ASSESSMENT & EVALUATION
EDUCATIONAL SERVICES PROGRAM

Higher Order Thinking Skills

- **Definition**
- **Teaching Strategies**
- **Assessment**

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Executive Summary

Definition

Higher order thinking skills include critical, logical, reflective, metacognitive, and creative thinking. They are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful applications of the skills result in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience and that promote continued growth in these and other intellectual skills. Higher order thinking skills are grounded in lower order skills such as discriminations, simple application and analysis, and cognitive strategies and are linked to prior knowledge of subject matter content. Appropriate teaching strategies and learning environments facilitate their growth as do student persistence, self-monitoring, and open-minded, flexible attitudes.

This definition is consistent with current theories related to how higher order thinking skills are learned and developed. Although different theoreticians and researchers use different frameworks to describe higher order skills and how they are acquired, all frameworks are in general agreement concerning the conditions under which they prosper.

Teaching Strategies

Lessons involving higher order thinking skills require particular clarity of communication to reduce ambiguity and confusion and improve student attitudes about thinking tasks. Lesson plans should include modeling of thinking skills, examples of applied thinking, and adaptations for diverse student needs. Scaffolding (giving students support at the beginning of a lesson and gradually requiring students to operate independently) helps students develop higher order learning skills. However, too much or too little support can hinder development.

Useful learning strategies include rehearsal, elaboration, organization, and metacognition. Lessons should be specifically designed to teach specific learning strategies. Direct instruction (teacher-centered presentations of information) should be used sparingly. Presentations should be short (up to five minutes) and coupled with guided practice to teach subskills and knowledge.

Teacher- and/or student-generated questions about dilemmas, novel problems, and novel approaches should elicit answers that have not been learned already.

Sincere feedback providing immediate, specific, and corrective information should inform learners of their progress.

Small group activities such as student discussions, peer tutoring, and cooperative learning can be effective in the development of thinking skills. Activities should involve challenging tasks, teacher encouragement to stay on task, and ongoing feedback about group progress.

Computer-mediated communication and instruction can provide access to remote data sources and allow collaboration with students in other locations. It can be effective in skill building in areas such as verbal analogies, logical thinking, and inductive/deductive reasoning.

Assessment

Valid assessment of higher order thinking skills requires that students be unfamiliar with the questions or tasks they are asked to answer or perform and that they have sufficient prior knowledge to enable them to use their higher order thinking skills in answering questions or performing tasks. Psychological research suggests that skills taught in one domain can generalize to others. Over long periods of time, individuals develop higher order skills (intellectual abilities) that apply to the solutions of a broad spectrum of complex problems.

Three item/task formats are useful in measuring higher order skills: (a) selection, which includes multiple-choice, matching, and rank-order items; (b) generation, which includes short-answer, essay, and performance items or tasks; and (c) explanation, which involves giving reasons for the selection or generation responses.

Classroom teachers recognize the importance of having students develop higher order skills yet often do not assess their students' progress. Several performance-based models are available to assist them in teaching and assessing these skills. Comprehensive statewide assessment of higher order skills is feasible but would be expensive. Florida and a number of other states now incorporate the measurement of higher order skills in their statewide assessments.

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HIGHER ORDER THINKING SKILLS

The challenge of defining "thinking skills, reasoning, critical thought, and problem solving" has been referred to as a conceptual swamp in a study by Cuban (as cited in Lewis & Smith, 1993, p. 1), and as a "century old problem" for which "there is no well-established taxonomy or typology" (Haladyna, 1997, p. 32). In addition, explanations of how learning occurs have been viewed as inadequate, with no single theory adequately explaining "how *all* learning takes place" (Crowl, Kaminsky, & Podell, 1997, p. 23).

Several factors may account for these views about thinking and learning. First, different types of learning require different teaching strategiesCno single method works for all learning, although specific strategies work for specific types. Second, intelligence is no longer seen as an unchanging general ability but rather a kaleidoscope of abilities that can be affected by a variety of factors, including teaching strategies. Third, the understanding of the thinking process has shifted to a multidimensional view—much more like a complex network of interactive capabilities rather than a linear, hierarchical, or spiral process. Fourth, the research over the last two decades has focused on more specialized topics such as insight, wait time for problem solving, visual imagery and metaphors, and schemata.

Despite the challenges related to defining higher order thinking, educators, administrators, and evaluators in Florida and across the nation have expressed agreement about the value of teaching it (Carrol, 1989; Cotton, 1997; Ennis, 1993; Glaser & Resnick, 1991; Haladyna, 1997; Howe & Warren, 1989; Huberty & Davis, 1998; Kauchak & Eggen, 1998; Kerka, 1986; King, 1997; Marzano, Brandt, Hughes, Jones, Presseisen, Rankin, & Suhor, 1988; Patrick, 1986; Siowck-Lee, 1995; Young, 1997). There is a renewed awareness that, although information and memory provide "a refrigerator in which to store a stock of meanings for future use," it is judgment that "selects and adopts the one to be used in an emergency . . ." (Dewey, 1933, p. 125). Complex real-life problems often demand complex solutions, which are obtained through higher level thinking processes. Teaching higher order thinking, then, provides students with relevant life skills and offers them an added benefit of helping them improve their content knowledge, lower order thinking, and self-esteem (DeVries & Kohlberg, 1987; McDavitt, 1993; Son & VanSickle, 1993).

The need to set standards for higher order thinking skills has been documented throughout the 1980s and 1990s. In the 1980s, documentation came from the National Assessment for Educational Progress (NAEP); the National Commission on Excellence in Education in *A Nation at Risk* (1984); Goodlad's *A Place Called School* (1984), which focused on social studies and science; the 1985 Commission on Reading report called *Becoming a Nation of Readers* (Anderson, 1985); and the 1986 Carnegie Forum on Education and the Economy's Task Force on Teaching (Carnegie Corporation, 1986).

Reports written in the 1990s have documented similar results. According to Kent Ashworth, the director of dissemination for the NAEP, little has changed in the last 20 years (Legg, 1990). Linn (1993) reported that the state-by-state NAEP results in mathematics signaled another "wake-up America call, along with stumbling verbal SAT scores in the fall of 1991" (p. 2). Such deficits stem from too much focus on lower-level objectives and not enough on meaningful learning and higher order thinking (Raudenbush, Rowan, & Cheong, 1993; Kauchak & Eggen, 1998).

Nationwide responses to these grim reports included creation of the National Council on Education Standards and Testing (NCEST), the Bush Administration's America 2000 proposals (U.S. Department of Education), and the Department of Labor's Secretary's Commission on

Achieving Necessary Skills (SCANS) report. In Florida, standards for learning outcomes and the Florida Comprehensive Assessment Test (FCAT) series were established to shift attention to the development of higher order thinking skills. Florida expresses the goal of enabling students "to make well-reasoned, thoughtful, and healthy lifelong decisions" (Florida Department of Education [DOE], 1996–97, p. 3). This goal aligns with the foundation skills and workplace competencies from SCANS, in which education will be considered successful when each student "thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons" (SCANS, 1991). Examples of the Florida Sunshine State Standards (Florida DOE, 1996) related to higher order thinking are listed below.

- Reading: "analyzes the validity and reliability of primary source information and uses the information appropriately"
- Math: "uses and justifies different estimation strategies in a real-world problem situation and determines the reasonableness of results of calculations in a given problem situation"
- Language Arts: "selects and uses strategies to understand words and text, and to make and confirm inferences from what is read, including interpreting diagrams, graphs, and statistical illustrations"
- Science: "understands the interconnectedness of the systems on Earth and the quality of life"
- Social Studies: "uses maps, globes, charts, graphs, and other geographic tools, including map keys and symbols to gather and interpret data and to draw conclusions about physical patterns"

In the FCAT, the focus on higher order thinking skills has been particularly noticeable in mathematics, where word problems are more complex and address real-life situations more than previous tests.

Several recent initiatives by the DOE have also sharpened the focus on higher order thinking skills. In November 1997, the DOE completed an assessment feasibility study on listening and verbal communication skills, information literacy skills, and problem-solving skills (King, Rohani, & Goodson, 1997). This current study extends the previous and ongoing initiatives by the DOE by reporting on the analysis of research and discourse on thinking processes. The study has identified the major theorists and provided an overview of their concepts and theories. To assist classroom teachers, the study provides definitions, teaching strategies, assessment strategies for both statewide and classroom assessment, sample teaching assignments, test questions, and an extensive resource list.

The research for this paper included searching for higher order thinking skills and related subtopics, names associated with research on these topics, and journal titles. Electronic searches included use of the engines on the Internet in the field of education and on-line library files, including LUIS and OCLC. Manual searches included a review of the DOE feasibility study on statewide assessment of problem solving, including related reference materials (King, Rohani, & Goodson, 1997).

This paper was compiled after analyzing the key articles identified from the searches. The major sections of this paper are (1) Definition, (2) Teaching Strategies, and (3) Classroom and Statewide Assessment of Higher Order Thinking Skills.

DEFINITION

Major Concepts

Several major concepts relevant to the higher order thinking processes are to follow, based on three assumptions about thinking and learning. First, the levels of thinking cannot be unmeshed from the levels of learning; they involve interdependent, multiple components and levels. Second, whether or not thinking can be learned without subject matter content is only a theoretical point. In real life, students will learn content in both community and school experiences, no matter what theorists conclude, and the concepts and vocabulary they learn in the prior year will help them learn both higher order thinking skills and new content in the coming year. Third, higher order thinking involves a variety of thinking processes applied to complex situations and having multiple variables.

Context

The level of thinking depends upon the context, with a real-world situation offering multiple variables to challenge thinking processes. Going through a cafeteria line and making decisions about types and amounts of food one should eat requires a much more sophisticated thinking process than counting carbohydrates and fats in a classroom (Crowl et al., 1997). Successful higher order thinking depends upon an individual's ability to apply, reorganize, and embellish knowledge in the context of the thinking situation.

Metacognition

The self-correcting nature of thinking is called "metacognition." Metacognition includes awareness of one's thinking processes, self-monitoring, and application of known heuristics and steps for thinking. One's success with metacognition depends, in part, on a belief in one's ability to get smarter as well as the beliefs of others, such as teachers, in one's ability (Crowl et al., 1997).

Procedural Knowledge

Procedural knowledge sometimes is misunderstood as a higher order thinking skill. While it may be a prerequisite for higher order thinking, it actually is a type of knowledge—specifically, knowledge of rules and their application (Crowl et al., 1997). The ability to recite a rule or set of procedures is "information learning"; the ability to apply a rule or procedure to a routine single-variable situation is "application." Neither of these capabilities involves higher order thinking. Instead, applications of procedural knowledge that also involve analysis and synthesis of two or more concepts would be considered higher order thinking. Examples include

> "constructing map projections and grids, writing clear and concise case reports, calculating the fixed overhead costs for a project, designing spreadsheets, drawing conclusions about the impact of social reform on the universality of social programs, and establishing meaningful relationships with coworkers" (Huot, 1995, p. 2).

Comprehension

Comprehension, a part of lower order thinking skills, is integral to higher order thinking skills development. In fact, some research and teaching strategies focus on comprehension as if it were within the higher order domain. While it is an important prerequisite, it is not a higher order thinking skill. Comprehension remains the process by which individuals construct meaning from information and form new “schemata” through specific activities (Crowl et al., 1997), including, but not limited to,

- generating and answering questions that demand higher order thinking about old and new ideas;
- confronting conflicting ideas and information, problems, or dilemmas;
- exploring and making discoveries;
- conducting systematic inquiries;
- summarizing, reciting, and discussing new ideas and their relationships;
- relating new understandings to other concepts;
- applying new ideas and information in basic problem-solving activities; or
- reflecting and verbalizing about cognitive processes involved in comprehension.

Creativity

Although some references do not explicitly include creativity as higher order thinking, it cannot be unmeshed from the process. The very act of generating solutions to problems requires the creative process of going beyond previously learned concepts and rules. Creativity involves divergent and convergent thinking to produce new ideas (Crowl et al., 1997). Its place in the network of higher order thinking skills was well articulated in Pasteur’s observation that “chance favors only the prepared mind” because “only a trained mind can make connections between unrelated events, recognize meaning in a serendipitous event,” and produce a solution that is both novel and suitable (cited in Crowl et al., 1997, pp. 192–193).

Major features of creativity are listed below.

- Creativity involves the consistent use of basic principles or rules in new situations, such as Benjamin Franklin's application of conservation and equilibrium (Crowl et al., 1997); Picasso's creation of "Guernica," resulting from sketches and modifications of previous work; Watson and Crick's discovery of the DNA double helix structure; and Edison's invention of an electric lighting system (Weisberg, 1995).
- Creativity involves discovering and solving problems. Innovative approaches are used to accurately evaluate shortcomings, and actions are taken to remedy those weaknesses (Crowl et al., 1997).
- Creativity involves selecting the relevant aspects of a problem and putting pieces together into a coherent system that integrates the new information with what a person already knows (Sternberg & Davidson, 1995; Crowl et al., 1997). In a basic sense, it involves a series of decision-making choices between "two or more competing alternatives of action," each having "several pros and cons associated with it" (Crowl et al., 1997, p. 169).
- Creativity overlaps with other characteristics, such as "intelligence, academic ability, dependability, adaptiveness, and independence" and can "evolve within each of the seven intelligences" (Crowl et al., 1997, pp. 195–196).
- Creativity requires many of the same conditions for learning as other higher order thinking skills. The learning processes are enhanced by supportive environments and deteriorate with fears, insecurities, and low self-esteem. Creativity deteriorates with extrinsic motivation, restraint on choice, and the pressure of outside evaluation (Crowl et al., 1997).

Insight

Insight is the sudden unexpected solution to a problem (Schooler, Fallshore, & Fiore, 1995). Complexity seems to be the spark for solving problems through insight. Noninsight solutions require using rules, while insight solutions require problem-solving and cognitive strategies as defined by Gagné, Briggs, and Wager (1988). From another perspective, noninsight solutions require comprehension and application, while insight solutions require analysis, synthesis, and evaluation as defined by Bloom (1956). Other research on higher order thinking also applies directly to the concept of insight as follows:

- Insight involves many of the same features as creativity, including examining all factors that could be causing a problem, searching for a new way to state the problem, finding alternative approaches, persevering, taking risks, applying broad knowledge, and recognizing analogies (Schooler et al., 1995).
- Playfulness, creativity, and an ability to unify separate elements are major parts of insight. Causes of impasses include failure to recognize relevant cues or patterns, overemphasis on irrelevant cues, underemphasis of relevant cues, and searches in the wrong spaces (Schooler et al., 1995).
- Dimensions of learning support insight in (1) both pattern recognition and reasoning (Schooler et al., 1995), (2) the second dimension of acquiring and integrating diverse knowledge, (3) the third dimension of extending and refining knowledge through purposefully widened observation and reasoning, (4) the fourth dimension of making choices among alternatives, and especially (5) the fifth dimension of developing productive habits of mind with systematic control of reasoning and scientific methods.

A study by Beyth-Maron (cited in Cotton, 1997) found that critical thinking underscores the ability to make good choices.

- As with creativity, the "emotional tone of the person solving problems" affects insight (Sternberg & Davidson, 1995, p. xi). Metacognition and cognitive strategies, such as persevering, address the attitudes and habits of mind involved in insight (Gagné, Briggs, & Wager, 1988; Sugrue, 1994). Motivation and fear of failure influence risk taking and persevering (Legg, 1990).

Intelligence

In the past decade, intelligence has been defined more broadly (Crowl et al., 1997; Kauchak & Eggen, 1998; Kirby & Kuykendall, 1991). Intelligence is

- no longer limited to the idea of a single ability or global capacity to learn, adapt, and think rationally;
- inclusive in its general and specific abilities to embrace general knowledge, comprehension, thinking, and problem solving;
- multidimensional in mental processes involving convergent and divergent thinking; and
- multilevel, including linguistic-verbal, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal, and intrapersonal abilities that influence one's approaches to problem solving and thinking.

Problem Solving

A problem is "a situation in which the individual wants to do something but does not know the course of action needed to get what he or she wants" (Crowl et al., 1997, p. 160). The process of problem solving requires "a series of successive decisions, each of which depends on the outcomes of those that precede it" (p. 189). In a review of research and reports, King, Rohani, and Goodson (1997) have identified 31 problem-solving tasks, from problem finding through evaluation.

Critical Thinking

Some researchers and scholars use the terms "critical thinking" and "higher order thinking" interchangeably, while others define "critical thinking" as a form of higher order thinking. Some use the terms "critical thinking" and "problem solving" interchangeably; yet for others, critical thinking is a form of problem solving. Still others define "critical thinking" as a part of the process of evaluating the evidence collected in problem solving or the results produced by thinking creatively (Crowl et al., 1997; Lewis & Smith, 1993). Critical thinking is a particular domain that has been defined in detail through Gubbins' *Matrix of Critical Thinking* (cited in Legg, 1990), Facione, P. (n.d.), and the McREL Institute (Marzano, R. J., and others. 1992). Critical thinking also has been described in the following ways:

- goal-directed, reflective, and reasonable thinking, as in evaluating the evidence for an argument for which all the relevant information may not be available (Cotton, 1997; Crowl et al., 1997; Facione, 1998; Lewis & Smith, 1993; Patrick, 1986)
- an essential component in metacognitive processes (Crowl et al., 1997)
- analysis, inference, interpretation, explanation, and self-regulation; requires inquisitive, systematic, analytical, judicious, truth-seeking, open-minded, and confident dispositions toward critical-thinking processes (Facione, 1998)

- the disposition to provide evidence or reasoning in support of conclusions, request evidence or reasoning from others, and perceive the total situation and change one's views based on the evidence (Cotton, 1997)

Theories Related to Learning and Higher Order Thinking Skills

No one has yet explained the process of thinking much better than Dewey (1933), who described it as a sequenced chaining of events. According to Dewey, this productive process moves from reflection to inquiry, then to critical thought processes that, in turn, lead to a "conclusion that can be substantiated" (p. 5) by more than personal beliefs and images. Thought can straighten out entanglements, clear obscurities, resolve confusion, unify disparities, answer questions, define problems, solve problems, reach goals, guide inferences, shape predictions, form judgments, support decisions, and end controversies.

According to Dewey, thinking does not occur spontaneously but must be "evoked" by "problems and questions" or by "some perplexity, confusion or doubt." The observations or "data at hand cannot supply the solution; they can only suggest it" (p. 15). Furthermore, it is this "demand for the solution" (p. 14) that steadies and guides the entire process of reflective thinking; the "nature of the problem fixes the end of thought, and the end controls the process of thinking" (p. 15). Dewey's conceptualization parallels current discussion and research about problem solving and metacognitive strategies and the importance of teaching students to think about their own thinking processes (Kauchak & Eggen, 1998). As students become aware of their thinking processes, they realize how their own personal makeup can play a role in how they make their choices and interpret situations (Jacobs, 1994; Tversky & Kahneman cited in Ohio State University, n.d.; Kahneman, Slovic, & Tversky, 1982). Factors such as culture, experience, preferences, desires, interests, and passions can radically alter the decision-making process (Kahneman et al., 1982). Nevertheless, with time and more experience in systematic thinking, individuals and groups can develop the principles to guide decision making so that "a certain manner of interpretation gets weight, authority" as long as "the interpretation settled upon is not controverted by subsequent events" (p. 126).

The following section provides explanations of the work of key learning theorists, practitioners, and researchers in the field of thinking and learning. Researchers and teachers choose from a variety of frameworks for learning, with each framework approaching learning from simpler to more complex stages. However, the frameworks are artificial—they are only meant to be a means of defining the thinking/learning process; they can in no way capture the intricacies of the thinking process. "The boundaries separating the forms of complex thinking are sometimes blurred and somewhat artificial, often reflecting the particular interest of individual investigators" (Crowl et al., 1997, p. 170).

Piaget

According to Piaget, the developmental stages are the key to cognitive development. School-age and adolescent children develop operational thinking and the logical and systematic manipulation of symbols. As adolescents move into adulthood, they develop skills such as logical use of symbols related to abstract concepts, scientific reasoning, and hypothesis testing. These skills are the foundation for problem solving, self-reflection, and critical reasoning (Crowl et al., 1997; Miles, 1992). Recent research shows that children perform certain tasks earlier than Piaget claimed, vary in how rapidly they develop cognitively, and seem to be in transition longer than in the cognitive development stages (Crowl et al., 1997). However, research also shows that biological development, together with instructional techniques, affects the rate of movement from one stage of learning to the next.

Bruner

According to Bruner, learning processes involve active inquiry and discovery, inductive reasoning, and intrinsic motivation. Stages of cognitive development are not linear; they may occur simultaneously. Bruner introduced the "spiral curriculum" in which learners return to previously covered topics within the context of new information learned. Both Piaget and Bruner focus on active learning, active inquiry and discovery, inductive reasoning, intrinsic motivation, and linkage of previously learned concepts and information to new learning. Stages include enactive (hands-on participation), iconic (visual representations), and symbolic (symbols, including math and science symbols) (Crowl et al., 1997).

