DOCUMENT RESUME

ED 266 436 CS 008 338

AUTHOR	Marzano, Robert J.; Hutchins, C. L.
TITLE	Thinking Skills: A Conceptual Framework. A Special Issue of "Noteworthy."
INSTITUTION	Mid-Continent Regional Educational Lab., Aurora, CO.
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE	85
NOTE	64p.
PUB TYPE	Information Analyses (070)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Abstract Reasoning; *Cognitive Processes; Curriculum; Educational Change; *Educational Research; *Learning Theories; Memory; *Models; *Psychological Studies; Schemata (Cognition)
IDENTIFIERS	*Thinking Skills

ABSTRACT

The first chapter of this publication, which focuses on a new definition and integration of thinking skills in the curriculum, presents a model that unifies current research and theory with a new understanding of the traditional notion of content and with a different approach to instruction. The model proposed in this chapter synthesizes recent research around three interactive elements, which make up the second through fourth chapters: (1) content thinking, which includes declarative, procedural, and contextual knowledge, and the integration of these elements; (2) reasoning, which consists of transferring content (that is, storage and retrieval of declarative, procedural, and contextual knowledge), matching these elements with what is already known, and restructuring or producing new knowledge; and (3) learning to learn, which describes attending (paying attention), setting goals, monitoring attitudes, and self-evaluating the thinking processes. The document concludes with a discussion of a few restructuring issues considered necessary for the systematic teaching of thinking skills; specifically, how each of the three thinking skill areas necessitates fundamental changes in schools, testing, evaluation, and the integration of instruction. (EL)

A Special Issue of Noteworthy

Thinking Skills

A CONCEPTUAL FRAMEWORK

Robert J. Marzano

C. L. Hutchins

McREL MID-CONTINENT REGIONAL EDUCATIONAL LABORATORY

Noteworthy is a publication of the Mid-continent Regional Educational Laboratory (McREL). McREL is a non-profit organization, funded in part by contracts and grants from the Office of Educational Research and Improvement (OERI) of The United States Department of Education. This issue of *Noteworthy* has been supported by a contract from OERI. The opinions expressed do not necessarily represent official OERI or Department of Education policy.

McREL serves a seven-state region consisting of the states of Colorado, Kansas, Missouri, Nebraska, North Dakota, South Dakota and Wyoming. Its mission is to help improve educational practice in this region and further the quality of education across all groups of students.

Thinking Skills

A CONCEPTUAL FRAMEWORK

Robert J. Marzano
C. L. Hutchins

DEDICATIONS

To Dr. Daisy Arredondo for her partnership and support.

R. J. M.

To Miriam F. Jeffrey for many hours of inspiration, especially those early morning classes for one.

C. L. H.

ACKNOWLEDGEMENTS

Yvonne Theisen for typesetting.

Steve Niemczura for graphics and design.

Lyn Moran Hutchins for proofreading.

TABLE OF CONTENTS

AN OVERVIEW

Helping students learn how to think effectively is a high priority for every educator. We are all aware of how much the future demands that students be able to process ever-increasing amounts of information, make complex decisions and cope with the uncertainties of a rapidly changing world.

If our instincts did not to tell us how important thinking skills are, a variety of studies and reports have made the point. For example, the presidentially commissioned report, *A Nation At Risk* (1983), indicates that higher levels of thinking skills should be taught in schools. The Educational Commission of the States, in a report entitled *The Information Society: Are High School Graduates Ready?* (1982) states that:

> Today's minimum skills are demonstrated successfully by a majority of students. Higher order skills, however, are achieved only by a minority of 17-year-olds. If this trend continues, as many as two million students may graduate in 1990 without the skills necessary for employment in tomorrow's marketplace. (p. 2)

The College Board and other educational groups have also emphasized the importance of curriculum change that will ensure the teaching of thinking skills in America's schools. These calls parallel the messages contained in such recent best-sellers as *Megatrends* (Naisbitt, 1982) and *In Search Of Excellence* (Peters and Waterman, 1982).

No educator would deny the importance of trying to teach students how to think. The problem is how it should be done.

One approach is the introduction of a special, supplementary activity to help students master thinking skills. This add-on approach to improving higher level thinking skills offers little hope for success. One difficulty is that it requires cramming yet another activity into an already tight curriculum. Too often we have met the demand for change by adding another course to the curriculum. The current course of study simply can't stand another entry unless some equally desirable activity is displaced.

Block (1985) suggests another obstacle to introducing thinking skills as a separate course in the curriculum. He points out that the current "back-to-basics" movement is an effort to counter the anti-egalitarian effect of creating discrete programs for select groups and select types of learning (e.g., gifted and talented, learning style programs and computer literacy). He argues that because education functions as a centrist force in our society, the continued fracturing of a core curriculum reduces the effect that common experiences and shared values have in holding the society together. As a result, add-on programs will face stiff pressure from public policy, no matter how logical they are.

Another reason that an add-on approach is not likely to succeed is provided by Bereiter

(1984). He warns that unless thinking skills instruction is integrated into existing instructional practices it will not be reinforced and used. Such an approach, he argues, will go the way of all frills. In other words, since thinking is what schools are supposed to be all about, if the approach used to teach thinking is not a part of every course, it is unlikely that students or teachers will assimilate it into their routines for learning and teaching.

Another difficulty with most current approaches to teaching thinking skills is that they start with the premise that basic thinking skills already are taught but that "higher level" or "higher order" skills are not taught. In fact, the current research and theory on information processing or "thinking" does not support a distinction between a set of "lower" level skills and a different set of "higher" skills. If there is a higher-lower distinction to be made, it is in the varied levels of complexity inherent in the content we ask students to master or the problems we ask them to solve.

What is needed is a reconceptualization of our current curriculum and instructional practices. We need to integrate a systematic approach to introducing thinking skills into the school experience so that students can develop the skills to cope with ever-increasing complexity in their studies as well as life in general. To do that will require the development of a new, unified approach to defining what we mean by thinking skills and the integration of those thinking skills into the daily interplay among teacher, students and curriculum.

The development of such an approach will mean a significant change in current pedagogy. Current state-of-the-art instructional models are not as learner-oriented as they need to be. These models represent theories about instruction more than they do theories about how people learn. For example, Benjamin Bloom's mastery learning model was developed within the traditional framework of ensuring that students master "content." The model emphasizes the importance of defining a concrete outcome for an instructional activity, presenting or modeling information or skills to be mastered, providing students with an opportunity to learn with appropriate guidance and feedback, and building speed and accuracy through independent work; the outcome is then measured by some paper and pencil, objective test. Similar models have been suggested by many others.

These step-by-step approaches to teaching do not directly accommodate differences in how students process information and they do not take into account the most recent understanding we have from such fields as cognitive psychology and psycholinguistics. For example, most current teaching tries to assure "objectivity" in the teaching and testing process by asserting that there is only one "right" answer and only one "right" way to arrive at that answer. In the Bloom model the student is asked to demonstrate mastery of an "objective" before he or she goes on to another objective. Neither life nor advanced work in any academic area is like that.

Current research and theory on cognition suggest that knowledge of an academic area is fluid and generative. As we learn more we reshape or restructure what was previously learned. Consequently, students need to develop thinking skills that will help them identify contexts in which alternative answers are possible and to identify optional strategies for arriving at those answers. Thinking is not likely to flourish when all that is required of students is to figure out the teacher's or textbook writer's conception of a given content area.

That is not to suggest that a thinking skills program should ignore "content." Quite the contrary, a comprehensive approach to improving thinking skills will emphasize the mastery of content; but it will do so by helping students organize and process content in a generative way. Thus, in addition to providing students with a framework for mastering content, it would also help them develop strategies for processing information and help them consciously develop learning skills. Introducing such an approach into most classrooms will require a significant shift in how teachers view curriculum and what they do with it. Such an approach also will have a dramatic impact on how teachers and students work together, what their goals are and how we judge their achievements.

Fortunately, there is new theory and research to sustain such a shift in our conceptions of teaching and learning. The purpose of this chapter is to present a model that unifies current understanding of thinking and learning with a new understanding of the traditional notion of "content." The model implies an entirely different way of approaching instruction. Those who are familiar with such areas as cognitive psychology, artificial intelligence, psycholinguistics and human motivation will be able to identify how the model is tied to those theoretical bases. For those not familiar with recent developments in these areas, it will provide an introduction to some of the most significant new ideas available for improving education.

A New Learning and Teaching Model

The model proposed synthesizes recent research around three interactive elements:

1. Content Thinking
2. Reasoning
3. Learning-to-Learn.

These elements are interactive; none of the elements is easily taught alone. Nor, in isolation, do they closely resemble how we actually think. Any approach to defining content must take into account the way in which the mind processes that content and the motivation for learning the content.

We see these elements as so interactive that we have described our approach as a "unitary model." We believe this approach is consistent with the comprehensive approach to curriculum suggested by Tyler (1975) and Gow and Casey (1983) and current theory on human behavior. It also is consistent with Sternberg's (1984) insistence that instruction in reasoning and thinking be based on sound theory and the best available research.

At the core of our unitary approach is Anderson's 1983 model of cognition. His own words provide the best way to describe a unitary approach to cognition:

> The most deeply rooted preconceptions guiding my theorizing is a belief in the unity of human cognition, that all higher cognitive processes, such as memory, language, problem solving, imagery, deduction and induction are different manifestations of the same underlying system." (Anderson, 1983; p.1)

Anderson was not the first to propose a unitary conception of cognition. Several others have used a unitary approach to explain such constructs as problem solving (Newell and Simon, 1972), inference (Lehnert, 1978) and general schema systems (Bobrow and Winograd, 1977). Anderson has simply taken the idea farther than anyone else in explaining thinking.

The remainder of this chapter will introduce our unitary approach to defining the nature and interaction of the three elements of our model (content thinking, reasoning and learning-to-learn).

1. Content Thinking

Anderson and others (Johnson-Laird, 1983; Winograd, 1973) distinguish between two types of memory:

a. Declarative

b. Procedural.

Our model incorporates these two types of memory as two different kinds of content thinking along with a third:

c. Contextual.

a. Declarative Knowledge

Declarative knowledge contains information about the world; in the broadest sense, it is the substance of everything we know. As Sywlester puts it, declarative memory confirms who/what/when/where/why facts. He also indicates that "mastery of a procedure or skill often begins at the declarative memory level" (1985; p. 71). This assertion is consistent with research findings about learning classroom content—namely that without factual knowledge students have little success in acquiring the procedures within a content area (Heller and Reif, 1984; Larkin, 1981; Anderson, 1982). We can generalize, then, that one type of knowledge or thinking necessary for understanding content is factual or declarative knowledge. Later we will suggest a structure for organizing declarative content that is consistent with research on cognition.

b. Procedural Knowledge

Procedural memory contains our knowledge of how to do things. It is a second type of knowledge or thinking necessary for understanding content. For example, a sailor knows such declarative information as the names of various parts of a boat and the characteristics of certain types of storms. But without procedural information about how to raise a sail and how to tack, sailing would still be difficult.

An important characteristic of procedural knowledge is that it is integrally linked with declarative knowledge. The operational steps a sailor goes through to tack or that a cook goes through to "cream" sugar and butter are inextricably tied to the content of sailing and cooking. These operational steps usually do not generalize to other situations.

In broad terms, the distinction between declarative and procedural knowledge defines two quite different domains of content. We not only want students to know the facts and concepts that define subjects such as history or algebra, we also want them to be able to carry out procedures that are inherent in the "content" of that subject—such as using primary resources in a history class or learning how to balance two sides of an equation in algebra. In general, this distinction between declarative and procedural knowledge is not alien to how most teachers think about the content of what they teach. In practice, however, they are not always able to define the declarative knowledge of their subject or the procedural knowledge of their discipline. Current practice could be improved if teachers and curriculum developers systematically identified and distinguished the declarative and procedural knowledge they want their students to master.

c. Contextual Knowledge

Contextual knowledge is the knowledge we must have about the conditions under which it is appropriate to carry out a specific procedure. We must know the context or what Anderson calls the "antecedent conditions" that establish a framework for deciding when and which procedure to execute. Thus, given the context experienced by most first graders, the symbols

$$2 + 2$$

would lead students to add the figures and provide the answer 4. But, if the same cues (2 + 2) are presented in an advertising context, a designer might see the task as devising a new way to graphically use the symbols to convince someone that buying a new product is as simple as "two plus two." The context, then, for when a procedure should be used is as important as the procedure itself. Many times the recognition of the context in which it is appropriate to carry out a specific process corresponds to what we think of as common sense. Context is seldom taught directly in most classrooms.

Earlier we stressed the importance of viewing declarative, procedural and contextual knowledge in a unified way. An illustration of how the three elements are unified when we think is found in the format of an *if/then* statement called a "production" within cognitive psychology. Productions operate like computer programs in the mind. Consider the following:

IF: 1: it is snowing,
2: the time is before 9:00 a.m. on a work day,
3: the snow accumulation is six inches; and,
4: the car I need to get to work is in the garage,

THEN: I shovel the driveway.

Technically the *if* part of the program includes the declarative knowledge an individual has about the nature of snow, its effect on driving conditions, etc. It also includes the contextual information about the fact that today is a day I have to get to work; the action implied by the *then* part of the program (shoveling the driveway) is the procedural knowledge.

In summary, a student needs three kinds of knowledge to master content: 1) declarative knowledge about the content, 2) procedures inherent to the content and 3) the contextual conditions under which the procedures should be used. In the absence of any three of these elements, the student will not be successful. For example, if a person had no factual knowledge about snow or did not know how to shovel a driveway, he or she would not be able to engage in the appropriate action. Equally important, if a person did not recognize that it was Monday and time to get to work, he or she would not know it was appropriate to apply the knowledge of the concept of snow to the procedure of shoveling. If the context were different, if it were Sunday, not Monday, the appropriate action might be to go out sledding with friends rather than shovel the driveway.

The processes of matching up these elements of content brings us to the second part of the model.

2. Reasoning

Reasoning is the process by which we integrate the three kinds of content we have just defined. Our framework for defining reasoning is also adapted from the work of Anderson. His model of reasoning was conceived as a set of linear micro-processes he used to develop a computer simulation program called ACT, Adaptive Control of Thought. Our model should be understood as a metaphor for his since we assume that reasoning skills appropriate for classroom use are much more holistic than those designed for computer simulation. Our model consists of these three elements:

a. transferring content (i.e., storage and retrieval of declarative, procedural and contextual knowledge),

b. matching these elements with what is already known, and

c. restructuring or producing new knowledge.

These three elements of reasoning cannot be ordered hierarchically; that is, one is not of a higher order than the other. All are necessary elements of reasoning. They are all essential to any reasoning process.

a. Transferring

This process is what a great deal of school learning is all about—teaching us to "know" by memorizing and recalling different content inherent in specific subjects, or problem areas. Using the previous example, we must know about snow, identify its depth, know the effects of different levels of snow on driving conditions, recognize that this is Monday and we must be at work by nine, know what time it is, etc.

According to Anderson, knowledge of this type is a by-product of effectively *storing* and *retrieving* information in memory. This implies that students should not simply be presented with information; but they should also be taught effective storage and retrieval techniques so as to make recognition more efficient. In fact, very little instruction of this kind goes on in most schools now. Later we will discuss instructional strategies for helping students improve their tranferring skills.

b. Matching

The concept of matching is best explained by Powers (1973) and Glasser (1981). Glasser, for example, posits that our minds have "comparing stations" that control for what we attend to and direct our behavior. Thus, for example, if you have your "room comfort station" on as you read this chapter, your body is subconsciously monitoring the temperature and other room conditions. So long as they are within a range you find acceptable, nothing happens. But, if the door is suddenly opened and you feel a cold draft, you will match these incoming signals with your repertoire of temperature-controlling procedures and you will execute one that is appropriate to the situation. You might, for example, decide to get up and close the door or ask the person who came through the door to close it. On the other hand, if you are in a context where such actions would be inappropriate, you might decide to move to another room where it is warmer. From a cybernetic point of view these comparing stations are central to human behavior. We are always looking for or controlling for antecedent conditions. When we recognize information that does not match with what we want or expect, we review our options and change our behavior.

In the real world, of course, this matching process can be either quite simple or quite complex. And, people possess considerably different levels of this reasoning skill. The more sophisticated their matching skills are, the more "comparing stations" they can use. This sophistication, by the way, is related to our ability to recognize and distinguish complex levels of content.

Fortunately, we can classify and group the different types of matching processes. It is this classification that produces a list of thinking activities that are most frequently identified as "higher order thinking skills." We will describe all of these classifications in more detail in Chapter 3, but here is a brief description of each matching skill:

(1) *Categorizing*—Given the infinite number of discriminate stimuli in the world, categorizing helps a person "render the unfamiliar familiar, and because one is able to generalize about an object based on knowledge about its category, one is able to know more about the object than just what can be ascertained by looking at it." (Mervis, 1980; p. 279).

(2) *Reasoning Analogically*—Few skills are as pervasive or essential to one's existence as the ability to reason analogically. Broadly defined, analogical reasoning occurs when unfamiliar stimuli are introduced with some reference to the more familiar. (Alexander, 1984). Thinking by analogy involves solving a problem by applying knowledge from one domain or situation to another. It is most typically presented by a problem like: "limb is to tree as leg is to chair."

(3) *Extrapolating*—Extrapolation is the process of matching the patterns in one area of content with information in a totally different context. For example, we might extrapolate some process in cooking (kneading dough) and apply it to hand washing a sweater.

(4) *Evaluating Evidence*—Evaluation of evidence refers to the procedures for determining whether information follows prescribed rules of logic. Commonly this translates into identifying whether a claim is supported by relevant information. Toulmin (1958; Toulmin, et al., 1979) has developed a model which helps us evaluate the logic of claims. (In many thinking skills programs this process is called critical thinking.)

