze and organize the information provided, pulling out main points and developing an organization, providing a structure into which facts and concepts can be fitted. The ability to do this depends not only on the learning strategy used by the learner but also on the learner's prior knowledge. Even an effective strategist will miss the main point in areas in which he or she is a novice.

The eruption of research in cognitive psychology has pushed the frontiers of research into studies of meaningful prose passages. Most of the research to date has been on brief passages, but there are now a number of studies using material like textbook passages. As we saw earlier, we have learned a great deal about strategies that facilitate learning and retrieval of information in print.

Among the most widely known such studies are those carried out by researchers at the Institute of Education, University of Goteburg (Marton & Saljo, 1976a, 1976b; Svensson, 1976). The Goteburg group used concepts of cognitive psychology, such as deep versus surface processing, in describing the approaches of students studying chapters of textbooks and other meaningful, relatively complex, reading. Their results, like those of Gates (1917) and other pioneers, indicate that questions can influence student learning. Marton & Saljo (1976b) found that questions designed to produce more thoughtful, integrative study were more effective that questions of fact. Nevertheless, study questions are not automatically a guarantee of better learning. Students sometimes tended to look only for answers to the questions while disregarding the other content of the chapter (Marton and Saljo, 1976a). Rothkopf (1972) and other students of prose learning suggest that factual questions after reading may be more effective than factual questions before reading. Wilhite (1983) found that pre-questions focusing on material at the top of the organizational structure did facilitate learning, especially for the less able students. What instructors need are questions that get students to think about the material.

G. Programmed Instruction and PSI

In the 1960s "programmed textbooks" began to appear. These were instructional books developed by applying the learning-in-small-steps sequences advocated by B. F. Skinner. Such books and booklets have sometimes been designed as adjuncts to traditional teaching material, but often they were intended to replace textbooks.

The research with Skinnerian types of programs was not encouraging. Students did learn from the programs, but learning was generally slower than with conventional printed materials (but faster than with lectures) (Smith, 1962). Reviews by Kulik, Cohen, and Ebeling (1980), Lange (1972), Nash, Muczyk, and Vettori (1971), and Schramm (1964) show programmed instruction to be superior to traditional instruction in about 40 percent of the over a hundred research studies reported, equally effective in about half the studies, and relatively seldom less effective.

One would expect strict control over the structure and pace of learning to be most helpful to students with poor study habits—those who read passively and tend to slide over important uncomprehended points—but little research has been done to determine what kinds of students gain from programmed texts or what types of objectives can be most efficiently achieved. On the basis of the theoretical relationship between uncertainty and curiosity, it might be expected that most students would be bored by the usual practice of writing programmed materials so that every question is answered correctly by almost every student. From Atkinson's motivation theory it would be expected that students with a high need for achievement (those who work hardest in situations with moderate probabilities of success) would find the usual small-step program more boring that other students would. And this is what Moore, Smith, and Teevan (1965) found.
But even for students in general, a logical sequence of items may be less efficient for learning than a random sequence (Rosen, Frincke, & Stolurow, 1964). This makes sense in terms of the motivational theory that lack of change or surprises makes for boredom and also helps to explain why short programs, requiring half and hour or less, seem to be more effective and less boring than longer programs covering large blocks of material or an entire course (Beard, 1972).

The fervor of the 1960s' proponents of teaching machines has now subsided, and research is beginning to clarify the uses of programmed materials. For a while it appeared that programmed materials might enable educators to shortcut the difficult problems of curriculum and course organization, but programs that teach unimportant concepts or untrue information are not of much help to education, and it is now recognized that the writing of a good program requires as much scholarship as the writing of a good textbook

(Krumboltz, 1964). Unfortunately, programming is difficult work, and as yet scholars seem less willing to write programs than to write books. Thus, there are still only a very limited number of good programs for college use, although programmed texts are frequently used in military and industrial training and some educational computer programs essentially are programmed books. Just as the independent study research indicated that extreme lack of structure was not effective, here it appears that too much structure is ineffective.