Bloom

In each of Bloom's three taxonomies (cognitive, affective, and psychomotor), lower levels provide a base for higher levels of learning (Bloom, 1956; Kauchak & Eggen, 1998). Comprehension and application form linkages to higher order skills; here, the learner uses meaningful information such as abstractions, formulas, equations, or algorithms in new applications in new situations. Higher order skills include analysis, synthesis, and evaluation and require mastery of previous levels, such as applying routine rules to familiar or novel problems (McDavitt, 1993). Higher order thinking involves breaking down complex material into parts, detecting relationships, combining new and familiar information creatively within limits set by the context, and combining and using all previous levels in evaluating or making judgments. There also appears to be some interaction across taxonomies. For example, the highest level of the psychomotor taxonomy involves the use of our body's psychomotor, affective, and cognitive skills to express feelings or ideas as in the planning and execution of a dance performance or song designed to convey a particular message.

Gagné

According to Gagné, intellectual skills begin with establishing a hierarchy according to skill complexity. Within this structure, discriminations are prerequisites for concrete and defined concepts, simple rules, complex higher order rules, and then problem solving. Cognitive strategies may be simple or complex (Gagné, 1985; Briggs & Wager, 1981; Gagné, Briggs, & Wager, 1988). Attitudes and motor skills, related varieties of learning, may involve lower as well as higher order thinking—spanning from a simple application of a tool to a complex systems analysis and evaluation. Bloom (1956) and Gagné and Briggs (1974) allow for greater possibilities of teaching complex skills to younger learners and the possibility that learners can be "young" at any age, starting at lower levels and connecting to higher levels of thinking. This variation for learning capabilities does not fit as well in Piaget's and Bruner's frameworks.

Marzano

To Marzano, the dimensions of thinking (Table 1) feed into dimensions of learning, both of which build upon contributions from other scholars and researchers (Marzano et al., 1988). For example, Gagné refers to the generalizations that describe relationships between or among concepts as "rules" (Gagné, 1974; Gagné, Briggs, & Wager, 1988), while Marzano calls them "principles" (Marzano et al., 1988, p. 37). The book *Dimensions of Thinking* has been designed as a practical handbook with definitions, examples, and classroom applications.

Table 1

Dimensions of Thinking

Dimension	Concept	Element
Metacognition	knowledge and self-control	commitment, attitudes, attention
	knowledge and control of process	types of knowledge important in metacognition: declarative, procedural, conditional
	executive control of behavior	evaluation, planning, regulation
Critical and Creative Thinking	critical thinking	goals, dispositions
	creative thinking	intense desire and preparation, internal rather than external locus of evaluation, reframing ideas, getting away from intensive engagement to allow free-flowing thought
	critical and creative thinking	application
Thinking Processes	concept formation	labels, levels
	principle formation	cause-and-effect, correlational, probability, axiomatic, and fundamental principles
	comprehension	processes, strategies
	problem solving	processes, strategies
	decision making	models, processes
	research (scientific inquiry)	describing phenomena, testing hypotheses
	composition	planning, translating, reviewing
	oral discourse	process, application
	relationships between processes and skills	
Core Thinking Skills	focusing	defining problems, setting goals
	information gathering	observing, formulating questions
	remembering	encoding, recalling
	organizing	comparing, classifying, ordering, representing
	analyzing	identifying attributes and components, relationships and patterns, main ideas, errors
	generating	inferring, predicting, elaborating
	integrating	summarizing, restructuring
	evaluating	establishing criteria: a philosophical perspective
	generalizations about thinking and skills instruction	
Relationship of Content Area Knowledge to Thinking	content areas as schema dependent	types of schema
	content areas as models and metaphors	tasks, systems
	content areas as changing bodies of knowledge	from simple to complex and diverse, hierarchical to heterarchical, mechanical to holographic, determinate to indeterminate, linear to mutual causality, assembly to morphonenesis, objective to perspective
	content areas as special approaches to investigation	conditions needed

Dimensions of learning (McREL, 1997) evolved from constructs expressed by scholars and researchers in a 1988 framework on dimensions of thinking (Marzano et al., 1988) and the follow-up experiences of educators in classroom situations (Huot, 1995). These dimensions parallel early concepts expressed by Dewey (1933).

Rather than differentiate levels of thinking skills, the dimensions of learning establish a learner-centered framework with

> . . . a set of practical, research-based instructional strategies that infuse critical thinking and self-directed learning into curriculum and instruction; a flexible planning approach that allows teachers to focus on (1) knowledge to be learned, (2) broad issues and their applications to contemporary life, and (3) the meaningful use of knowledge. . . . (Huot, 1995, p. 1)

Educators have used the dimensions of learning as a resource for instructional strategies, managing school improvement, planning instruction and assessment, making systematic reforms, and defining what students must be able to do in order to solve problems and make decisions in many situations (McREL, 1997). In studies conducted by Huot (1995), Marzano et al. (1988), and McREL (1997), the dimensions of learning are identified as follows.

- **Dimension 1**: fostering positive attitudes and perceptions about learning in a supportive and safe learning environment

  (Dewey [1933] emphasized open-mindedness, wholeheartedness, and responsibility for thinking in environments of freedom, curiosity, variety, spontaneity, and novelty, and with joyful, structured, and integrated learning about thinking in all subjects.)

- **Dimension 2**: acquiring and integrating knowledge, with emphasis on procedural knowledge

  (Dewey [1933] explained that thinking must include access to "past experience and a fund of relevant knowledge" [p. 15] to unravel confusion or generate a solution; it requires integration of character and mind through infusion of intellectual subjects with "so-called 'informational' subjects" [p. 278]; students use what they already know to attend to new knowledge [p. 68].)

- **Dimension 3**: extending and refining knowledge through thinking

  (Dewey [1933] emphasized that changes in knowledge and belief rest upon careful and extensive study, purposeful widening of the area of observation, reasoning out the conclusions of alternative conceptions and "personal examination, scrutiny, and inquiry" [p. 8].)

- **Dimension 4**: using knowledge in meaningful tasks, including systems analysis (ecosystems, systems of government, number systems, etc.) and authentic tasks over a period of time

  (Dewey [1933] observed that students use the power of thought to enrich meaning [pp. 17–23] and cannot learn to think via drill and practice on isolated tasks that have nothing in common with or too much familiarity with their earlier life experiences [p. 68]; students learn best "when something beyond their ken is introduced" [p. 289] to which they can apply "the old, the near, the accustomed" [p. 290].)

- **Dimension 5**: developing habits of mind that help one organize new information, think, and learn, such as seeking accuracy, avoiding impulsiveness, and persisting when answers are not apparent

> (Dewey [1933] proposed that "correct habits of reflection" are a central factor in thinking, involving systematic movement from one thought to another, instead of an "irresponsible stream of fancies"; noting or observing facts instead of just "something . . . brought to mind"; using quality proof and logic as the "basis of belief," and carefully looking into things, instead of reckless or impatient glances "over the surface"; following up ideas and outcomes of discovery instead of "haphazard, grasshopper-like" guessing; and "suspending judgments till inferences have been tested by the examination of evidence" instead of "whim, emotion, or accidental circumstances" [pp. 4, 9–10, 89, 165–178].)

The McREL Institute makes the dimensions framework a practical tool by offering a teacher's manual, a newsletter, and other resources to teachers that link their teaching strategies in the dimensions to standards and benchmarks. These resources show teachers how to apply the dimensions in real classroom situations and how to integrate the dimensions in curriculum frameworks across a variety of subject areas. Tips on how to apply the dimensions are specific and evolve from a dialogue with teachers entrenched in the process of learning. Marzano's 1994 book, *Assessing Student Outcomes: Performance Assessment Using the Dimensions of Learning*, includes a detailed list of questions corresponding to each reasoning process.

Glaser

Much of the structure and information in "dimensions of thinking" and "dimensions of learning" relates not just to the work of Dewey (1933) but also to Glaser (1941). Glaser drew upon concepts articulated by Dewey and reported research from the 1930s and 1940s. Their work, together with contemporary research, shows the stability of several major concepts for higher order thinking. Glaser reported that the type of thinking required for problem solving originates in a perceived difficulty, state of doubt, or perplexity. It begins with "making acquaintance with the particular facts that create a need for definition and generalization," in order to see "the correct difficulty to be overcome" (p. 23), not with "definitions, rules, general principles, classifications, and the like" (Dewey, p. 186). Furthermore, the way a problem is "apprehended or defined limits the kind of answers that will occur to the thinker. To get out of the rut requires a reformulation of the issue" (Glaser, p. 25). This perspective suggests that higher order thinking involves more than a simple hierarchy or continuum. The importance of dispositions like attitudes and habits of mind also come into play in steering the thinking process in the right direction or taking it off course through aberrations of analysis, selection, association, inference, generalization, and language comprehension (pp. 26–29), such as

- ambiguity or misunderstanding of directions, word elements or language, or simple lack of information, material, or statements beyond the educational level of the individual;
- habits of thinking, false analogies, and logical errors; previously conceived orientations, rigid mind sets, and the tendency to block the correct response; perhaps egocentric perceptions of relationships, particularly by young children; or to read one's own beliefs or prejudices into interpretations; and
- failing to see what has to be solved; to isolate and define values of a problem; to consider all data, fallacies of inspection, observation, generalization, and confusion; and the influence of feelings and temporary physiological conditions.

Vygotsky

Vygotsky (cited in Crowl et al., 1997) seems to have consolidated major concepts of cognitive development.

- Cognitive development progresses as children learn; biological maturity accounts for "elementary processes" such as reflexive responses.
- When learning a specific skill, students also perceive the underlying principles.
- Social interaction and social culture play major roles in learning and cognitive development; children internalize knowledge most efficiently when others, such as teachers, parents, or peers, guide and assist them; significant people in an individual's life contribute to the development of "higher mental functions"; people's cognitive processes function differently when working on their own versus working in groups.
- Everyone has a "zone of proximal development," and asking certain questions or giving suggestions will move the individual toward potentially higher levels; such support helps students in solving problems until they can solve them independently and may include hints, questions, behavior modeling, rewards, feedback, information giving, self-talk, or peer tutoring (pp. 69–71).

Haladyna

Haladyna (1997) expressed the complexity of thinking and learning dimensions by classifying four levels of mental processes (understanding, problem solving, critical thinking, and creativity) that can be applied to four types of content (facts, concepts, principles, and procedures). Applying a set of skills across dimensions of content fits well with the actual complex, recursive, and systemic processes of higher order thinking. Although his terminology often varies from other theorists', the territory is similar:

Haladyna's terms	Gagné's terms	Bloom's terms
facts	information	knowledge
concepts	concepts	comprehension
principles, procedures	rules	application
critical thinking	problem solving	synthesis and evaluation
creativity	no direct match	no direct match

Gardner

According to Gardner (1983), multiple intelligences form a major part of an individual's dispositions and abilities. These intelligences are independent of each other and account for the spectrum of abilities used in different fields of work, such as teaching, surgery, athletics, dancing, art, or psychotherapy.

Gardner's theory, which regards intelligence as having seven dimensions (Table 2), has been receiving recent attention related to teaching (Kauchak & Eggen, 1998). Schools are shifting curricula and teaching methods to accommodate the diverse abilities and talents of students (Crowl et al., 1997). Teachers may have a greater impact by creating lessons that "use the various types of intelligence in classroom activities" (p. 187).

Table 2
Activities and Abilities Related to Intelligences

Types of Intelligence	Forms and Textures
linguistic-verbal	language, rhythms, inflections, meaning, and order of words (stories, books, humor, rhymes, songs)
logical-mathematical	reasoning with strings and patterns of symbols (pattern blocks, activities to form numbers and letters, building, measuring, cooking, gardening, other math-logic applications)
musical	pitch, melody, tone, and sound movements in time (rhythm sticks, varieties of music, interaction with musicians, dance exercises)
spatial	visual perception, transformation, modification, and creations (colors, shapes, spaces, games with movement and coordination)
bodily-kinesthetic	body motion and manipulation of objects (games with movement and manipulation, hands-on projects, dance exercises, sports, tactile activities)
interpersonal	relationships with others (cooperative games or exercises, peer or paired activities, public performances, conversation, exercises to focus on sensitivity to diverse needs)
intrapersonal	knowledge of self (exercises to express and acknowledge feelings, possibly journals or speeches or drawings; resources and exercises to identify and analyze one's own thinking processes, skills, interests, and feelings)

Although Gardner is commonly credited with theories related to multiple intelligences, others also have developed models of thinking that reflect the multifaceted nature of intelligence. Table 3 shows a variety of models reflecting specific abilities: Gardner's multiple intelligences, Guilford's structure of intellect, and Sternberg's triarchic theory. Some of the abilities associated with the different types of intelligence include forms of thinking, reasoning, and problem solving.

Certain components of models or theories of intelligence are similar to factors identified in models and theories of learning. For example, Guilford's products (cited in Crowl et al., 1997, p. 184) resemble the learning outcomes described by Gagné, Briggs, and Wager (1988). "Units" are like the lower levels of discriminations and verbal information, “classes” are like the classification of concepts, “relations” are like the rules formed by relating one concept to another, and “systems” are like the systems of rules integrated into problem-solving strategies.

Similarly, Guilford’s “content areas” are ways of receiving and perceiving information and instruction, and Guilford’s “operations” parallel the mental processes that teaching strategies attempt to influence. There also are parallels with the notion of learning capabilities, in that Gagné and Briggs refer to stating, classifying, demonstrating, generating, and originating as the functions associated with different learning outcomes (i.e., stating verbal information, classifying concepts, demonstrating rules, generating problem solving, and originating cognitive strategies). These functional terms guide instructional designers in their specification of learning strategies and test items and have meanings that are similar to Guilford’s terms of cognition, memory retention, memory recording, and divergent and convergent production.

Table 3
Perspectives About Intelligence

STRUCTURE OF THE INTELLECT

(Guilford cited in Crowl et al., 1997, p. 184)

Operations (Mental Processes)	Content (Type of Information)	Products (Outcomes)
Cognition	Visual	Units
Memory retention	Auditory	Classes
Memory recording	Symbolic	Relations
Divergent production	Semantic	Systems
Convergent production	Behavioral	Transformations
Evaluation		Implications

MULTIPLE INTELLIGENCES

(Gardner, Gardner & Hatch; all cited in Crowl et al., 1997, p. 185; Armstrong; Gardner; Gardner & Hatch; Sternberg; cited in Kauchak & Eggen, 1998, pp. 27–30)

Intelligence	Abilities
Linguistic-verbal	Sensitive use and awareness of language
Logical-mathematical	Reason, recognize, and manipulate logical-mathematical patterns
Musical	Appreciate and produce musical pitch, melody, and tone
Spatial	Perceive and transform perceptions
Bodily-kinesthetic	Use and control the body and objects
Interpersonal	Sense needs, thoughts, and feelings of others
Intrapersonal	Recognize and respond to one’s own needs, thoughts, and feelings

TRIARCHIC THEORY

(Sternberg cited in Crowl et al., 1997, p. 185)

Aspects of Intelligence	Focus
Componential	Metacomponents to organize and monitor one’s thinking Performance components to recognize and perform Knowledge-acquisition to organize and comprehend information
Experiential	Ways to confront new and unfamiliar situations Ways to cope with novel or unfamiliar situations Automatization of familiar task behaviors to reduce demands for mental capacity during problem-solving operations
Contextual	Ability to adapt, select, or shape the environment in order to succeed

It is often difficult to distinguish intelligence from the higher order thinking processes. McPeck (1990), in examining the dimensions of critical thinking as defined by Watson and Glaser, found the characteristics identified “to be very similar to what we normally mean by general scholastic ability, or intelligence” (p. 23). This observation illustrates the type of interdisciplinary extensions that have been occurring through dialogue and research about how to describe “the intimate connection between the kinds of knowledge and their corresponding kinds of skills” (p. 28). McPeck concludes that it is just as important to teach the structure of a discipline (p. 49) as to teach thinking skills, and that “most problems are in fact ‘multicategorical’ and not domain-specific” (p. 113).

The concept of multiple dimensions of thinking has long-standing stability in teaching and learning when viewed in a larger context. For example, Symonds, in his 1936 book *Education and the Psychology of Thinking*, stated that “Thinking is not the application of independent units, one at a time, but rather a skillfully conducted interplay of habits and skills” (as cited in Glaser, 1941, pp. 66–67). This skillful interplay of habits and skills matches the concepts of Dewey (1933) as well as the more contemporary “dimensions of learning” of McREL (1997). Another dimension, “content and context,” provides the individual with something to think about, but serves primarily as “the vehicle that carries” the thinking skills (Fogarty & McTighe, 1993, p. 161).

Summary of the Development of Higher Order Thinking Skills

Higher order thinking includes critical, logical, reflective, metacognitive, and creative thinking. These skills are activated when students of any age encounter unfamiliar problems, uncertainties, questions, or dilemmas. Successful applications of these skills result in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience, and promote continued growth in higher order thinking, as well as other intellectual skills.

Terms used to describe higher order thinking have been diverse. Some of the key definitions are provided in Table 4.

Table 4

A Sampling of Terms Associated with Higher Order Thinking

Terms	Descriptions
cognition	the "mental operations involved in thinking; the biological/neurological processes of the brain that facilitate thought" (Alvino cited in Cotton, 1997, p. 3); "all of our mental processes, such as perception, memory, and judgment" (Crowl et al., 1997, p. 36)
comprehension	the process by which individuals "construct meaning from incoming information" (Crowl et al., 1997, p. 149)
creative thinking	generating and producing ideas through brainstorming, visualizing, associating relationships, making analogies, inventing, inferring, and generalizing (Fogarty & McTighe, 1993)
critical thinking	an attitude of suspended judgment, logical inquiry, problem solving, evaluative decision or action (National Council on Teacher Education's [NCTE] Committee on Critical Thinking and the Language Arts as cited in Carrol, n.d.); skillful, responsible thinking that facilitates good judgment, relies upon criteria, is self-correcting and sensitive to context (Lipman cited in Legg, 1990); skepticism, curiosity; questioning of beliefs, aims, definitions, conclusions, actions, appraisal of frameworks or sets of criteria by which judgments are made (Patrick, 1986)
graphic frame	an organizing pattern to visually represent relationships; serves as a medium for organizing new information and patterns of relationships (e.g., flowcharts, cartoons, symbols, diagrams, time lines, grids, graphs, concept maps, chains, towers, circles, pyramids, boxes) (Clarke, 1990)
higher order thinking	understanding of facts, concepts, principles, and procedures (Haladyna, 1997); analysis, synthesis, and evaluation (Bloom, 1956)
inquiry	investigating beliefs or forms of knowledge, taking care to consider the grounds that support them and the conclusions drawn from them (Dewey, 1933)
insight	"seeing" a correct solution; sudden coherency or change in perceptions, feeling, thought (Gruber, 1995); the "aha" experience, from a state of not knowing to knowing (Gick & Lockhart, 1995)
metacognition	mental process of being aware of monitoring, supervising, organizing, and making executive decisions about one's own thinking process (Crowl et al., 1997); thinking about thinking, the use of information and strategies to solve problems (Pogrow, 1990; Pogrow & Buchanan, 1985); mind's management system; ability of the mind to control its own processing of how we think (Sternberg; Gagné; Flavell; Presseisen; all cited in Costa, 1990)
problem solving	application of more than one rule/more than four concepts to solve problems to situations with multiple variables, multiple relationships (King, Rohani, & Goodson, 1997); combines two or more rules to solve a problem (Gagné, Briggs, & Wager, 1988)
rational thinking	the interdependent skills of creative thinking, critical thinking, and problem solving (Ennis cited in Lewis & Smith, 1993)
scaffolding	support and guidance gradually removed until one can work independently (Rogoff; Rogoff, Malkin, & Gilbride cited in Crowl et al., 1997)
schemata	systems of relationships between concepts (Crowl et al., 1997); complex networks of related knowledge (Rumelhart cited in Costa, 1990); cluster of knowledge associated with a type of problem; typical solution procedures (Gick & Lockhart, 1995)
scripts	simple routines developed through repeated practice of elaborate reasoning procedures (Galambos cited in Costa, 1990)
transfer	"the ability to apply thinking skills taught separately to any subject" (Alvino cited in Cotton, 1997, p. 3)

Higher order thinking skills are grounded in lower order skills such as discriminations, simple application and analysis, and cognitive strategies and linked to prior knowledge of subject matter content (vocabulary, procedural knowledge, and reasoning patterns). Appropriate teaching strategies and learning environments facilitate the growth of higher order thinking ability as do student persistence, self-monitoring, and open-minded, flexible attitudes.

In higher order thinking, the path is not clear in advance, nor readily visible from any single vantage point. The process involves interpretation about uncertainty using multiple and sometimes conflicting criteria. It often yields multiple solutions, with self-regulation of thinking, to impose meaning and find structure in disorder (Clarke, 1990). However, the higher order thinking process and its value are best described by Lewis and Smith (1993).

> Higher order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. A variety of purposes can be achieved through higher order thinking . . . deciding what to believe; deciding what to do; creating a new idea, a new object, or an artistic expression; making a prediction; and solving a nonroutine problem. (p. 136)

Table 5 is a synthesis of research related to the development of higher order thinking skills. Despite the different names theorists have given to the elements of thinking skills development, the fundamental process is the same. This framework describes a process in which students are challenged to interpret, analyze, or manipulate information. It involves the filling in of information that is missing from a logical sequence, extending an incomplete argument or evidence, and rearranging the information to effect a new interpretation by moving through a series of interconnected steps (Lewis & Smith, 1993).