(5) *Evaluating Value*—This is the process of matching information presented with a value system, frequently your own internalized value system. This matching process is consistent with Paul's (1984) conception of "dialectic" thinking which he asserts is the primary thinking skill of the future.

c. Restructuring

The final type of reasoning skill is the building or restructuring of information in long-term memory. Anderson calls this step "execution." The outcome of this effort is, in a sense, the production of new knowledge—at least for the individual involved.

There are three restructuring skills:

(1) *Elaborating*—Elaborating is a process by which we infer information which is missing. Various categories of inference have been developed. Warren, et al., (1979) for example, distinguish among three general types of inferences such as elaborations about concept characteristics, elaborations about causality, and elaborations about context. Halliday (1967) and Grimes (1972) add that one can also elaborate about purpose or goal. Elaboration adds to and greatly expands on what we perceive or recognize.

(2) *Problem Solving*—Van Dijk and Kintsch (1983) state that problems occur when there is an explicit goal to be reached and there are specific operations or mental steps to be performed to reach that goal. An intrinsic characteristic of problems is that there is missing information and the solving of the problem involves providing that information. (For example, finding the "unknown term" in algebra.) The missing information may be declarative, procedural or contextual in nature. When the missing information has been supplied the problem is usually solved.

(3) *Inventing*—Inventing is the process of turning a very general idea into a finished product. It is a form of creativity. As a process, it is far less structured than problem solving in either its form or outcome. The product of inventing can be a written information, such as an essay or a poem, a new machine, a painting, a musical composition, etc.

A key point to remember is that restructuring creates new knowledge, no matter what its form. This distinction may be difficult to understand because we usually associate the idea of knowledge production with a product: a book, a finding, a theory, etc. Those are knowledge products, but at a psychological level, the conclusions we arrive at are also knowledge products. Whenever we are confronted with a problem, attempt to create something or simply elaborate on what we perceive, we are building new knowledge.

3. Learning-To-Learn

The third type of thinking we call "learning-to-learn." This type of thinking is, in a sense, our conscious control of the other two functions; it is "thinking about thinking." Specifically the process includes:

a. Attending

b. Setting goals

c. Monitoring attitudes

d. Self-evaluating our thinking processes.

Research on cognition points out that all these functions can be consciously managed. And, within the framework of a unified model, they must be a part of the overall effort to help students improve their thinking. Teaching these functions directly frees them from the tyranny of learning only what others have thought before; it is the way we can advance productivity in our society.

In Chapter 4 we will consider learning-to-learn in depth. Below we briefly describe each component:

a. Attending

Both Glasser (1981) and Powers (1973) point out that any individual has thousands of "comparing stations." Unfortunately, our working memory can cope with only a few of these stations at a time (Norman, 1969). This means that at any given moment we must select the comparing stations we use. In common language the selection of a comparing station is called focusing attention. Focusing attention or limiting the number of comparing stations we have "turned on," increases our efficiency at accomplishing tasks—so long as we do not exclude important contextual information. Neisser (1967) calls this a controlled state; Lindsay and Norman (1977) call it a conscious state. Everything becomes more streamlined because there are fewer options to consider. At the same time, however, we must recognize that in focusing our attention on a small set of comparing stations we have depressed or reduced our ability to use other stations or, speaking more informally, considering other options.

b. Goal-Setting

There are two types of attention: automatic and voluntary (Lura, 1973). Automatic attention is the attention we involuntarily give to data or information that occurs spontaneously in our environment. Voluntary attention is goal driven; we chose to respond to one set of stimuli over another. In other words, we are either consciously controlling what we attend to or reacting unconsciously to stimuli in our environment. When we set a new goal, we activate a new set of comparing stations by focusing our attention on those stimuli that are relevant to the goal.

Helping students understand that they consciously make decisions about what comparing stations they will use and helping them to understand how they can control attention through specific goal-setting behavior aids them in improving the efficiency of their thinking as well as their sense of satisfaction in accomplishing what they have undertaken.

c. Monitoring Attitudes

Once goals are set, epistemic thinking becomes an important factor in learning. Epistemic thoughts are those attitudes that form the basis of one's reality. (For example, the thought, "This task should be easy for me" is epistemic. It would control behavior relative to the task.) McCombs (1984) asserts that this type of thinking is the driving force behind goal-seeking behavior. At a common sense level most of us would agree that our belief about whether we can successfully accomplish a task has a great deal to do with our motivation or willingness to undertake the task. Weiner (1972) and others suggest that another important epistemic thought is our attitude as to whether effort versus ability is more likely to produce success. If we believe that effort is the key ingredient in success we are more likely to be motivated and to accept responsibility for carrying out the task. If, however, we belief that ability (or luck or the work of others) is the key to success and we doubt our ability to carry the task out, we are less likely to assume responsibility for the work or to appear to be motivated. In other words, a useful attitude is that sustained effort will eventually lead to success.

d. Self-evaluating

Once an individual actually engages in a task, i.e., sets out to accomplish a goal, the process becomes cybernetic. That is, we use the goal as a means of changing and correcting our behavior much as a guided missile changes direction and speed based on the information it receives relative to the approaching target. In a sense, we are constantly learning as we monitor these signals and redirecting our efforts. The key to how well we learn is the degree to which our monitoring activities are conscious. If we actively examine the feedback data we get and evaluate it in terms of the extent to which it suggests we are approaching our target, we are more likely to learn. If we don't have good feedback data or if we don't listen to it, we are less likely to learn.

Unification

As mentioned previously, the model we have described is only an analogy for the real process of thinking. In the process of thinking we don't break the steps down as neatly as we have described them here and they do not occur in a neat, linear fashion as suggested by our lists; that is why we have described the model as "unitary." But, at the same time, by breaking the process down into elements, albeit abstract elements, we can help students improve their thinking skills.

Advance Organizer

The pages that follow expand the model with additional research and theory. The organization follows the order in which the model was outlined in this chapter:

Content Thinking

- Declarative Knowledge
  - Concepts
  - Relationships
  - Patterns
- Procedural Knowledge
- Contextual Knowledge

Reasoning

- Transferring
  - Storing
  - Retrieving
- Matching
  - Categorizing
  - Reasoning Analogically
  - Extrapolating
  - Evaluating Evidence
  - Evaluating Value
- Restructuring
  - Elaborating
  - Problem Solving
  - Inventing

Learning-to-Learn

- Attending
- Setting Goals
- Monitoring Attitudes
- Self-evaluating the Thinking Process.

CONTENT THINKING

The introduction identified three types of "content thinking" or knowledge:

1. Declarative
2. Procedural
3. Contextual.

This chapter will describe all three types and how they can be integrated into instruction.

1. DECLARATIVE KNOWLEDGE

Recent years have seen breakthroughs in our understanding of declarative or factual knowledge. We now know enough about it to draw some conclusions for instruction. For example, we know that declarative knowledge is hierarchical in nature. Basic units are put together to form complex organizational structures.

a. Concepts

The most basic unit of declarative knowledge is the concept. Within education the term "concept" is widely misused to represent a variety of constructs. Here we use it in a technically rigorous way. A concept is the socially accepted meaning of one or more words which express the idea or object symbolized by the concept (Klausmeier and Sipple, 1980; p. 78). For example, the word *dog* is a label society uses to represent four-legged animals with certain characteristics. Although we will describe concepts in some depth shortly, for now we can liken concept knowledge to word or vocabulary knowledge. We might say that vocabulary knowledge is the outward indication of an individual's store of concepts. It is no wonder, then, that vocabulary knowledge has been cited as one of the strongest predictors of general academic ability. For example, Anderson and Freebody (1981) report that the strong relationship between vocabulary and general intelligence is one of the most robust findings in the history of intelligence testing.

b. Propositions

The hierarchical level of information above the concept in complexity is the proposition. Propositions are groups of concepts organized in such a way as to be true or false.

> Thus . . . 'John' is a concept but is not information that can be true or false in nature . . . whereas 'John is ill' would be a proposition because it could be true or false (van Dijk, 1980; p. 207).

There is ample research evidence to show the primacy of propositions in processing information (Bransford and Franks, 1971). That is, we naturally organize information into propositions. They are so basic to the processing of information that we might say they constitute a good operational definition of an "idea."

c. Relationships

One level higher in the organization of knowledge are relationships. Relationships link one proposition to another. To illustrate, consider the following:

> Bill is tall but . . .
> he doesn't play basketball.

Here there are two propositions: 1) "Bill is tall" and 2) "he does not play basketball." These propositions are connected using a relationship signaled by the linguistic conjunction "but." Note that this particular relationship indicates that two propositions have a negative or contrasting relationship to each other in some way. Conventional instruction in grammar does not emphasize this distinction and, instead, suggests that all conjunctions function in the same way. Research indicates that if we cannot recognize these basic relationship differences between ideas (propositions), processing breaks down (Kintsch and van Dijk, 1978; Waters, 1978).

d. Patterns

Above the level of relationships is a larger organizational structure of information called the pattern of knowledge. For example, when you read a chapter in a textbook you look for the overall pattern of the information It might be that the chapter is actually about some major generalization or it might describe a set of events that happened in a given order. Generalization and sequence are both examples of organizational patterns. If we miss the overall organization of a piece of information we might be able to understand bits and pieces of it, but we will not understand the information as a unified whole (Meyer, 1975).

Unfortunately, most textbooks are not written in a format that makes these organizational patterns obvious to students (Pearson, 1981). Similarly, information presented orally in content area construction is not organized into salient patterns. For the most part, then, the burden is on the student to create some type of organizational pattern for information read or heard. In fact, studies indicate that the most successful students look for or create patterns as a basic comprehension strategy (Goetz, Palmer and Haensly, 1983); less successful learners do not appear to have this metacognitive awareness. Fortunately, current research indicates that students can be taught organizational patterns and how to use them as basic techniques for understanding content area material (Taylor and Samuels, 1983; Leslie and Jett-Simpson, 1983).

Knowing the declarative information within a content area, then, requires a knowledge of the concepts, propositions, relationships and organizational patterns for propositions. Three of these four declarative elements represent distinct areas for instruction. That is, instruction can and should be planned for concept attainment, relationship identification and pattern recognition. Proposition recognition has been excluded from the list because there appears to be no need to teach children this form of information organization. As mentioned previously, propositions are basic to thinking. One theory of information processing—called the semiotic extension theory—asserts that humans are genetically predisposed to organize information into propositions (McNeill, 1975). In other words, organizing information into propositions is so fundamental to thinking that no formal instruction in the nature of propositions is necessary. Research supports this point. For example, Sachs (1967) found that while memory for specific aspects of a sentence faded quickly, the memory for the propositional sense of a sentence was remarkably stable. Similar findings have been reported by Pearson (1974-75) and Bransford and Franks (1971).

Below, we briefly consider instruction strategies for teaching concepts, relationships and patterns.

(1) Concept Attainment

In the previous section we likened concept knowledge to word knowledge—knowing the label (word) society uses to represent a concept. Before discussing instructional techniques for teaching concepts we should go into a little more depth about the nature of concepts.

Some theorists believe that concepts are basically linguistic in nature (e.g., Klausmeier and Sipple, 1980; Fodor, 1976). For example, Condon (1968) believes that until a label (word) is established for a set of experiences no concept exists. That is, without the label there is no concept—only experiences stored in long-term memory. The label organizes these experiences into a unified whole.

Other theorists stress the "imagery" nature of concepts (e.g., Richardson, 1983; Paivio, 1971). Imagery means more than just "pictures in the mind." Mental images include the tactile, auditory, emotional and visual aspects of perception (Sheikh, 1983). For example, when you ride on a roller-coaster you store in your long-term memory all the sensations (sounds, feel, emotion) associated with the ride as well as mental pictures of the ride. Those theorists who stress the imagery aspects of concept knowledge, then, claim that you must have a "primary experience" in order to develop a concept. This perspective is consistent with the theories of Piaget.

The imagery nature of our knowledge of concepts is usually overlooked. Instead, vocabulary instruction usually focuses on linguistic development; that is, we ask students to learn dictionary-like definitions. In the absence of an image or experimental base for the concept, particularly abstract concepts, many students develop only the ability to rotely define the concept without integrating it into their working knowledge.

Instruction will be most effective when it integrates both the linquistic and imagery nature of concepts; the two perspectives are in no way contradictory. That is, instruction in concepts should highlight both the linguistic or verbal nature and the visual, tactile, auditory and emotional nature of the concept. A logical sequence for concept development instruction would be to begin with those characteristics which are related to imagery. For example, students should first have experiences which create images of the concepts. They should then be given a label for those experiences. They might then be asked to describe what they know about the label. Over time this description will become more and more precise until it finally evolves into what we might call a technically accurate definition.. A straight-forward instructional process for concept instruction might follow these steps:

Step 1. Provide primary experiences that develop images for the concept (e.g., visual, tactile, auditory, emotional).

Step 2. Provide students with a label or word to represent the concept.

Step 3. Require students to describe the concept in their own words. Let them draw on the full range of their experiences. Help them link it to other, related knowledge and contrast it with other concepts that have some similarities with the one being learned.

Step 4. Over time have students sharpen their descriptions of the concept until it evolves into a technically accurate definition.

Step 2, 3 and 4 are familiar to most subject area teachers. The stumbling block in this process is usually Step 1. How can you provide primary experiences in all concepts you want to teach? If you wish to teach the concept of "parachuting" to young students do you take then up in an airplane and give them direct experiences?—of course not. Step 1 need not be a stumbling block because primary experiences do not have to be direct. Imagery characteristics can be developed by "guided imagery"—imagining what an experience is like. In effect, this is the way we obtain primary experiences about most concepts. Few people have parachuted from an airplane. However, most people have jumped from a limited height, felt a strong wind rushing against them and stood at a great height. They put the memory of these experiences together to form their concept of parachuting even though they have never directly experienced it.

Guided imagery, then, is a way of artificially creating primary experiences for concepts within a classroom setting. The technique has a rich theoretical and research basis. Guided imagery has long been used in psychotherapy under the name of oneirotherapy (Sheikh and Jordon, 1983). It has been shown to be basic to most memory techniques (Bellezza, 1981; Paivio, 1971) and is one of the most powerful techniques currently in use in sports training (Suinn, 1983). For example, athletes spend a significant amount of time mentally imaging the feat they are about to perform. Also, many of the learning techniques which purport to integrate left and right brain functions (e.g., Hart, 1983; Zdenek, 1983) are basically adaptations of guided imagery.

One important feature of these four concept attainment steps is that they gradually build to a structured definition of the concept. Klausmeier and Goodwin (1971) suggest that a complete definition should include the following components:

- a linguistic definition of the concept
- the defining attributes of the concepts
- examples and non-examples of the concept
- the taxonomy of which the concept is a part including the superordinate-coordinate-subordinate relations of the particular concept to other concepts
- some of the principles (or situations) in which the concept is used
- kinds of problems whose solution will involve the use of the concept
- the names of the attributes of the concept and related vocabulary words.

The importance of concept development implies a need for direct, systematic instruction in vocabulary. This was Becker's (1977) recommendation after a thorough analysis of the research on various interventions for the educationally disadvantaged.

Direct instruction in all concepts is not practical, however. For example, Harris and Jacobson (1972) identify over 7,000 words (concepts) used in elementary school textbooks. Direct instruction in these concepts would require students to learn about 30 new words per week. However, other vocabulary studies have established that a relatively small number of words account for the majority of the concepts encountered by students. For example, of the 86,741 common English words identified by Carroll, Davies and Richman (1971) over 40 percent appeared only once in all of the books, journals and newspapers they studied. Dupuy (1974) has proposed a viable solution to the problem by operationally defining a "basic" concept—one which is commonly used in the English language and forms the basis for many other words. That is, if you know a basic word it provides a vehicle to understand many other words. Dupuy has estimated that there are only 12,000 basic words in the English language and only 7,000 are used in K-12 classroom. If these 7,000 basic words were taught systematically it would require students to learn only 15 new words per week. Marzano (1984) asserts that the process can be streamlined even further if words are presented in "clusters"—groups of related concepts. In a study of elementary school concepts he found that over 50 percent of those concepts could be organized into 15 clusters and over 75 percent into 25 clusters. All elementary school concepts could be organized into 61 clusters.

The names of the 15 clusters and some example concepts from Marzano's word list are shown in Table 2.1.

TABLE 2.1

15 Clusters Identified in Elementary Textbooks (Marzano, 1984)

	Clusters: Examples of Words in Each Cluster and Descriptions	Number of Concepts in Clusters	Cumulative Number of Concepts
1.	Occupations/careers: manager, mayor, coach, businessperson, printer, publisher	364	364
2.	Types of motion: action, stillness, chase, plunge	321	685
3.	Size/quantity: time, large, amount, many, monstrous, two	310	995
4.	Animals: pet, dog, snake, spider, bird	289	1284
5.	Feelings/emotions: feeling, terror, shame, anger, sad, happy, love, excitement	282	1566
6.	Food/meal/types of eating: supper, meal, cookie, meat, vegetables, butter, cook	263	1829
7.	Time/time relationships: lifetime, noon, season, month, today, earlier, now, afterward	251	2080
8.	Machine/engines/tools: equipment, engine, oven, hammer, ax, spoon	244	2324
9.	Types of people: women, boy, neighbor, dweller, hero, enemy, mother	237	2561
10.	Communications: talk, explain, suggest, question, command, vow, complain	235	2796
11.	Transportation: car, plane bicycle, ship	205	3001
12.	Mental actions: plan, search, teach, select, believe	193	3194
13.	Human traits: lazy, patient, stubborn, humorous	175	3369
14.	Location/direction: here, back, inside	172	3541
15.	Literature/writing: story, word, poem, pen, telegram	171	3712

One of the reasons why instruction that teaches words in clusters is more efficient is tied to the way our short-term and long-term memories work. Research suggests that when we are trying to learn something that will not extinguish easily overtime, we must move it from our short-term memory to our long-term memory. We do that by tying the concept we are learning to something we already know; hence the close tie that has been recognized between our ability to see associations among things and our ability to learn them. When we pull the cluster of concepts like the one we are about to learn from our long-term memory down into our working short-term memory and hook the new concept into our working understanding of related ideas, that is the best and most efficient time to learn other, related concepts.