One method of teaching that has had a consistently positive effect on the acquisition of knowledge is Keller's Personalized System of Instruction (PSI). Like some other systems of individualized instruction, the Keller Plan involves a sequence of units of material, frequent readiness testing, and individual pacing. Its distinctive features are heavy emphasis on instructor-prepared written materials to supplement textbooks and extensive use of tutors for individual assistance and evaluation of students. In 1968, Keller described the five features that distinguish the Keller Plan from conventional teaching procedures; it is individually paced, mastery oriented, and student tutored; it uses printed study guides for communication of information; it includes a few lectures to stimulate and motivate students.

Students beginning a Keller course find that the course work is divided into topics or units. In a simple case, the content of the units may correspond to chapters of the course text. At the start of a course, the students receive a printed study guide to direct their work on the first unit. Although study guides vary, a typical one introduces the unit, states objectives, suggests study procedures, and lists study questions. Students may work anywhere to achieve the objectives.

Before moving on to the second unit in the sequence, the students must demonstrate their mastery of the first unit by perfect or near-perfect performance on a short examination. They are examined on the unit only when they feel adequately prepared; they are not penalized for failure to pass a first, a second, or later examinations on the unit. When the students demonstrate mastery of the first unit, they are given the study guide for the next unit. They thus move through the course at their own pace. A student may meet all course requirements before the term is half done or may require more than a term to complete the course.

The staff for implementing the Keller Plan includes the instructor and undergraduate tutors. The instructor selects and organizes material used in the course, usually writes study guides, constructs examinations for the course, and gives fewer lectures and demonstrations than in a conventional course (perhaps six in the course of a semester). These lectures are not compulsory, and examinations are not based on them. The tutors evaluate readiness tests as satisfactory or unsatisfactory. Since they have been chosen for mastery of the course content, the tutors can prescribe remedial steps for students who encounter difficulties with the course material. The tutors also offer support and encouragement for beginning students. A number of experiments have corrected the methodological errors in early studies and offer convincing data on the effectiveness of PSI, not only in introductory psychology courses but also in other fields (Kulik, Kulik, & Carmichael, 1974; Kulik et al., 1979). Unfortunately, interest in teaching with PSI seems to have diminished in the past few years.

Lloyd and Lloyd (1986) surveyed faculty members who had used PSI as well as a sample of chairpersons of departments of psychology. Responses from both groups indicated less use of PSI, and almost all who continued to use PSI had made extensive modifications, typically retaining study guides and frequent testing but modifying or omitting self-pacing, 100% mastery, and the use of student proctors.

The effectiveness of PSI in affecting achievement may have been related to the effectiveness of frequent testing in affecting students' time-on-task. For the past decade or more, time-on-task has been a favorite variable of educational researchers studying teaching at the elementary and high school levels. Early research demonstrated that student achievement of basic skill and knowledge objectives was, as one might expect, related to the amount of time spent in practice or study. More recent research has demonstrated the equally plausible conclusion that it is not simply the amount of time spent but how it is spent that counts. What matters is what goes on in the mind of the learner.

A key feature of PSI is frequent testing, a device that motivates students to study. But the long-term effects of frequent testing must, we would expect, depend on the quality of the tests and the kind of interactions students have with the more advanced students who correct the tests and provide tutorial assistance. If objective tests requiring only test wiseness and memory of facts are used, some students are likely to rely on the expectations that, over several trials, chance alone will bring success or at worst, they will rely on chance plus memorization of definitions and lists. If tutors simply correct tests and advise re-reading the assignment before retaking the test, students gain little from the interaction. Ideally PSI courses would use essay, oral, or other measures requiring thinking about the material learned and tutors would engage in meaningful dialogue with each student. To increase the probability that students would be motivated to continue learning without the prod of a test, the frequency of testing might be reduced as the course progressed. The ideal, unfortunately, is rarely attained.

H. Testing

Whatever teachers' goals and no matter how clearly they present them, students' goals are strongly influenced by tests or the other activities that determine grades. No matter how much teachers try to nurture intrinsic motives for learning, students must still get acceptable grades to achieve other academic and vocational goals. Tests provide an operational definition of goals that is very compelling for the students. Thus, if teachers say that they are concerned about developing skills and strategies for further learning and problem solving and that they hope to help students develop cognitive structures that will form a foundation for continued learning and then give tests that require memory of individual facts, definitions, and isolated information, students will memorize the facts, definitions, and information on which they expect to be tested. In so doing they will use memorization, repetition, and other learning strategies unlikely to be useful for achieving the higher-order cognitive objectives we have proclaimed.