Table 5

Development of Higher Order Thinking Skills

LEVEL 3: HIGHER ORDER THINKING

Situations ⇔	Skills ⇔	Outcomes
situations of multiple categories, for which the student has not learned answers, preferably real-life context	multidimensional skills of applying more than one rule or transforming known concepts or rules to fit the situation	outcomes that are created through thinking processes, not generated from rote responses of prior learning experiences
• ambiguities • challenges • confusions • dilemmas • discrepancies • doubt • obstacles • paradoxes • problems • puzzles • questions • uncertainties	• complex analysis • creative thinking • critical thinking • decision making • evaluation • logical thinking • metacognitive thinking • problem solving • reflective thinking • scientific experimentation • scientific inquiry • synthesis • systems analysis	• arguments • compositions • conclusions • confirmations • decisions • discoveries • estimates • explanations • hypotheses • insights • inventions • judgments • performances • plans • predictions • priorities • probabilities • problems • products • recommendations • representations • resolutions • results • solutions

⇕

LEVEL 2: BRIDGES—Connecting Networks and Operations

Linkages ⇔	Schemata ⇔	Scaffolding
extension of prior learning to new context and higher order skills—may require mastery or automatization of prior learning	network, organization, representation, or architecture for organizing new learning	guidance, structure, visual and verbal representations, modeling of higher order thinking

⇕

LEVEL 1: PREREQUISITES

Content and Context ⇔	Lower Order Thinking Skills ⇔	Dispositions and Abilities
• subject area content (vocabulary, structure, concept definitions, procedural knowledge, reasoning patterns) • thinking terms, structures, strategies, errors, fallacies • teaching strategies and learning environment (safe, motivating, supportive)	• cognitive strategies • comprehension • concept classification • discriminations • routine rule using • simple analysis • simple application	• attitudes, adaptiveness, tolerance for risk, flexibility, openness • cognitive styles (e.g., field dependence, locus of control, response rates) • habits of mind (persistence, self-monitoring, self-reflection) • multiple intelligences (linguistic-verbal, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal, intrapersonal)

Level 1: Prerequisites

The extent to which students develop higher order thinking ability depends upon how content and context interplay with students' lower order thinking skills, dispositions, and abilities. In lesson planning, the teacher may sometimes find it difficult to distinguish the highest level in the "lower order" category from the lowest level in the "higher order" category. After all, thinking skills are not actually as separate as individual "building blocks," even though scholars and researchers often use such metaphors. Nonetheless, mastery of content and lower order thinking are particularly important prerequisites to higher order thinking according to Gagné, Briggs, and Wager (1988):

> Any lesser degree of learning of prerequisites will result in puzzlement, delay, inefficient trial and error at best, and in failure, frustration, or termination of effort toward further learning at the worst. . . . Lesson planning which utilizes the hierarchy of intellectual skills may also provide for diagnosis of learning difficulties. (p. 222)

Students' innate intelligences, learning environment, and use of lower order thinking skills can affect their cognitive development. In Table 5, cognitive strategies, which might have been placed in the connecting network (Level 2), appear as part of lower order thinking skills (Level 1). They "often intrinsically possess a simple structure," such as underlining main ideas, outlining, and paraphrasing (Gagné, Briggs, & Wager, 1988, p. 70). Other examples include the use of mnemonic devices, imagery, analogies, or metaphors to simplify recall of information.

Dispositions and abilities play key parts of the thinking process. Marzano (1993) describes one set of dispositions as "habits of mind." These include seeking accuracy and clarity, being open-minded, restraining impulsiveness, and taking a position or direction, as well as self-regulation, critical thinking, and creative thinking. Other researchers treat self-regulation as part of metacognition, and critical and creative thinking as separate dimensions (Fogarty & McTighe, 1993).

Level 2: Bridges

Connecting networks and operations help provide the bridge to higher levels of thinking. Altogether, the dimensions of content and context, lower order thinking, and dispositions and abilities help to develop the schemata, connections, and scaffolding for the connecting networks and operations. When students link prior learning to new contexts, tap into their own schemata, and have the proper scaffolding for new information, they move toward higher order thinking. Students "broaden their knowledge of the world by building relationships among different concepts" (Crowl et al., 1997, p. 148), and when combined, these relationships form rules that are the major prerequisites for higher order rule using and problem solving (Gagné, Briggs, & Wager, 1988).

Bridges from lower to higher order thinking are created by interweaving thinking activities with content through "elaborating the given material, making inferences beyond what is explicitly presented, building adequate representations, analyzing and constructing relationships" (Lewis & Smith, 1993, p. 133). For example, in understanding reading material, students become involved in making inferences and using information that goes beyond what is written, thus interweaving lower and higher order thinking with the content of the material. Linkages from the connecting networks are critical because "in very simple terms, we remember those things for which we have made many linkages" (Marzano, 1993, p. 156). "It is mainly the content that begins in relatively simple forms and grows towards complexity. . . the nature of thinking does not change . . . but adapts to increasing challenge" (Clarke, 1990, p. 24).

Level 3: Higher Order Thinking

Situations, skills, and outcomes are the components that challenge the thinker to do higher order thinking. Some interpretations might have placed metacognitive thinking as part of the connecting network; however, in Table 5 it appears as one of the higher order thinking skills. The contemporary concept of metacognition actually comes from Sternberg's (cited in Crowl et al., 1997) triarchic theory of intelligence. This theory includes the components of thinking, approaches to experiences, and context of responses to problem-solving situations. The three parts of the triarchic theory are the componential aspect, the experiential aspect, and the contextual aspect.

Metacognitive strategies are complex. They include problem finding, defined by Bruner (cited in Gagné, Briggs, & Wager, 1988) as a task requiring the location of incompleteness, anomaly, trouble, inequity, and contradiction. They link problem finding and creativity through activities of planning, self-monitoring of progress, and self-adjustments to problem-solving strategies (Sternberg & Lubart, 1995, p. 276; Young, 1997).

TEACHING STRATEGIES

Some fundamental principles of learning should guide all teaching strategies, whether focused on higher order or lower order thinking. The American Psychological Association (APA) summarized recent changes in perspectives on learning in a report entitled *Learner-Centered Psychological Principles: Guidelines for School Redesign and Reform* (Presidential Task Force on Psychology in Education, cited in Kauchak & Eggen, 1998).

Table 6
APA Summary of Basic Principles of Learning

Nature of Learning	Learners freely and actively pursue personally meaningful goals and construct meaning through internal mediation, discovery, perceptions, thoughts, and beliefs.
Goals of Learning	Learners seek meaningful, coherent representations of knowledge.
Construction of Knowledge	Learners link new information and its meaning with past and future-oriented knowledge.
Higher Order Thinking	Metacognition facilitates creative thinking, critical thinking, and development of expertise.
Motivational Influences	Motivation for learning results from individual beliefs about personal control, competence, and expectations for success or failure; ability; clarity and saliency of values, interests, and goals; and general feelings and mental states.
Intrinsic Motivation	Learners have natural enthusiasm, curiosity, and joy for learning that can be undermined by fear of failure, insecurity, self-consciousness, fear of punishment, or ridicule.
Motivational Learning Tasks	Relevant and authentic learning tasks of optimal difficulty and novelty for the individual student will stimulate curiosity, creativity, and higher order thinking.
Constraints and Opportunities	Genetic and environmental factors affect physical, intellectual, emotional, and social development.
Social Acceptance and Self-Esteem	Respectful, caring relationships that express belief in individual potential, appreciation of individual talents, and acceptance of individuality will lead to greater learning and self-esteem.
Individual Differences	Learners have different capabilities and ways of learning due to environment and heredity; basic principles of learning, motivation, and effective instruction apply to all learners.
Cognitive Filters	Learners construct reality and interpret life experiences filtered through their personal beliefs, thoughts, and understandings.

These principles suggest that learning is a very individual activity—goals and learning tasks that are meaningful for one teacher or learner may not be meaningful for another. In the learning process, individuals seek coherent representations of knowledge that both fit into what they already know and also have future usefulness. How well they progress depends in great part upon the teacher; the climate the teacher establishes and the instructional strategies the teacher uses can motivate students to learn and think on higher levels.

A major factor in the growth of higher order thinking capability is a student-centered classroom. It supports the open expression of ideas, provides active modeling of thinking processes, develops thinking skills, and motivates students to learn. Without it, students will not persist in higher level thinking processes. In this open environment, a teacher's awareness of student motivation can dramatically affect a student's progress. A teacher who incorrectly assumes that a student lacks motivation to think at a higher level may miss the real reason for nonperformance—a lack of prerequisite knowledge and skills or lack of interest in the content or activities; or the teacher may not understand that a learner's motivation is sometimes influenced by cultural differences of values placed on learning (however, motivational differences are not due to race, ethnicity, or economic status) (Crowl et al., 1997).

In the student-centered environment, great expectations lead to greater achievement. Teachers who expect more of their students express more positive interactions; smile more frequently; use more eye contact; have closer proximity to students; provide clearer and more thorough explanations; give more enthusiastic instruction and follow-up questions; require more complete and accurate answers; provide more prompting and encouragement; allow more time to answer questions; and give more praise, less criticism, more complete feedback, and more conceptual evaluations (Kauchak & Eggen, 1998).

The teacher avoids comparing students with each other. Constructive critical responses to student work are meant to provide strategies to overcome a student's learning difficulty—"procedures such as displaying students' grades, exhibiting student assignments, or sharing in other ways the accomplishments of successful students decrease rather than increase the motivation level of low-achieving students" (Crowl et al., 1997, pp. 246, 248). The successful teacher conveys the message that "making mistakes is okay; in fact, it is an important part of learning" (p. 273).

In lesson planning, the teacher sets appropriate short- and long-term instructional goals because unrealistic expectations can increase anxiety. Students will persist in achieving goals that are "challenging, specific, and attainable in the near future" through reasonable effort and persistence (Crowl et al., 1997, p. 241). There is no busywork in this student-centered, thinking classroom, and student progress is monitored using several methods—not just tests.

Specific Methods and Strategies to Enhance Higher Order Thinking Skills

Once the teacher establishes the student-centered classroom and creates a framework for incorporating thinking skills into lessons, he or she can then consider strategies and methods that can enhance students' thinking ability.

Instructional Communications

To reduce the risks of ambiguity and confusion and improve student attitudes about thinking tasks, the teacher should provide students clear instructions for assignments as suggested in the studies by Hines, Cruickshank, and Kennedy; and Snyder et al. (all cited in Kauchak & Eggen, 1998). For this reason, careful lesson planning is essential. Factors to consider in lesson planning include organization of activities, clarity of explanations, modeling of thinking skills in action, examples of applied thinking, feedback on student thinking processes, instructional alignment of objectives and activities, and adaptations for diverse student needs.

Kauchak and Eggen (1998) found that the following strategies contribute to the particular kinds of instructional communications necessary for developing higher order thinking skills.

1. Align learning goals, objectives, content ideas and skills, learning tasks, assessment activities, and materials and aids.
2. Establish organized activities and routines.
    a. Prepare a task analysis of the thinking skill to be learned: identify the particular thinking skill to be learned, the prerequisite knowledge and skills, the sequence of related subskills, and the readiness of students to learn (diagnosis of prerequisite knowledge and skills).
    b. Prepare sample problems, examples, and explanations.
    c. Prepare questions that go beyond simple recall of factual information to focus on advanced levels of comprehension, such as How? Why? and How well?
    d. Plan strategies for diagnosis, guidance, practice, and remediation.
    e. Explain and follow established routines, such as starting on time and following the planned sequence of activities.
    f. Convey enthusiasm, genuine interest in a topic, warmth, and a businesslike approach with thorough preparation and organization, minimal transition time between activities, clear expectations, and a comfortable, nonthreatening atmosphere.
3. Explain the task clearly.
    a. Set goals at the beginning of an assignment.
    b. Provide examples of finished products.

c. Avoid vague, ambiguous terminology such as “might,” “a little more,” “some,” “usually,” and “probably.” These terms suggest disorganization, lack of preparation, and nervousness.

d. Introduce tasks with a clear and simple organizing framework such as a diagram, chart, preview, or one paragraph overview.

e. Introduce key concepts and terms before further explanation and study.

f. Use questions that focus attention on important information.

g. Give emphasis with verbal statements, nonverbal behaviors, repetition, and written signals.

h. Make ideas vivid with pictures, diagrams, examples, demonstrations, models, and other devices.

4. Give transition signals to communicate that one idea is ending and another is beginning.

5. Provide feedback at frequent intervals with a corrective feedback to clarify incorrect or partially incorrect responses.

Scaffolding

Scaffolding involves giving students support at the beginning of a lesson and then gradually turning over responsibility to the students to operate on their own (Slavin, 1995). This limited temporary support helps students develop higher order thinking skills. It functions in much the same way that scaffolding does when providing safety and access for a window washer or painter. However, scaffolding must be limited to “only enough support so that learners make progress on their own” (Kauchak & Eggen, 1998, p. 313). Too much or too little support can interfere in the development of higher order thinking skills. For example, when teachers give students help even though the students do not ask for it, as reported in a study by Graham (cited in Crowl et al., 1997), students get the message that they cannot do the task on their own.

Students differ in the ways that they organize knowledge and events in their memories (also known as their "schemata" or "script knowledge"). These differences influence how they understand current information and events and are "partially explained by cultural background" (Crowl et al., 1997, p. 98), but are not fixed. Scaffolding can change the schemata and scripts by which students learn new information and skills (Crowl et al., 1997). The following strategies provide the type of structural support needed for developing thinking skills.

1. Use scaffolding at the following times (Kauchak & Eggen, 1998):
   a. During initial learning, use scaffolding along with a variety of examples to describe the thinking processes involved.
   b. Use scaffolding only when needed, by first checking for understanding and, if necessary, providing additional examples and explanations.
   c. Use scaffolding to build on student strengths and accommodate weaknesses.
2. Provide structured representations and discussions of thinking tasks.
   a. Visually represent and organize problems in concrete examples such as drawings, graphs, tables, hierarchies, or tables (Clarke, 1990; Crowl et al., 1997; Kauchak & Eggen, 1998).
   b. Demonstrate how to break up a thought problem into convenient steps, using a number of examples and encouraging students to suggest additional examples (Glaser, 1941).

c. Discuss examples of problems and solutions, explaining the nature of problems in detail and relating the worked-out solutions to the problems. This practice reduces the student's need for additional teacher assistance (Kauchak & Eggen, 1998).

3. Provide opportunities for practice in solving problems (Kauchak & Eggen, 1998; Howe & Warren, 1989).

   a. Provide teacher-directed practice before independent practice, spot-checking progress on practice and providing short responses of less than 30 seconds to any single request for assistance (Fisher et al.; McGreal; both cited in Kauchak & Eggen, 1998).

   b. Assign frequent, short homework assignments that are logical extensions of classroom work (not more than 20 minutes for elementary students; 10 problems a night works better than 50 a week) (Kauchak & Eggen, 1998).

   c. Link practice in the content area to complex, real-life situations (Kauchak & Eggen, 1998).

Learning and Thinking Strategies

Learning strategies, sometimes referred to as cognitive strategies, include rehearsal, elaboration, organization, and metacognition to assess and regulate one's own thinking (Crowl et al., 1997). They may involve skills such as highlighting, diagramming, visualizing, or using mnemonics. Some learning strategies are more complex, such as "multipass," a strategy used to improve reading comprehension. Multipass also would apply to the initial learning of new concepts, rules, and principles by means of written information. In the first "pass," students survey material for a general idea of what the information covers and how it fits together. In the second “pass,” students size up the important points, looking for “contextual cues to important information.” In the third “pass,” students attempt to answer questions about a passage.

The following strategies have been known to help develop individual learning and thinking capabilities.

1. Deliberately design lessons or programs for the express purpose of teaching specific learning and thinking strategies (Darmer, 1995, abstract; Kauchak & Eggen, 1998, p. 310).
2. Teach self-reflection and self-evaluation about thinking processes (Cotton, 1997, p. 4; Easterwood, 1996, abstract). The following effective approaches were reported in several studies by Crowl et al., (1997):
    a. Challenge preexisting ideas (beliefs, concepts, and misconceptions) by presenting situations that students are unable to explain—paradoxes, dilemmas, and perplexities.
    b. Guide students in how to do systematic inquiry, allowing them to think independently, but preventing them from pursuing dead ends and simplistic answers.
    c. Encourage students to reflect upon and make sense of new information by making judgments in writing or discussions about its relevance, telling in their own words how to integrate their findings with their previously existing ideas, opinions, or approaches.
    d. Encourage and guide students to formulate hypotheses, speculate on consequences, guess, brainstorm, and discuss how their thinking processes have worked to change their ideas.

e. Monitor and correct inefficient strategies.

f. Encourage continuous reflection of beliefs about thinking, thinking processes, and evaluation of effectiveness.

3. In approaching different learning and thinking tasks, use cognitive maps and advance organizers to show the major steps or parts (Cotton, 1997; Crowl et al., 1997).

4. Teach the initial and rehearsal strategies for complex tasks (Crowl et al., 1997).

   a. Teach how to preview, question, read, reflect, recite, and review (PQ4R) when learning from written materials (Crowl et al., 1997).

   b. Provide instruction in “abstracting, analyzing, outlining, summarizing, and generalizing”; this improves “both reasoning and reading ability” (Glaser, 1941, p. 70).

   c. Emphasize broad problem-solving strategies, algorithms (specified set of steps for solving problems), or heuristics (widely applicable problem-solving strategies such as using means–end analysis for ill-defined problems, working backward when parameters are known, and drawing analogies for unfamiliar problems) (Kauchak & Eggen, 1998).

   d. Provide practice for routines of different strategies, algorithms, and heuristics until they are overlearned, so that their use becomes fast, effortless, and consistent (Kauchak & Eggen, 1998).

   e. Teach specific learning strategies by talking about the strategy, modeling it while thinking out loud, and providing opportunities for practice (Crowl et al., 1997; Kauchak & Eggen, 1998). Show persistence in thinking things through and confidence in the thinking process; students who hear teachers express self-confidence in reasoning actually develop greater confidence in themselves. The following strategies were reported in a study by McTighe (as cited in Crowl et al., 1997).

- Provide names and definitions for each thinking skill.
- Ask students for synonyms and examples.
- Model steps for using each skill.
- Explain appropriate and inappropriate contexts for using each skill.
- Arrange practice of skills in cooperative learning groups.

5. Strengthen comprehension and skills in applying related concepts, rules (principles and procedures), decision-making processes, and problem-solving strategies.
   a. Diagnose students' existing schemata (conceptions and misconceptions) by asking probing questions (Crowl et al., 1997).
   b. Provide hands-on situations for students to "mess around" with interpreting raw data or generating new explanations (Crowl et al., 1997).
   c. Provide examples of questions or stems of questions that require higher order thinking and encourage students to answer them independently, in pairs, or in groups (Crowl et al., 1997).
   d. Redirect, probe, and reinforce the development of critical and creative thinking skills (Cotton, 1997).
   e. Provide practice, without the expectation of extrinsic rewards, grades, or tests, in making choices, brainstorming, finding problems, experimenting with chosen themes and approaches, and developing tentative solutions to a variety of problems

involved in areas such as painting, music, storywriting, and other art challenges, as well as scientific and mathematical undertakings (Crowl et al., 1997).

f. Provide practice on how and when to apply procedural knowledge, including rules and facts (Crowl et al., 1997).

- Provide opportunities for discovery of procedural knowledge.
- Explain the goals of the procedure.
- Define problems/situations for which the procedure is appropriate.
- Explain why particular strategies are appropriate for the problems/situations.
- Demonstrate the step-by-step application of a procedure.
- Provide students with practice in choosing appropriate procedures and carrying out the steps of procedures.
- Provide feedback on student performance of procedures.

g. Include individualized options in lesson plans designed to teach higher order thinking.

- Provide choices among assignments, such as having 70% required and 30% optional (Kauchak & Eggen, 1998; Crowl et al., 1997).
- Create multidimensional classrooms with learning tasks that encourage intellectual diversity, using modalities for several kinds of intelligences, such as linguistic, logical-mathematical, musical, or spatial (Kauchak & Eggen, 1998).
- Vary sequence of instruction and application. Students with low induction aptitude benefit from receiving training before performing an application

task, while those with high induction aptitude benefit from performing the application task first (Donnelly, 1996, abstract).

- Use cultural/community resources and information to express the acceptance and valuing of different perspectives that are necessary for successful learning by all students (Kauchak & Eggen, 1998).
- Use participation tasks that are open-ended, involving several ways to solve problems, such as tasks that include opportunities for students to make different kinds of contributions, call on a variety of knowledge and skills (including reading, writing, constructing, and designing), and incorporate multiple media (Cohen; Bowers; both cited in Kauchak & Eggen, 1998).
- Use multiability tasks with varied activities to accommodate differences in language proficiency, abstract thinking, and influence of emotion.
- Help students see themselves as effective learners so they can develop a greater internal locus of control (Katkovsky, Crandall, & Goods, 1967; Lefcourt, 1966; Strickland; all cited in Crowl et al., 1997).
- Provide alternate learning materials with additional support and guidance for those who need it and additional enrichment activities for the others (Kauchak & Eggen, 1998).
- Use mastery skills test management: Students who pass the quizzes are allowed to continue; those who do not pass are moved into additional activities (Guskey & Gates; Slavin; all cited in Kauchak & Eggen, 1998).