Thus, our instructional recommendation is that we teach concepts in clusters that are semantically similar or related. The current practice is to have students learn a series of somewhat unrelated words each week. For example, one week's vocabulary or spelling words are frequently drawn from a story being read. This practice increases the mental operations involved and favors those students whose out-of-school experiences or general intelligence makes it easier to perform these operations.

Going one step farther, we recommend that teachers focus on word clusters that include words from vocabulary lists one grade level higher than the grade they teach since most standardized tests include words from the next higher grade than the student is in to increase the difficulty level of the item. Practically, this is not difficult if you use a list such as Marzano's (1984) that organizes all elementary vocabulary words around clusters, by grade level difficulty.

Concept attainment, then, can be approached in a manner that is consistent with the way individuals naturally learn. We believe that such an emphasis would increase the declarative content knowledge of all students, especially those who traditionally have trouble with content area concepts.

(2) Relationship Identification

The way an individual usually recognizes relationships between ideas is by looking for various syntactic, semantic and rhetorical signals for those relationships. For example, in the sample sentence used earlier the word *but* signaled that the two propositions had a contrastive relationship. Many theorists in the area of linguistic study called "discourse analysis" have attempted to classify the various types of relationships that can exist between ideas (e.g., Halliday and Hasan, 1976; Pitkin, 1977). Five basic relationships have been identified: 1) addition, 2) contrast, 3) time, 4) causality and 5) reference. Marzano and Dole (1983) define these relationships in the following way for instructional purposes:

1. addition: two ideas "go together" in some way; e.g., "He is kind and he is intelligent."

2. contrast: two ideas "don't go together" in some way; e.g., "He is tall but he isn't a good basketball player."

3. time: one event happens before, during or after another event; e.g., "He went home. Then he went to the game."

4. cause: one event causes another; e.g., "He went home because Jana went home."

5. reference: two ideas share a common concept e.g., "I like Yvonne: she is nice."

Students can be taught to look for these relationships as a way of "linking" information. We call this process "relationship identification." It requires that students:

Identify separate ideas that are related.

Identify the type of relationship between the ideas, (e.g., addition or contrast).

Identify the linguistic signal for the relationship (e.g., and, or, but).

Activities such as these have been shown to increase students' comprehension and understanding of the nature of textual information

(Robertson, 1968; Marshall and Glock, 1978-1979). At a more sophisticated level, Anderson (1978) has developed a diagraming technique for relationships which can be used as a study skill activity with complex content area material. In Anderson's procedure students are taught to identify the basic relationship between ideas in textbooks and use symbols (e.g., arrows, equality signs, inequality signs) that represent how ideas are related in an outline representation of the information.

Relationship identification activities can also go far beyond the level of simply teaching students to recognize relationships. Some very deep levels of abstraction can be discussed and highlighted by considering the underlying meaning signaled by relationships. To illustrate, consider the following:

She was beautiful but
she was not conceited

Here there are two propositions joined by a contrast relationship. Recall that the purpose of a contrast relationship is to convey the message that the joined ideas in some way "do not go together." A student's ability to recognize this relationship would indicate one level of awareness. Another level would be the consideration of why these two propositions "don't go together." That is, the assertion that "being beautiful" does not go with "not being conceited" implies some basic beliefs on the part of the author of these propositions about how people who are beautiful sometimes behave. Questions and discussion which highlight this level of meaning are akin to what Doyle (1983) calls metacomprehension activities. The more sophisticated these relationships become and the more they require the readers to bring some knowledge to the text that is not explicitly contained in it, the more we approach the kind of interpretive skills we try to teach students when they are confronted with quality literature and complex thought.

Another way of increasing the sophistication of relationship identification is to make finer distinctions among the different types of relationships. For example, Marzano (1983) has shown that the five basic relationships can be further subdivided into 22 different relationships each with its own meaning and linguistic signals. These 22 relationships are illustrated in Figure 2.2.

Figure 2.2

Types of Relationships

Addition

1. Equality:
   He is tall and he is handsome.
2. Restatement:
   I am tired. In fact, I am exhausted.
3. Example:
   He does many things well. For example, he is excellent at cards.
4. Summation:
   He does many things well.
   He cooks. He sews.
   In all he is an excellent homemaker.

Contrast

1. Antithesis:
   I will be there, but I won't be happy.
2. Alternative:
   Either it will rain or it will snow.
3. Comparison:
   Bill is tall. In comparison his brother is short.
4. Concession:
   I don't like violence. Nonetheless, I'll meet you at the fights.

Time

1. Subsequent action:
   They went to the game. Afterward they went to the dance.
2. Prior action:
   They went to the dance after they went to the game.
3. Concurrent action:
   Bill thought about Mary while Mary thought about Bill.

Cause

1. Direct Cause:
   He won the race by maintaining his concentration.

2. Result:
Bill went home. Consequently the party ended.
3. Reason:
He went to the store because he needed food.
4. Inference:
Mary is going on a long trip. In that case she should plan well.
5. Condition:
Unless you stop, I will leave.

Reference

1. Same word reference:
Bill is my friend.
I like Bill.
2. Personal pronoun reference:
Bill is my friend.
I like him.
3. Synonym reference:
Bill bought a new car.
This automobile is one of his nicest possessions.
4. Metaphoric:
Bill went to Seattle.
This haven for the weary is located in Washington.
5. Related concept reference:
Bill bought a new car.
The tires alone cost $400.
6. Whole idea reference (this, that):
Mary went out with Bill.
This bothered Mike.

Relationship identification helps students begin to see the interconnectedness of ideas and the necessity of creating linkages in the information they read or hear.

(3) Pattern Recognition

Patterns are organizational structures which "hold together" large blocks of information. A relationship might join two ideas, a pattern might unify 50 ideas. To illustrate a pattern consider the following:

> I have a regular routine I follow in the morning. First, I sit up on the edge of the bed to see if I'm alive. Then, I brush my teeth and wash my face. Then its time for my morning jog. I usually go from 2 to 5 miles depending on the weather. Next I . . . .

The unifying structure for this information is a sequence of events that happen in a set order:

> First I sit up on the edge of the bed.
> Then I brush my teeth.
> Then it's time for my jog.
> Next I . . . .

Sequence is a very basic pattern used to organize many different types of information.

Six basic patterns, including sequence, have been identified (Marzano and Dole, 1983). They include:

1. sequence patterns
2. topic patterns
3. generalization patterns
4. process patterns
5. similarity patterns
6. dissimilarity patterns.

As examples of these other patterns we describe topic patterns and generalization patterns below:

Topic patterns are those in which the characteristics of a single concept or a few concepts are described. Characteristics are: a) states of being, b) habitual actions and c) unusual actions for the concept. When you identify a concept pattern you are actually identifying characteristics of a concept. For example, here is a pattern organized around states of being:

> My car is the nicest on the block.
>
> It is painted blue with white trim.
>
> It has white-wall tires and a 409 engine.

Generalization patterns are those in which a set of propositions is an example of another proposition; here is an example:

> At times life gets difficult.
>
> Finances become a problem.

A period of poor health may develop.

Family problems can crop up.

Work may become boring.

Here the first sentence is the generalization; the others are the examples. In many cases a generalization pattern contains a summary statement at the end, thusly:

In short, it's easy to lose your zest for living.

To a degree, generalization patterns are related to topic patterns. The primary difference is that topic patterns contain characteristics of a concept; generalization patterns contain examples of a statement.

The first step in teaching pattern recognition is to teach students the different types of patterns by name. Once this is done students can use those patterns to organize information they read or hear. To illustrate consider the following excerpt from a social studies text:

> Islamic laws include dietary rules. Food must be prepared according to these rules. Foods that may and may not be used are listed. Muslims may not drink alcohol. This includes wine, beer, and whiskey. They are not allowed to eat pork, either. Devout Muslims often say that people who drink alcohol or eat pork are unclean. By Islamic definition, then, many [people] are unclean.
>
> Islamic law also includes criminal law. The Koran lists punishments for crimes against property or persons. The Koran says that thieves should have their hands chopped off. Each kind of crime has its own punishment.
>
> Islamic law carefully explains the place of women in society. Islamic women must obey their husbands in all matters. An Islamic husband may have four wives. Each wife has her place. Usually, Islamic wives are allowed to leave their homes for only a brief time. They may not deal with men other than their husbands.

One pattern students might see in this passage is a topic pattern about the concept "Islamic law":

<u>Islamic law includes dietary rules</u>:

Food must be prepared according to them.

Restricted and non-restricted foods are listed.

The Koran lists specific punishments.

Thieves have their hands cut off.

Each crime has a specific punishment.

<u>It also explains the place of women</u>:

Women must obey their husbands.

Wives have their place.

Wives are allowed to leave home only for a brief time.

Another pattern a student might see in this information is a generalization pattern:

<u>Islamic law is very restrictive</u>:

It dictates which foods can and cannot be eaten.

It prescribes specific and harsh punishments for criminals.

It limits the activities of women.

The point is that no single pattern exclusively fits the passage. In fact, many passages have all six patterns. This has strong implications for teaching declarative information; it suggests that a teacher should act as a guide in helping students see the many ways of organizing information within the content area. Rather than being viewed as static data to be learned as presented by the teacher or textbook, content should be viewed as fluid information which can be arranged in many ways to best fit the prior knowledge of the student.

Highlighting the interpretational nature of content is not new to curriculum theory. Hawkins (1974) refers to this as "unpacking" the curriculum; Bussis, Chittenden and Amarel (1976) refer to it as accessing the "deep structure" of the curriculum.

2. PROCEDURAL KNOWLEDGE

Procedural knowledge is knowledge of how to do things. As mentioned in Chapter 1, it is intimately tied to declarative knowledge. If students do not know the factual knowledge of a content area they cannot learn procedures which are built on that factual information. As Sywlester (1985) says, mastery of a procedure begins with declarative knowledge. This is supported by current research on teaching; specifically, without basic declarative knowledge, students have difficulty learning the procedural knowledge within a content area (Heller and Reif, 1984).

Although obviously important, procedural knowledge is frequently overlooked in instruction. For example, Beyer (1984) asserts that insufficient instruction in procedural knowledge about school work is a leading factor in the poor performance of many students. The implication is that content area teachers should identify those procedures specific to their content and explicitly teach and reinforce them. For example, a social studies teacher might identify such procedures as map reading or locating information in a reference book. A mathematics teacher might identify procedures for solving specific types of problems. Science teachers need to identify the various processes or procedures involved in their respective areas. Sometimes a relatively simple laboratory exercise may involve dozens, even hundreds, of such procedures. If the teacher is not aware of this complexity, it is easy to fail to build the prerequisite knowledge necessary to be successful. The effect is to penalize the less able student.

Research indicates that when learning a procedure an individual will progress through three stages. Fitts (1964) calls the first stage the cognitive stage. At this stage the learner can verbalize the process (describe it, if asked) and can perform at least a crude approximation of the procedure. According to Anderson (1983), at this stage it is common to observe verbal "mediation" during which the learner rehearses the information required to execute the skill. In the second stage, called the "associative stage" by Fitts, the performance of the procedure is smoothed out. At this stage errors in the initial understanding of the procedure are detected and dropped along with the need for verbal rehearsal. During the third stage, the autonomous stage, the procedure is refined. It is at this level that the procedure becomes automatic (Laberge and Samuels, 1974). That is, the procedure once called on by the learner is automatically executed and takes very little of the available space in working memory.

The stages described by Fitts and Laberge and Samuels parallel research by Hall and others. Their research suggests that when a person encounters a new operation or an innovation one can usually observe a predicable set of stages through which they progress as they deal with the new knowledge (Hall, 1976). They are identified in Figure 2.3.

Figure 2.3

Brief Definitions of Stages of Concern About the Innovation.

Awareness: Unconcerned about the innovation.

Informational: Concerns about general characteristics of the innovation and what is required to use it.

Personal: Concerns about one's role and possible conflicts between that role and anticipated demands of the innovation.

Management: Concerns about time, organizing, managing, and making the innovation work smoothly.

Consequence: Concerns about student outcomes.

Collaboration: Concerns about working with others in use of the innovation.

Refocusing: Concerns about finding another and even more effective way.

To illustrate a possible approach to teaching a procedure, using the stages suggested by Fitts and the others cited, a teacher might begin by identifying the declarative information essential to understanding the concepts tied to the procedure.

The first stage would be accompanied by making sure that students had an opportunity to understand how the procedure is related to knowledge already learned. Questions asked and answered about each procedure might include: What is it like? How does it compare with other procedures? What are its parts? What are its functions? What are other things that might be confused with the procedure but are not like it? Why is the procedure important? Why should I know about it?

At the second stage, the procedures would be explicated, described, broken down into their components or subprocesses. Students will want to ask questions like: Is this the right way? Does it work like this? Does this part of the procedure fit with the other parts? As this stage proceeds, students will naturally smooth out procedures even if they are initially inefficient. This smoothing out process usually involves adaptation to each student's own style. The students may delete, add or combine elements to make it work for them. During this phase it will be important for the teacher to provide feedback about the effects of these modifications.

Moving students to the third stage requires systematic and consistent use of the procedure. Anderson (1982) claims that for very complex procedures a relatively long period of practice time is required. This is consistent with the recommendations of Hunter (1984) and Good, Grouws and Ebmeier (1983) that students should receive ample opportunity for independent practice.

Simply stated, we recommend that effective procedural instruction include the identification of important subject area procedures, the description of these procedures, their presentation to students and the use of activities that allow students to integrate the procedures into their own manner of interacting with the content. Evertson (1980) found that this is precisely what effective teachers do with procedures related to social behavior in the classroom. That is, good teachers describe the procedures (rules) they expect students to follow and then give them explicit practice in the procedures until they become integrated with the students' behavior. We suggest that the same process be followed to teach academic procedures inherent in specific subject areas.

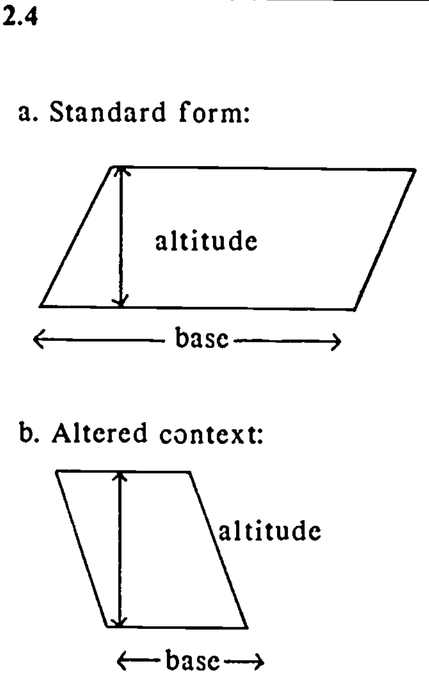
3. CONTEXTUAL KNOWLEDGE

Contextual knowledge is actually a component of procedural knowledge but important enough to be isolated as a type of knowledge in its own right. Recall from the introductory chapter that contextual knowledge is knowledge of when to use a procedure and the ways that contextual or situational variables affect the procedure. For example, *2+2* represents the procedure of adding two one-digit numbers. If we represented this problem in a different format, like that below, we would be changing the contextual information surrounding the procedure:

$$\begin{array}{r} 2 \\ +\underline{2} \end{array}$$

One cannot assume that students who have learned a procedure in one context will be able to perform the procedure in what appears to them to be a different context. A rather famous study by the Gestalt psychologist, Max Werthermeir, (in Resnick, 1983) is commonly used to illustrate this point. Werthermeir (1945, 1959) reported interviewing children who had been taught to find the area of a parallelogram by dropping a perpendicular line and then multiplying the perpendicular by the base of the parallelogram. The students performed well on this task as long as the problem was presented in the standard way as illustrated in the top of Figure 2.4.

Figure 2.4



However, when Werthermeir asked the students to find the area of the parallelogram in a different position (as in the bottom of Figure 2.4) students reported that the problem "was not fair" or that they "haven't had that yet."

To teach contextual knowledge in a classroom setting requires a keen eye on the part of the teacher—specifically, an eye for which content knowledge contains important contextual information. Some content knowledge by its very nature is mostly contextual. For example, teaching students how to use punctuation correctly is primary contextual. Most students readily understand that a comma signals a pause. They also readily understand the procedure for using a comma, placing a small curved line between two words. However, the context in which the procedure should be used is difficult for many students to integrate into their knowledge of commas. The contexts in which commas should be used includes:

between items in a series, whether the items are words, phrases or clauses

between clauses of compounded sentences

after introductory phrases and clauses

at the beginning and end of nonrestrictive clauses

at the beginning and end of appositives.

Once key contextual information has been identified the teacher should then present the content in the different contexts. For example, mathematical and scientific algorithms (like the parallelogram algorithm) should be presented in different formats. Students should even be encouraged to identify different formats or modes of representation. The students should then be asked to discuss how the contexts changed their approach to the information.

INTEGRATION OF DECLARATIVE, PROCEDURAL AND CONTEXTUAL KNOWLEDGE

Earlier we made the point that our model of thinking skills is an integrated one; i.e., the components do not stand alone. The same is true for the elements of the component we have called "content thinking." The three elements of declarative, procedural and contextual knowledge are quite interactive in the real world.