This argues strongly against exclusive use of objective true-false, multiple-choice, or even short-answer questions of the type most teachers construct. A number of research studies have demonstrated that students study differently for objective than for essay tests and that the methods of study used for objective tests are not effective for long-term retention or use of the material learned (McClusky, 1934; Monaco, 1977; d'Ydewalle, Swerts, & de Corte, 1983). One of the great educational liabilities of large lecture classes is the tendency to rely primarily on objective tests for grading. Even one good essay question may make a difference in student learning. Thus in moderate- to large-sized courses combining objective questions with an essay may be reasonable. Better yet would be a broadening of the variety of assessment devices to include simulations and real-life activities. Frederickson (1984) has pointed out that standard multiple-choice tests administered in conventional test situations do not provide adequate evidence of real-life performance. With the increasing availability of computers, more instructors are using computers in testing but frequently the computer is used simply as an item bank rather than as a way to assess thinking in simulations of real-life problems.

The other aspect of testing that consistently makes a difference in student learning is the kind of feedback given. Simply returning a grade or score is less effective than providing explanations or guidance for improvement. This principle also holds true for computer-based instruction (Roberts & Park, 1984).

We have already seen that cooperative peer learning is effective, but a barrier to cooperative learning is the competition often engendered by "grading on the curve." Covington and Omelich (1984) divided their 435-student introductory psychology course into four groups— norm-referenced versus criterion-referenced grading and single-test versus retest option. The experiment lasted for two weeks, ending with the midterm examination. Both retesting and criterion-referenced grading helped motivation. A path analysis suggested that the retesting option improved performance, which enhanced motivation, which in turn resulted in further gains in learning.

In taking typical classroom examinations, the task of the student involves a number of complex cognitive activities. McKeachie (1986) describes some of the things that can account for a poor answer on an essay test.

1. The student does not understand the question.
2. The student has not learned the material.
3. The student lacks specific cues for retrieval.
4. The student lacks an appropriate strategy for retrieving the material.
5. The student lacks words needed for an answer.
6. The student lacks a conception of the required solution; for example, when asked to "explain," the student lacks an adequate conception of what is involved in an adequate explanation.
7. The student cannot hold the required material in active memory while writing the answer.

As we saw earlier the task is complicated by the problem of anxiety aroused by the test, especially for students high in test anxiety.

I. Teaching Methods: A Summary

Our survey of teaching methods suggests that the effectiveness of teaching methods depends upon one's goals. For the goal of factual knowledge lectures and reading assignments are likely to be as good or better than other methods. For goals of long term retention, thinking, and motivation less structured methods involving more student activity are likely to be superior. In fact, the amount of active thinking by students may be more important as a mediating variable than the teaching method variable per se. Time on task is an important variable, but the questions are "What tasks?" "How is the time spent?" If we want students to become more effective in meaningful learning and thinking, they need to spend more time in active, meaningful learning and thinking - not just sitting passively receiving information. We have seen in the case of independent study and programmed learning that neither extremely unstructured or extremely structural methods are effective. When we examine attribute-treatment interactions in a later section of this paper we will see the structure makes a difference for students and affects different students' achievements differentially.

VI. Academic Tasks and Activities

Recent work in cognitive psychology has stressed the importance of task characteristics in determining students' reactions to and cognitions for school tasks (Brown et al., 1983; Doyle, 1983; Mosenthal, 1983). Brown et al. (1983) have suggested that four aspects of the person and environment need to be considered in understanding student cognition. In their tetrahedral model (Brown et al., 1983) they note that student characteristics, the nature of the materials (e.g., verbal, visual, complexity, sequencing), the learning activities (attention, rehearsal, elaboration), and the criterial tasks (e.g., type of exam, paper assignment) all influence student learning. Mosenthal (1983) adds a fifth dimension, context, that concerns the classroom context in which the students and tasks are embedded. The task construct is assumed to organize and guide students information processing (Doyle, 1983).

There are three general components of the task in Doyle's (1983) model. The first component involves the product the student is required to formulate. For example, a student writing an original essay for an English class has a very different product to create than does a student in an English class who is creating an essay by performing a sentence-combining task.