- Use peer tutoring to allow more able students to work with other students on specific skills (Kauchak & Eggen, 1998).
- Use cooperative learning such that each member investigates independently and later explains a different concept, process, or skill to the others (Kauchak & Eggen, 1998).
- Use collaborative problem solving for problem analysis, not for problem solution (Kewley, 1996, abstract).
- Use team-assisted individualization that combines cooperative and mastery learning. Students in mixed-ability learning teams receive direct teacher instruction on how to proceed, work on individual assignments with assistance and support from other members, and receive rewards for team performance (Slavin cited in Kauchak & Eggen, 1998).
- Use computer programs that target specific concepts and skills (Kauchak & Eggen, 1998).

Direct Instruction

Direct instruction, involving teacher-centered presentations of information, generally does not work well for developing higher level thinking skills (Crowl et al., 1997). Nevertheless, the following strategies can make direct instruction more effective.

1. Limit direct teaching methods to the introduction of strategies and skills (Patrick, 1986).
2. Combine direct instruction with guided practice to teach students well-structured subskills and knowledge, such as teaching the learning strategies of rehearsal, elaboration, organization, monitoring, or metacognition (Crowl et al., 1997).

3. Avoid long lectures and use minilectures instead. Keep lectures very short (up to five minutes). The amount learned from a lecture decreases as the length of the lecture increases. Minilectures should be even shorter for younger, slower, or poorly motivated students or for complex or abstract content. A study by Kauchak & Eggen (1998) offered the following suggestions:
    - Introduce new content with a familiar frame of reference. Analogies work well for this purpose. "The closer the fit of the analogy, the more learning is facilitated. . . . Red blood cells are our bodies' oxygen railroad" (pp. 295–296).
    - Express briefly what will be learned, why it is important, when it will be useful, and how it should be applied.
    - Break up segments with questions, discussions, and other devices because attention increases when a question is asked (Crowl et al., 1997).
    - Keep student responses to questions short because attention decreases when a student is called on.
    - Use visual displays to organize information—networks, hierarchies, schematic diagrams, and matrices show relationships among ideas or concepts.
    - Include demonstrations, debates, and student-initiated questions. These improve student attention and involvement.
    - Develop and link content to the overall section or purpose of learning.
    - Include transition signals between topics.
    - Provide review and closure through summaries, both verbal and visual.

Questioning Strategies

To generate higher order thinking processes, questions must elicit answers that have not already been presented. Planning the questions in advance of actual learning time helps assure questions go beyond simple recall of information. Recalling the steps in a major procedure or skill may be useful, but memorization of steps does not help the learner understand why or how the steps should be used, nor does it help the learner apply the steps in a problem situation.

The following strategies for asking questions have been shown to improve the development of thinking skills.

- Ask questions of all students equally, calling on nonvolunteers as well as volunteers (Kauchak & Eggen, 1998).
- To stimulate curiosity or demand problem solving, ask questions about paradoxes, dilemmas, and novel problems and approaches (Crowl et al., 1997; Kauchak & Eggen, 1998).
- Have students generate their own questions about topics (Crowl et al., 1997).
- Start with lower-order questions, remediating as needed, and lead up to higher-order questions (Kauchak & Eggen, 1998).
- Provide wait time after a question because students differ in the rate at which they respond (Crowl et al., 1997; Kauchak & Eggen, 1998).

Feedback

Feedback informs learners of their progress. The following strategies for providing feedback are effective.

- Use informal checks such as thumbs up or thumbs down to show who got a problem right (Rosensine & Stevens cited in Kauchak & Eggen, 1998).
- Provide immediate, specific, and corrective information, using a positive emotional tone (Brophy & Good; Rosenshine & Stevens; all cited in Kauchak & Eggen, 1998).
- Avoid expressions of low expectations such as "That was a good first effort" (Crowl et al., 1997).
- Avoid insincere feedback or excessive praise because they do not work except for very young children (Kauchak & Eggen, 1998). Praise is effective only when students believe they have earned it. Use praise to help students "develop their own standards for success" (Crowl et al., 1997).
- Adjust feedback to response. For correct quick, firm answers, use short, general praise (e.g., "good answer"). For correct but hesitant answers, respond with encouraging feedback and explanation (e.g., "Yes, the apostrophe in this case indicates a contraction, not a possessive. We see there is no possession suggested in the sentence") (Kauchak & Eggen, 1998, p. 280). For incorrect answers due to carelessness, simply correct the error. For incorrect answers due to misunderstanding, provide more explanation and questioning, but do not overexplain. Take this approach with every student. For a number of incorrect errors by several students, reteach the material. When a student is unable to respond, prompt the student until an acceptable answer is given—do not redirect the question to another student (Kauchak & Eggen, 1998). Reinforce desired

behaviors, and at the same time, use appropriate behavioral strategies to eliminate undesirable behaviors (Crowl et al., 1997).

Team Activities

Group size must be limited to six or fewer for group work to remain manageable and focused. Before they can work well in teams or groups, students must learn skills such as listening carefully, maintaining focus, and providing support and encouragement (Kauchak & Eggen, 1998). Students must also receive challenging tasks, encouragement to stay on task when grappling with open-ended questions, and ongoing feedback about their progress (Crowl et al., 1997).

Team or group work facilitates knowledge construction through social interaction. Team and group work profit from careful strategic planning, including development of tasks, group procedures, materials, and assessment methods (Kauchak & Eggen, 1998). Student performance improves with monitoring of student activities and minimized transitional periods from one activity to another (Brophy; Crawford; both cited in Crowl et al., 1997).

The forms of group work found to be effective for the development of thinking skills include student discussions, peer tutoring, and cooperative learning. In any of these situations, using introductory activities to develop rapport or “warm up” for the team or group can facilitate group interaction (Kauchak & Eggen, 1998). At the start of a group, use some team-building activities such as name-learning games with follow-up quizzes on naming partners. Use additional time for students to do getting-to-know-you interviews (interests or hobbies) or “something that no one else knows about me” activities for group members. Use this information to introduce group members to the rest of the class.

Student Discussions

Student discussions “stimulate thinking, challenge attitudes and beliefs, and develop interpersonal skills” (Kauchak & Eggen, 1998, p. 250). When organized and managed well, discussions allow students “to develop critical thinking abilities and investigate questions that don’t have simple answers” (Kauchak & Eggen, 1998, p. 250). For best results, assure the presence of student background knowledge before using discussions. Begin with moral dilemmas to develop understanding and clarification of values or use other types of dilemmas to develop other critical thinking and problem-solving skills. Arrange groups for face-to-face discussion, such as in semicircles or circles, so that the teacher is included as part of the semicircle or circle (Kauchak & Eggen, 1998).

Peer Tutoring

Peer tutoring pairs up students of different abilities to increase understanding and skill learning (Kauchak & Eggen, 1998). Make sure tutors are trained; untrained tutors sometimes imitate the worst from their teachers, such as punitiveness or a lack of helpful feedback. Students should learn how to explain objectives, stay on task, encourage their peers to talk about the lesson, and provide supportive comments, praise, and positive feedback. Place cross-age or same-age students in one-to-one pairs and supply them with structured learning materials for practice and feedback. Provide clear structure through student worksheets, including a focused agenda for tutor and tutee. Provide teacher monitoring, feedback, and guidance during peer tutoring to check progress and correct mistakes or misunderstandings. Restructure whenever a peer tutoring pair is not working.

Cooperative Learning

Cooperative learning is effective for developing cognitive, affective, and interpersonal skills through individual accountability. It involves more students and teamwork than peer tutoring and capitalizes on student diversity by placing students on learning teams and rewarding the group's planning and inquiry performance. Cooperative learning increases motivation, time on task, and student involvement and improves student self-esteem. Learning tasks should require cooperation and communication. Provide useful resources for study such as the Internet, textbooks, and reference books. Use student-generated charts or worksheets to support the organization of inquiry results and rotate student roles (Kauchak & Eggen, 1998). Cooperative learning includes group investigation, student teams-achievement divisions (STADs), and Jigsaw II.

Group investigation involves placing students in study groups to investigate a common topic. Group investigation gives students "the chance to wrestle with ill-structured tasks, which are the kinds of problems we face in real life" and to "clarify and then structure the problem" (Kauchak & Eggen, 1998, p. 245). To help students engage and stay involved, introduce the topic and ask students to identify subtopics that each group will investigate; divide students into groups according to student interest and balance of achievement, gender, and cultural background; arrange for group presentations to share the information gained; and provide feedback to groups and individuals on results and presentations.

STADs group students into teams and subteams as study groups. STADs study groups use four- or five-member teams, subdivided into pairs or trios, to study and master basic skills topics. These are more structured than group investigation teams. Using STADs can support the learning of concepts and rules in areas such as language arts, math, science, social studies, and health (Kauchak & Eggen, 1998). Plan activities by identifying content and skills to be mastered, presentation and practice activities, assignments to groups, improvement points, and group rewards. Prepare worksheets (and answers) that require direct application of the concepts, principles, or rules taught. Create quizzes for each student to parallel the worksheet information but with changes to prevent students from merely memorizing and providing rote responses. Before organizing into groups, teach students "quiet talk" and explain how to use it during discussions. The following are strategies for STADs:

- Organize teams in work spaces and divide each team into two pairs or a trio and a pair.
- Provide one worksheet to each pair or trio and focus attention on the use of the worksheets for studying, so that everyone on the team can explain each item on the worksheet.
- Focus on improvement points from quiz scores so that groups compete against themselves rather than each other and explain the purpose of this process to the students.
- Instruct students to work individually and discuss their problem-solving strategies within each pair and trio.
- During teamwork time, focus on promoting cooperation and providing encouragement and praise.
- Calculate team improvement points from individual scores and give team rewards; improvement can be reflected in individual team grades.

Jigsaw II is more structured and involves group goals, individual accountability, and equal opportunity for success. In Jigsaw II, assignments require individual members to investigate specific areas of expertise and then to return to the group to share results (Kauchak & Eggen, 1998). Jigsaw II strategies are as follows:

- Divide content into roughly equal subtopics and organize them into worksheets or charts. Assign topics in which individuals are expected to obtain expertise and reflect assignments on worksheets.
- Locate and organize resources.
- Divide students into groups for balance of achievement, gender, and cultural background.
- Explain procedures.
- Monitor study activities and make appropriate rescues available.
- Convene groups to discuss and compare information.
- Administer and score quizzes using improvement points.
- Provide feedback on group performance.

Computer Mediation

Computer-mediated communication provides opportunities for access to remote data sources, collaboration on group projects with students in other locations, and sharing of work for evaluation or response by other students (Kauchak & Eggen, 1998). Computer-assisted instruction (CAI) and computer-based instruction (CBI), when combined with regular instruction, “improves students’ attitudes, motivation, and academic achievement” (Crowl et al., 1997, p. 35). The following applications of such computer-mediated communication have been shown to be effective in improving learning of prerequisite and higher order thinking skills:

- practicing inferencing skills and problem-solving strategies (Kauchak & Eggen, 1998);

- skill building in areas such as verbal analogies, logical reasoning, and inductive/deductive thinking (Cotton, 1997); and
- drilling and practicing, which incorporate probes or tests (Crowl et al., 1997).

Summary of Teaching Strategies

Lessons involving higher order thinking skills require particular clarity of communication to reduce ambiguity and confusion and improve student attitudes about thinking tasks. Lesson plans should include modeling of thinking skills, examples of applied thinking, and adaptations for diverse student needs. Scaffolding (giving students support at the beginning of a lesson and gradually requiring students to operate independently) helps students develop higher order learning skills. However, too much or too little support can hinder development.

Useful learning strategies include rehearsal, elaboration, organization, and metacognition. Lessons should be specifically designed to teach specific learning strategies. Direct instruction (teacher-centered presentations of information) should be used sparingly. Presentations should be short (up to five minutes) and coupled with guided practice to teach subskills and knowledge.

Teacher- and/or student-generated questions about dilemmas, novel problems, and novel approaches should elicit answers that have not been learned already.

Sincere feedback providing immediate, specific, and corrective information should inform learners of their progress.

CLASSROOM AND STATEWIDE ASSESSMENT OF HIGHER ORDER THINKING SKILLS

Higher order thinking skills include critical thinking, problem solving, decision making, and creative thinking (Lewis & Smith, 1993). They encompass the skills defined in Bloom's Taxonomy of Educational Objectives (Bloom, 1956); the hierarchy of learning capabilities propounded by Briggs and Wager (1981), Gagné (1985), and Gagné, Briggs, and Wager (1988); and a number of other less well-known conceptualizations. An example is Gubbins' *Matrix of Critical Thinking Skills* (as cited in Legg, 1990), which includes (1) problem solving, (2) decision making, (3) inferences–inductive and deductive reasoning, (4) divergent thinking, (5) evaluative thinking, and (6) philosophy and reasoning.

Assessment methods for measuring higher order thinking include multiple-choice items, multiple-choice items with written justification, constructed response items, performance tests, and portfolios. These methods can be used in both classroom and statewide assessments, but for convenience, consider the two kinds of assessments separately.

Validity and Generalizability of Higher Order Thinking Skills and Dispositions

Assessing the validity of measures of higher order thinking skills is more difficult than assessing those of lower order thinking skills. It is necessary to verify that higher order processes were used in arriving at correct answers. For example, some items (especially multiple-choice) must be answered through the use of higher order thinking by students who have not previously encountered the problems presented. Other students can arrive at correct answers to the same items by calling on prior knowledge. In addition to those related to the influence of prior knowledge, questions concerning the generalizability of higher order skills remain to be answered.

A comprehensive definition of validity was formulated by Messick (1995).

> Validity is an overall evaluative judgment of the degree to which empirical evidence and theoretical rationales support the *adequacy* and *appropriateness of interpretations* and *actions* based on test scores or other modes of assessment (Messick, 1989b). Validity is not a property of the test or assessment as such, but rather of the meaning of the test scores. The scores are a function not only of the items or stimulus conditions, but also of the *persons* responding as well as the *context* of the *assessment*. In particular, what needs to be valid is the meaning or interpretation of the scores as well as any implications for action that this meaning entails (Cronbach, 1971). The extent to which score meaning and action implications hold across persons or population groups and across settings or contexts is a persistent and perennial empirical question. This is the main reason that validity is an evolving property and validation a continuing process. (p. 5)

Norris (1989) considered two questions of importance in determining the validity of tests of critical thinking: "(a) Is critical thinking generalizable? and (b) What is a critical thinking disposition?" (p. 21). He also raised the question of whether critical thinking dispositions are generalizable. Students may have the skills to think critically but may not employ them in testing situations because of other factors such as lack of subject-specific knowledge or their religious or political beliefs.

Generalizability of critical thinking skills has two aspects—epistemological and psychological. Epistemological generalizability holds that there are skills such as inductive reasoning that apply to all subject matter contents. Critics of this point of view argue that each subject matter area has a unique epistemology and that each area has its own set of critical thinking skills. Psychological generalizability presumes that epistemological generalizability exists and that skills acquired in one subject matter can be applied in others.

An important goal of education should be the production of critical thinking dispositions in students.

> Critical thinkers are disposed to seek reasons, try to be well informed, use credible sources and mention them, look for alternatives, consider seriously points of view other than their own, withhold judgment when the evidence and reasons are insufficient, seek as much precision as the subject permits, among other activities. (Norris, 1989, p. 22)

Much of the evidence for generalizability of higher order thinking skills comes from psychological studies of transfer. Perkins and Salomon (1989) summarized a considerable amount of research conducted during the last 30 years that indicated that cognitive (higher order) skills are context bound. However, they pointed out that

> . . . recent research shows that, when general principles of reasoning are taught together with self-monitoring practices and potential applications in varied contexts, transfer often *is* obtained (e.g., Nickerson, et al., 1985).
>
> In summary, recent research and theorizing concerning transfer put the negative findings cited earlier in a different light. These findings do not imply either that people have little ability to accomplish transfer or that skill is almost entirely context bound.

> Rather, the negative results reflect the fact that transfer occurs only under specific conditions, which often are not met in everyday life or laboratory experiments (Brown, Kane, & Long, in press). When the conditions are met, useful transfer occurs. (p. 22)

The work of Perkins and Salomon suggests that instruments can be constructed that are both valid for the measurement of higher order skills and sensitive to instruction.

Lohmann (1993) argued that while intelligence test scores have most often been used as predictors of educational attainment, their most important use may be as measures of educational outcomes. Many studies have shown that intelligence and educational attainment are positively correlated and it is reasonable to conclude that increases in education cause increases in intelligence. “Intelligence tests (particularly the so-called performance variety) often measure something Cattell (1963) and others call fluid ability (Gf). General academic achievement tests, on the other hand, usually measure something Cattell calls crystallized abilities (Gc)” (p. 13). Lohmann pointed out that transfer of old learning to new situations is greater for fluid than for crystallized intelligence. Thus, both kinds of abilities are the products of education, but fluid abilities are more closely akin to higher order thinking skills than crystallized abilities. He cited the results of the Follow-Through Study in which highly structured projects were more successful in producing crystallized abilities than more unstructured ones, while the reverse was true for fluid abilities. Similar results were cited for other investigations.

Haladyna (1997) and Sternberg (1998) adopted much the same view as Lohmann (1993). Haladyna characterized abilities (Gf) as being developed over long periods of time compared to achievement (Gc), which can be developed in a shorter time frame. He defined abilities as “complex combinations of what we have called knowledge and skills, but they also include affective components like motivation and attitude" (p. 14). Examples of abilities are critical thinking, problem solving, and creativity.

Sternberg (1998) conceptualized abilities as being forms of developing expertise. He pointed out that ability tests measure achievement of content that students encountered in previous grades. He viewed abilities as educational outcomes and not as the causes of such outcomes.

> Individual differences in developing expertise result in much the same way they result in most kinds of learning—from (a) rate of learning (which can be caused by amount of direct instruction received, amount of problem solving done, amount of time and effort spent in thinking about problems, and so on) and from (b) asymptote of learning (which can be caused by differences in numbers of schemas, organization of schemas, efficiency in using schemas, and so on; see Atkinson, Bower, & Crothers, 1965). (p. 14)

Peterson (1986) employed a real-life problem in each of 3 academic content domains (social sciences and humanities, social sciences and natural sciences, and social sciences and psychology) crossed with 6 generic problem-solving skills (decision making, communication, analysis, synthesis, valuing, and execution) to conduct a multitrait-multimethod study of the structure of these 18 skill/task observations. Subjects were university students: lower level, 20; upper level, 26; and graduate level, 16. Confirmatory factor analysis was used to evaluate a model that contained a general second-order factor, 6 skill factors, and 3 subject content factors. This model provided a moderately good fit to the data, but most of the common variance was accounted for by the general factor. A model containing only skill and subject matter factors did not provide a good fit. Peterson concluded that a general reasoning test, a vocabulary test, or a general knowledge test would provide as much information as a test of generic problem-solving skills. However, he pointed out that because all variables were measured by written responses, a general writing ability could have inflated the influence of the general problem-solving factor.

Whimbey (1985) reported correlations of three reasoning tests (the *Cornell Critical Thinking Test*, the *Whimbey Analytical Skills Inventory,* and the *New Jersey Test of Reasoning*), with achievement scores from the New Jersey College Basic Skills Placement Test (NJCBSPT).

NJCBSPT Achievement	**Cornell**	**Whimbey**	**NJ Reasoning**
Reading Comprehension	.68	.76	.82
Sentence Sense	.62	.75	.81
Computation	.49	.76	..67
Elementary Algebra	.40	.70	.59
Essay	.44	.56	.69

Correlations of achievement with the Cornell test were lower than with the other two tests, perhaps because it measures some special ability or possibly because of its low reliability (reported to be below .70). Whimbey concluded that special tests of higher order abilities are unnecessary because they have so much overlap with achievement tests. "There are numerous time-proven, standardized academic aptitude and achievement tests, such as the Degrees of Reading Power, California Achievement Tests, Differential Aptitude Tests, and the Scholastic Aptitude Test, which are practical indicators of students' analytical skills" (p. 39).

Kosonen and Winne (1995) studied the effects of teaching statistical laws of reasoning in two experiments with college undergraduates and one with 7th- and 10th-grade students. Students were taught abstract rules of probability and asked to apply them to everyday problems. Statistical results in all three experiments indicated that the posttest means of instructed students were significantly higher than those of the control students. Standardized treatment effect sizes were all above .5 and most were above 1.0 (one standard deviation larger). With respect to the question of whether formal statistical rules are domain-specific, the authors state

> A larger claim that statistical reasoning transfers or generalizes across domains is more difficult to support because the definition of domain is unclear. Students in our studies addressed problems that ranged over various everyday activities including hiring people with particular qualifications, conducting a survey of attitudes, playing a recreational board game, choosing restaurants with good food, judging people's nature on the basis of brief social interactions, generating a marketing strategy on the basis of business competitors' profits, monitoring equipment in a fast-food restaurant, predicting a child's aptitude for sports, and so forth. We believe that these topics represent a broad spectrum of domains and, on this interpretation, we conclude that our and other studies demonstrate that students who receive effective instruction in abstract, formal rules of reasoning can transfer those rules across domains. (pp. 44–45)

The psychometric generalizability of performance tasks was studied by Shavelson, Baxter, and Gao (1993). They used one data set in elementary science and two in math to study the effects of different tasks, methods of measurement, and raters on the assessment scores of elementary students obtained from the same subject matter domain. They found that the greatest inconsistency in student scores was due to task variability. Depending on the data set, they estimated that in order to reach acceptable levels of generalizability, between 8 and 23 tasks would be required. They also found that student performance was dependent, in part, on different methods (expert observation, student notebooks, computer simulation, and short answer questions) of measuring student performance in the same subject matter content.