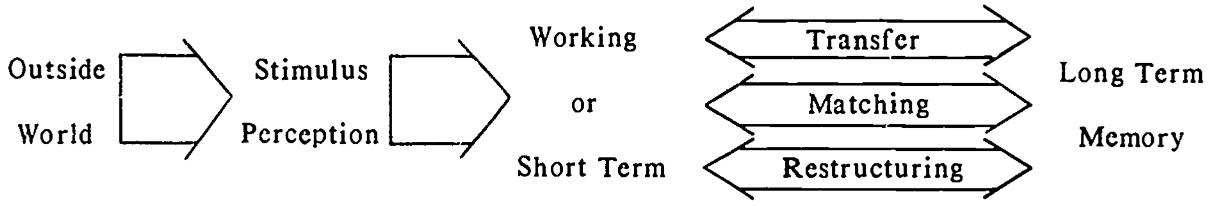
One way to illustrate this integration is to reference the work of general systems theorists. People within that field point out that with the exception of the thousands of single concepts (words) in our knowledge base, most of the "stuff" of nature is actually systemic. Bertalanffy (1967, 1969) indicates that nature consists of an array of progressively elaborated systems. His hierarchy includes nine levels. Boulding (1968) has constructed a hierarchy of seven levels of systems ranging from the simplicity of what he calls "clockworks" to an overarching perspective expressed in "transcendent systems." Level six, for example, is the human level in which the individual person is the system. Level seven is the level of social organization. A great deal of the content of education particularly at the secondary and college levels, is at these higher system levels. We believe that it is more appropriate to refer to "higher" levels of thinking in terms of the graduated complexity of these systems rather than the quality of our thinking per se.

One example will help make the point. In the Midwest and other farming areas of the country, agriculture is in crisis. The system is being restructured to make it more difficult for the family farm to survive. To succeed on a family farm without a second source of income, one must understand the complex system that is farming. For example, the farmer must understand the cost structure of agriculture including such things as the trade off between the costs of labor and technology. (Several years ago productivity could be increased best through investments in technology rather than labor. Increasing costs of capital investments, however, have reversed that situation and now, at least temporarily, productivity can be improved more economically through investments in labor rather than technology.) The farmer must understand financial management and be able to understand the consequences of wide swings in interest rates, rates of inflation and rates of return on farm assets. He or she must know different methods of financing debt and be aware of the potential instability of different sources of equity capital. The successful farmer must have an understanding of the effects of international trade, monetary exchange rates, national debt and inflation rates on the demand for agricultural products. He or she must have marketing skills to compensate for losses from federal price supports and subsidy programs. And, of course, he or she must possess a detailed knowledge of agriculture production per se—soil quality, fertilizer, animal husbandry, and on and on. The days when you could successfully farm by just planting in the spring, plowing in the summer and harvesting in the fall have long gone. Successful farming requires detailed knowledge of systems and subsystems in biology, finance, etc. Content, procedures and context are intertwined in a very complex way.

Our understanding of the complex, integrated way in which we think about systems has been recently expanded by research of human intelligence. What is emerging is the picture of the intelligent person as a "system" thinker—someone able to see the complex interactions of systems and subsystems. Whether it's a farmer, an international financier, a high level government official or a student in an automobile class who understands the relationships between carburetor adjustments, air intake, gas consumption and spark ignition, success in the twenty-first century will depend on what we term **Systemic Thinking**—the integration of all the content and—functions we describe in this monograph.

REASONING

Figure 3.1



To understand what we mean by reasoning skills consider Figure 3.1, an adaptation of a model described by Anderson (1983).

The figure illustrates the recent understanding that our minds utilize two distinct components as they interact with the outside world: a short term, working memory that has limited storage capacity and a much larger long term memory. For example, Dyer (1976) states that it has been conservatively estimated that long term memory can store an amount of information equivalent to one hundred trillion words and that all of us use but a tiny fraction of this storage capacity. Short term memory, on the other hand, can hold only about seven elements at any one time (Norman, 1969). What we call reasoning involves three processes:

1. Transferring, the first process, is actually two subprocesses: the storage and retrieval of specific knowledge. Storage deposits information into long term memory. Retrieval brings the knowledge back out into short term memory. Memorization and recall would be the two common usage words that reflect these processes.

2. Matching is the process of comparing information in short term memory with information in long term memory; later we will explain how this process works.

3. Restructuring involves the creation of new knowledge or the modification of old knowledge.

These processes work together in a unified way. For example, because our short term memories are relatively limited, we must either find a way of recording our ongoing experiences (That's why we take notes during a presentation and why good speakers usually limit their main ideas to four or five and frequently give us mnemonic devices to remember what has been said.) or we must place the new knowledge or information we are receiving into long term memory as quickly as possible.

Transferring knowledge to long term memory requires us to either create or build upon structured knowledge already in our minds. Thus, for example, when we want to learn a new vocabulary word like "mnemonic" we search our minds for words that are like the new one—"memory," "retention," etc. We match the new concept with the old concept to identify ways it is the same or different and integrate it into our permanent knowledge base. In the process, we restructure the old knowledge base.

We call this integrated process "reasoning" because it incorporates most of the active processes we associate with thinking. And, in fact, most existing "thinking skills" programs focus on one or more of the processes just named. We have reserved the word "thinking," however, to incorporate all of the elements of our model, most of which have previously been neglected within formal education—such as pattern recognition, identification of different types of declarative knowledge, etc. We restrict the concept of "reasoning" only to those elements of the process that involve the transfer of knowledge between long and short term memory through matching and restructuring.

1. TRANSFERRING

a. Storing
b. Retrieving

Storing and retrieving (memorizing and recalling) are combined in our model because they are both components of the transfer process and as far as instruction is concerned, there is a great deal of overlap between them. That is, the instructional techniques which facilitate storage also facilitate retrieval.

A fairly simple set of steps can be taught to students which vastly improves their storage and retrieval capabilities:

Step 1. Identify the information you wish to remember.

Step 2. Use guided imagery to highlight the information.

Step 3. If the information is part of a related set of information, use a memory framework.

Step 1 might seem trivial but it is critical to the storage and retrieval process. As Lindsay and Norman (1977) explain, in order to make sense of the information constantly bombarding us we must pick and choose among the data. We could not possibly attend to all information available at any point in time. Hence, selection of important information is the first step in efficient processing. If students know the importance of patterns, relationships and concepts, they can use these organizational structures as the framework for selection of information. That is, students can look for key concepts, relationships and patterns to be stored and retrieved.

Step 2, guided imagery, is a cornerstone of most memory techniques. Guided imagery creates a greater number of "cues" than are usually stored with incoming information. Early work by Penfield and Perot (1963), pioneer brain surgeons, indicated that we tend to store all components of experiences in long term memory. That is, we store the visual, auditory, kinesthetic, emotional and verbal attributes of an event or experience there. These form what Underwood (1969) calls "attributes" or cues to memory. If these cues are strong, the experience can be recalled by bringing one of the cues to consciousness. This explains why people report that any one experience can generate a number of remembrances. As you read this monograph you are being bombarded with images, kinesthetic sensations, sounds, etc. Each of these could be a cue to a set of experiences stored in long term memory. If the cue is strong enough, the experience to which it is attached will be recalled. Consequently, as you read this chapter an extreme in the temperature of the room might be a cue to an experience you had ten years ago.

The purpose of Step 2 in the storage and retrieval process is to artificially strengthen the cues for information via guided imagery. It involves artificially generating images, sensations, feelings and verbal information about a thought. That is, when you use guided imagery you take a thought and artificially expand it so that it has all of the sensory components listed above. For example, if students were to use guided imagery about George Washington they might first form a strong mental image of Washington on his horse (image). They might also imagine they smell the saddle leather and what it might be like to sit on his horse (sensations). The students might also verbalize some facts about George Washington in their minds—"George Washington was the first President; he was born in . . . ." (verbal information). Finally, the students might try to conjure up a sense of patriotism (feelings).

Step 3 of the storage and retrieval process is used only if a student wishes to recall many different pieces of information. For example, if a student has identified sets of information for a history test, then Step 3 might be appropriate. The key to Step 3 is the use of a memory framework. Memory frameworks create "locations" in which information is stored. When students recall the location they also retrieve the information. A good metaphor to describe memory frameworks is that they create mental "slots" into which students deposit information via guided imagery.

One of the simplest memory frameworks to teach students is the rhyming pegword method (Miller, et al., 1960) in which students first memorize the following jingle:

> One is a bun; two is a shoe; three is a tree; four is a door; five is a hive; six is sticks; seven is heaven; eight is a gate; nine is a line; ten is a hen.

A student wanting to deposit information into one of the slots would use guided imagery to make the association between the "pegword" and the information. To illustrate, assume a student wanted to put the information about George Washington into slot #1. The student might imagine a large hot dog bun, the pegword for slot #1, with a diminutive George Washington standing inside. The student would then imagine all elements, described above (e.g., the smell of the leather, the verbal information, etc.). Retrieving the information (e.g., for a test) would simply require saying the jingle to recall that the pegword for slot #1 is the bun. This cue would then call up the visual images of George Washington in the giant bun which would cue the remaining information. There are many other types of memory frameworks (e.g., loci or place methods, linking methods, acronyms) which allow students to create an almost inexhaustible supply of slots.

Memory frameworks are very useful study tools and illustrate to students the power of their minds. Unfortunately, many classroom teachers never utilize them because of the unwarranted educational stigma attached to "rote learning." However, we believe that helping students to learn to identify important information in material they read and then store that information efficiently using memory frameworks is an important part of the overall development of thinking skills.

2. MATCHING

The essence of matching is to determine how new information is similar to and different from old information. We mentioned in Chapter 1 that there are five basic matching skills:

a. categorizing
b. reasoning analogically
c. extrapolating
d. evaluating evidence
e. evaluating value.

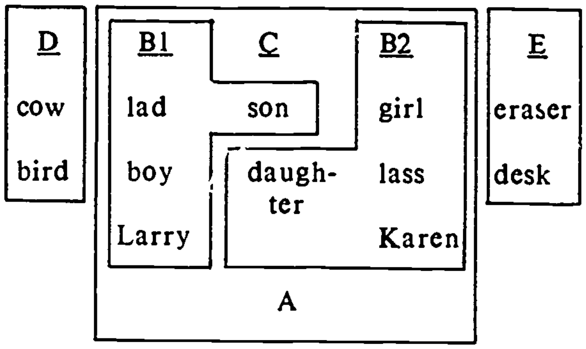
We will consider each briefly.

a. Categorizing

Categorization is usually done with concepts. That is, we tend to compare and contrast concepts and classify them into categories. The skill of categorization is directly related to the concept of clustering introduced in Chapter 2 as a way of facilitating vocabulary development. One of the best ways to use categorization in a regular classroom setting is to utilize semantic feature analysis.

The theory of semantic features asserts that words are known or comprehended based on specific semantic features they possess or do not possess. Figure 3.2 illustrates some semantic features:

Figure 3.2



As described by Marzano, Distefano, Valencia and Hagerty (1986) the words in set A are all human, animate and two-legged. The words in B1 and B2 are differentiated by the fact that all B1 words contain the added semantic feature of male; all B2 words have the semantic feature female. Words in Set C do not share a male/female distinction but they do share a semantic feature which might be called siblings. Set D words are animate but gender-neutral. Set E words are inanimate.

Johnson and Pearson (1984) recommend a six-step process for using semantic feature analysis in the classroom.

Step 1. Select a category (animals).

Step 2. List, in a column, concepts within the category (see Figure 3.3).

Step 3. In a row across the top of the grid, list the attributes or features shared by some of the concepts (furry, bark, four legs).

Step 4. Put pluses or minuses beside each concept under each feature. A plus indicates that the concept usually has a given feature.

Step 5. Ask students to add additional concepts and features and complete the expanded matrix with pluses and minuses.

Step 6. As a group, discuss the concepts and their features.

An example of this analysis is shown in Figure 3.3.

Figure 3.3

TOPIC: ANIMALS

	furry	bark	four legs
dogs	+	+	+
snakes	-	-	-
birds	-	-	-
horses	-	-	+

Semantic feature analysis can be used with preschoolers as well as college students. It can be a valuable tool within content area classrooms. For example, assume that a history class is beginning a unit of study on attributes of great leaders. Attributes of leadership can be placed on the top of the grid and the leaders to be studied down the left-hand side of the matrix. Students can fill in pluses and minuses in the matrix to indicate which features are possessed by each leader. This is illustrated in Figure 3.4.

Figure 3.4

	A	B	C
Napoleon			
Hitler			
Alexander the Great			
Henry VIII			

Key:
A = Flamboyant
B = Egotistical
C = Brilliant Strategist

b. Reasoning Analogically

According to Reese Jenkins (*Personal Report*, 1985), historian and director of the Thomas Edison papers at Rutgers University, Edison's genius was in part due to his ability to use analogical reasoning. For instance, when writing about the kinetoscope, a forerunner of the motion picture, Edison is quoted as saying:

> I am experimenting upon an instrument which does for the eye what the phonograph does for the ear. . . . The invention consists in photographing continuously a series of pictures in a continuous spiral on a cylinder or plate in the same manner as sound is recorded on the phonograph.

Within education analogical reasoning refers to a particular type of reasoning problem such as "A is to B as C is to D" (A:B :: C:D). According to Sternberg (1977) the process of analogical reasoning contains four components: encoding, inferring, mapping and applying.

(1) Encoding

Encoding is the identification of the attributes or characteristics of the concepts within the analogy.

(2) Inferring

Inferring is the identification of the rule that relates adjacent concepts. For example, in the analogy *feather:bird :: leaf:tree*—the relationship between adjacent concepts is part-to-whole.

(3) Mapping

Mapping is the identification of the relationship between non-adjacent terms. For example, in the analogy above, feather and leaf are parts; bird and tree are wholes.

(4) Applying

Applying refers to identifying the missing component in an analogy of the form *feather:bird :: ________:tree.*

Sternberg's components can be translated into a fairly straightforward procedure for solving analogy problems.

Step 1. Identify characteristics of the concepts in the first set.

Step 2. Identify possible relationships between these concepts.

Step 3. Identify which concept in the first set is most closely related to the element in the second set.

Step 4. Identify what is missing in the second set.

The key to analogical reasoning appears to be Step 2, identifying the relationships between adjacent concepts. Students will generally be able to identify some type of relationship. However, it might not be the one that would be most commonly identified by other students or the one expected by a test maker. Consequently, students' abilities to solve formal analogy problems (e.g., those found on tests) can be greatly improved by teaching them the common relationships found in analogy tests. Lewis and Green (1982) in their study of analogy tests identify a number of relationships students should be exposed to. Those relationships include:

a. Similar concepts: Adjacent concepts are basically the same or very similar in meaning:

swim: float :: shout: __________

a) whisper
b) argue
c) scream*

b. Opposite concepts: Adjacent concepts have opposite or very dissimilar meanings:

these: those :: go: __________

a) proceed
b) run
c) come*

c. Class membership: Adjacent concepts share class membership:

horse: lion :: blue: __________

a) bird
b) pink*
c) mood

d. Class name and class member: One concept is a class name; the other is a class member.

April: month :: bee: __________

a) flower
b) spring
c) insect*

e. Derivation: One concept turns into another:

flower: bud :: butterfly: __________

a) pollen
b) wings
c) caterpillar*

f. Function: One concept performs a function on or for another:

teacher: student :: driver: __________

a) golf
b) speed
c) car*

g. Quantity or size: concepts are related by quantity or size:

mountain: hill :: tiger: __________

a) jungle
b) housecat*
c) lion

In a classroom setting students can be presented with analogies from published materials and/or they can be asked to create their own analogies using concepts from different content areas.

c. Extrapolating

Extrapolation is a direct extension of pattern recognition. As was explained in Chapter 2, pattern recognition helps students identify and organize information they read or hear into large chunks. This activity is fairly "text bound"—it does not force the reader to go beyond the <u>information</u> actually presented. Extrapolation on the other had, forces students to identify how <u>patterns</u> of information from one source of information might be similar to patterns from another source. Using the six pattern types mentioned in the second chapter (e.g., topic patterns, generalization patterns, sequence patterns, process patterns, similarity patterns and dissimilarity patterns) we operationally define six kinds of extrapolation:

1. matching the characteristics stated in one topic pattern with characteristics in another

2. matching the examples of one generalization with the examples of another

3. matching the sequence of events in one situation with that of another

4. matching a process in one situation with the process in another

5. matching the similarities between two patterns from one content area with the similarities between patterns from another content area

6. matching the dissimilarities between two patterns from one content area with the dissimilarities between two patterns from another content area.

To illustrate, assume that students have read a description in a basal reader about how to bake a cake. As part of this process pattern about cooking students might have identified the following elements as important to the pattern:

Gather the ingredients.

Mix the ingredients.

Put them in the oven.

Put the icing on.

Once they have determined that the basic pattern is a "process" they can then be asked to try to identify some other process that is not about cooking which contains some of the same elements as the process for baking a cake.

Students in Detroit might extrapolate this pattern to building cars. They would then be asked to show how the process of building cars has the same components as the process for baking a cake. Thus students might identify the following likenesses.

Baking a Cake	Making a Car
Gathering the ingredients	Shipping materials (e.g., aluminum, rubber) from different parts of the country
Mixing the ingredients	The assembly line operation
Putting the cake in the oven	Using different heating processes (e.g., welding) in the assembly line
Putting on the icing	Painting the car and putting on the trim.

As long as a students can demonstrate how the extrapolated pattern has the same components as the initial pattern their answer is correct. Extrapolation, then, fosters divergent thinking. In fact, it is very similai to the construction of metaphors. For example, both metaphor and extrapolation have a topic (the pattern being extrapolated to a new context) and a vehicle (that context to which the pattern is being extrapolated). Ortony (1980) states that a cognitive ability such as this develops long after a child has mastered the rudimen^s of language processing. However, Arter (1976) found that instruction in the use of metaphorical models facilitated the learning of low ability students.

d. Evaluating Evidence

Evaluating evidence refers to identifying whether a piece of information has backing or proof and, if so, how valid the proof is. Within many thinking skills programs this skill is called "critical thinking." The skill desciibed here is based on the work in logic of Toulmin (1958; Toulmin, Rieke and Janik, 1979). Students can be taught a fairly straight forward process for evaluating of logic. As described by Marzano, et al., (1986) that process is:

Step 1. Identify an unusual claim. A claim is a statement of fact. An unusual claim is one that is not self-evident or one you weren't aware of before. For example, "The sky is sometimes blue" is self-evident. However, the claim that "From an aerodynamic perspective, bees should not be able to fly" is not self-evident.