The product influences the the second component in Doyle's model, the cognitive operations involved in performing the task. These are the learning activities in the Brown et al. (1983) tetrahedral model. The cognitive operations involved in creating an original essay and in a sentence combining task are quite different and will evoke different learning on the student's part.

The third component in Doyle's model concerns the resources available for students to use in completing the task. In a sentence-combining task the student has more "material" provided by the task, in contrast to the essay where the student must generate material to complete the essay. The resources provided by the task interact with the student's characteristics in terms of the student's skills, prior knowledge, and motivation for the task.

Given this brief sketch of the components of tasks, it is clear how tasks assigned in classrooms can influence student learning. Although cognitive psychologists have explored the influence of task characteristics on student learning in experimental studies, there has been little ecologically valid research on classroom tasks. Accordingly, while the general model and some of its aspects have been discussed by Doyle (1983), there are still great gaps in our knowledge about the nature of tasks in the classroom and their influence on student learning. In addition, while researchers interested in elementary and secondary schools have started to investigate task characteristics, there has been little ecologically valid research on the task construct in postsecondary settings except for the extensive research literature on adjunct questions (Hamaker, 1986). Part of our research agenda is to address this gap.

One of the issues that needs to be addressed includes constructing a descriptive taxonomy of classroom tasks. Doyle (1983) has suggested four basic types of tasks: memory, procedural, comprehension, and opinion tasks. Memory tasks require the student to memorize some material. Procedural tasks require the student to employ a particular procedure or algorithm, as in solving math problems. Comprehension tasks are tasks that ask the student to demonstrate their understanding of some material. Opinion tasks ask the student to analyze and evaluate material in some way. These four types of tasks parallel to some extent the six levels in Bloom's taxonomy of tasks.

Another way of classifying tasks would be to use Gagne's learning hierarchy idea. The fact that there can be different levels of difficulty and abstraction for tasks suggests that purely content labels (e.g., math, English, psychology) are not useful descriptions. What is needed is a task analysis of the demands of the task and the cognitive operations involved to complete the task.

Our research will be one attempt to develop a descriptive taxonomy of college classroom tasks. We will be looking at the types of exams and papers assigned to students. As the task model and previous research studies suggest, students who are given multiple-choice tests should learn the material differently from those who are given essay exams. In addition, we will be examining the level of the materials assigned to the class. For example, students reading primary sources (e.g., Shakespeare, Freud) will learn different things from those reading secondary sources such as textbooks. The use of the task construct will help us characterize the classroom context in a more detailed fashion than previous research and should help provide some insight into the nature of instruction and student learning in college classrooms.

VII. Attribute-Treatment Interactions

As we have pointed out throughout this paper, different types of students may react differently to different types of instruction. This idea is labeled attribute-treatment interaction or ATI research in educational psychology and is an example of the more general idea of person-environment fit in psychology. Cronback and Snow (1977) summarize many of the studies of ATIs and Corno and Snow (1986) provide a recent update. We briefly review ATI research in higher education here.

1. The Interaction of Intelligence and Prior Knowledge with Structure of Teaching Knowledge

Intelligent students do better than less intelligent students in most educational situations. But it does make a difference how students of differing intelligence are taught. Remmers (1933), in three experiments comparing varying combinations of lecture and recitation, found fairly consistent results favoring a greater proportion of recitation for more able students and a greater proportion of lecture for the less able students. Ward's study (1956) indicated that the most able students, more than other students, are favorably influenced by small classes. Calvin, Hoffman, and Harden (1957) found in three experiments that less intelligent students consistently did better in group problem-solving situations conducted in an authoritarian manner than in groups conducted in a permissive manner. The same difference did not occur for bright students. Hansen, Kelley, and Weisbrod (1970) found that TIPS, a system involving frequent testing, was most effective for less able students. All of these probably indicate that less structured methods, such as discussion, are more appropriate for bright students than for less able students.

Siegel and Siegel (1964) found that low-ability students performed better on a test of conceptual acquisition if they had been previously tested with an emphasis on factual rather than conceptual learning. High-ability students were affected by the difference in methods based on their previous knowledge; high-ability students with high previous knowledge benefited from emphasis on conceptual learning, while the unsophisticated high-ability student, like the low-ability student, performed better on conceptual acquisition if previous emphasis had been on factual learning.