Linn (1994) also studied the psychometric generalizability of performance tasks in math at grades 4 and 8. Twelve tasks were used at the 4th-grade level and 16 at the 8th-grade level. Tasks were administered to students in “bundles” of 2 to 4 tasks. Administration times for bundles ranged from 4 to 6 hours. Linn's results were in agreement with those of Shavelson et al. (1993). Approximately 15 tasks or more, depending on the grade level and data set, would be required to achieve an acceptable level of generalizability.

Published Measures of Higher Order Thinking Skills

Ennis (1993) listed 7 possible purposes for which published tests of critical thinking may be used. These purposes are listed as follows:

1. Diagnosing the levels of students’ critical thinking.
2. Giving students feedback about their critical thinking prowess.
3. Motivating students to be better at critical thinking.
4. Informing teachers about the success of their efforts to teach students to think critically.
5. Doing research about critical thinking instructional questions and issues.
6. Providing help in deciding whether a student should enter an educational program.
7. Providing information for holding schools accountable for the critical thinking prowess of their students.

(pp. 180–181)

Ennis suggested that published tests could be used for the first 5 purposes but not the last 2 because they are not comprehensive in their coverage of critical thinking skills and they are not secure. He listed 10 published tests that measure a variety of skills and 4 that measure only one aspect of critical thinking. He provided no validity or reliability information for these tests but suggested that potential users should take and score tests under consideration and examine their contents before selecting them for any of the first 5 purposes listed above. A list of these tests is provided in Appendix B.

The *California Critical Thinking Skills Test* (CCTST) is based on a definition of critical thinking skills identified as a result of a two-year Delphi study conducted by the American Philosophical Association (Facione, P., 1990a). It consists of two forms, each containing multiple-choice questions that measure five subskills (analysis, evaluation, inference, deductive reasoning, and inductive reasoning) and an overall critical thinking score. Internal consistency reliabilities for the total scores of Forms A and B were reported to be .70 and .71 respectively (Facione, P., cited in Jacobs, 1994). Jacobs's study yielded total score alpha reliabilities of .56 and .59 for Forms A and B, respectively. Subscore reliabilities ranged from .04 to .53. Facione and Facione (1994) reported results of a quasi-experimental validation study of college students who were enrolled in a critical thinking course and control students who had not fulfilled that requirement. Significant pre- and postcourse gains were reported for the experimental students but not for controls. Significant pretest correlations were found between the CCTST and SAT Verbal (.550), SAT Math (.439), Nelson-Denny Reading (.491), and college grade point average (.200). These results were also reported by Facione (1991).

The *California Critical Thinking Disposition Inventory* (CCTDI) (Facione, Sanchez, Facione, & Gainen, 1995) is a 75-Likert item measure derived from the American Philosophical

Association study (Facione, P., 1990a). It produces several scale scores and a total score. The scales are "discipline neutral" (i.e., they can be used in liberal arts, sciences, and professional disciplines). Descriptions of scales follow (italics theirs).

- The *Inquisitiveness* scale on the CCTDI *measures one's intellectual curiosity, and one's desire for learning even when the application of the knowledge is not readily apparent*.
- The *Open-mindedness scale addresses being tolerant of divergent views and sensitive to the possibility of one's own bias.*

(Facione, Sanchez, Facione, & Gainen, 1995, p. 6)

- The *Systematicity* scale measures *being organized, orderly, focused, and diligent in inquiry*.
- The *Analyticity* scale targets *prizing the application of reasoning and the use of evidence to resolve problems, anticipating potential conceptual or practical difficulties, and consistently being alert to the need to intervene*.

(p. 7)

- The *Truth-seeking* scale targets the disposition of *being eager to seek the best knowledge in a given context, courageous about asking questions, and honest and objective about pursuing inquiry even if the findings do not support one's self-interests or one's preconceived opinions*.

- The CT *Self-Confidence* scale measures the trust one places in one's own reasoning processes. CT *self-confidence allows one to trust the soundness of one's own reasoned judgments and to lead others in the rational resolution of problems*.

(p. 8)

- The *Maturity* scale targets the disposition to be judicious in one's decision making. The CT-mature person can be characterized as one who *approaches problems, inquiry, and decision making with a sense that some problems are necessarily ill-structured, some situations admit of more than one plausible option, and many times judgments must be made based on standards, contexts, and evidence which preclude certainty.*

(p. 9)

Internal consistency reliabilities for the seven scales were reported to be between .71 to .81. The reliability for the total score was .91. In separate studies, correlations between the CCTDI and the CCTST were .67 for 20 highly motivated college students, .21 for 106 nursing students, .38 for 238 high school students, and .14 for 191 native Spanish-speaking high school students.

The *Ennis-Weir Critical Thinking Essay Test* was used by Davidson and Dunham (1996) to assess the effectiveness of a yearlong instructional program in intensive English with Japanese students. Treatment students (n = 17) received training in critical thinking skills while control students (n = 19) received only intensive English instruction. Total scores on the test can range from -9 to +29. The mean of the treatment students was 6.6, which was significantly higher ($p < .001$) than the 0.06 mean of the control students.

Reed and Palumbo (1987, 1988a) and Reed, Palumbo, and Stolar (1987, 1988b) used sections of the *Ross Test of Higher Cognitive Processes* (*Analysis of Relevant and Irrelevant Information* and *Analysis of Attributes*) and sections of the *Watson-Glaser Critical Thinking Appraisal* (*Deduction* and *Interpretation*) as pre- and posttests to evaluate the effects of computer programming instruction on problem-solving ability. The first investigation involved 23 college students who were given 81 hours of instruction in BASIC over an 8-week period. Significant pre- and postdifferences (pretest mean = 44.00, *SD* = 8.22; posttest mean = 45.65, *SD* = 7.74) were found. A significant reduction in computer anxiety was also found. The second investigation involved 21 college students enrolled in a BASIC programming course and 8 students in a Logo class. Statistically significant gains were found for both the Logo and BASIC groups. For the Logo group, the pretest mean was 43.75, *SD* = 9.74; the posttest mean was 46.63, *SD* = 10.25. In the BASIC group, the pretest mean was 45.40, *SD* = 6.13; the posttest mean was 47.15, *SD* = 5.39. No differences were found between the 2 groups. Failure to include control groups in these studies makes it impossible to rule out effects due to testing. However, the authors of the first study interviewed randomly selected students to determine whether or not they could recall, at posttest time, the exact answers they had given on the pretest. In all cases, students indicated that they could not recall previous answers.

Gadzella et al. (1996) reported results of a 14-week study in which college students were pre-tested with Form A of the Watson-Glaser, received instruction in critical thinking skills and in analyzing critical thinking examples, and were posttested with Form B of the Watson-Glaser. Significant pre- and posttest differences were found for the total score and 2 of the subscores (Interpretations and Evaluation of Arguments) but not for the 3 other subscores (Inference, Recognition, and Deductions). Pre- and posttest means and standard deviations were 47.69, 10.03 and 51.00, 7.88, respectively.

Item/Test Formats

Higher order thinking skills can be measured by a variety of item and test formats. Sugrue (1994, 1995) integrated information from three research-based, domain-specific problem-solving models and identified three response formats for measuring higher order thinking skills: (1) selection (multiple-choice, matching), (2) generation (short answer, essay, performance), and (3) explanation (giving reasons for selection or generation of a response).

Multiple-Choice Items

Prominent investigators of critical thinking have endorsed the use of the multiple-choice format in measuring at least some higher order skills. Paul and Nosich (1992) recommended the use of multiple-choice, multiple-rating, and short-essay items in constructing an instrument for the national assessment of higher order thinking. Multiple-choice items could be used for assessing “micro-dimensional critical thinking skills, like identifying the most plausible assumption, recognizing an author's purpose, selecting the most defensible inferences, and such like” (p. 7).

Facione (1989), Norris (1989), and Ennis (1993) all recognized that subjects can select keyed responses to multiple-choice items for the wrong reasons and distractors can be chosen for valid reasons. Facione (1989) and Norris (1989) recommended that a think-aloud procedure be employed to investigate the construct validity of multiple-choice items during test construction. Subjects are asked to tell what they are thinking as they select their answers. When correct responses were chosen through faulty thinking or incorrect responses through valid thinking, items could be modified or discarded. Norris and King (1984) used this methodology in constructing the *Test on Appraising Observations.*

Simpson and Cohen (1985) used a think-aloud procedure in connection with item analytic data to demonstrate the validity of multiple-choice items categorized as knowledge or thinking items based on Bloom's taxonomy. A medical pathology course was the context for their procedure.

Ennis (1993) suggested that answer justification be incorporated into the actual test. Subjects would be asked to select correct responses and then to provide written justifications for their choices. An advantage of this procedure is that subjects could be given credit for nonkeyed responses if they provided adequate justification. Answer justification for higher order thinking items was first recommended by Bloom (1956), who cast both item and justification in multiple-choice format.

Hancock (1994) cited a number of empirical studies in which multiple-choice and constructed-response tests measured the same higher order skills. He constructed multiple-choice and constructed-response items to measure the knowledge, comprehension, application, and analysis skills of undergraduate and graduate students in introductory educational measurement and research statistics courses. His findings indicated that the two-item formats were generally comparable for all four skill levels.

Killoran (1992) illustrated a variety of ways that multiple-choice items can be used to assess both lower and higher order thinking skills in social studies. Standard multiple-choice items can be developed to measure (1) recognition of important terms and persons, (2) comparisons and contrasts, (3) cause and effect, (4) generalizations, (5) chronology, and (6) special item types, such as fact and opinion and use of sources. Data-based questions, including maps, tables, outlines, cartoons, etc., can measure (1) comprehension, (2) explanation, (3) conclusion or generalization, and (4) prediction (pp. 106–107). Examples of stems for constructing items are given in Appendix B.

Writing Test Items to Evaluate Higher Order Thinking Skills (Haladyna, 1997) is an important resource for teachers who want to construct items for measuring higher order skills. The book gives instructions on how to write and score multiple-choice and constructed-response items, performance tasks, and portfolios in three domains—cognitive, affective, and psychomotor. Procedures for item review and statistical analysis of item responses are presented.

Performance Tests

Performance tests, including hands-on tasks (e.g., laboratory problems), essays, short-answer constructed-response measures, and portfolios, have been widely recommended for measuring higher order thinking skills. They have been proposed as replacements for multiple-choice tests (Shepard, 1989; Wiggins, 1989, 1993), which have been criticized as placing "too much emphasis on factual knowledge and on the application of procedures to solve well-structured, decontextualized problems" (Linn, Baker, & Dunbar, 1991, p. 19). With few exceptions (e.g., the *Ennis-Weir Critical Thinking Essay Test*), performance tests are domain-specific measures. They can be "authentic" in that they can be highly related to instruction and serve as good examples of teaching procedures. They can deal with complex, real-life problems that require students to employ several higher order skills in their solution. They can generate student interest and motivation.

Performance tests also have limitations. They can be costly and time consuming and they can lack generalizability (Linn, Baker, & Dunbar, 1991; Shavelson, Baxter, & Gao, 1993;

Shavelson, Baxter, & Pine, 1992). In addition, Facione (1990) noted that the application of many critical thinking subskills, particularly inference and evaluation, may not be apparent in the final version of an essay or report.

> By its very nature the essay omits claims considered and judged irrelevant, arguments evaluated as not of sufficient significance to the issues at hand to warrant mention, evidence queried but not used in the final form of the essay, alternatives conjectured but ultimately abandoned, and conclusions drawn but ultimately reconsidered and disregarded. (p. 7)

Newmann (1990) constructed an essay test of higher order thinking skills in social studies that required students to write persuasively about constitutional issues. Its purpose was to assess students' interpretation, analysis, and use of knowledge in the social sciences rather than to measure "discrete thinking skills such as hypothesis testing or evaluating the reliability of sources" (p. 369). It was designed to permit "comparisons of students over time, and between teachers, schools, districts, and states" (p. 369). The task consisted of (1) a two-page narrative, which described a court case involving the search of a student's purse and locker by a high school principal who suspected her of smoking and selling marijuana, (2) background information on constitutional rights, and (3) instructions for responding. Each essay was assigned one of five scores: (1) unsatisfactory, (2) minimal, (3) adequate, (4) elaborated, or (5) exemplary. The narrative, background, instructions, and scoring criteria are presented in Appendix B. The test was used in

> fifty-one classrooms of thirty-eight teachers of the diverse social studies subjects in grades 9–12 in seven high schools. Although the classes covered U.S. history, world

> history, politics, sociology, economics, etc., we tested all students on the constitutional exercise. In spite of the fact that none of the classes focused teaching on this particular civic competence, we found that teachers' promotion of thinking in their daily lessons, regardless of the subject taught, had a strong positive relationship to students' persuasive writing on the constitutional issue, even after controlling for student writing ability and general social studies knowledge. (p. 370)

Newmann (1990) concluded that the exercise requires higher order thinking and understanding of relevant content. Success on the test is related to the extent to which higher order thinking is stressed in the classroom.

Enright and Beattie (1992) developed a five-step model called SOLVE for assessing critical thinking skills in mathematics. The five steps are Study the Problem (S), Organize the Data (O), Line Up a Plan (L), Verify the Plan (V), and Evaluate the Match (E).

Portfolios

Portfolios are collections of student assignments and projects (essays, performance tasks, etc.), which are gathered over an extended period of time, usually one academic year. Depending on its purpose, the portfolio may also contain teacher evaluations, standardized test scores, and student reflections on their accomplishments. Portfolios that are intended to demonstrate growth and proficiency are often limited to single subject matter areas. Lankes (1995) cited an example of one school at which students were required to complete 14 portfolios in various content areas. However, portfolios may also contain real-world assignments that cut across many subject areas and allow students the opportunity to employ higher order skills in completing them. Portfolio performances are different from the performance tasks cited above in that they may occur over long periods of time and may be revised by students as a result of teacher input or self-reflection. Disadvantages of portfolios for formal assessment include high costs of scoring (McRobbie, 1992) and questions about the authorship of portfolio entries (Gearhart, Herman, Baker, & Whittaker, 1993).

Haladyna (1997) provided a template to aid teachers in designing an evaluation portfolio. It should contain (1) a table of contents; (2) a provision for a reflective letter that allows the student to summarize his or her successes, frustrations, insights, feelings, etc.; (3) the specific tasks to be accomplished and evaluated; (4) the page limit; (5) the extent of collaboration allowed with other students; (6) a statement of the permissibility of editorial assistance; (7) an indication of whether or not an appendix containing preliminary drafts, etc., is required; and (8) grading criteria (the scoring rubric) that make the student aware of how points will be assigned to the various sections of the portfolio.

Classroom Assessment of Higher Order Thinking Skills

Stiggins, Griswold, and Wikelund (1989) summarized a number of studies, which suggest that assessments based on teacher observation and judgment and teacher-made tests are not generally of high quality and that teacher assessment of higher order thinking skills is rare. Few items written by teachers measure skills above the three Bloom taxonomy levels of knowledge, comprehension, and application and a high percentage of them are recall (knowledge) items. Stiggins et al. studied the assessment practices (use of oral and test questions) of 36 teachers who taught mathematics, science, social studies, and language arts at grade levels 1 to 12. Excluding math items, over one-half of the test questions at all grade levels were recall measures (55%) followed by inference (19%), analysis (16%), comparison (5%), and evaluation (5%). In math, 72% of the questions measured inference, 19% measured recall, and 9% measured comparison. Oral questions followed the same pattern, with slightly less than half of them measuring recall. Teachers who had received training in teaching and/or testing higher order thinking skills tended to use fewer recall questions than teachers who had no training.

More recently, Bol and Strage (1993) studied the relationships between the instructional goals and the assessment practices of 10 high school biology teachers. Individual interviews with the teachers indicated that they wanted students to acquire an understanding and appreciation of biology and its real-world applications. They also stressed the importance of having students develop higher order thinking skills (distinguishing important from unimportant information, integration and interpretation of information, critical thinking and problem solving, and time and effort management). Examination of test items used by the teachers revealed that more than half required only factual information and almost none required application skills.

Assessment Models

Baker, Aschbacher, Niemi, and Sato

Baker, Aschbacher, Niemi, and Sato (1992) developed a performance-based model for assessment of student understanding of subject matter content. They suggested that it may assist others who need to develop similar measures. They illustrated the model through the development of instruments on the Civil War era of U.S. history and the analysis of an unknown substance in chemistry. The history writing prompt used in the example is given in Appendix B. A major purpose of the model is to generate tasks that are comparable by design rather than by statistical equating. The structure of the measures and the production of scoring rubrics are thought to reduce variability from topic to topic. The model consists of four assessment components:

- a prior knowledge measure, which assesses (and activates) students' general and topic-relevant knowledge;
- provision of primary source materials (text), that is, new information in written text for students to read;
- a writing task in which students integrate prior and new knowledge to explain subject matter issues in response to a contextualized prompt; and
- the scoring rubric for the writing task.

(p. 7)

The prior knowledge measure consisted of 20 short-answer constructed-response items. They measured basic concepts, principles, and background knowledge related to the task. In the history example, items included “states rights” and the “Kansas-Nebraska Act.”

Text materials are primary sources that students must use in responding to the prompt. In the example, the texts used were the speeches of Abraham Lincoln and Stephen Douglas. The writing task was an essay written in one class period by a student who had no help from peers, parents, or teachers. The task could be modified to extend over longer periods of time and include collaboration with others.

The essay scoring rubric consists of six dimensions, a General Impression of Content Quality scale that focuses on the overall quality of the content understanding, and five analytic scales, which are listed as follows.

- prior knowledge (facts, information, and events outside the provided texts used to elaborate positions)
- number of principles or concepts (number and depth of description of principles)
- argumentation (quality of the argument, its logic and integration of elements)
- text (use of information from the text for elaboration)
- misconceptions (number and scope of misunderstandings in interpretation of the text and historical period)

(pp. 4–5)

Students are allowed 15 minutes to respond to the prior knowledge items, 25 minutes to read primary sources, and 50 minutes to read the prompt and write the essay.

Baker et al. (1992) provided detailed specifications for developing assessments (prior knowledge test, essay task, and text materials) and for rater training, scoring, and reporting. They also provided samples of training materials and student responses at different performance levels.

Sugrue

Sugrue's (1994, 1995) problem-solving model contains three major interacting components: knowledge structures, cognitive functions, and beliefs about oneself. For good problem solvers, knowledge structures are well organized. Concepts and principles are integrated and linked to applications by conditions and procedures.

Concepts are categories of things, people, events, etc., that are similar with regard to some important attributes. They share the same name. According to studies by de Kleer and Brown, Genter and Stevens, Glaser, and Merrill (as cited in Sugrue, 1994),

> A principal is defined as a rule, law, formula, or if-then statement that characterized the relationship (often causal) between two or more concepts. Principals can be used to interpret problems, to guide actions, to troubleshoot systems, to explain why something happened, or to predict the effects a change in some concept(s) will have on other concepts as reported in studies by de Kleer and Brown, Gentner and Stevens, Glaser, and Merrill. (p. 9)
>
> Procedures and conditions are links from concepts and principles to applications.
>
> A procedure is a set of steps that can be carried out to achieve some goal. Conditions are aspects of the environment that indicate the existence of an instance of a concept, or that indicate that a principle is operating or might be applied, or that a particular procedure is appropriate. Good problem solvers should be able to recognize situations where a principle is operating; they should also be able to recognize situations where procedures can be performed to identify or generate instances of a concept; and they should be able to carry out those procedures accurately. Good problem solvers should be able to assemble a procedure based on a principle to engineer a desired outcome in an unfamiliar situation. (p. 10)

The cognitive functions assessed by the model are planning and monitoring. Planning consists of laying out the steps to be followed in solving the problem. Monitoring refers to being aware of different parts of one's performance, including time spent and time available, progress toward the solution of the problem, and changes in tactics when necessary.

Three beliefs about oneself and the task are important in problem-solving assessment. Perceived self-efficacy (PSE) refers to the student's assessment of his or her ability to solve the problem. Perceived demands of the task (PDT) involves the student's belief about the difficulty of the task. Perceived attraction of the task (PAT) refers to the student's interest and motivation in completing the task. Assessment of these beliefs is necessary to complete a profile of problem-solving performance.

Sugrue (1994, 1995) recommended that multiple item formats for measuring multiple aspects of the content domain to which the task belongs be used to assess problem solving. Tasks presented to students should not be ones they have encountered previously. A student profile based on multiple formats and multiple aspects could help determine the extent to which the overall assessment is novel for individual students.

Content Analysis

A content analysis is a major requirement for developing an assessment. The Overview Content Analysis Form that follows was developed by Sugrue (1994) and completed for problem solving in solution chemistry.