Step 2: Decide if the claim is in the domain of common knowledge. If it is then it requires no backing or proof.

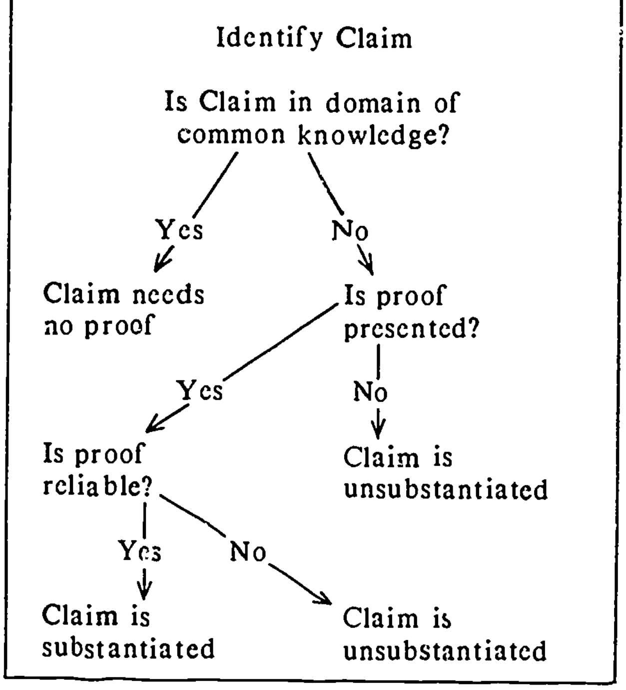
Step 3: If the claim is not considered common knowledge, is proof presented for it? If no proof is presented, the claim is unsubstantiated.

Step 4: If proof is presented, how reliable is it?

Step 5: If the proof is unreliable, the claim is unsubstantiated. If the proof is reliable, the claim is substantiated.

This process is represented diagrammatically in Figure 3.4.

Figure 3.4



One of the more difficult parts of the process is Step 4, determining the reliability of proof. Most critical thinking programs attempt to teach students the various ways that backing or proof can be unreliable. Below we will consider three ways.

(1) Oversimplification of Cause

To illustrate this type of unreliable backing consider the following:

> The primary cause of World War I was the unrest of the working classes in Europe.

This statement is not totally incorrect. There is some truth to the assertion that the unrest of the working class in Europe added to the outbreak of World War I. However, it was not the primary cause of World War I; it was not even one of the more important causes. Here the author of this claim has taken a very complex set of causal relationships (e.g., the relationship of World War I to its many causes) and oversimplified them.

(2) Overgeneralizing

Overgeneralizing occurs when a generalization far exceeds the facts which accompany it. Overgeneralizations are common in everyday speech. For example, an individual might rush into work in the morning and announce: "This has been the worst morning of my life. My car wouldn't start, when it finally did, I got stuck in traffic and then got a ticket!" In fact, the morning was probably not the worst of his or her life. The overgeneralization is accepted as a way of dramatizing the situation. However, in newspaper articles, media presentations or serious conversations, overgeneralizations should be recognized and identified as unsubstantiated claims.

(3) Use of Informal Fallacies

Informal fallacies occur quite frequently. Common examples include ambiguities, vagueness or part/whole and whole/part errors.

Ambiguities occur when a word or idea is used which can have more than one meaning. To illustrate, consider the following example of ambiguity offered by Stottlemeier (1979; p. 87):

> Girls alone are not permitted in the pool.

Does the sentence mean that girls, as distinguished from other categories of people (men, women, and boys) are not allowed in the pool or that single girls unaccompanied by another are not permitted?

Lipman states that certain types of ambiguities must be tolerated in social interaction. Sometimes ambiguities even serve a useful purpose. This is commonly the case when they are used in poetry. But in everyday discourse they are usually dysfunctional.

Vague words lack clean cutoff points. To illustrate, consider the following example offered by Stottlemeier (1979; p. 89):

> Is it cold today?

What is cold? Cold to one person might be warm to another. If you live in San Diego the concept of cold might be quite different than if you lived in Fairbanks.

Lipman states that students should be able to recognize vague words and be able to distinguish contexts in which they are unacceptable from those in which they are acceptable.

Part/whole and whole/part errors occur when you assume that if a part of a whole has a specific feature, then the whole must have the feature (part/whole error), or, if you assume that if the whole has the feature, then all the parts must have the feature (whole/part error). To illustrate consider the examples below.

> Mary's face is beautiful, therefore, she must have a beautiful nose (whole/part error).
>
> My car has the best tires made; therefore, it is one of the best cars made (part/whole error).

Students can be taught to evaluate errors of logic whenever they hear or read information presented as fact. This means that they should be mentally asking such questions as:

> Are their statements being made which are out of the realm of common knowledge?
>
> Is there proof or backing for these claims?
>
> Does the proof or backing contain any of the common sources of unreliability (e.g., oversimplification of causal relationships, overgeneralizing, use of informal fallacies)?

c. Evaluating Value

Evaluation of value is the process of determining whether information is considered good, bad or neutral on some accepted scale. To illustrate, consider the following two statements:

a) Wood is used to build houses.

b) The Russians pulled out of the 1984 Olympic games.

As described by Marzano, et al., (1986) most people consider the information in the first statement as neutral; however, many Americans consider the information in the second statement as negative. You can usually tell if you value something by the emotional reaction it elicits.

The purpose of evaluating value is to identify the weight or merit (good, bad, neutral) placed on information, identify the assumptions under which the value weight was assigned and identify a set of assumptions that would yield a different value weight.

An outcome of the evaluation of value process is that students recognize the subjectivity of their own value systems. This is consistent with Paul's conception of "dialectic" thinking. He states that:

> Children can learn to consider it natural that people differ in their beliefs and points of view and they can learn to grasp this not as a quaint peculiarity of people but as a tool for learning. They can learn how to learn from others, even from their objectives, contrary perceptions and differing ways of thinking (Paul, 1984; p.12).

Spiro (1980) has stated that this "attitudinal" component of thinking is the central aspect of cognition. It allows one to see the information base from which judgments are created.

3. RESTRUCTURING

In the introductory chapter we gave a brief example about how the addition of new information to existing information in long term memory restructures the old knowledge and, in effect, creates new knowledge. Stated more broadly, all reasoning procedures mentioned thus far create new knowledge to a certain extent. However, some of the procedures mentioned are more focused on that purpose than others. There are three basic restructuring procedures that stand alone: 1) elaboration, 2) problem solving and 3) invention.

a. Elaborating

Elaboration involves inferring information not explicitly stated in information read or heard. Various categories of inference have been proposed by researchers and theorists (e.g., Bruce and Schmidt, 1974; Warren, et al., 1979). Within our model three types of inference seem most important: 1) elaboration of characteristics, 2) elaboration of causes and consequences and 3) elaboration of author intention.

(1) Elaboration of Characteristics

As early as 1920, psychologists (e.g., Hull, 1920) were hypothesizing that humans store characteristics of concepts in long term memory. That is, in addition to a linguistic label for a concept we also store the characteristics of the concept. Every time you read or hear a word which represents a concept all of the characteristics of the concept are available to you. For example, if you read a story about a little girl named Mary, all of the characteristics of little girls come to mind simply by reading the label "little girl." The author does not have to explain how little girls act, how they dress, etc. This comes with the label.

Teachers can use this principle to structure questions which help students elaborate on the concepts they read and hear, thereby building new information about those concepts. Specifically, a teacher can select concepts and have students elaborate on unstated information. There are four types of concepts commonly found in content material: 1) animate creatures, 2) places, 3) things and 4) events. Below is listed the information usually associated with such concepts:

<u>Animate creatures (e.g., dog)</u>

Physical dimensions: four-legged, furry ...

Emotional and psychological state of being: friendly, vicious ...

Habitual actions: chases cars, chews on bones ...

Out-of-the-ordinary actions: a particular dog saved someone's life ...

<u>Places (e.g., Colorado)</u>

Location: in the Rocky Mountains.

Size, shape, terrain: Colorado is a moderately large state that has a square shape. It is mountainous but it also has flatlands.

Events that habitually occur there: Colorado has a lot of snow in the winter but very little precipitation in the other seasons.

Out-of-the-ordinary events or other characteristics: Colorado has one of the highest average elevations of any state in the union.

<u>Things (e.g., The Empire State Building)</u>

Physical dimensions: over 100 stories tall.

Location: in Manhattan, New York.

Customary use: office building and a place where tourists go.

Out-of-the-ordinary use or other characteristics: once was the tallest building in the world.

<u>Events: (e.g., weddings)</u>

Participants: bride, groom, parents.

Goal or reason: unite two people.

Time and duration: 1 or 2 hours on a weekend.

Location: church, synagogue.

These "frames" for concepts can be used to structure questions or assignments which require students to elaborate on concepts read or heard. To use a simple example, assume elementary school students had read a story about a young girl named Jana. The teacher might use the animate creature frame to ask such questions as:

What did Jana look like?

How tall do you think she was?

What did she dress like?

What type of personality did she have?

Was she a happy child? Sad? Why?

What are some things you think Jana might have normally done on the way to school?

What are some things Jana did that were very different from what you or other children normally do?

At a more advanced level students might be assigned to research the information in a concept frame. For example, if they encounter the concept "festival" in a social studies unit, they might be asked to research the participants, location, reasons, etc., for this "event" concept.

(2) Elaboration of Causes and Consequences

Inferring causes and consequences appears to be a basic human drive. Johnson-Laird (1983) identifies causation as one of the basic "conceptual primitives" that build up more complex concepts. That is, we attempt to infer causes about our own and others' behavior and subsequent behaviors and attitudes (Lavelle and Keogh, 1980). This natural tendency can be translated into questioning techniques. Specifically, teachers may select statements from reading material and ask students to elaborate on the causes and consequences of that statement.

(3) Elaboration of Author Intention

The intentions behind communications are studied within the field of linguistics called "pragmatics." Theorists in pragmatics, such as van Dijk (1980), Bruce (1975), Halliday (1967), and Tough (1976) have attempted to describe the different intentions that can be behind a message. Commonly six different intentions are identified:

1. instrumental: using language as away of getting things
2. regulatory: using language as a means of controlling others
3. expressive: using language to express feelings, emotions and opinions
4. informative: using language to inform others
5. imaginative: using language to create new ideas
6. heuristic: using language as a means of finding out new information.

These categories of intention can be used to reinforce elaborations. That is, students can be asked to identify the intention behind information read or heard and the specific cues which signal the intention behind the message.

b. Problem Solving

Problem solving occurs when an individual must fill in missing information. This is at the core of all problems: information necessary to accomplish a goal is missing. Without the missing information no problem exists. Problem solving differs from invention, the next process, in the specificity of the goal. When you invent, your goal is initially very general. As a matter of fact, what you end up with via the inventing process might be very different from what you initially intended to do. During problem solving the goal is usually obvious and quite explicit—often, it is even imposed on you (e.g., you need to get to work but your car won't start). As van Dijk and Kintsch (1983) state, a problem exists when there is an explicit goal to be reached. There are specific operations to be performed to reach the goal and some component of the specific operations is not know to the problem solver.

In this model we make the distinction between two types of problems: 1) everyday problems, and 2) academic problems. Everyday problems are like the example above (e.g., your car won't start). Academic problems are like those encountered in a math class or science class (e.g., solving simultaneous linear equations, determining the effect of mixing two chemicals). Obviously academic problems are very restricted in content, whereas everyday problems can relate to such diverse topics as coming up with the money to go on a vacation, threading a needle or mowing the lawn before it rains. Another major difference between the two types of problems is the freedom of choice relative to the goal. With everyday problems there is always the possibility of rejecting the initial goal. For example, an individual might initially have the goal of mowing the lawn. Clouds gather overhead and the situation becomes problematic (e.g,. "How can I get the lawn done before it starts to rain?"). The individual has the option to ignore the initial goal of mowing the lawn and watch television instead. With academic problems, the student usually does not have such freedom.

Regardless of the type of problem (everyday or academic) good problem solvers attack problems systematically rather than in a haphazard fashion (Covington, 1985; Bransford, Nitsch and Franks, 1977). This implies that students should be provided with an initial framework with which to attack problems. The initial framework should not be prescriptive in nature. That is, the problem solving framework should be presented to students as a starting place from which they can develop their own problem solving plans of attack.

(1) Everyday Problems

Below is a general problem solving framework for everyday problems:

Step 1. When a problem arises, stop whatever you are doing and try to affirm the following beliefs:

> The problem probably has a number of solutions and you will surely find one or more of them.
>
> If you look for it, help will be available.
>
> You are perfectly capable of taking care of the problem.

Step 2. Begin talking to yourself about the problem. Verbalize the thoughts you are having; i.e., think aloud about the problem.

Step 3. Start looking for what is missing and identify possible solutions.

Step 4. For each solution identify the tools you will need or things you might have to have to attempt the solution, or the actions you will have to take.

Step 5. Determine how accessible the tools for each solution are.

Step 6. Identify the solution(s) you think has the highest probability of working and assess the risk factor associated with each solution.

Step 7.. Try out the solution that you feel has the highest probability of success and that fits your comfort level of risk.

Step 8. If your solutions don't work, clear your mind and be willing to see the problem in a totally different way. Then go back to step 3. Keep doing steps 3 through 7 until you solve the problem.

Step 9. If no solution can be found, "revalue" what you were trying to accomplish. Look for a more basic goal that can be accomplished even though the one at hand cannot.

There are a few aspects of this problem solving framework that should be highlighted. Step 1 deals with attitudes that appear to aid problem solving. In general, good problem solvers have confidence in their ability to solve a problem. That is, they think about themselves a certain way when they solve problems (Weiner, 1983). Step 1 helps students become aware of their beliefs about themselves as problems solvers and reinforce those beliefs which aid in problem solving.

Step 2 reinforces a common technique used by good problem solvers—thinking aloud. (Rowe, 1985) Technically, this is called verbal mediation—the act of talking to yourself to help define and solve a problem.

Steps 3, 4 and 5 deal with identifying what is technically called the "problem space"—the parameters of the problem—what you know and don't know about the problem.

Steps 6 and 7 deal with the inherent threat to self-worth imposed by problems (Covington, 1985). Abraham Maslow once stated that we tend to stay away from those situations which threaten how we perceive ourselves. Covington states that learning how to deal with the inherent risk in problem solving is a valuable tool for the strategic thinking necessary to solve problems. Steps 6 and 7 help students accomplish this.

Step 8 is meant to help students generate different types of solutions when the cues they have already tried don't work. DeBono (1985) refers to this as "lateral thinking" and asserts that is an important element of problem solving.

Finally, Step 9 helps students adjust their expectations and energies when a goal cannot be accomplished.

(2) Academic Problems

For academic problems students should be given a task-specific problem solving framework. Polya (1957) developed a framework for academic problem solving which current research (e.g., Polson and Jeffries, 1985) seems to validate. Basically, that framework has four components: 1) understand the problem, 2) design a plan, 3) carry out the plan and 4) look back to see what worked.

Understanding the problems involves identifying what is given, what is unknown and the operations you can perform on the givens to solve what is unknown. This is perhaps the most difficult part of problem solving because there are so many types of possible unknowns. To illustrate, consider the following four types of problems:

1. A train can travel 10 miles in 4 minutes. How far will it travel in 14 minutes?

2. An airplane leaves location A for location B traveling at 200 miles per hour. 2500 miles away at the same time a plane leaves location B for location A traveling at 300 miles per hour. At what point will the planes intersect?

3. You are to build a vehicle which is capable of carrying a person weighing no less than 150 pounds for a distance of 100 feet over solid ground. This vehicle is not to have wheels. A wheel is defined as any standard wheel or caster or any construction in part with a circular piece of material.

4. A man was found in his locked room on the floor. Next to him was a pool of water and a pool of blood somewhat mixed together. There was also a note indicating that the man had committed suicide. How did he kill himself?

In problem 1 the missing information is a simple formula (rate x time = distance). If a student knows that formula, no problem exists; she or he simply plugs in the formula and works out the answer. In problem 2 the same formula is invalid. Assume that a student trying to solve this problem knows that formula. There is still something missing—how the "distance" part of the formula will interact for two sets of data. Problem 3 has a different type of unknowns—the way that a set of constraints will affect a common process (e.g., building a vehicle). This type of problem is given to elementary school students in the competition entitled "Olympics of the Mind" (Gourley and Micklus, 1982). Finally, problem 4 has a totally different type of unknown—possible murder weapons not commonly used. (The answer is, by the way, "He was stabbed with an icicle.")

The point here is that step 1 in the academic problem solving framework is very difficult because of the many types of unknowns that can exist for problems. In fact, van Dijk and Kintsch (1983) identify five or six different types of unknowns for a simple mathematics story problem. That is, there are different types of unknowns for different wordings of the problem. What this implies is that teachers should carefully identify the types of unknowns for problems that are presented to students, and present problems in groups with similar types of unknowns. In this way students will gradually learn the types of unknowns found in academic problems and be able to use that knowledge in future academic problem solving situations.