In an introductory biology course, Gay (1986) created two groups equivalent in scholastic aptitude but differing in conceptual understanding of protein synthesis. Subjects studied computer-assisted videodisc modules about protein synthesis under two conditions. In the program-controlled condition, material was sequenced logically; in the learner-controlled condition, subjects controlled sequence, pace, presentation mode, and amount of practice. Those with low prior understanding benefited most from the program-controlled instruction while high-prior-knowledge students in the learner-controlled condition spent less time while achieving as well as high-prior- knowledge students in the program-controlled condition.

Hall, Rocklin, Dansereau, Skaggs, O'Donnell, Lambiotte, & Young (1986) found cooperative, dyadic learning to be more effective than individual learning, a finding supporting other research we have received on peer learning. In addition, they found that students scoring high on a test of induction, one of the components of intelligence, benefited particularly from peer learning, a finding which they explain in terms of the greater ability of high ability students to process the multiple sources of input in dyadic learning.

These results fit well with the wisdom of college faculties who have generally urged smaller classes, greater use of discussion, and a higher conceptual level in honors classes. Bright students will generally be able to handle a greater information-processing load than less able students; that is, the able students can figure out things better for themselves and provide their own organization. The less able students are more likely to benefit from attempts to simplify and organize the material for the students, organization that may be detrimental for the better students (see Snow, 1976). Siegel and Siegel, however, inject a cautionary note— being bright is not enough. The naive bright student is perhaps more like the less able student than is sometimes recognized by college honors committees, a point also illustrated in the research of Mayer, Stiehl, and Greeno (1975).

The importance of prior knowledge is also indicated by the study of Stinard and Dolphin (1981). Using self-paced mastery examination modules in an anatomy and physiology course, they found that the self-paced testing helped students with less science preparation. Contrasted with comparable students in a conventional course, these students used the self-paced tests as guides and stimuli for increased study time.

2. Personality Variables

Comparing students in conventionally taught classes with those in which students were given major responsibility for the course, Patton (1955) found that the degree to which students accepted responsibility in the latter classes was positively correlated with gain in ability to apply psychology and interest in psychology. What sort of student accepted responsibility in such a course? Patton found that the students who liked his experimental class and assumed responsibility were likely to be independent of traditional authority figures and high in need for achievement.

Similarly, in the Oberlin studies of independent study (McCollough & Van Atta, 1958) students who were less rigid and less in need of social support profited more in measured achievement from independent study that those students who were not as independent.

Domino (1968, 1971), using the Achievement via Independence and Achievement via Conformity scales of the California Psychological Inventory, found in two studies that independent students did better with teacher styles stressing independence, while students high in Achievement via Conformity did better with more structure. Similarly, Van Damme and Masai (1980) found that students high in external locus of control achieved better relative to "internal" students in PSI (Personalized System of Instruction) courses than in lecture, and better still in a form of PSI with additional guidance and structure.

Despite the variety of measures used, the studies cited in this section show some consistency in finding that a certain type of student, characterized as independent, flexible, or high in need for achievement, is happy and achieves well in classroom situations that give students opportunity for self-direction.

VIII. What Do Effective Teachers Do?

One of the most persuasive studies of effective teaching was that carried out by Wilson, Gaff, Dienst, Wood, and Barry (1975) a little over a decade ago. They asked faculty members in six colleges and universities to nominate three colleagues whom they regarded as having significant impact on students; they asked seniors to name the teacher who had contributed most to their educational development; they obtained data on changes in students from the freshman to senior year on the Omnibus Personality Inventory (changes on the scales measuring intellectual interests were particularly relevant). They asked faculty members to name students to whose development they had contributed. The convergence between these sources of data give some confidence in the validity of the conclusions about effective teachers. Among the most important characteristics of effective teachers were high levels of interaction with students outside the classroom, striving to make courses interesting, using frequent examples and analogies in teaching, referring to contemporary issues, and relating content to other fields of study. The characteristics identified fit well with other data from research on student ratings of teaching as related to student learning. (Cohen, 1981; Feldman, 1976; Marsh, 1984; Murray, 1985).