OVERVIEW CONTENT ANALYSIS FORM

Content/topic area:

solution chemistry

Important concepts (names only):

solution; solute; solvent; concentration; evaporation; density; buoyancy; temperature; boiling point; freezing point

Procedures/techniques/tests for identifying instances of the concepts (names only):

Tyndall test; use balance to measure mass per unit volume (density); buoyancy test; glass tube test; use of heat and thermometer to find boiling points of the liquids; evaporation

Procedures/techniques for generating instances of the concepts (names only):

stirring; heating; plus procedures for identifying/checking that the product is, in fact, an instance of the concept

Principles that link any of these concepts (brief statements):

The greater the concentration of a solution, the lower its freezing point.

The greater the concentration of a solution, the higher its boiling point.

The greater the concentration of a solution, the greater its density.

The greater the concentration of a solution, the greater its buoyancy.

The higher the boiling point of a solution, the lower its freezing point.

Procedures/techniques for applying any of these principles (names only):

same as for identifying and generating instances of concepts (goal would be to change state of one concept by manipulating another; therefore, one would need to test for changes in concentration, buoyancy, etc.)

(p. 26)

Sugrue (1994) provided sample multiple-choice, open-ended, and hands-on items for solution chemistry. They are presented in Appendix B.

The Mid-Continent Regional Educational Laboratory

The Mid-Continent Regional Educational Laboratory (McREL) authentic assessment model (Marzano et al., 1992) is organized around 14 complex reasoning processes within 6 general competencies. The competencies are listed below.

1. Knowledge of concepts, generalizations, processes, and strategies that are considered critical to specific content areas.
2. Ability to utilize complex reasoning processes.
3. Ability to gather and utilize information from a variety of sources in a variety of modes.
4. Ability to communicate effectively through a variety of products.
5. Ability to regulate one's own learning and development.
6. Ability to work in a cooperative/collaborative manner.

(p. 4)

A number of subcompetencies are contained within each competency. The 14 complex reasoning processes and questions that students could ask in relation to them are as follows.

Comparing:	How are these alike? How are they different?
Classifying:	What groups can I put things into? What are the rules governing membership in these groups?
Structural Analysis:	What is the main idea or what is the most important information? What is the dominant pattern? What are the supporting patterns? What are the supporting pieces? How are the pieces related?

Supported Induction:	What conclusions/generalizations can you draw from this and what is the support for these conclusions? What is the probability for this and what is the support for that conclusion?
Supported Deduction:	What has to be true given the validity of this principle? What is the proof that this must be true?
Error Analysis:	What’s wrong with this? What are specific errors that have been made? How can it be fixed?
Constructing Support:	What is the support for this argument? What are the limitations of this argument?
Extending:	What's the general pattern of information here? Where else does this apply? How can the information be represented in another way (graphically, symbolically)?
Decision Making:	What/whom would be the best or worst? Which one has the most or least?
Investigation:	What are the defining characteristics (definitive)? Why/how did this happen (historical)? What would/would have happen/ed if (projective)?
Systems Analysis:	How does this operate? What are the relationships among components? What effect does one part have on another?
Problem Solving:	How can I overcome this obstacle? Given these conditions, what can I expect the answer to be?

Experimental Inquiry: What do I observe? How can I explain it? What can I predict from it?

Invention: How can this be improved? What new thing is needed here?

(pp. 36–37)

Although the competencies and reasoning processes apply to all subject matters, Marzano et al. (1992) emphasize that they always apply to domain-specific content. It is important that students acquire sufficient declarative knowledge (e.g., concepts and facts) and procedural knowledge (e.g., strategies and algorithms) within a specific content domain before they can be expected to engage in the complex reasoning processes that may be required by performance measures. They provide details for (1) constructing authentic classroom tasks and examples of them, (2) securing tasks to maximize reliability for districtwide or state-level assessment, and (3) generalizing rubrics for rating declarative and procedural knowledge and complex reasoning skills. Examples of classroom tasks for supported deduction, error analysis, and constructing support for elementary students are given in Appendix B.

The Advanced International Certificate of Education

The Advanced International Certificate of Education (AICE) (University of Cambridge, Local Examinations Syndicate, 1997a) is an assessment model for college-bound students who are 18 years of age or older. Schools that fully participate in the program offer courses in 3 broad areas: mathematics and sciences (9 courses), languages (8 courses), and arts and humanities (9 courses). To receive an AICE certificate, students must take examinations in at least 5 courses (all courses include critical thinking and other higher order thinking skills). One course from each broad subject area must be included. Assessment requirements for each course typically include some combination of externally scored examinations and school-based assessments, which can include essays, performance tests, and portfolios. Successful students may receive college credit or be eligible for advanced courses at many colleges and universities.

As an example, the assessment objectives of the AICE course in economics (University of Cambridge, Local Examinations Syndicate, n.d.) cover all levels of Bloom's taxonomy. The curriculum on which the assessments are based include

- resources and the economic problem (factors of production and scarcity, choice and opportunity cost);
- allocative mechanisms (market system, command economy, mixed economy);
- the circular flow of national income (the circular flow model, consumption and saving, economic fluctuations);
- specialization, trade, and exchange (the open economy: trade and exchange);
- international trade (protection, commodity agreements, exchange rates, international monetary system, balance of payments, multinational companies);
- economic development (living standards, developing economies); and
- policy objectives and instruments (full employment, price stability, economic growth).

(pp. 4–6)

A sample of test items (University of Cambridge, Local Examinations Syndicate, 1997b) from the externally scored 1997 economics examination are given in Appendix B.

The International Baccalaureate Diploma Program

The International Baccalaureate (IB) Diploma Program (International Baccalaureate North America, n.d.) is a curriculum and assessment model for high schools. Students will acquire knowledge in the areas of language, literature, mathematics, science, and social studies with particular recognition and emphasis on the interrelatedness of the various disciplines by

- developing a proficiency in the communication skills of reading, writing, and speaking and listening;
- developing a proficiency in the process of calculating, problem solving, observing, measuring, and estimating;
- developing a proficiency in the intellectual skills of analysis, synthesis, induction, deduction, and critical and aesthetic judgment; and
- developing the skills and attitudes that contribute to intelligent and productive participation in the economic system as well as developing an appreciation for both unique and common characteristics of other individuals and cultures.

(Escambia County School District, n.d., p. 4)

The curriculum and examinations consist of six subject matter areas, a special course entitled Theory of Knowledge, the Creative Action and Service project, and an extended essay. The six subject matter areas are (1) Language A1, the student's native or strongest language; (2) Language A2, a second modern language; (3) Individuals and Societies, social studies, philosophy, business, etc.; (4) Experimental Sciences; (5) Mathematics; and (6) the Arts and Electives. The Theory of Knowledge course is taken by students in their senior year to help them integrate the knowledge, skills, and understandings attained from all their IB course work. The

Creative Action and Service project can emphasize sports, theater, community service, or other extracurricular activities. The extended essay “offers the opportunity to investigate a topic of special interest and acquaints students with the kind of independent research and writing skills expected at a university” (p. 12).

Both internal and external assessments are made of a student’s course work. Teacher assessments (internal) can make up to 20% of a student’s grade.

The IB program is offered by a number of Florida high schools. IB graduates are eligible for advanced placement or course credit at a large number of American universities.

Statewide Assessment Models of Higher Order Thinking Skills

Sternberg

Sternberg and Baron (1985) indicated that the measurement of students’ thinking abilities should be accompanied by a curriculum that included thinking skills instruction. He concluded that collaboration by state department personnel, cognitive psychologists, and testing organizations provided a good model for future efforts to develop statewide assessment of higher order thinking skills. Examples of items from the fourth-grade Connecticut test are given in Appendix B.

Paul and Nosich

Paul and Nosich (1992) were commissioned by the U.S. Department of Education and the National Center of Educational Statistics to develop a model for the national assessment of higher order thinking. Their report (a) identified 21 criteria for higher order skills testing, (b) developed a concept of critical thinking that meets these criteria, (c) identified 4 domains of critical thinking, and (d) recommended ways to measure the 4 kinds of critical thinking skills.

The 21 criteria are given as answers to the following questions (italics theirs):

1. *Can it be used for information processing skills?*
2. *Can it be used to test flexible skills and abilities that can be used in a wide variety of subjects, situations, contexts, and educational levels?*
3. *Can it account for important differences among the subject areas?*
4. *Can it be used to focus on fundamental abilities fitted to the accelerating pace of change and embedded in intellectual history?*
5. *Can it be used to improve instruction?*
6. *Can it make clear the interconnectedness of our knowledge and abilities, and why expertise in one area cannot be divorced either from findings in other area or from a sensitivity to the need for interdisciplinary integration?*
7. *Can it be used to assess those versatile and fundamental skills essential to being a responsible, decision-making member of the workplace?*
8. *Can it generate clear concepts and well thought-out, rationally articulated goals, criteria and standards?*
9. *Can it account for the integration of adult-level communication skills, problem-solving, and critical thinking, and legitimately assess all of them without compromising essential features of any of them?*
10. *Does it respect cultural diversity by focusing on the common-core skills, abilities and traits useful in all cultures?*

11. *Does it test for thinking that promotes (to quote the September 1991* Kappan*) "the active engagement of students in constructing their own knowledge and understanding?"*

12. *Does it concentrate on assessing the fundamental cognitive structures of communication?*

13. *Can it be used to assess the central features of making rational decisions as a citizen, a consumer, and a part of a world economy?*

14. *Can it avoid reducing a complex whole to oversimplified parts?*

15. *Can it articulate what is central to basic skills for the future?*

16. *Can it provide the kind of skills that are seen as valuable outside the school as well as inside it?*

17 and 18. *Can critical thinking be assessed in a way that requires evaluation of authentic problems in realistic contexts where the abilities assessed include those of formulating the problem and initial screening of plausible solutions?*

19. *Can critical thinking be assessed nationally in a way that is financially affordable?*

20 and 21. *Can critical thinking be assessed so as to gauge the improvement of students over the course of their education and to measure the achievement of students against national standards?*

(pp. 5–8)

Paul and Nosich (1992) proposed an assessment that could meet the criteria implied by the 21 questions. It would consist of multiple-choice, multiple-rating, and essay items. Multiple-choice items are limited to reasoning skills such as recognition of assumptions, inferences, and detection of faculty reasoning. Some abbreviated examples are given in Appendix B.

Paul and Nosich (1992) proposed that a higher order skills examination be composed of both interdisciplinary and subject-specific items. The interdisciplinary items would be constructed by experts in the field of critical thinking, who would collaborate with subject matter experts on the subject-specific items. Students would choose the subject matter area in which they would be examined. All students at grades 6, 9, and 12 would take the objective parts of the exam. For economic reasons, the essay assessment would be administered only to representative samples of the student populations.

The Florida Department of Education

The Florida Department of Education (1997a–g) created the Florida Comprehensive Assessment Test (FCAT), which measures achievement in mathematics at grades 5, 8, and 10 and reading at grades 4, 8, and 10. Both mathematics and reading contain items at two cognitive levels based on Bloom's taxonomy. Level I items are intended to measure knowledge, comprehension, and application, where application is similar to that encountered in the classroom. Level II items are intended to measure application, analysis, synthesis, and evaluation, where application is unique to the situation described in the item. Level II items comprise 50%, 60%, and 70% of the 4th-, 8th-, and 10th-grade reading exams, respectively. They make up 50%, 60%, and 65% of the mathematics exam for the three grades. The mathematics assessment contains multiple-choice, gridded response, short response, and extended response items. The reading assessment contains multiple-choice, short response, and extended response items. The Sunshine State Standards define the content knowledge and skills for item development in both reading and mathematics. Higher order thinking skills are required by many test items as specified by Standard 4 of Goal 3 of Blueprint 2000: “Florida students use creative thinking skills to generate new ideas, make the best decision, recognize and solve problems through reasoning, interpret symbolic data, and develop efficient techniques for lifelong learning” (Florida Department of Education, 1997d, p. 5).

A separate assessment, *Florida Writes!* (Florida Department of Education, 1996), is administered in grades 4, 8, and 10. *Florida Writes!* is a holistically scored direct writing measure in which students at grade 4 write on narrative or expository topics, and students at grades 8 and 10 write on expository or persuasive topics. Scoring is based on focus, organization, support, and use conventions. Examples of mathematics, reading items, writing prompts, and rubrics may be obtained from the Florida Department of Education.

Pennsylvania Department of Education

In 1997, the Pennsylvania Department of Education (1997a) began to employ statewide mathematics tests at grades 5, 8, and 11 that contain both open-ended (performance) tasks and enhanced multiple-choice questions. Open-ended tasks

> require students to read a problem or task description and to write out their answers. Major components of such answers are both students' clear presentations of their computations and their explanations of the steps they followed in solving the problem. The types of tasks utilized do not always require solving a problem involving computations (p. 3).

Enhanced multiple-choice questions generally involve higher order thinking skills and refer to situations in real life or the classroom, give information to the teacher about the processes involved in problem solutions, and integrate process and knowledge. The five content areas involved in the test are (1) number sense, properties, and operations; (2) measurement; (3) geometry; (4) data analysis, statistics, and probability; and (5) algebra and functions. A general rubric is used for scoring open-ended tasks. The five-point rubric contains levels ranging from "Advanced Understanding" to "Excellent" to "Incorrect Response." Detailed scoring explanations and sample student responses are provided. The intermediate levels can accept incorrect answers if the student provides the necessary information for solving the problem. Sample enhanced multiple-choice and open-ended tasks for each grade level are shown in Appendix B.

Pennsylvania also administers a direct writing assessment to students in grades 6 and 9 (Pennsylvania Department of Education, 1997b). Three kinds of writing are assessed:

1. narrative/imaginative, which encourages creativity and speculation;
2. informational, whose function is "to present information through reporting, explaining, directing, summarizing and defining; to organize and analyze information through explaining, comparing, contrasting, and relaying cause/effect; or to evaluate information through judging, ranking or deciding" (p. 4); and
3. persuasive, because "(a) it requires thinking skills such as analysis, synthesis, and evaluation; (b) it requires writers to choose from a variety of situations and to take a stand; and (c) it is a skill frequently used in school and the workplace" (p. 4).

Students randomly receive one of nine prompts on which to write. The assessment is administered in two 40-minute sessions on two consecutive days. In the first session, students think about the topic, make notes, and write a first draft; in the second, they reread the prompt, review their drafts, and produce a final copy. Each paper is holistically scored on a six-point scale by two trained raters. A scoring rubric and anchor papers for each of the six points are provided to the raters. Sample prompts are given in Appendix B.

King, Rohani, and Goodson (1997) investigated the feasibility of assessing the real-world problem-solving skills of samples of Florida's elementary, middle, and high school students. They identified 31 problem-solving skills that almost completely overlap with the skills listed by various authors previously cited in this report. Also, in agreement with previously cited investigators, they recommended that the proposed assessments should contain multiple-choice (select) and constructed-response (generate) items and possibly computer-administered performance tasks (generate). Explanation of solutions could be required with all three kinds of items or tasks. Items would be constructed to measure the 31 skills in ways consistent with the Sunshine State Standards.

King, Rohani, and Goodson (1997) suggested that the administration of a multiple-choice and constructed-response instrument to a Florida statewide sample of about 3,500 students at each of three chosen grade levels would be feasible. Activities involved in the assessment would include formation and training of item writing and review committees; preparation of test booklets, answer documents, answer keys, and rubrics; conducting a pilot study and validation committee meeting; and producing final editions of all materials.

Summary of Classroom and Statewide Assessments

The measurement of higher order thinking skills requires that students be unfamiliar with the questions or tasks they are asked to answer or perform and that they have sufficient prior knowledge to enable them to apply their higher order thinking skills to answer the question or solve the problem. Meeting these requirements is problematic in dealing with either real-life or subject-matter domain problems. A recommended solution (Sugrue, 1994) is to examine students using multiple-item formats to measure multiple aspects of a domain. Student profiles of correct answers can help to determine the extent to which the overall assessment is novel for individual students.

Psychological studies of transfer of higher order thinking skills suggest that skills taught in one context generalize to other contexts if explicit teaching for transfer and self-monitoring is included in the instruction. Other studies suggest that over long periods of time individuals, as a result of educational and other personal experiences, develop higher order skills (intellectual abilities) that apply to the solutions of a broad spectrum of complex problems. Conversely, psychometric studies of the generalizability of higher order thinking skills when measured by hands-on performance tasks show great method and task variability in student performance; that is, individual student achievement is highly dependent on the tasks and methods used in the assessment. Estimates of the number of tasks needed in an assessment to achieve generalizable (reliable) results range from 8 to 23.

Published tests of higher order thinking skills have been found to be sensitive to instruction. Three studies of such tests involved single group pre- and posttest comparisons and two used quasi-experimental treatment and control groups. In all studies, results were statistically significant, but treatment effects were small. A recommended procedure (Ennis, 1993) for those who might want to use a published test to assess student levels of critical thinking or for evaluating programs or courses is to examine the test items for content validity, then to take the test themselves and examine their own performance critically.

Three item/task formats have been identified for use in assessing higher order thinking skills: (1) selection, which includes multiple-choice, matching, and rank order items; (2) generation, which includes short answer, essay, and performance items or tasks; and (3) explanation, which involves giving reasons for selection or generation responses. All three formats are valid for measuring some aspects of higher order thinking, but all three have some disadvantages. Multiple-choice and constructed-response items can be used for separately measuring many specific higher order skills such as deduction, inference, and prediction but are less successful for measuring synthesis and evaluation. Some validity problems can be avoided by using answer justification, where subjects select responses and then justify in writing their reasons for the choices they made. Multiple-choice items can sample many aspects of the subject matter, and performance tasks and essays can deal with complex real-life problems that require students to employ a number of higher order skills in solving them. However, final solutions to performance tasks and essays may not reveal the application of many higher order skills. Performance tasks and essays usually sample only a few aspects of the subject matter. Portfolios are useful in promoting and informally assessing reflective thinking skills.

Even though classroom teachers recognize the importance of having students develop higher order thinking skills, teacher-made tests are often heavily weighted with recall questions. Teachers who have received training in teaching and testing higher order thinking skills use fewer recall questions than those who have not received such training.

Three comprehensive performance based models for assessing higher order skills have been constructed. They contain detailed procedures for constructing performance assessments in specific content domains. Two international curricula and assessment systems are available to instruct advanced students in both subject matter content and higher order thinking skills. Students are assessed by both local school personnel and external examiners.

Statewide assessment systems for elementary, middle, and high school students may contain measures of higher order thinking skills. Two states, Florida and Pennsylvania, include select, generate, and select and explain items or tasks in their mathematics, reading, and writing assessments. In Florida, higher order skills comprise at least 50% of the items or tasks, and the Pennsylvania assessments also emphasize higher order skills.

A proposal for a nationwide test of higher order thinking skills and a report of a statewide pilot project for measuring such skills both emphasized the need for collaboration of subject matter experts and cognitive psychologists and/or critical thinking experts in preparing such assessments. The nationwide proposal contained a provision for multiple-choice and multiple-rating items to be administered to all students and essay items to be given to representative samples of students. The pilot project contained only multiple-choice items.

One study for the Florida Department of Education demonstrated the feasibility of statewide assessment of the real-world problem-solving skills of samples of students. Instruments for implementing the proposed assessments of the skills of elementary, middle, and high school students would consist of multiple-choice, constructed-response, and possibly computer-administered performance tasks.

Example items and tasks reveal a wide variety of ways that have been used to measure higher order skills. They also demonstrate the difficulties inherent in the construction of instruments to assess these skills for students at all educational levels. It should be possible to construct measures for them through the use of carefully developed item/test specifications and adequate pilot testing and analysis.

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APPENDIX A: SAMPLE TEACHING ASSIGNMENTS

The following samples of teaching assignments were discovered in materials reviewed during the course of this project. They have been selected or adapted to show a variety of approaches. These types of assignments can be adapted further to more fully support the development of higher order thinking skills. It is recommended that teachers review and plan how to adapt assignments to their own teaching strategies and context prior to implementation.

Riddles and Puzzles for a Thoughtful Classroom
Beyer (1997), pp. 67–68

Item 1
When outsiders first came to Tobuk, they found two kinds of people down there. The Amok always lied. All the other natives always told the truth. One day an outsider met three natives. She asked the first if she were Amok. The first native answered the question. The second native then reported that the first native denied being Amok. The third native then said that the first native really was Amok. How many of these natives were Amok?

Item 2
In y = 3x + 5x - 2
If
x = 0 then y = - 2
So
if x = 1 then y = ?

Item 3
These are trikes: 606 718 246 011
These are not: 56 618 441 306
What are trikes?

Item 4
Two cyclists start at the same time from opposite ends of a 100-mile-long road. Each bicycle moves at a speed of 40 miles per hour. At the moment they start, a fly leaves one of the bicycles and starts flying back and forth between the two cyclists until they meet. If the fly travels at 60 miles an hour, how many miles does it fly before the cyclists meet?

Item 5
If one greyhound can jump over a ditch two yards wide, how wide a ditch can six greyhounds jump across?

Item 6
I spring to the saddle, and Joris and he;
I galloped, Dirck galloped, we galloped all three.
What is the name of "he"?