Step 2, designing a plan, is fairly straightforward. Here the student asks "How am I going to find out what is unknown?" Research indicates strategies that can be used to answer this question. One strategy is called decomposition—breaking a problem down into smaller parts and solving each part. A student might do this with problems like 2 and 3 above, where there are a lot of pieces and a lot is unknown. Another strategy is to identify previously solved problems that are similar to the current problem. This is sometimes called "solution by analogy." Another strategy is called "generate and test." Here students generally guess as to what will work in identifying the unknowns. They then test their hypothesis. There are other common strategies used to identify the unknowns in a problem (e.g., solution by contradiction, working backwards or "backward mapping"). The generalization to be made here is that students should be taught a number of strategies and given enough practice so that they can identify those that work best for them.

Step 3 and 4 usually involve such strategies as summarizing what has been done, eliminating those things you know don't work and selecting an alternative. If steps 3 and 4 are carried out, students have the possibility of experiencing sudden flashes of insight relative to the problems (Rowe, 1985).

Teaching academic problems solving, then, involves giving students a general problem solving framework to follow. It also requires the teacher to identity:

what types of unknowns students will encounter in problems

what types of information students will be provided in problem situations

what types of strategies will work best for specific content area problems.

Finally, teaching academic problem solving involves presenting students with highly structured practice problems and then discussing how the problems can be solved (not just the answers to the problems) so that students can, over time, develop their own frameworks for solving academic problems.

c. Inventing

Invention is the process of creating new information or products. It is usually thought of as a process involving written language. Without a doubt, composing in written form is a premier thinking skill. For example, Nickerson (1984) identifies writing as one, if not the key procedure for enhancing thinking skills: "Writing is viewed not only as a medium of thought but also as a vehicle for developing it" (p. 33). The constructive nature of writing (its generation of new cognitive structures) has been well documented. For example, Flower and Hayes (1980) assert that writing is a generative process which creates new ideas for the writer.

We use the word invention to refer to the generation of new information or products in any form. Building a Rube Goldberg machine is invention (a drawing, a machine, a piece of music are all inventions). Invention occurs when you begin with a general goal of creating something and then follow the goal through to completion. There are three parts to the invention process: incubation and discovery, construction, and revising and polishing.

(a) Incubation and discovery

The incubation and discovery phase occurs when the idea is conceived and initially shaped. Flower and Hayes (1980) state that during incubation and discovery we primarily use non-linguistic information. That is, prior to actually beginning a project, the inventor must deal with information in a prelinguistic form. The ability to do this is a component of creativity.

According to Lewis and Greene (1982), Einstein was capable of using "wordless thought" to conceptualize complex physical properties. He is reported to have said, "When I examined myself and my methods of thought I came to the conclusion that the gift of fantasy has meant more to me than my talent for absorbing positive knowledge" (in Lewis and Greene, 1982; p. 24).

Apparently Einstein had perfected the technique of wordless thinking to such a high level that he preferred to perform experiments in his mind. Lewis and Greene refer to these as "thought experiments." About Einstein's thought experiments they say:

> In the early 1900's Einstein performed a thought experiment that was to shake the world of physics to its foundations. He had begun to realize that Newton's theory of gravitation, until then the unchallenged dogma, was seriously flawed. To explore the concept he pictured himself as the passenger in an elevator hurtling through the farthest reaches of space at a speed faster than light. He then visualized a slot opening on one side of the elevator cage so that a beam of light was projected onto the opposite wall. This enabled him to realize that if the elevator were moving with sufficient velocity, it would travel a finite distance in the time required for the beam to pass across the cage so that an observer in the cage would see the light beam as curved (p. 24).

Lewis and Greene recommend the following steps for developing wordless thinking ability in students.

Step 1. Have students learn how to attain a state of relaxation. They should loosen any tight clothing, sit in a relaxed position and keep their breathing regular.

Step 2. Next, students should open their minds to images of all kinds. At first they should make no attempt to exert any control over their images. However, they should attempt to create detail in their images; they should see shapes and details in color and enhance the images by adding sounds and scents.

Step 3. Once they have obtained a basic ability to create images they should practice "holding" a particular image for an extended period. At first this will be very difficult, because the mind will want to jump to associated images.

Step 4. Step 3 should be continued until students have a sense of control over their ability to image things.

(b) Construction

The second phase of the inventing process is construction. Here students begin to develop a physical or linguistic representation of what they created or discovered during the incubation and discovery phase. If they are composing a written product (e.g., an essay) they might begin to write down ideas. At first they might make a very rough outline and then fill in some sentences and paragraphs. They would keep adding to and deleting from what they had written until their basic idea had gone from a skeleton to an unpolished creature with some meat on its bones. If students were creating a machine of some type, the construction phase might involve making and testing prototypes of the machine. The overall intent of the construction phase of inventing is to produce a rough approximation of the product—one that has all necessary components but is not yet the final form.

(c) Revising and Polishing

The revising and polishing phase is actually a set of phases. The inventor keeps going over his/her product adding to and deleting with more and more attention to detail. After this phase is completed the inventor has a fully developed product.

LEARNING-TO-LEARN

The learning-to-learn skills are those which facilitate learning of all types. The assumption underlying these learning-to-learn skills is that learning within a classroom setting is a function of generalized competencies that are used in all learning situations—not just those related to school. If students are taught these generalized competencies they can use them in any situation—school related and non-school related.

To some extent every student has become proficient learning at something. And, as they become proficient, they at least intuitively learned to learn. As a result, it might be that students do not have to learn these skills at all. Instead, they may simply need to learn to consciously control these skills and be responsible for using them in school.

There are four general competencies in the learning-to-learn area:

1. Attending

2. Goal setting

3. Monitoring attitudes

4. Self-evaluating.

We will consider each area separately and then consider how they might be combined into an instructional framework.

1. ATTENDING

Cognitive psychologists identify two types of attention: automatic and voluntary (Luria, 1973). Automatic attention is reflexive—a stimulus to a response. Automatic attention occurs when some novel situation enters into an individual's awareness. For example, if a young child hears a loud noise he or she will turn the eyes and head toward the noise. Voluntary attention occurs when an individual willfully shifts the general background of attention. For example, when driving at night in an open convertible you might voluntarily turn your attention to the stars At this point new information becomes available to you because the backdrop of perception has changed. You begin to notice things about the sky of which you were previously unaware. Under voluntary attention there is an awareness of the context or frame being used to process information and a consequent higher level of control of the information. It is the increase in frequency of voluntary attention within the classroom that is of educational relevance. For convenience we refer to that ability here as controlling attention.

Operationally, controlling attention can be described as a process with four components:

1. being aware of your level of attention at a given moment

2. being aware of the level of attention required for the task at hand

3. comparing your level of attention with that required for the task

4. adjusting your level of attention if necessary.

Important to the utilization of this process is an understanding of the critical attributes of attention. In this model we have identified two critical attributes which should be taught and reinforced with students: 1) the physical characteristics of attending and 2) the "bracketing" of spurious thoughts.

a. Physical Characteristics of Attending

The act of attending has some physical characteristics (Harman, 1969; Luria, 1973). With very young children the physical characteristics involve sitting-up straight, widening of the eyes and deep breathing. These physical actions have the effect of increasing the energy level for a task. With older students energy level can be increased without necessarily exhibiting these secondary characteristics of attending. What we suggest is that as a preparation for teaching the attention control process described above, students should be asked to explore and identify the physical attributes of attending. When they are not attending but wish to increase their level of attention, they then can voluntarily generate the physical characteristics.

b. Bracketing

The second critical attribute of attending is bracketing. Bracketing is a concept with philosophical roots. The working principle behind bracketing is that sometimes it is beneficial to put certain ideas "on the back burner" and think about them at a later date. This is a skill that has been reportedly used by many of society's great minds. Bertrand Russell (1971), for example, used the concept.

In a classroom situation bracketing can be used to set aside important thoughts that are unrelated to the topic of instruction. For example, a student in a reading class might become aware that he or she is thinking about the quiz in the upcoming math class and not about the reading lesson. Although the math quiz is certainly important, thinking about it during reading does little for the student's performance in reading or math. Hence the student would bracket or consciously put aside his or her thoughts about the math quiz and return attention to them after the reading lesson.

Once students are aware of the critical attributes of attending they can then utilize the attention control process. Initially this will be teacher directed. That is, during class the teacher will request that students use the attention control process when student engagement slackens. However, over time students themselves should begin to initiate attention control. They might use it when they are tired or when they are in a situation that does not contain much intrinsic interest for them.

2. SETTING GOALS

Over forty years ago Sears (1940) found that successful students tended to set explicit goals. More recently Brophy (1982) found that successful students set increasingly more difficult goals. That is, they use goal setting as a way of challenging themselves. Bandura and Schuck (1981) found that goal setting should be proximal (short-term) rather than distal (long-term) for optimum results.

A review of the current programs which teach goal setting (e.g., Tiece, 1976) indicates that there are some general guidelines for setting effective goals. Those guidelines might be described to students in this way:

Step 1. Start with short term goals: Most people find it difficult, especially in the beginning, to stay committed to long term goals. It is better to begin with short term goals, or if you do have a long term goal, to break it down into a series of short term goals.

Step 2. Make your goals concrete: The most useful goals appear to be the more concrete goals. Some goals are easy to make concrete (e.g., "I want $1,000"). Fortuntely, most abstract goals can be turned into concrete goals with a little bit of thought.

Abstract Goal	Concrete Goal
Having more fun at home	Laughing with my fun family at least once per night about something that happens at home.
Feeling better about myself	Each day writing down at least three things I did that were accomplishments.

Step 3. Allow yourself to fail. Sometimes you set a goal and don't accomplish it. Other times you set a goal but change it. Both of these are appropriate actions to goal setting. Goals should be tools to help in life, not rules that constrain. If a goal is not of interest anymore, it should be changed or dropped.

Once students have a grasp of the basics of goal setting, they can be given the following process to use:

State your goal in written form.

Identify a time frame in which you plan to accomplish your goal.

Daily imagine yourself accomplishing the goal.

Periodically identify the next steps to take to accomplish the goal.

Occasionally review your goal to see if you should change it.

3. MONITORING ATTITUDES

Once a goal is set an individual will generally monitor his or her progress and attitudes toward the goal. Technically, these mental attitudes are called "executive principles" or "executive thoughts." For example, the attitude that "I should always be fair in my dealings with other people" would be an executive principle governing many behaviors. These principles are so important to human behavior that some theorists have hypothesized that there is a special type of memory which houses them called "executive memory" (e.g., Sternberg, 1984; Gardner, 1983).

As described by Marzano et al (1986), there are three types of executive attitudes which appear to be useful to consider when dealing with difficult tasks: general attitudes about work, attitudes that stimulate exploration and attitudes that broaden preception.

a. General Attitudes about Work

Research indicates that people who are highly successful at accomplishing goals have some special attitudes about work. For example, in the area of problem solving Whimbey (1980) found that good problem solvers exhibited these characteristics:

a commitment to persistent, systematic analysis of problems

a concern for accuracy

the patience to employ a step-by-step process

an avoidance of wild guessing

a determination to become actively involved with the problem.

Similar findings to Whimbey's have been reported by Sternberg (1984), Chi et al. (1982) and Larkin (1981). If we summarize the research, three basic attitudes about work emerge:

a willingness to be actively involved in a task

a commitment to persistence

a sensitivity to feedback.

Individuals who are highly efficient at accomplishing tasks operate from these principles. They have an ability to get deeply involved in a task; they have a strong commitment to precision and accuracy when engaged in tasks, and they are sensitive to how well the task is going and make corrections or try something different if necessary.

b. Attitudes That Stimulate Exploration

It is believed by some theorists that at an unconscious level human beings are fearful that circumstances work against the accomplishment of goals. For example, in a paper entitled "On the Need to Know and the Fear of Knowing," Abraham Maslow pointed out that humans are taught culturally not to trust themselves or the inherent order of life. This is consistent with research findings in student motivation (e.g., Harter, 1980, 1983). Specifically, it has been found that a key factor in motivation to complete a task is a student's trust that circumstances will not necessarily work against the completion of the task. It appears, then, that the controlling principles relevant to academic success might be:

> A belief that life is trustable. That is, circumstances do not automatically work against the accomplishment of a goal.

Research suggests that people who operate from this controlling principle are willing to engage in a wider range of behavior than those who operate from its negative counterpart (e.g., life is not trustable). It has also been found that a willingness to engage in many and varied activities is a major factor in problem solving (Whimbey, 1984), creativity (Perkins, 1980) and productivity (Fromm, 1968).

c. Attitudes That Broaden Perception

One of the more powerful scientific realizations in the past few decades has been that perception is fundamentally subjective in nature. That is, we perceive only what we expect to perceive. Frank Smith (1978) dramatizes this by saying:

> What we have in our heads is a theory of what the world is like, a theory that is the basis of all our perceptions and understanding of the world, the root of all learning, the source of all hopes and fears, motives and expectancies, reasoning and creativity. And this theory is all we have. If we can make sense of the world at all, it is by interpreting our interactions with the world in the light of our theory. The theory is our shield against bewilderment (p. 57).

In isolation this assertion implies a deterministic view of human cognition. If we perceive only what we expect to perceive, we are stuck in a perceptual "programming loop."

However, along with science's realization that perception is subjective is the parallel hypothesis that human beings have the power to shift perceptions at will. That is, we can choose to see things in a different way. This concept of voluntary paradigm shifting has affected a wide range of human endeavors from theory and practice in research (Skrtic, 1983; Schwartz and Ogilvy, 1979) to economic theory (Henderson, 1985) and to human productivity (Bodek, 1984-1985). Another way of saying this is that individuals who know that their perceptions are subjective and can voluntarily shift them have a very powerful tool which can be used for school-related and non-school-related tasks. We might say, then, that two attitudes which exert a high level of control over cognition and behavior are:

> a belief that perceptions are subjective and are generated from a specific point of view
>
> a belief that one's point of view is controllable along with a willingness to change a given point of view.

How do you introduce to students the concept of monitoring attitudes? The first step is to discuss with them the fact that attitudes affect behavior and the possibility that attitudes can be controlled and changed.

The second step is to make students aware of some of the basic attitudes discussed above. This can be done through discussion and/or by reading books, short stories and plays that seem to emphasize these attitudes. For example, Carol Snyder's *Memo: To Myself When I Have A Teenage Daughter* (1983) is about a thirteen-year-old girl name Karen who isn't ready for love affairs but is going through those painful formative years convinced that her mother doesn't understand her. However, her mother gives her a diary that she began when she was thirteen. This totally shifts Karen's perception of her mother. Suddenly, Mom becomes a human being. This dramatic turn around in Karen's perceptions of her mother can be used to introduce the concept that perceptions emanate from specific points of view and that you can change your point of view and your perceptions.

Once basic attitudes have been presented to the students, the next step is to help them identify their own thinking relative to the attitudes. Which attitudes do they already operate from? How do these attitudes affect their lives? This might be done in an experimental fashion. Students can be asked to keep a journal for a few days. Every time they become aware of one of the attitudes in their own lives they can record their thought and describe how the attitude shapes their behavior.

Finally, students can try to develop new attitudes about their ability to be successful. For example, students might practice saying the following affirmation:

> I can trust that when I try to do something, things will generally go well.

4. SELF-EVALUATING

During the attainment of and upon completion of a goal, effective learners commonly engage in self-evaluation techniques in which they identify what is working and what is not working relative to the goal. When goals are long term this is best accomplished by setting "milestones"—small goals which are indications that the larger goal is being accomplished. These milestones represent "checkpoints" along they way.

Another useful self-evaluation technique relative to long-term goals is action planning. A simplified version of action planning might be:

> Step 1. Identify actions you believe should be taken to accomplish the goal.
>
> Step 2. Prioritize those actions.
>
> Step 3. Keep moving through your list of prioritized actions with an emphasis on always doing something relative to your goal.
>
> Step 4. Periodically stop working and reassess your action plan. Are there any actions you have listed which you now believe are irrelevant to your goal? Cross those off your list. Are there any actions important to the accomplishment of your goal which you have not listed? Add these to your list.

Whereas the techniques described above are fairly concrete, self-evaluation can be quite difficult if goals and tasks are primarily cognitive. That is, for goals which require complex mental operations there is very little external evidence to indicate how the task is progressing. To overcome this inherent difficulty with mental tasks, students can be asked to "think aloud" as they engage in the task. Recall that we introduced thinking aloud (verbal mediation) in the third chapter in the discussion of problem solving. As Whimbey and Lochhead (1980) state, thinking aloud is a very powerful self-evaluation tool: "If both students and experts vocalize their thoughts as they work through complex ideas and relationships, the steps that they take are open to view and their activities can be observed and communicated" (p. 24).

Thinking aloud as a self-evaluation technique has been successfully used in mathematics and science-related tasks (e.g., Lochhead, 1985) as well as with language arts related cognitive tasks (e.g., Scardamalia and Berieter, 1983). In the "paired problem solving approach" (Lockhead, 1985) students are encouraged to work in pairs with one student acting as the listener and the other as the "doer." The listener has two major tasks: 1) to constantly check accuracy for the doer and 2) to demand constant vocalization from the doer. After students have received practice as listeners and doers they switch roles. Over time the process of monitoring how well a task is progressing becomes second nature and students no longer need the aid of a "listener." Rather, they incorporate self-evaluation into their standard operating procedures when they engage in complex tasks.

THE ACTIVITY FRAMEWORK

The four generalized learning-to-learn competencies described above can be presented to students in isolation or they can be combined into what we call the "activity framework." It is presented in Figure 4.1:

Figure 4.1

ACTIVITY FRAMEWORK

1. Refocusing Phase: Relax and end whatever previous activity you were engaged in.

2. Awareness Phase:

   a. Notice your level of distraction (e.g., how much are you attending to thoughts unrelated to this class?).

   b. Notice your attitude toward the class (e.g., do you believe the class is valuable or not valuable? Do you believe the class is interesting or boring?).

   c. Notice your attitude toward working (e.g., are you committed to being involved in the class or do you want to coast?).

   d. Notice your attitude toward their ability (e.g., do you have a sense of power about your ability to perform well in this class or do you have a sense of sinking?).