One of the most prolific areas of research on effective teaching has been that dealing with student ratings of teaching. As Marsh's review (1984) demonstrates, teachers rated as effective by students tend to be those whose students perform well on achievement tests and evidence from peer ratings, self-ratings and other sources of data provide converging evidence of the validity of student ratings. Marsh (1986) has also shown that the qualities characterizing effective teachers, as perceived by students are much the same in Spain, Australia, Papua New Guinea, and North America. Enthusiasm and clear, well-organized presentations were most highly valued in all groups. The amount of work and the difficulty of the course did not relate as highly to rated effectiveness, but contrary to criticisms and faculty stereotypes of student ratings, teachers who assign more work and more difficult work tended to be those rated as most effective.

Are expressive lecturers more effective? Ever since the original reports of the "Dr. Fox" effect (Ware & Williams, 1975) there has been suspicion that expressive, enthusiastic lecturers produce high student ratings without affecting student learning. Researchers at the University of Manitoba have carried out an impressive series of well-controlled experiments demonstrating that teacher expressiveness does produce greater student learning, but the effects are complicated by interactions with other variables, such as incentive conditions, student ability, and student perceived control (Perry, 1985; Perry, Magnusson, Parsons, & Dickens, 1984).

Thus the conclusion of this line of research fits with that reported in earlier sections of this report. What is effective teaching depends on the students, the content, and the goals of teaching as well as upon teacher characteristics. Nonetheless, enthusiasm, expressiveness, energy, and a real commitment to students and teaching make a difference. in achieving most educational goals. Our task as researchers is to find more precisely those methods and techniques which are most facilitative of student achievement of higher level cognitive and motivational goals.

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Teaching and Learning in the College Classroom

A Review of the Research Literature

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Teaching and Learning in the College Classroom: A Review of the Research Literature

Introduction

In this supplement to our 1986 review we have selected recent reports of research and theory that supplement, enrich, or reinforce the work included in our earlier review. In our view, none of the recent publications lead to radical changes in the conclusions we presented in the earlier review. (The parenthetical references after each section heading refer to the relevant section of the 1986 review.)

Learning Strategies (Ch. III, Part B)

Students have relatively good metacognitive ability in predicting their readiness for examinations (Leal, 1987). Thus the high anxiety reported by many test-anxious students lacking effective study skills may well be the result of realistic appraisals of test performance as hypothesized by Benjamin, McKeachie, Lin, and Holinger (1981).

However, Tobias (1987) found that students' uses of learning strategies in a computer-controlled experiment of reading strategies did not correlate well with the students' reports of the strategies they normally used. While this may be a function of the difference between the laboratory situation and normal studying of text, it seems likely, as Tobias suggests, that students may neither know which strategies are most effective nor be aware of their own strategies for learning. It may well be that students have a general sense of their readiness, or lack of readiness, for an examination, but relatively less awareness of what to do to remedy deficiencies.

That this may be the case is demonstrated by Tobias's results indicating that mandatory review following an error in answering an adjunct question resulted in better performance than voluntary, student-controlled review.

Nonetheless, students are able to adjust their strategies to fit the demands of the situation. Sagerman and Mayer (1987) gave students four science passages to read. For one group each passage was followed by verbatim questions; for a second group by conceptual questions; and for a third group by no questions. The verbatim group did better in answering verbatim questions on the fourth passage than did the control group, but not on the conceptual questions. The conceptual group did better than the verbatim group on both conceptual and verbatim questions. These results fit well with those cited in our 1986 review on the advantage of essay over objective testing for student learning.

What do students do when they are assigned very difficult reading? Waern and Rabenius (1987) report that students predominantly turn to memorizing. The result in the experiment conducted by Waern and Rabenius was comprehension little better than guessing on a post-test.

German and Dutch research on learning and instruction is reviewed in the volume edited by Beukhof and Simons (1986). Friedrich and Mandl (1986) point out that metacognition is being related to broader concepts of motivation and action control in German research and that training in metacognitive self-regulation has been less successful than might have been expected in view of the correlations between metacognition and learning performance. Dutch results are similarly mixed (Simons & Vermunt, 1986). This may be due to the interactions between learning strategies, prior knowledge and the specific learning task. Training in learning strategies and metacognition may not be helpful if one is so lacking in necessary content knowledge as to be completely confused. At the other end of the prior knowledge continuum, training may also be of little value either because the learner already has effective strategies and thinking about them metacognitively may simply divert capacity from the learning task itself.