Item 7
One rabbit eats 2 pounds of food in a week. There are 52 weeks in a year. How much food would five rabbits eat in a week?

Item 8
Message (in code): Dpnf up Mpoepo bu podf.
The same translated: Come to London at once.
What is the secret letter for "x" in this code?

Item 9
What will be the day after the day after tomorrow,
if the day before the day before yesterday was Wednesday?

Item 10

Marc, Ana, Julia, and Daniel decide to have a checkers tournament at school. They want to be sure that each of them gets a chance to play each of the others one time. They ask you to make a schedule for the tournament. Here is the information you need to make a plan that works.

- They want to finish the tournament in one week. They can play from Monday to Friday.
- They will only play at lunchtime. There is enough time during lunch period to play a game of checkers.
- The students have two checkers sets, so two games can be going on at once.
- Marc can't play checkers on the days he is a lunch helper (Mondays and Wednesdays).
- Each player must play every other player once.

Make a schedule for the tournament.

Critical Thinking
Wellness and Teacher Education Centre, University of Regina, Canada
http://hlthed.uregina.ca/cni/instres/pourri/118

Family Decisions—Grade 6

Read the following item to the classroom:

Chris wanted to go to camp. His father promised Chris could go if he saved up the money. Chris worked hard on the paper route and saved the $75.00 it cost for the camp. But just before camp was going to start, Chris's father changed his mind. Some of his friends had decided to travel to Toronto to see a hockey game, and Chris's father didn't have enough money. His father asked Chris to give him the money he had saved. Chris didn't want to give up going to camp, so Chris thought of refusing.

Now decide whether or not Chris should give the money to his father.

If you answer YES, look at the sentences that follow and choose the one you think to be the best reason for saying YES, and put a one (1) in the box provided. Then choose the second best reason and put a two (2) in the box provided, and so on until all the sentences have been ranked.
If you answer NO, look at the sentences that follow and choose the one you think to be the best reason for saying no and put a one (1) in the box provided. Then choose the second best reason and put a two (2) in the box provided, and so on until all of the sentences have been ranked.

YES

___1. Because if Chris did refuse, in the future, he might not ever get to go to the camp.

___2. The father has a responsibility for Chris's growth and welfare. If he decides that it is better for Chris not to go to camp and to give Chris's father the money for a hockey trip, then the father is acting responsibly.

___3. Chris's father may not always keep his word, but he is trying to help Chris in the best way he knows. Chris should respect his father for trying to be a good father.

___4. Because it is Chris's father, Chris should listen to what his father says.

NO

___1. Chris has had the experience of working hard and saving money, and this will foster industry, initiative and responsibility, all of which are necessary if society is to remain stable.

___2. It's Chris's money, so he should be able to do whatever he wants with it.

___3. The father should recognize Chris as a person who is different but equal to himself; Chris has a right to make personal decisions.

___4. Chris's father made a promise. The father is behaving selfishly and is inconsiderate for asking Chris for the money.

Discuss in groups or pairs the reasons for the students' personal choices.

Critical Thinking (continued)
Wellness and Teacher Education Centre, University of Regina, Canada
http://hlthed.uregina.ca/cni/instres/pourri/115

Safety First—Grades 4 and 5

Have the students list 5 things that they did before school started this morning that were safety conscious activities. Discuss with the students why they believe that they acted safely and what would have been in jeopardy if they had not acted that way.

Ask the students to draw a poster of themselves doing a safety conscious activity. Have them title their work with a logo such as Safety Sally or Conscientious Cindy, etc. Evaluate the posters on creativity, clarity, and artistic expression.

Activities to Promote Critical Thinking: Classroom Practices in Teaching English
Jeff Golub, National Council of Teachers of English, (1986)

Estimation/Front-Ending—Grade 4

1. Introduce the concept of the front-ending process. Provide a brief demonstration of the process, followed by a practice session.
2. Ask students to come up with a list of words they need in order to explain front-ending. List the words on the blackboard.
3. Ask students to write letters to friends in other classrooms describing what they have learned.
4. Work on the revision of the drafts with students (guide students through questioning strategies rather than instructions).
5. Ask students to edit their letters.
6. Proofread each letter.

Newspaper Activities for Young Consumers
Adapted from Tess Greenup, *Albuquerque Journal/Tribune*: Newspapers in Education

Item 1
Look in today's newspaper and see if you can find advertisements for 3 items you have consumed or used in the past 24 hours. Complete the table below for each item.

Name of Item	Page # Where Ad Appeared	Advertised Price for Product

Answer the following questions in group discussion or on a separate sheet of paper.
1. How did the use of each of the three items make you a consumer?
2. Why did you or your parent decide to purchase each item?
3. What is the definition of the word "consumer"?

Item 2
Definition A: Goods are things you can buy. A notebook is a good. So is a newspaper.
Activity A: Look in today's newspaper and find 3 separate advertisements for 3 consumable goods. Clip the ads. (Some newspaper advertisements have many items in them. Clip the whole ad and circle with a crayon or colored marker one consumer good.) Paste each of your ads on a separate piece of paper. On the back of each paper, answer the following questions:
1. What is the common name for the good you selected?
2. What is the price of the good?
3. When, if ever, would this good really be needed? When would it be wanted, but not really needed?
4. What age group would be most likely to use this good?
   a. young people b. teenagers c. adults d. older people e. all ages
5. What firm or store advertised this good in the newspaper? Write the name.

Definition B: A service is a job you pay someone else to do. Hair dressers provide a service. Doctors provide a service. Can you name some other workers who provide services?
Activity B: Find advertisements for 3 services. Clip the ads and paste them on a sheet of paper. Then answer the following questions on the back of each paper.
1. What service is advertised?
2. What firm is advertising the service?
3. Is this service a want or a need for most people?
4. What is the price of the service?
5. Who would be most likely to want or need this service?
   a. young people b. teenagers c. adults d. older people e. all ages

Activity C: Find an advertisement in today's newspaper for a good you think your teacher needs. Then find an advertisement for a service you think your teacher wants, but does not need.

Item 3
Caveat emptor is a Latin phrase which means "Let the Buyer Beware."
Why do you think the words "Let the Buyer Beware" are significant?

Look in today's newspaper and find an advertisement for a good or service which you consider NOT to be a good buy. Clip the ad and paste it on a piece of paper. Write "caveat emptor" on the top of the page. Underneath the ad or on the back of the page write two reasons to explain why you think the good or service may not be a good buy.

Item 4
When consumers or sellers feel the law has been broken and the dispute cannot be settled, they must ask a third, independent party to settle the argument. One such party to settle disagreements is the court. The court is asked to settle a disagreement by means of a "law-suit."
Read the newspaper every day for a full week. Look for news articles or notices that tell about people or firms suing someone else because of a problem they have had. Clip the news stories and paste them on pieces of paper. Then tell in your own words what seems to be the problem by answering the questions below.

1. Who is suing whom?
2. Why?
3. What does the person or firm filing the suit want?
4. Who do you think should win this dispute? Why?
5. Why are laws necessary to protect the consumer and sellers?

Item 5
Activity A: Eggs usually are described as "USDA Grade A" or "USDA Grade AA." This labeling follows the requirements of a federal regulation under the Pure Food and Drug laws. Clip ads from the newspaper that refer to federal controls of foods, drugs, chemicals, and cosmetics.

Activity B: Pretend you are a reporter and interview 5 adults in your family, community, or school. Ask each adult this question: "What do you think is the most beneficial law or regulation which protects our food and drugs?" Write down the answer given by each person or record the answer on a tape recorder. Compare all 5 answers to each other. Then write a news story about what you find out.

Item 6

Activity A: Write 1 of the 5 laws listed below on the top of a poster. In the newspaper, find advertisements for goods to which the law would apply. Paste the ads on your poster.

Laws:

1. There must be truthful and accurate information about the contents of foods, and the contents must be listed in order of the amount contained in the product. If a "standard" has been established for a food, such as milk, ingredients need not be given.
2. Poisonous and dangerous household items must contain warnings and be packaged in containers that young children cannot open easily. Containers should give instructions for emergency information or care if the product is swallowed or gets into someone's eyes.
3. Labels must give the exact quantity contained in the package, using words that people can understand easily. They must be written in print large enough to read easily.
4. Nutrients, such as vitamins, minerals, and protein, must be listed on all diet foods and on all foods which claim to be enriched or in some way to improve health.
5. Labels on clothes, furs, and furniture must give truthful information about the items from which they are made and about how to care for the material.

Activity B: Clip an illustration from an ad and write your own label for that good.

Item 7

Activity A: Find the words CONSUMER, GOODS, SERVICE, WANT, NEED, LAW, VALUE, and REGULATE in ads and headlines in the newspaper and paste them on a sheet of paper. Beside each word, write what the word means.

Activity B: Fill in the blanks in the "news article" below with the words CONSUMER, GOODS, SERVICE, WANT, NEED, LAW, VALUE, and REGULATE.

Terry Bradface, owner of Flim Flam Records and Recording Studio, responded in Municipal Court today to charges that he had violated a ____________________'s rights by breaking a labeling ____________________. Bradface is accused of labeling his tapes and records falsely with stars' names although his records and tapes are performed by unknown singers and musicians. Bradface said the law does not ____________________ the ____________________ and ____________________ in his store. Bradface said that the records and tapes he sells are not a necessity, but a desire. In other words, he said his products are a ____________________ not a ____________________ in most people's lives. He argued then that mislabeling would not affect the ____________________ of the record or tape. Judge Jones disagreed with Bradface and ordered him not to put false information on his labels.

Item 8

The following survey and interview activity is one of the most useful for producing original newsletters. Refer to your students as reporters. Also, plan a reasonable unit of time for the publication of the newsletter. One day will probably not be enough time to complete the project, but you probably will not want to extend it over a week.

Assign surveys and interviews outside the classroom as homework assignments. Choose questions which come up in class or questions about a consumer topic being covered in the daily newspaper. These types of questions will give students a sense of being involved in "real" issues of importance. Start with questions which can be answered with "yes," "no," or "I don't know." Before sending students out for their interviews, have them construct an interview answer sheet like the one below. Instruct students to use this form to record their interviews.
Question: (WRITE QUESTION IN THIS SPACE. It is important that all students copy the question exactly alike.)

Respondent's Name	Yes	No	I don't know
1.			
2.			
3.			
4.			
5.			

Instruct each student to interview 5 people and to fill out the interview answer sheet. From these answers, the class can compile the data in class. Write "Yes," "No," and "I don't know" on the chalkboard and ask each student to list the number of responses for each answer. Add the responses and then have students discuss the results and generalize from the data. After this discussion, have each student write a news story and select the best article for publication in your newsletter.

Assign editors for the newsletter. Stress the importance of accuracy, fairness, and balance in the handling of information.

Keep layout and design simple at first. For example: a 2-column newsletter is easier to produce than a 3-column one.

Item 9

We keep a privately-owned free press simply because merchants are willing to pay for advertising to tell people about the goods and services they have to sell. More than 70 percent of a newspaper's revenue comes from advertising. Without advertising, the same newspaper which costs $.25 or $.50 would cost several dollars. Two main kinds of advertising appear in a newspaper: display and classified. Display ads usually are large enough to display an illustration of one or more products. Retail stores, manufacturers and service companies usually buy display ads. Classified ads are small ads at low cost, usually without illustrations. Individuals or businesses such as car companies usually buy these types of ads.

Both types of ads usually are supposed to do four things: (1) catch a reader's attention; (2) provide facts and information; (3) use persuasive techniques; and (4) convince a reader to buy a product or service or to agree with a particular viewpoint.

<u>Activity A</u>: Select a display ad that "catches your eye" and answer the following questions:

1. What is the name of the firm or company doing the advertising?
2. What is being sold? (If more than one good is advertised, count the number of items in the ad and tell what kind of merchandise is advertised.)
3. Is the price listed? What is the price?
4. Is the price asked a fair price to pay? Why? Why not?
5. What is the stated or implied reason for someone to buy what the ad is selling?
6. Copy any persuasive or "appeal" words from the ad.
7. Measure the entire ad. How many columns wide is the ad? How many inches deep is the ad? [Note: Some students when first looking at newspaper ads may focus on only one part or the inner block of an ad rather than approach the ad as a whole unit. This activity is useful in developing skimming skills to differentiate separate ads in a newspaper.]
8. Why did this ad catch your eye?
9. What symbols are used in the ad?
10. To which gender does this ad appeal? Males only? Females only? Both males and females?
11. To which age group does this ad appeal? To parents only? Children and parents? Teenagers only? Grandparents and older people?
12. What income range do you think the buyer of this product is in?
13. What one thing would influence you to buy this item?
14. What one single thing would influence you NOT to buy this item?
15. Will the product still be around in 5 years?
16. What will the product be used for? What is the intended use of the product? For work? For play? Study? Something else?
17. How accurate do you believe the ad is?
18. Where was the ad located in the newspaper? Does ad location have anything to do with the people who will read the ad?

<u>Activity B</u>: Select three classified ads placed in the newspaper by individuals and answer the following questions:

(1) What is being sold? (2) How is the item described? (3) Is the price listed? If so, what is the price? (4) How do you get in touch with the advertiser?

Item 10

Activity A: Find display ads which use one or more of these appeals:

Testimonial Appeal	Slogan Appeal
Bandwagon Appeal	Patriotism
Sex Appeal	Humor
Appeal to Your Well Being or Ego	Glamour
Bargain or Economy Appeal	

Clip an ad using a different appeal. Identify how the ad appeals to the reader.

Activity B: See how many of the following appeal words you can find in today's newspaper. Put a check mark by each one you find today.

free	magic	brand new	amazing	unbelievable	bargain
offer	sensational	compare	current	soothing	modern
reduced	latest	improved	suddenly	remarkable	sale
popular	miracle	easy			

Activity C: Pretend you are an ad director for your school. You need to attract students to enroll in a new recreation program. Use a testimonial appeal to create an ad. In the ad, use the type of design, illustrations, and language that will best get your message across. Choose a different type of appeal to create another ad for the same program. Again, use the type of design, illustration, and language to best convey your message.

Item 11
In advertising, the term “puffing” means exaggerating. Examples include “the finest in the world,” “best of all,” “sensational,” and “fantastic.” Puffing is not against the law since the exaggeration is a form of opinion.

However, there is a difference between “puffing” and deliberately giving false information. Lying about a product is dishonest and unlawful. An advertiser cannot claim that a product is something it is not, or that a product can do something it cannot do. That is dishonest and against the law.

Activity A: Pretend you are an ad writer for a newspaper. Write an ad for a product using “puffing.” Create another ad for the same product, using dishonest claims and untruthful information.

Activity B: Look in today’s newspaper and find an example of “puffing.”
What words and phrases are puffing? Rewrite the ad, using other ways to describe the product.

Item 12
Activity A: Look for any news articles in the newspaper which mention the Federal Trade Commission. Clip and share them with your teacher.

Activity B: Lottery prizes, such as a free trip or free auto, must be open to the public. This means anyone can win the lottery prize whether or not a person makes a purchase from a store offering the prize. Look for a newspaper ad which has a lottery prize advertised. Can you find the phrase, “No Purchase Necessary” to reflect this ruling?

Imagemaking in the Classroom

Adapted from Nancy King, Inner Visions/Outer Versions—Grades 11 and 12

Students read more productively when they understand that their personal identities and the times in which they live affect the way they interpret what they read.

1. Instruct students to think about any images, questions, or other responses that come to mind as they listen to a short passage. Then read the passage aloud or have them read a longer passage on their own.
2. Ask the students to respond to the text in one or more of the following ways:
   - Paint an image of a passage that compels (angers, irritates, intrigues, amazes) you.
   - Write down words, ideas, and/or phrases that came to mind during the reading.
   - Sculpt an image of the protagonist at the beginning in relationship to a significant place, person, or event in the protagonist's life. Choose a specific passage as your reference point.
   - Paint an image of a character in a moment of crisis.
   - Choose one character and write an internal monologue (character talks to himself or herself) of about one minute long, exploring your character's thoughts and feelings.
   - Select a passage that symbolizes an important moment in the character's life. Reread the passage aloud as if you are the character, using appropriate character motivation and intention.
   - Sculpt an image of a character at a particular point. The sculpture can represent non-human sources such as water, heat, hunger, dust, need, etc.
   - Pretend you are a character and write a brief autobiography.
   - As if you are the character, ask yourself a question of great importance to you at a specific point in the story.
   - Write a journal entry describing a character's actions, thoughts, and feelings at a certain point in the story.
   - Pick a character at a particular point. As your character, write a letter to an important person in your character's life. Identify this person and her/his relationship to your character. Tell about an aspect of your life (as your character) and ask this person a question of great importance to you.
3. Have the students share what they created, either by going around the room or having the student who is presenting pick the next student. Facilitate class discussions by asking students why they chose to create what they did or why a particular character or passage moved them. If students choose to write in the voice of the character, ask them questions and have them answer as if they are still the character.

Thinking Writing Tables
Pritchard (1993)—Grades 6, 7, and 8
ED 363 623

1. Have students analyze the following critical thinking assignment. Ask students to answer two questions:
    - What critical thinking task does this assignment require?
    - What topic does this assignment ask me to think critically about?

   Assignment: Categorize the advertisements for cars profiled by your group and tell what these categories suggest about the messages the ad writers wish to send.
   Thinking Task:
   Topic:

2. Using rewriting strategies, help students gather information and ideas about the assignment topic.
3. Negotiate with students the thinking steps they will use to carry out the assignment's critical thinking task.
4. Help students learn the basic format for thinking writing tables. Use a three-column table as the basic format.

Questions	Answers	Details
1.		
2.		
3.		

5. Help students convert thinking steps for the critical thinking task into questions.
6. Have students answer questions with information and ideas they generated during prewriting.
7. Have students write first drafts directly from their tables.
8. Involve students in peer review that reinforces understanding of the critical thinking skills they have learned.
9. Assign students new applications of the critical thinking tactics they have learned.

Deductive Thinking
Clarke (1990)—Grades 4 and 5

Item 1
As an exercise in problem analysis, ask your students to identify a task they have mastered and then to write a set of instructions showing an inexperienced person how to complete that task. When the instructions are written, you may ask the students to identify points in the procedure where problems can easily arise. For each problem, you can show them how to write out if/then conditional rules for solving these problems.

Item 2
If you have a flair for the dramatic, consider posing as an intergalactic space traveler who recently arrived on this planet with little more than English instruction via the AM/FM radio. Request written help with common tasks, such as

A. opening a can of tuna
B. making a peanut butter and jelly sandwich
C. buying a can of Drano
D. contacting NASA
E. catching a bus to Denver
F. dressing appropriately for a visit with the president
G. moving undetected through a school day

Item 3
Consider introducing the symbols and techniques of flowcharts or scripts as a way to represent procedures for a task. Working on common daily routines such as brushing teeth is both easy and enjoyable. Have other students troubleshoot the completed charts and then suggest alternatives if needed.

Item 4
Identifying events or issues as problems is the first step in problem solving. To give your students practice in isolating problems from the surrounding landscape, consider using history, literature, or science texts as sources. Ask them to identify problems from the text. (Newspapers also supply an endless flow of description rich in problems.)

Item 5

Problems for Research Teams

1. You and your research team are given two caterpillars, both in first instar. From one you remove the *corpora allata*. The other one you leave alone. What happens to each caterpillar? Why has this happened?
2. You and your research team are given two more caterpillars in their first instar. From one you remove the thoracic gland. The other you leave alone. What happens to each caterpillar? Why has this happened?
3. You and your research team are given two caterpillars in their last instar. One is 7 days old; the other is 10 days old. You tie a knot around the center of both. You wait 14 days. What has happened to each half of the caterpillars? Why has this happened?
4. You and your research team are given lots of caterpillars, each in its first instar. After cutting off their heads and tails, you connect the abdomens together with glass tubing. You take another caterpillar in its last instar—7 days old—and you cut off its head. You take the head and attach it to the abdomens of the other caterpillars. You wait two weeks. What has happened to the abdomens? Why has this happened?

Item 6

1. For a unit you are planning to teach, list the causal relationships that exist or may be implied by the context. Devise a simple pretest that will show how aware your students are of these relationships.
2. For a unit you plan to teach, make a list of the events or ideas you want your students to be able to explain. Design a small-group assignment that requires students to backmap those events or ideas.
3. Are there any events coming up in the school year for which student planning is required? (The prom is one possibility. Term papers, large tests, field trips and projects are more common.) To create a planning chart
    a. note the main goal or outcome at the right side of the page.
    b. ask the question, What is it going to take to accomplish this goal? Develop subgoals in a column to the left of the main goal.
    c. for each subgoal, map out the events in the order that will lead to the accomplishment of the subgoals. Work backwards from the subgoal toward the present moment.
    d. create a time line along the bottom of the page and note critical dates within the map itself.
    e. assign small groups the responsibility for each subgoal and all the steps along the causal path for that goal.
4. All of us try to predict the future. However, not many use an approach to prediction that makes our thinking visible. For an important event coming up in the near future, ask your students to work together to develop prediction chains. As incidents occur related to the event, allow your students to use new information to change their predictions. After the event occurs, ask them to explain any differences between what they predicted and what transpired.
5. What decisions are included in or implied by the content you plan to teach? Do these decisions offer your students a chance to think hypothetically? Teach your students to forward map the causal chains that would track different choices they might make.