3. Responsibility Phase:

   a. Hold-off or "bracket" any thoughts unrelated to assigned class work.

   b. Generate interest and value for the assigned class work.

   c. Commit to being involved and exerting necessary effort.

   d. Take a stand that you can do well.

4. Goal Setting Phase:

   a. Set some specific goals for the class.

   b. Integrate the teacher's goals with your own.

5. Task Engagement Phase:

   a. Be aware of whether you are getting closer to or further away from your stated goals.

   b. Make any corrections necessary in your own behavior or seek help to further the attainment of your goals.

6. Task Completion Phase:

   a. Determine if your goals were accomplished.

   b. Evaluate what worked and what did not work relative to your goal.

The activity framework is intended as a "casing" or context for all content area instruction. For example, classes can begin with phases 1-4. Students can be asked to end whatever activity they were previously engaged in (Phase 1). If they are particularly distracted, they can be led through some basic relaxing activities to help clear their minds and focus on the upcoming tasks for class. They can then be given a few minutes to become aware of basic attitudes which will affect their performance (Phase 2). Once students become aware of the attitudes they have brought to class they should be requested to take responsibility for generating some attitudes that will be particularly useful to them in performing well within the class (Phase 3).

Usually Phases 1-3 will take only a few minutes at the beginning of class. However, the time spent is well worth it because students will likely be more highly engaged and successful. Sometimes the teacher may want to expand the time used for phases 1-3. This might involve a prolonged relaxing activity or a prolonged time when students discuss thoughts they would like to bracket but are experiencing a difficult time with. In a similar fashion teachers and students might engage in a prolonged discussion of how their attitudes are affecting their performance.

Phase 4 can also be quite short or extended. In its brief form students would be asked to write a few academic goals they wish to accomplish during class. They would also be asked to incorporate the teacher's goals into their own. During the extended version of Phase 4, students might review long-term goals they have set, make entries in their journals relative to how well the goal setting process is working for them or engage in some action planning relative to specific goals.

During Phase 5 students and teacher engage in standard content area activities. As a matter of fact, most of the instructional models currently within use (e.g., Hunter, 1984; Rosenshine, 1979) fit neatly into phase 5. To illustrate, consider the seven step Hunter model:

Step 1. Provide students with a mental set (anticipatory set) for the information to be learners.

Step 2. Identify the objective and purpose of the upcoming lesson.

Step 3. Provide new input to students.

Step 4. Model new knowledge or new procedures for students.

Step 5. Check for understanding.

Step 6. Provide guided practice.

Step 7. Provide independent practice.

With the exception of Step 2, this process fits nicely in Phase 5 of the Activity Framework (Hunter's Step 2 would be redundant with Phase 4 of the Activity Framework). Within Phase 5 students would generally be involved in what we have called "content thinking." Our description of content thinking in the second chapter, then, should add clarity to Hunter's suggested instructional sequence. That is, teachers could define whether they want to introduce (Step 3) new declarative knowledge (e.g., a new concept, a relationship or a pattern of information), new procedural knowledge (e.g., teach students how to "do something" new like read a bar graph) or new contextual knowledge (e.g., teach students a new situation in which a known procedure could be used). This step would be followed by some form of modeling, checking for understanding, guided and independent practice activities.

Finally, classes would end with phase 6. Here students and teachers would review to see if they had accomplished their stated goals. If so, they would try to identity what worked best for them. If goals were not accomplished, they would try to identify what did not work well.

Over time the activity framework will become something students use in all activities—in and out of school. If we can believe current research and theory, such a practice will make them more powerful and independent learners.

RESTRUCTURING ISSUES

The introductory chapter suggested that the teaching of thinking will require some shifts in current educational practices. These changes have been described as restructuring issues and have been discussed in depth by Arredondo and Marzano (1985). Some educational theorists believe that without instructional changes education will continue to function primarily as a socioeconomic sorting mechanism in society.

For example, socioeconomic sociologist Persell (1977) in *Education and Inequality: The Roots and Stratification in America's Schools*, documents the extent to which public schools sort and classify students. Persell states that "in today's America, the institution of education is called upon to maintain, reproduce, and legitimize the inequalities of society" (p. 30). Arredondo and Marzano (1985) state that if we continue to produce large numbers of under-educated young people from the public schools, a growing public concern and discontent will be the inevitable result.

There are a number of indications that we are producing large numbers of under-educated youth. For example, the present high school dropout statistics indicate that approximately 25% of the nation's population between the ages of 14-18 years are no longer enrolled in school. Estimates of the size of this out-of-school population run as high as 40% in some larger cities where the largest percentage of these youths are members of minority groups. For example, in New York City, 50% of all high school age blacks and Hispanics have left school. Of these 40,000 teenagers, only 9,000 will find jobs that match their skill levels.

Of equal concern are the accusations that large numbers of high school graduates leaving school today are functionally illiterate, unprepared for any existing job and lacking in the knowledge or skills needed to be a productive member of society. If this situation is true, public school systems are the obvious starting point for the remediation of this situation.

Of even greater concern is the fact that schools historically have been asked to prepare students for working in the production sectors of our society—manufacturing, transportation and food-production industries. Jobs in these areas did not require a high degree of academic skill. Today there are fewer of these jobs in our society. Instead, we have more jobs that involve much higher levels of abstract thought. Insurance agents, people in finance, farmers, real estate agents and many others are required to work with complex information, make complex decisions and upgrade their knowledge and skills on a regular basis. Schools must be more successful than they have had to be in past to prepare students for life in the twenty-first century.

Our society's success in competing with other nations also depends on an increase in productivity. That increase will not occur if we do not learn to think more effectively.

A basic assumption of this monograph is that the teaching of thinking skills is one of the most powerful mechanisms for ending the sorting function of public education and improving student competency and productivity. The small percentage of students now leaving school with the thinking skills necessary for success in the present and future society are able to do so because many of them have acquired these skills either outside of school or as an indirect result of classroom instruction. For example, most of those students who do learn the thinking skills defined in this monograph develop them because of their backgrounds or out-of-classroom experiences.

Students from higher level socioeconomic backgrounds have many out-of-school opportunities to learn these skills; students with lower socioeconomic backgrounds have less of an opportunity to develop them. For example, extracurricular activities also provide settings in which some of these skills, particularly the learning-to-learn skills, are acquired; these activities are more frequently engaged in higher socioeconomic students than those from lower socioeconomic backgrounds.

As school systems identify the thinking skills that ought to be taught, place them in the curriculum, teach these skills, and then test for specific skill development, all students will have the direct opportunity to acquire the competencies necessary in the information age. Such a change would have a concomitant impact on the fabric of public schools. Below, we will consider a few restructuring issues we believe are necessary for the systematic teaching of thinking skills. Specifically, we will consider how each of the three thinking skill areas (content thinking, reasoning and learning-to-learn) necessitates fundamental changes in schools. We will also consider necessary changes in testing and evaluation and the integration of instruction.

RESTRUCTURING ISSUES RELATED TO THE TEACHING OF CONTENT THINKING SKILLS

The content thinking skills presented in this monograph suggest a number of restructuring issues. Fir is the need to have teachers become aware of and explicitly teach declarative, procedural and contextual knowledge in each subject area. This is not a new suggestion. As mentioned earlier, it was Becker's (1977) recommendation, after a thorough analysis of the research on various interventions for the educationally disadvantaged, that systematic instruction in the basic concepts should be an educational priority. Becker specifically asserted that the educationally disadvantaged would benefit as well as all other students:

> By the use of carefully structured programs to boost vocabulary competency for low performing children in the early grades, the number of children in the lower end of this range can be reduced. By structuring school programs to teach basic operations in the various areas of knowledge using basic words, the advanced children would not necessarily be held back (p. 539).

Content area curriculum should be restructured so as to make salient those concepts that are crucial to the subject area. This implies a rethinking and restructuring of most existing courses.

A second issue has to do with the manner in which we teach these concepts. We believe instruction should be consistent with the way students naturally learn concepts. The adoption of such a recommendation would involve another major restructuring—the restructuring of our models for instruction.

In Chapter 2 we mentioned the growing body of research which suggests that knowledge is developed and stored in two primary forms: imagery and verbal. Kaufman (in Sheikh, 1983) states that these are the two primary forms of thinking. Yet within formal education there is a lack of attention to and even a distrust of the nonverbal aspects of cognition in spite of the growing evidence to support its central role in information processing. We believe that to teach thinking effectively teachers will need to highlight and model the nonverbal aspects of learning. Our curriculum and instruction models must not approach everything in a linguistic way. We must operationalize the belief that many problems and a great deal of thinking involves experiences and skills that go beyond the rote learning of dictionary-like definitions of words and concepts. Again, restructuring of our current instructional models will be necessary to accomplish this.

The introduction of "relationship identification" and "pattern recognition" into the curriculum suggests another restructuring issue: the conscious introduction of organizational patterns into textbooks and oral presentations. For example, the more that complex organization patterns and relationships are made salient in written material and oral presentations, the easier information is to process and retrieve. Most textbooks and many class presentations, however, do not clearly use such organizational patterns. As a result, students have to provide these patterns for themselves. As mentioned previously, better students look for or create these patterns as a basic comprehension strategy while less successful learners do not appear to have this meta-cognitive awareness. Consequently, it is the job of the teacher to provide organizational patterns students can use to organize textbook and lecture material.

Finally, classroom instruction needs to be restructured to create a balance between the teaching of declarative knowledge (e.g., facts) and the teaching of procedural and contextual knowledge. It is not a matter of choosing between the domains but making sure that we include all of them. That will be difficult for many teachers unless they are given strong support in learning how to teach procedures and context.

RESTRUCTURING ISSUES RELATED TO THE TEACHING OF REASONING SKILLS

In their review of the research on instruction related to the teaching of reading, Pearson and Tierney (1983) state that current instructional practice most commonly has the following characteristics:

- use of many practice materials
- little explanation of cognitive tasks
- little interaction with students about the nature of specific tasks
- emphasis on one correct answer to the extent of supplying the answers for students if they exhibit problems with or confusion over a task.

Pearson and Tierney imply that this is a general model commonly used in all content areas at all grade levels. If this is true, it can be said that current instructional practice does not conform to what appears to be necessary for effective teaching and learning of basic cognitive abilities. What is needed is an instructional style that places the teacher in the role of a filter between the students and the assigned academic tasks. This role would be consistent with Fuerstein et al.'s (1985) assertion that cognitive abilities are learned most effectively during "mediated learning experiences." Direct instruction in reasoning using this perspective would place the teacher in the role of helping students learn how to store, retrieve, match or build new information. The teacher would become much more process oriented, helping students think and verbalize about the thinking activities that a lesson called on them to apply.

RESTRUCTURING ISSUES RELATED TO THE TEACHING OF LEARNING-TO-LEARN SKILLS

The direct teaching of learning-to-learn strategies represents a major restructuring from the current instructional models that focus responsibility for learning on the teacher rather than the student. Basically, an emphasis on learning-to-learn strategies would convey the message that students must take an active role in the learning process. Baird and White (1982) contend that only minor improvements will be made within education unless there is a fundamental shift from teacher to student responsibility for learning. We believe that can only be accomplished by helping students learn how to focus their attention, set goals and monitor their own attitudes and progress.

It appears that many of the individuals considered successful in today's technological society are aware of the learning-to-learn skills and systematically use them. For example, Peters and Waterman (1982) cite examples of top executives cultivating such meta-cognitive strategies as goal setting, monitoring feedback, and cognitive restructuring. Not surprisingly, there are many powerful training programs within business and industry (e.g., Tiece, 1976) which use adaptations of the learning-to-learn process presented here. However, within mainstream education few components are systematically taught even though there has been a long standing mandate from the research community that such meta-cognitive awareness should be taught as a part of the formal education process. For example, McCombs (1984) asserts that this area holds the promise of unlocking a door for "those students whose deficiencies preclude them from enjoying the positive benefits of learning and self-development" (p. 216).

TESTING AND EVALUATION ISSUES INVOLVED IN THE TEACHING OF THINKING SKILLS

One key to the success or failure of teaching thinking in schools will be found in the restructuring of testing and evaluation. Doyle (1983) states that accountability drives the academic tasks presented to students. Students tend to take seriously only those tasks for which they are held accountable (Carter and Doyle, 1982; King, 1980; Winne and Marx, 1982). We believe that teachers have this same sensitivity. As a result, current models of testing and evaluation must be revised to include an explicit focus on thinking skills.

Such a focus would require that the areas described in this model should be academically assessed. The difficulty is that many of the competencies described above cannot be assessed using traditional formats sucn as multiple choice questions. Furthermore, some competencies we have described here have no "correct answer" to use as a criterion (e.g., evaluation of value). Consequently, the inclusion of many of the components of this model would necessitate a shift in the scope and practice of assessment. Specifically, assessment would have to involve data gathering techniques commonly associated with qualitative research (e.g., Miles and Huberman, 1984). We believe that without such a shift, formal education will remain entrenched in current testing practices which commonly are discriminatory against certain socioeconomic groups.

RESTRUCTURING ISSUES INHERENT IN THE UNITARY NATURE OF INSTRUCTION

We have entitled the approach to teaching described in this monograph as a "unitary approach." This is because in developing the model we have made an assumption that all components (e.g., content thinking, reasoning and learning-to-learn) must be an integrated part of all content and instruction. The learning-to-learn skills represent the framework for content teaching. To ignore these skills is to ignore the context in which learning occurs. All too often elegantly structured lessons are wasted because students have not generated the necessary energy, effort and interest to engage in the lesson.

Given that students have accepted responsibility for their involvement in the learning process, the unitary model implies that classroom content must be viewed as the balanced presentation of three types of information: 1) declarative, 2) procedural, and 3) contextual. The omission or overemphasis of any one type of information will create gaps in learning that threaten students understanding of the totality of the content.

Finally, when presenting content area material, teachers must mediate the learning process by modeling and reinforcing the reasoning skills necessary to process content and expand on content.

All three components of the unitary model are "basic." All three are needed to restructure instruction so as to halt and reverse the sorting function of the current educational system.

Training programs based on the conceptual framework for thinking skills presented in this monograph are available from the Mid-continent Regional Educational Laboratory.

REFERENCES

Alexander, P.A. (1984) Training analogical reasoning skills in the gifted. Roeper Review, 6, (4), 191-194.

Anderson, J. (1982) Acquistion of cognitive skills, Psychological Review, 1982, 89, 369-406.

Anderson, J. (1983) The architiecture of cognition, Cambridge, Mass.: Harvard University Press.

Anderson, R., & Freebody, P. (1981) Vocabulary knowledge. In J.T. Guthrie (Ed.) Comprehension and teaching. Newark, NJ: International Reading Association.

Anderson, T. (1978) Study skills and learning strategies. Technical Report N. 104. Urbana, Illinois: Center for the Study of Reading.

Arter, J.L. (1976) The effects of metaphor on reading comprehension. Unpublished doctoral dissertation, University of Illinois.

Arredondo, D. & Marzano, R. (1985) Restructuring education through the teaching of thinking. Paper submitted to Educational Leadership.

Baird, J.R. & White, R.T. (1982) Promoting self-control of learning. Instructional Science, 11, 227-247.

Bandura, A. & Schunk, D. (1981) Cultivating competence, self-efficacy and intrinsic interest through proximal self-motivation. Journal of Personality and Social Psychology, 41 (3), 586-598.

Becker, W. (1977) Teaching reading and language to the disadvantage --What we have learned from field research. Harvard Educational Review, 47, 518-543.

Bellezza, F.S. (1981) Mnemonic devices: Classification, characteristics and criteria. Review of Educational Research, 51, 247-275.

Bereiter, C. (1984) How to keep thinking skills from going the way of all frills. Educational Leadership, 42 (1), 75-77.

Bertalanffy, L. von (1967) Robots, Men and Minds, New York: George Braziller.

Bertalanffy, L. von (1969) General Systems Theory, New York: George Braziller.

Beyer, B. (1984) Improving thinking skills -- defining the problem. Phi Delta Kappan, 45, 12-18.

Block, J.H. (1985) Belief systems and mastery learning. Outcomes, 4, (2), 3-14.

Bobrow, D.G. & Winograd, T. (1977) An overview of KRL, a knowledge representation language. Cognitive Science, 1, 3-46.

Bodek, N. (1984-85/Winter-Spring) Werner Erhard on transformation and productivity: An interview. Revision, 7 (2), 30-38.

Boulding, K.E. (1968) General Systems and Holism, In E. Laszlo (Ed.) Modern Systems Research for the Behavioral Scientist, Chicago: Aldine Publishing Co.

Bransford, J.D., & Franks, J.J. (1971) The abstraction of linguistic ideas. Cognitive Psychology, 2, 331-350.

Brophy, J. (1982) Classroom organization and management. Washington D.C. National Institute of Education.

Bruce, B. C. (1975) Belief systems and language understanding. Cambridge, MA: Bolt, Beranek & Newman.

Bruce, B.C., & Schmidt, C.F. (1974) Episode understanding and belief guided parsing. New Brunswick, NH: Rutgers University.

Bryen, D. N. (1983) Inquires into child language, Boston, MA: Allyn & Bacon.

Bugelski, B.R. (1977) The association of images. In J.M. Nichol's (Ed.) Images: perception and knowledge. Boston: D. Reidel.

Bugelski, B. R. (1983) Imagery and thought processes. In A.A. Sheikh (Ed.) Imagery: Current theory, research and application. Hillsdale, N.J: Erlbaum.

Carroll, J., Davies, P., & Richman, B. (1971) Word frequency book. Boston, MA: Houghton, Mifflin.

Carter, K., & Doyle, W. (1982, March) Variations in academic tasks in high and average ability classes. Paper presented at the annual meeting of the American Education Research Association. New York.