Although our review is intended to focus on research, we would be serving our readers badly if we did not include a book review in the Winter 1984 issue (published in August 1987) of *Contemporary Education Review* that reviewed books published in 1985 and 1986. The review, "Are there programs that can really teach thinking and learning skills?" by Pressley, Cariglia-Bull, and Snyder (1984), not only provides an incisive critique and analysis of the programs for improving thinking and learning skills described in the book reviewed—*Thinking and Learning Skills, Volume 1: Relating Instruction to Research* (Segal, Chipman, & Glaser, 1985)—but also gives the reader a brief introduction to Pressley's own Good Strategy User model. The reviewers point out the need for better experimental data both on the overall effectiveness of the programs and on the interactions between particular skills and the student's knowledge base in different content areas.

Thinking and Problem Solving (Ch. III, Part C)

Nisbett, Fong, Lehman, and Cheng (1987) review research demonstrating that even brief formal training in inferential rules can enhance their use in reasoning in non-classroom situations. This is significant because, as indicated in our basic review of the research literature (McKeachie, Pintrich, Lin, & Smith, 1986), formal training in logic courses or other courses in reasoning has generally had little transferable effect on reasoning outside the courses in which the training was done. In fact the emphasis in recent years has been to stress the domain-specificity of thinking skills.

Nisbett et al. (1987) show that transfer occurs when individuals have an intuitive grasp of an abstract rule, such as the law of large numbers, and are given this abstract rule or are given training on examples. The law of large numbers involves the principle that one needs larger samples when generalizing about populations that vary more in the relevant attribute than when generalizing about populations that vary less. Thus people are more willing to assume that all tribesmen on a remote island are brown based on a small sample of brown, fat, tribesmen, than that all are fat.

Studies of the effect of graduate training in psychology, chemistry, medicine, and law showed little difference among students at the beginning of training but significant differences after two years both for scientific and everyday problems in the use of statistical, methodological, and conditional reasoning. Chemistry training had no effect, law produced improvement in the logic of conditional but not in statistical or confounded variable problems, while students in psychology and medicine gained on all three types of problems. These studies open up a new area of research on pragmatic reasoning rules as well as hope for dramatic improvements in teaching reasoning.

Derry, Hawkes, and Tsai (1987) presented TAPS, a theory of problem solving based on observations of young adults who talked while solving complex word problems. The theory is used to diagnose and remedy problem-solving difficulties in such areas as prerequisite knowledge, schema recognition, or higher-level strategies such as memory-management or -checking routines.

Domain-specific knowledge is emphasized by Bransford, Sherwood, Vye, and Rieser (1986), who suggest that programs for teaching general problem-solving skills would be strengthened by additional focus on domain knowledge. They review research indicating that teachers need to go beyond blind drill-and-practice methods of teaching mastery to methods that encourage students to explain or defend their understanding to peers or to the teacher if understanding is to be achieved in ways that permit problem-solving strategies to be usefully transferred.

The importance of mindfulness in learning has been stressed by Salomon and Globerson (in press). Langer and Piper (1987) have shown that teaching in a conditional rather than an absolute way reduces mindlessness. Thus if a new object is introduced as "this could be" rather than "this is," subjects are likely to generate more creative answers to the task of generating novel uses for the object. This fits with the general lore of teaching that dogmatic teaching produces narrower, more restricted learning.

One of the pleasant current research findings is that pleasant feelings facilitate memory and problem solving. In her most recent study, Isen, with Daubman and Nowicki (1987), demonstrated that positive feelings, produced by a few minutes of a comedy film, resulted in better performance than arousal produced by exercise or by a film depicting concentration camps. The authors attribute these gains to a tendency to combine material in new ways and see greater relatedness. So keep your students happy!

Student Motivation (Ch. IV)

One of the major themes of our research program is that motivational and cognitive variables interact in such intimate conjugations that they must be jointly considered in any comprehensive theory of student learning and thinking. Increasing a student's skills for learning and problem solving not only affects ability to learn and think but also increases the student's sense of self-competence—one of our basic motivational variables. Conversely, increasing a student's motivation for learning and thinking affects the student's development and choice of skills and strategies for learning and problem solving.

Beginning freshmen who explain failure as the result of fixed ability often receive lower grades than comparable students who explain failure in terms of external, unstable, specific causes. Students with a negative explanatory style are less likely to have specific academic goals and make less use of academic advising than those with a more positive style of explaining failure (Peterson & Barrett, in press). Thus one method of improving student performance may be to help students recognize the possibility of developing needed skills as well as clarifying academic goals.

McCombs (1987, April) provides support for this view in a review of research and theory indicating that, for students to develop the motivation necessary for self-directed learning, they must believe that they have the ability to achieve the level of competence necessary for reaching personally meaningful goals. McCombs suggests that if we are to provide useful suggestions for teachers, we need better methods of assessing students' goals, their evaluations of their competencies, and their assessment of the personal significance of particular learning tasks as well as their belief in their ability to assume self-direction and take responsibility for their own learning. This is the direction of our research in NCRIPTAL, as exemplified by our Motivated Strategies for Learning Questionnaire.

McCombs (1986) extends an earlier review of research and theory, listing six principles:

1. Human behavior is basically motivated by needs for self-development and self-determination.

2. The self-system operates as the base set of "filters" through which all information is processed, transformed, and encoded.

3. The self-referent nature of this filtering process maintains the illusions of control or self-determination that lie at the base of self-esteem maintenance.

4. Self-reference can become an effective strategy for generating motivation to learn and for producing more effective learning.

5. Affect plays a major role in self-system development, motivation, and the engagement of self-regulated learning processes and strategies.

6. Autonomous learning is an inherently natural process driven by the need to fulfill self-development and self-determination goals.

In McCombs' model, needs for self-development and self-determination lead to self-system structures—goals, values, beliefs. Self-system structures interact with self-evaluative processes to determine outcome expectancies which, in turn, generate affect, which influences motivation leading to performance. Performance outcomes cycle back to affect self-system structures, and self-regulation processes interact with metacognitive and cognitive structures to produce a dynamic system.

McCombs (1987, August) developed a test battery to assess self-evaluations of competence and personal control.

Test Anxiety and Affect (Ch. IV, Part A.4)

A different way to synthesize study skills and interference models has recently been suggested by Naveh-Benjamin, McKeachie, and Lin (1987). Instead of claiming that both skill deficiency and interference from worry occur in all highly test-anxious students, these authors suggest that different types of such students possess different types of deficits. A first type includes highly test-anxious students with good study skills who do not have problems in encoding and organizing (learning) the information, but rather have a major problem in retrieval for tests, probably due to interfering thoughts. A second type includes highly test-anxious students with poor study habits who have problems in all stages of processing, both in learning the information and in retrieving it. Such a distinction was supported by results comparing performance of these types of highly test-anxious students in evaluative and non-evaluative situations. Results showed that those highly test-anxious students with good study skills did well on a task requiring organizational skills in a non-evaluative situation. In such a situation they were able to use their knowledge without interfering thoughts. However, in an evaluative situation they did as poorly as the other highly test-anxious students who lack study skills. In contrast, highly test-anxious students with poor study skills performed poorly in a non-evaluative situation as well as on tests.

Further support for the above distinction between two types of highly test-anxious students was obtained in a study by Naveh-Benjamin (1985) which showed that each of the above types of highly test-anxious students benefited from different training programs. Using desensitization and study skills training, results showed that highly test-anxious students with good study habits benefit more from a desensitization training program that reduced their interfering thoughts. These students showed a greater decrease in anxiety and an improvement in course performance over the semester in comparison with a group of the same type of students who received study skills training. In contrast, those highly test-anxious students with poor study habits benefited more from a training program intended to improve their study skills. These students showed a greater decrease in anxiety and increase in course grades over the semester in comparison with a group of the same type of students who received desensitization training.

Summary

The research included here reinforces our conclusion that motivational as well as cognitive elements are intimately conjoined in student learning so that strategies of teaching and of teaching more effective skills for learning and thinking must take account of both.

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