Chi, M.T., Glaser, R. & Rees. E. (1982) Expertise in problem solving. In. R. Sternberg (Ed.) Advances in the psychology of human intelligence. Hillsdale, N.J.: Erlbaum.

Condon, J.C. (1968) Semantics and communication. New York: MacMillan.

Covington, M.V. (1985) Strategic thinking and the fear of failure. In J.W. Segal, S.F. Chipman & R. Glaser (Eds). Thinking and learning skills, Vol. 1. Hillsdale, N.J: Erlbaum.

deBono, E. (1985) The CoRT thinking program. In J.W. Segal, S.F. Chipman & R. Glaser (Eds). Thinking and learning skills, Vol. 1. Hillsdale, N.J.: Erlbaum.

Doyle, W. (1983) Academic work. Review of Education Research. 53, 159-199.

Dyer, W.W. (1976) Your enoneus zones, New York: Funk & Wagnalls.

Education Commission of the States. (1982) The information society: Are high school graduates ready? Denver, CO.

Evertson, C. (1980) Differences in instructional activities in high and low achieving junior high classes. (R & D Report No. 6105) Austin, Texas: Texas University. Research and Development Center for Teacher Education.

Feurstein, R Instrumental enrichment: An intervention program for cognitive modifiability. Baltimore: University Park Press.

Fitts, P.M. (1964) Perceptual-motor skill learning. In A.W. Melton (Ed.). Categories of Human Learning. New York: Academic Press.

Flower, L. & Hayes, J.R. (1980) The cognition of discovery. Defining a rhetorical problem. College Composition and Communication, 13, 21-32.

Fodor, J.A. (1976) The language of thought. Hassocks, Sussex: Harvester Press.

Fromm, E. (1968) The nonproductive character orientation. In. L. Gorlow & W. Katkousky (Eds.) Readings in the psychology of adjustment. New York: McGraw Hill.

Gardner, H. (1983) Frames of mind. New York: Basic Books Inc.

Glasser, W. (1981) Stations of the mind. New York· Harper & Row.

Goetz, E.T., Palmer, D.J. & Haensly, P.A. (1983) Metacognitive awareness of text variables in good and poor readers. In J. Niles (Ed.) Searching for meaning in reading/language processess and instruction. Rochester, N.Y.: The National Reading Conference.

Good, T., Grouws, D. & Ebmeier, H. (1983) Active mathematics teaching. New York. Longman.

Gourley, T. J. & Micklus, C.S. (1982) Problems, problems, problems: Discussion and activities designed to enhance creativity. Glassbro, New York: Creative Publications.

Gow, D.T. & Casey, T.W. (1983) Selecting learning activities. In. F. English (Ed.) Fundamental curriculum design. Alexandria, Virginia: Association for Supervision and Curriculum Development.

Grimes, J.E. (1972) The thread of discourse. Ithaca, New York: Cornell University.

Hall, G.E. (1976) The Study of Individual Teacher and Professor concerns about Innovation. Journal of Teacher Education, 28 (1).

Halliday, M. (1967) Notes on transitivity and theme in English. Journal of Linguistics, 3, 37-81.

Halliday, M., & Hasan, R. (1976) Cohesion in English. London: Longman.

Harris, A. & Jacobson, M. (1972) Basic elementary reading vocabularies. New York: MacMillan.

Harter, S. (1983) The development of the self-system. In M.R. Hetherington (Ed). Carmichael's manual of child psychology: Social and personality development. New York, NY: Wiley.

Harter, S. (1980) The perceived competence scale for children. Child Development, 51, 218-235.

Hawkins, D. (1974) The informed vision: Essays in learning and human nature. New York: Agathon Press.

Heller, J. & Reif, F. (1984) Prescribing effective human problem-solving processes: Problem description in physics. Cognition and Instruction, 1, 1984.

Henderson, H. (1984-1985/Winter-Spring) Post-economic policies for post-industrial societies. Revision, 7, 20-29.

Hull, C.L. (1920) Quantitative aspects of the evolution of concepts. Psychological Monograpghs, 28 (1).

Hunter, M. (1984) Knowing, teaching and supervising. In. P. Hosford (Ed.) Using what we know about teaching. Alexandria Virginia: Association for Supervision and Curriculum Development.

Johnson, D.D. & Pearson, P.D. (1984) Teaching reading vocabulary. New York: Holt, Rinehart and Winston.

Johnson-Laird, P.N. (1983) Mental models. Cambridge, Mass.: Harvard University Press.

King, L.H. (1980) Student thought processes and the expectancy effect. (Research Report No. 80-1-8). Edmonton, Alberta, Canada: Centre for Research in Teaching. The University of Alberta.

Kinstch, W., & van Dijk, T.A. (1978) Toward a model of text comprehension and production. Psychological Review, 85, 363-394.

Klausmeier, H.J. & Goodwin, W. (1971) Learning and human abilities: Educational psychology, New York: Harper & Row.

Klausmeier, H.J., & Sipple, T. (1980) Learning and teaching concepts. New York: Academic Press.

LaBerge, D., & Samuels, S.J. (1974) Toward a theory of automatic information processing in reading comprehension. Cognitive Psychology, 6, 293-323.

Larkin, J. (1981) Enriching formal knowledge: A model for learning to solve texbook problems. In. J. Anderson (Ed.) Cognitive skills and their acquisition. Hillsdale, N.J.: Erlbaum.

Lavelle, N. & Keogh, B.K. (1980) Expectations and attributions of parents of handicapped children. New Directions for Exceptional Children, 4, 1-27.

Lehnert, W.G. (1978) The process of question answering, Hillsdale, N.J.: Erlbaum.

Leslie, L., & Jett-Simpson, M. (1983) The effects of recall instruction and story deletions on children's story comprehension. In J. Niles & L. Harris (Eds.) Searching for meaning in reading/language processing and instruction. Rochester, NY: National Reading Conference.

Lewis, D & Greene, J. (1982) Thinking better. New York: Holt, Rinehart & Winston.

Lindsay, P.H., & Norman, D.A. (1977) Human information processing. New York, NY: Academic Press.

Lochhead, J. (1985) Teaching analytic reasoning skills through pair problem solving. In. J.W. Segal, S.F. Chipman & R. Glaser (Eds). Thinking and learning skills: Vol. 1. Hillsdale, New Jersey: Erlbaum.

Luria, A. (1973) The working brain. New York: Basic Books.

Marshall, N., & Glock, M. (1978-79) Comprehension of connected discourse: A study into the relationship between the structure of text and the information recalled. Reading Research Quarterly,.76, 10-56.

Marzano, R. (1984) A cluster approach to vocabulary instruction. Reading Teacher, 38 (2), 168-173.

Marzano, R. (1983) A quantitative grammar of meaning and structure. Denver, CO: Mid-continent Regional Educational Laboratory.

Marzano, R. & Dole, J. (1983) Teaching relationships and patterns of information. Denver: Mid-continent Regional Educational Laboratory.

Marzano, R., D. Stefano, P., Valencia, S. and Hagerty, D. (1986) Reading diagnosis and instruction: Theory into practice. Englewood Cliffs, N.J.: Prentice Hall.

McCombs, B. (1984) Processes and skills underlying continuing intrinsic motivation to learn: Toward a definition of motivational skills training intervention. Educational Psychologist, 19, (4), 199-218.

McNeill, D. (1975) Semiotic extension. In R.L. Solso (Ed.) Information processing and cognition: The Loyola Symposion. Hillsdale, N.J.: Erlbaum.

Mervis, C.B. (1980) Category structure and the development of categorization. In. R.J. Spiro, B.C. Bruce & W.F. Brewer (Eds.) Theoretical issues in reading comprehension, Hillsdale, N.J.: Erlbaum.

Meyer, B.J. (1975) The organization of prose and its effects on memory. Amsterdam: North Holland Publishing Co.

Miles, M. & Huberman, A. (1984) Qualitative data analysis. Beverly Hills, CA: Sage Publications Inc

Miller, G.A., Galanter, E. & Pribram, K.H. (1960) Plans and the structure of behavior, New York: Holt Rhinehart & Winston.

Naisbitt, J. (1982) Megatrends, New York: Warner.

National Commission on Excellence in Education. (1983) A nation at risk: The imperative for educational reform. Washington, D.C.: Government Printing Office.

Neisser, V. (1967) Cognitive psychology. New York: Appleton.

Newell, A. & Simon H. (1972) Human problem solving, Englewood Cliffs, N.J.: Prentice-Hall.

Nickerson, R. (1984) Kinds of thinking taught in current programs. Educational Leadership, 42 (1), 26-37.

Ortony, A. (1980) Metaphor. In R.J. Spiro, C.B. Bertram, & W.F. Brewer (Eds.) Theoretical issues in reading comprehension. Hillsdale, NJ: Erlbaum.

Paivio, A. (1983) Strategies in language learning. In. M. Pressley & J.R. Levin (Eds.) Cognitive strategy research: Educational applications. New York: Springer - Verlag.

Paivio, A. (1971) Imagery and verbal processes. New York: Holt.

Paul, R. (1984) Critical thinking: Fundamental to education for a free society. Educational Leadership. 42. (1), Sept. 1984.

Pearson, P.D. & Tierney, R. (1983) In search of a model of instructional research in reading. In. S.G. Paris, G. M. Olson & H.W. Stevenson, (Eds) Learning and motivation in the classroom. Hillsdale, New Jersey: Erlbaum.

Pearson, P.D. (1974-75) The effects of grammatical complexity on children's comprehension, recall and conception of certain semantic relatives. Reading Research Quarterly, 10, 155-192.

Penfield, W. & Perot, P. (1962) The brain's record of auditory and visual experience: A final summary and discussion. Brain 86, 595-696.

Perkins, D.N. (1984) Creativity by design. Educational Leadership, 42, 1, 18-25.

Persell, C. H. (1977) Education and inequality: The roots and stratification in America's schools. New York: Free Press.

Personal Report (April, 1985) New York: Research Institute of America.

Peters, T. & Waterman, R.H. (1982) In search of excellence. New York: Harper & Row.

Pitkin, W.L. (1977) X/Y: Some basic strategies of discourse. College English, 38, 660-672.

Polson, P.G. & Jeffries, R. (1985) Insturction in general problem-solving skills: An analysis of four aaproaches. In J.W. Segal, S.F. Chipman & R. Glaser (Eds). Thinking and learning skills: Vol. 1. Hillsdale, N.J.: Erlbaum.

Polya, G. (1957) How to solve it. Princeton, N.J.: Princeton University Press.

Powers, W.T. (1973) Behavior: The control of perception. Chicago, IL: Aldine.

Resnick, L. (1983) Toward a cognitive theory of instruction. In. S. Paris, G. Olson & H.W. Stevenson (Eds). Learning and motivation in the classroom. Hillsdale, New York: Erlbaum.

Richardson, A. (1983) Imagery: Definition and types. In A.A. Sheikh (Ed). Imagery: Current theory, research and application: Hillsdale, N.J.: Erlbaum.

Robertson, J. (1968) Pupil understanding of connectives in reading. Reading Research Quarterly, 3, 387-417.

Rosenshine, B. (1979) Content time and direct instruction. In. P. Peterson & H. Walberg (Eds.) Research on Teaching Berkeley, CA: McCutchan Publishing Co.

Rowe, H.A. (1985) Problem solving and intellignece. Hillsdale, N.J.: Erlbaum.

Russel, B. (1971) The conquest of happiness. New York: Liveright.

Sachs, J.S. (1967) Recognition memory for syntactic and semantic aspects of connected discourse. Perception and Psychophysics, 2, 437-442.

Scardamalia, M. & Bereiter, C. (1983) Child as coinvestigator: Helping children gain insight into their own mental processes. In. S.G. Paris, G.M. Olson & H.W. Stevenson (Eds). Learning and motiviation in the classroom. Hillsdale, N.J.: Erlbaum.

Schwartz, P., & Ogilvy, J. (1979) The emergent paradigm: Changing patterns of thought and belief. Values & lifestyles program. Menlo Park, CA: SRI International.

Sears, P.S. (1940) Levels of aspiration in academically successful and unsuccessful children. Journal of Abnormal and Social Psychology, 35, 498-536.

Sheikh, A.A. (Ed.) (1983) Imagery: Current theory, research and application. Hillsdale, N.J.: Erlbaum.

Sheikh, A.A. & Jordan, C.S. (1983) Clinical uses of mental imagery. In A.A. Sheikh (Ed.) Imagery: Current theory, research and application. Hillsdale, N.J.: Erlbaum.

Skrtic, T. (1983) The doing of emergent paradigm research into educational organizations. Overland Park, KS: Unversity of Kansas.

Smith, F. (1978) Understanding reading. New York: Holt, Rinehart & Winston.

Snyder, C. (1983) Memo to myself when I have a teenage daughter. New York: Coward-McCann.

Spiro, R.J. (1980) Constructive processes in prose comprehension. In R.J. Spiro, C.B. Bertram, & W.F. Brewer (Eds.) Theoretical issues in reading comprehension. Hillsdale, NJ: Erlbaum.

Sternberg, R.J. (1984) What should intelligence tests test? Educational Researcher, 13, 5-15.

Sternberg, R.J. (1983) Criteria for intellectural skills training Educational Researchers, 12, 6-12.

Sternberg, R.J. (1977) Intelligence, information processing and analogical reasoning: The componential analysis of human abilities. Hillsdale, N.J.: Erlbaum.

Stottlemeier, H. (1979) Philosophical inquiry: An instructional manual to accompany Harry Stottlemeir's discovery. Upper Montclair, New Jersey: The Institute for the Advancement of Philosophy for Children.

Suinn, R. M. (1983) Imagery and sports. In A.A. Sheikh (Ed.) Imagery: Current theory, research and application. Hillsdale, N.J.: Erlbaum.

Sywlester, R (1985) Research on memory: Major discoveries, major educational challenges. Educational Leadership, 42 (7), 69-75.

Taylor, B., & Samuels, S.J. (1983) Children's use of text in the recall of expository material. American Educational Research Journal. 20, 517-528.

Tiece, L. (1976) Achieving your potential. Seattle: The Pacific Institute.

Tough, J. (1976) Listening to children talking. London: Schools Council Pulbications.

Toulmin, S. (1958) The uses of argument. Cambridge, England: Cambridge University Press.

Toulmin, S. Rieke, R., & Janik, A. (1979) An introduction to reasoning. New York, NY: Macmillan.

Tyler, R. (1975) Basic principles of curriculum and instruction. Chicago: University of Chicago Press.

Underwood, B.J. (1976) Attributes of memory. Psychological Review, 76, 559-573.

vanDijk, T.A. (1980) Macrostructures. Hillsdale, NJ.: Erlbaum.

vanDijk, T.A. & Kintsch, W. (1983) Strategies of discourse comprehension. New York: Academic Press.

Warren, W.H., Nickolas, D.W. & Trabasso, T. (1979) Event chains and inferences in understanding narratives. In. R.O. Freedle (Ed.) New directions in discourse processing, Vol. 2, Norwood, N.J.: Ablex.

Waters, H.S. (1978) Superordinate-subordinate structure in semantic memory: The roles of comprehension and retrieval processes. Journal of Verbal Learning and Verbal Behavior, 17, 587-597.

Weiner, B. (1976) Attribution theory, achievement, motivation and the education process. Review of Educational Research 42 (2), 203-215.

Weiner, B. (1983) Speculations regarding the role of ffect in achievement --change programs guided by attributional principles. In. J., M. Levine & M.C. Wang (Eds). Teacher and student perceptions. Hillsdale, N.J.: Erlbaum.

Wertheimer, M. (1945, 1959) Productive thinking. New York: Harper & Row.

Whimbey, A. & Lochhead, J. (1980) Problem solving and comprehension: A short course in analytical reasoning. Philadelphia: Franklin Institute Press.

Winne, D.H., & Marx, R.W. (1982) Students and teachers views of the thinking processes for classroom learning. Elementary School Journal, 82, 493-518.

Winograd, T. (1972) Understanding natural language. New York: Academic Press.

THE THINKING SKILLS

I. CONTENT THINKING

Acquiring Declarative Knowledge

1. Attaining concepts: learning and relating new concepts to those already known.
2. Identifying relationships: establishing relationships between and among ideas.
3. Recognizing patterns: organizing blocks of information in meaningful ways.

Acquiring Procedural Knowledge

4. Proceduralizing: breaking a complex process into its component parts.

Acquiring Contextual Knowledge

5. Recognizing context: determining situations in which specific information and skills should and should not be used.

II. REASONING

Transferring

1. Storing and retrieving: enhancing information for easy retrieval.
2. Memory frameworks: storing large sets of information in long-term memory.

Matching

3. Categorizing: organizing concepts into meaningful groups.
4. Reasoning analogically: recognizing the relationship between two concepts and identifying another set of concepts with a similar relationship.
5. Extrapolating: matching the pattern of information from one context to another.
6. Evaluating evidence: deciding whether information follows the rules of logic.
7. Evaluating value: deciding how information matches with internalized values.

Restructuring

8. Elaborating: expanding information by identifying unstated characteristics, causes, purposes and backgrounds.
9. Problem solving: identifying missing information in goal-driven situations.
10. Inventing: conceiving of and developing products in a polished state.

III. LEARNING-TO-LEARN

1. Attending: monitoring attention and raising it when necessary.
2. Setting goals: setting explicit short-term and long-term learning goals and developing strategies to meet those goals.
3. Monitoring attitudes: identifying attitudes toward learning/school and fostering those which facilitate academic success.
4. Self-evaluating: monitoring progress toward goals and making adjustments in behavior if necessary.

McREL
12500 E. Iliff Ave. Suite 201
Aurora, Colorado 80014
(303) 337-0990

McREL
4709 Belleview Ave.
Kansas City, Missouri 64112
(816) 756-2401