Item 7

Basic Steps in Concept Mapping

1. Identify the major concepts. In a text, the dominant concepts often appear in the titles, subtitles, and lead sentences in paragraphs. In an interview, dominant concepts can be identified by asking: "What do you mean by this word?" or "What can you tell me about this concept?" Look for major subcategories in the concept, definitions, causes, or effects.
2. Place the concepts on paper from most inclusive (abstract) to most specific (concrete). Dominant concepts are most often placed at the top of a page, subordinate concepts further down the page and explanatory or illustrative concepts at the bottom. Mapping may have to go through several drafts to achieve a hierarchical (or other) shape.
3. Link the concepts and label each link. Linking lines between concepts explain their relationship. In English, the linking words are most often verbs. Active and passive verbs usually indicate cause/effect relationships. Variations of "to be" verbs usually indicate membership in a category. Conjunctions (e.g., *and* or *but*), subordinating conjunctions (e.g., *since* or *although*), and prepositions (e.g., *by*, *from*, *in* or *to*) can all serve as useful linking words.
4. Branch out from each concept to include definitions, illustrations, and factual evidence. Generally speaking, the more specific information that can be included in a concept map the more useful the map will be as a study guide and writing guide. Names, dates, statistics, and specific instances prove more memorable when linked to an organizing concept. Maps as guides to lectures or presentations usually contain less information.
5. Use cross-links to analyze additional relationships. Working "top down" usually explains the main relationships. Other relationships (links) appear when one looks at any two concepts on an evolving map and asks, "Is there a connection between these concepts?" Often there is. Significant cross-links can be labeled.

Item 8

1. Make a list of the vocabulary necessary for success in a unit you plan to teach. Consider different drawings or other visual organizers that would include all the words on the list:
   a. Develop a large drawing to hang in your room and add the words one at a time.
   b. Have students draw a picture that will anchor the words as they progress through the unit.
2. Develop a focusing question for a class you plan to teach. Use a two- or three-minute free-write that asks the students to look at the question and assess what they already know about the subject. Consider each of the following processing possibilities:
   a. To begin a class, have students read their free-writes and record what they know on a transparency or blackboard.
   b. To begin a class, have pairs of students read their free-writes to each other and identify similarities and differences so they can explain them to the class.
   c. After the free-write, introduce new information through lecture, film, or reading. Then
   d. ask the students to revise what they wrote to accommodate the new information.
   e. At the end of a class period, ask students to free-write their questions and comments. Make transparencies of a few and use them to open the next class.
3. For any text handout, show students how to "web" a text. Ask them to identify a major idea in the next and to trace that trend or theme by circling words and connecting them with lines. Can they use the webbed words to generate questions?
4. Ask groups of students to extrapolate a trend or theme from a chapter, put it on separate paper as a time line, and then explain it to the rest of the class.
5. For any aspect of content that falls in serial order, pin a roll of paper on the wall and show students how to map out critical events in a time line.
   a. As the time line grows, ask them to make connections between events with a pen. Can they label the connections?
   b. Use colored pens or crayons to label different trends, themes, or causes.
6. Divide a story, fable, myth, or other short narrative into small segments and put each segment on paper. Give one to each student. Ask the group to reconstruct the narrative by taping the pieces to a wall. Can each member of the group explain how he or she did it? What ideas give coherence to a story?
7. Are there recurring events in any unit you teach? Would counting and graphing clarify important issues? Redesign a unit plan to emphasize focused scanning and organizing information for analysis. Design graphs or grids that will help students organize and measure recurring events.

Problem Solving
Hammerman and Musial—Grades 4 and 5
ED 395 764, pages 52–62

A set of performance assessments that enables the student to "demonstrate knowledge and multiple science abilities through communication, problem solving, inventiveness, persistence, and curiosity."

Performance assessments are a set of tasks that include hands-on activities, criterion-referenced test items, and open-ended writing prompts.

Item 1

Can You Dig It?

Materials:
1. Large rectangular baking pans or cardboard trays filled with about two to three centimeters of sand or cat litter (cardboard trays from canned food may be obtained from grocery stores—approximately 26 cm x 36 cm x 5 cm)
2. Plastic spoons or other small tools to use to dig through the sand
3. Plastic fossils (or other real fossils, if possible) of crinoid, brachiopod, pelecypod, and petrified wood
4. Fossil kits from Creative Dimensions, P.O. Box 1393, Bellingham, WA 98227 (optional)

Students will be given a fossil-rich site. They will be asked (helped) to make a scale drawing one-half the size of the site and label the coordinates on a grid. Using sample tools, students will excavate four different fossils from the site. They will describe the fossils and use coordinate symbols to indicate the location of the specimens on the scale drawing. Fossils may be presented in the pans so that the findings for each student will be identical. Each student or student group can generate individual data by varying the fossil positions from pan to pan. Teachers may decide which situation is best.

Tell students they have been invited by the local museum paleontologist to assist with an exploratory dig at a fossil-rich quarry. Their task is to assist the paleontologist in identifying the site by drawing a map one-half the size of the site. Students should mark off two centimeter sections along the top and sides of the map. They can label the top of the grid with letters and the sides with numbers. Students will search for the fossils, describe them, and record the location where they were found on the map. (By varying the positions of the fossils for each student, students can generate their own data.)

Practice Dig

After weeks of preparation with the paleontologist, you have arrived at the site for the "dig." It is an abandoned sedimentary rock quarry that, over time, has been covered with loose material. Buried in the material are fossils. To begin, you must record observations of the site, including a description and the size of the area to be investigated.

Description (material, color, landscape features, etc.)

____

____

Size of area (in centimeters)

____

Make a scale drawing of the area on a separate sheet of paper, one half the size of the actual area you are investigating. Mark off the drawing in 2 cm blocks so it looks like a grid. Label the grid with letters across the top or bottom and numbers along the side.

Be sure to draw the lines of the grid on your scale drawing so you can identify the location of your fossils when you find them. Fossil locations will be identified by letter and number. For example, C 2 would be the third square from the left or the right intersecting with the second one from the bottom or the top (depending on how you label your grid).

Using the digging tools provided, carefully probe the landscape until you find four fossils. Write a description of each fossil and give its coordinate location on the data table below.

	Description	Coordinates
W		
X		
Y		
Z		

Next put each letter W, X, Y, and Z or a drawing of each fossil on the grid to show the location where each was found. Your scale drawing becomes a map of your dig. How could your map be used by another explorer to find the location where your fossils were found?

Item 2

Now, Picture This

Materials:

1. fossils
2. hand lenses
3. drawing pencils
4. balances
5. metric rulers
6. sets of weights

Students are asked to make a drawing of each of the four fossils. This is an important skill researchers need in order to record the intricate features of their find. Students will measure the length, width, and mass of each fossil. Then, they will study each fossil's characteristics to determine if any resemble organisms that are alive today.

Discuss with students the fact that scientists record as much information as possible when doing research in the field. Making careful drawings is an important way of recording characteristics and unusual details of the fossils. Recording the size and the mass provides additional information. As an aid in identifying the fossils, it is important to note whether the fossil resembles anything that the students (or researcher) is already familiar with, such as characteristics of known organisms.

Practice Dig

The four specimens you excavated from your site are fossils of organisms that lived long ago. Draw each specimen in the space on the data table below. Measure the length and width (at the longest and widest points) of each fossil and record your findings on the table. Use the balance and weights to find the mass of each specimen in grams and record the results. Some of the fossils resemble currently existing organisms. Make inferences as to what organisms the fossils look like.

Drawing of Specimen	Length (cm)	Width (cm)	Mass (g)	Organisms Fossil Resembles

Item 3

Here's Looking at You, Kid

Materials:

1. fossils
2. reference books for fossils
3. hand lenses
4. fossil kits (optional)

Comparing similarities and differences among fossils and between fossils and other known organisms gives scientists clues to evolutionary patterns.

Students are often interested in knowing the names of fossils. Ask them to begin by comparing the fossils to one another. Do they have any characteristics in common? Are any two alike? Challenge students to find at least one way two of the fossils are alike.

Next give students access to field guides and reference books for fossils and let them find the type and name of each specimen. Have students record the names on their Practice Dig sheets. From these resources, students can often find names or pictures of similar present-day organisms. Students should research and learn as much as they can about their four fossils and the organisms they resemble.

Practice Dig

Comparing Specimens to One Another
Use a hand lens to study your specimens. Compare them and list a way any two are alike.

____

____

Comparing Specimens to Other Organisms
You may use reference books to help you find the names of fossils and any similar present-day organisms. Record the fossil specimen names, the names of organisms they resemble, and the characteristics that are similar to the present-day organisms.

Fossil	Specimen Name	Similar Organism	Similar Characteristics
W			
X			
Y			
Z			

Optional Task
What interesting information do scientists know about various fossils? (For use with Creative Dimensions Fossil Kit or another fossil kit)

For each of the fossils you found, locate the information card or research information about different fossils in your fossil kit. Use the information to find the following data for each fossil:

Name	Age	Origin	Type of Fossil
______________	___________	____________________	______________________

Two Items of Interest

____

____

____

(continued on next page)

(Practice Dig continued)

Name **Age** **Origin** **Type of Fossil**

______________ ___________ ___________________ _____________________

Two Items of Interest

____

____

____

Name **Age** **Origin** **Type of Fossil**

______________ ___________ ___________________ _____________________

Two Items of Interest

____

____

____

Name **Age** **Origin** **Type of Fossil**

______________ ___________ ___________________ _____________________

Two Items of Interest

____

____

____

In what ways can information from the past help us understand the present?

____

____

____

Thinking Skills
Excerpt from *Big Ideas*, a curriculum design overview developed by ESE Program Development and Services, Bureau of Instructional Support and Community Services, Florida Department of Education—Grades 6, 7, and 8.

Item 1

Application of Advanced Proportion Strategy to a Mixture Problem

A mix contains peanuts and almonds in a ratio of 4 to 3. If 35 pounds of mix are made, how many pounds of almonds will be used?

Step 1: The students map the units and write the known values:	Ratio / Pounds Peanuts 4 _____ Almonds 3 _____ Total _____ 35
Step 2: The students use their knowledge of missing addends to come up with the unknown value in the ratio column: 4 + 3 = 7	Peanuts 4 _____ Almonds 3 _____ Total 7 35
Step 3: The students write and solve the proportion to determine the number of pounds of almonds: 3/7 = 15/35	Peanuts 4 20 Almonds 3 15 Total 7 35

Item 2

Data Gathering, Advanced Proportions, and Probability-Statistics Strategies

Step 1: Data Gathering The students conduct a survey in their class to determine the preferences for white and chocolate milk. The students also find out from the office the total enrollment for the school.	There are 32 students in the class; 22 prefer chocolate milk and the rest prefer white. There are 479 students in the school.
Step 2: Advanced Proportions The students map the units for the advanced proportions strategy and insert the relevant application.	Fifth Grade Class / Entire School Chocolate 22 ____ White 10 ____ Total 32 479
Step 3: Probability and Statistics The students solve a proportion to estimate the number of chocolate milk cartons to purchase for the entire school: 22/32 = 329/479	Chocolate 22 329 White 10 ____ Total 32 479
Step 4: Missing Addends The students determine the estimate for white milk using their knowledge of missing addends: 479 – 329 = 150	Chocolate 22 329 White 10 150 Total 32 479

APPENDIX B: SAMPLE TESTS AND TEST ITEMS

Standardized Higher Order Thinking Skills Tests (Ennis, 1993)

Tests Covering More Than One Aspect of Critical Thinking

The California Critical Thinking Skills Test: College Level (1990) by P. Facione

The California Academic Press, 217 La Cruz Ave. Millbrae, CA 94030. Aimed at college students but probably usable with advanced and gifted high school students. Incorporates interpretation, argument analysis and appraisal, deduction, mind bender puzzles, and induction (including rudimentary statistical inference).

Cornell Critical Thinking Test, Level X (1985) by R. H. Ennis and J. Millman

Midwest Publications, PO Box 448, Pacific Grove, CA 93950. Aimed at grades 4–14. Sections on induction, credibility, observation, deduction, and assumption identification.

Cornell Critical Thinking Test, Level Z (1985) by R. H. Ennis and J. Millman

Midwest Publications, PO Box 448, Pacific Grove, CA 93950. Aimed at advanced or gifted high school students, college students, and other adults. Sections on induction, credibility, prediction and experimental planning, fallacies (especially equivocation), deduction, definition, and assumption identification.

The Ennis-Weir Critical Thinking Essay Test (1985) by R. H. Ennis and E. Weir

Midwest Publications, PO Box 448, Pacific Grove, CA 93950. Aimed at grades 7 through college. Also intended to be used as a teaching material. Incorporates getting the point, seeing the reasons and assumptions, stating one's point, offering good reasons, seeing other possibilities (including other possible explanation), and responding to and avoiding equivocation, irrelevance, circularity, reversal of an if-then (or other conditional) relationship, overgeneralization, credibility problems, and the use of emotive language to persuade.

Judgment: Deductive Logic and Assumption Recognition (1971) by E. Shaffer and J. Steiger

Instructional Objectives Exchange, PO Box 24095, Los Angeles, CA 90024. Aimed at grades 7–12. Developed as a criterion referenced test, but without specific standards. Includes sections on deduction, assumption identification, and credibility; distinguishes between emotionally loaded content and other content.

New Jersey Test of Reasoning Skills (1983) by V. Shipman

Institute for the Advancement of Philosophy for Children, Test Division, Montclair State College, Upper Montclair, NJ 08043. Aimed at grades 4 through college. Incorporates the syllogism (heavily represented), assumption identification, induction, good reasons, and kind and degree.

Ross Test of Higher Cognitive Processes (1976) by J. D. Ross and C. M. Ross

Academic Therapy Publications, 20 Commercial Blvd., Novato, CA 94947. Aimed at grades 4–6. Sections on verbal analogies, deduction, assumption identification, word relationships, sentence sequencing, interpreting answers to questions, information sufficiency, relevance in mathematics problems, and analysis of attributes of complex figure skills.

Test of Inquiry Skills (1979) by B. J. Fraser

Australian Council for Educational Research Limited, Frederick Street, Hawthorn, Victoria 3122, Australia. Aimed at Australian grades 7–10. Sections on using reference materials (library usage, index, and table of contents); interpreting and processing information (scales, averages, percentages, proportions, charts and tables, and graphs); and (subject-specific) thinking in science (comprehension of science reading, design of experiments, conclusions, and generalizations).

Test of Inference Ability in Reading Comprehension (1987) by L. M. Phillips and C. Patterson

Institute for Educational Research and Development, Memorial University of Newfoundland, St. John's, Newfoundland, Canada 3X8. Aimed at grades 6–8. Tests for ability to infer information and interpretations from short passages. Multiple-choice version (by both authors) and constructed-response version (by Phillips only).

Watson-Glaser Critical Thinking Appraisal (1980) by G. W. Watson and E. M. Glaser

The Psychological Corporation, 555 Academic Court, San Antonio, TX 78204. Aimed at grade 9 through adulthood. Sections on induction, assumption identification, deduction, judging whether a conclusion follows beyond a reasonable doubt, and argument evaluation.

Tests Covering Only One Aspect of Critical Thinking

Cornell Class Reasoning Test (1964) by R. H. Ennis, W. L. Gardiner, R. Morrow, D. Paulus, and L. Ringel

Illinois Critical Thinking Project, University of Illinois, 1310 S. 6th St., Champaign, IL 61820. Aimed at grades 4–14. Tests for a variety of forms of (deductive) class reasoning.

Cornell Conditional Reasoning Test (1964) by R. H. Ennis, W. L. Gardiner, J. Guzzetta, R. Morrow, F. Paulus, and L. Ringel

Illinois Critical Thinking Project, University of Illinois, 1310 S. 6th St., Champaign, IL 61820. Aimed at grades 4–14. Tests for a variety of forms of (deductive) conditional reasoning.

Logical Reasoning (1955) by A. Hetzka and J. P. Guilford

Sheridan Psychological Services, PO Box 6101, Orange, CA 92667. Aimed at high school and college students and other adults. Tests for facility with class reasoning.

Test on Appraising Observations (1983) by S. P. Norris and R. King

Institute for Educational Research and Development, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, A1B 3X8. Aimed at grades 7–14. Tests for ability to judge the credibility of statements of observation. Multiple-choice and constructed-response versions. (p. 183)

Killoran (1992)

Developing Standard Multiple-Choice Questions

Multiple-choice questions come in two formats: standard and database. Standard multiple-choice questions can in turn be grouped into several basic types.

Recognition of Important Terms and Persons

We can phrase recognition questions in a variety of ways. Questions about a term ask for recognition of its main features; questions about people ask for their achievements, failures, or ideas; questions about a concept ask for its definition or for an example. Questions testing recognition of important terms, persons, and concepts require students to analyze information—to recognize significance and to understand the relationship between the general and the particular. Questions might appear as follows:

- The purpose of [the Open-Door Policy] was to . . .
- Which statement was or is true of [nativism]?
- Which statement best reflects the ideas of [Booker T. Washington]?
- The concept of [manifest destiny] is best illustrated by . . .
- [Marbury v. Madison] was important because . . .
- Which statement about [the Spanish-American War] is most accurate?

In creating questions about terms, persons, and concepts, we can use the following as a guide:

- Questions about terms ask students if they know what it is—
  its purpose, its causes, its effects, or its significance.
- Questions about persons ask students to identify the time periods in which they lived, their backgrounds, or their accomplishments or failures.
- Questions about concepts ask the student to either define the concept or give an example of it.

Compare and Contrast

Comparing and contrasting two things improves our understanding of both. It highlights and separates events, ideas, and concepts from other data. Compare and contrast questions might be phrased as follows:

- [Harriet Tubman, Booker T. Washington, and Martin Luther King, Jr.] were similar in that they all . . .
- A study of [World War I] and [World War II] shows that both were . . .
- Which belief is common to both [imperialism] and [nationalism]?

- A major difference between [urbanization] and [frontier life] is that in [frontier life] . . .

Cause and Effect

History is a seamless web of events leading to other events. Causal explanation give history much of its meaning. Cause-and-effect questions test students' understanding of the relationship between an action or an event and its corresponding effect. To answer these questions, students must be able to identify causes, effects, and the links between them. We might phrase this type of question as follows:

- Which was a significant cause of [United States' entry into World War I]?
- Which best explains why [U.S. labor unions] were [first organized in the late 1800s]?
- Which situation led to the [blockade of Cuba in 1962]?
- Which is a direct result of the Supreme Court decision in [Roe v. Wade]?
- Which is a long-term result of [the Monroe Doctrine]?

Generalization

To form a generalization, students must examine a group of facts, statistics, and trends. From this specific information students draw out a general principle, rule, opinion, or conclusion. Generalization questions must ask students to associate specific events or facts with a general idea. Examples of multiple-choice questions that test generalizations are:

- Which is the most accurate statement about [social mobility] in the United States?
- In an outline one of these is a main topic and the other three are subtopics. Which is the main topic?
- The idea that [a nation's domestic policy can determine its foreign policy] is best illustrated by . . .

Chronology

Arranging events in chronological order allows us to see patterns, order, or sequences in the events taking place. Chronological questions may appear as follows:

- Which historical time period occurred [first]?
- Which sequence of events best describes the historical development of [the Women's Movement in the United States]?
- Which group of events is in the correct chronological order?
- Which event took place during [the Woodrow Wilson administration]?

Special Types

A number of standard multiple-choice questions test specialized knowledge and skills.

Fact or opinion

Statements of fact are the raw material of historians and social scientists. Students should be tested on their ability to distinguish between fact from opinion. Questions could phrase as follows:

- Which statement about [the Reconstruction Period] would be most difficult to prove?
- Which statement about [World War II] is an opinion rather than a fact?

Use of sources

Historians and social scientists consult a variety of sources to discover what has happened in the past or what is happening in different parts of the world today. Sources are classified as either primary or secondary. Questions asking students to distinguish primary sources from secondary sources could be phrased as follows:

- Which would be an example of a primary source of information on [World War I]?
- Which is a secondary source of information about [the Civil War period]?

Use of reference books

Students should be familiar with the common types of reference books. Questions testing students' familiarity with these reference books could be phrased as follows:

- To find information about [a region's topography], which source would you most likely consult?
- Which would be the best source to consult to obtain accurate information about [a recent speech of a U.S. Senator]?

Frames of reference

Students should be able to identify the practitioners of social studies—people who study society from different viewpoints or frames of reference. Questions testing student familiarity with these various types of social sciences could be phrased as follows:

- Which social scientist uses [artifacts, fossils, and ruins] to study [prehistoric culture]?
- With which statement would a historian agree?

Developing Database Questions

Unlike a standard multiple-choice question, a database question is based on data presented as part of the question. The data may include such items as maps, tables, outlines, political cartoons, line graphs, pie charts, bar graphs, readings, fictionalized conversations, or time lines. Database questions can be grouped into four general categories.

Comprehension Questions

These questions ask students to demonstrate understanding of a specific item, figure, or number presented in the data. Comprehension questions may take any of the following forms:

- The [eagle] in the cartoon is a symbol representing . . .
- According to the table, in which time period was [union membership] the highest?
- According to the graph, which section of the country had the largest [decrease in manufacturing jobs]?

Explanatory Questions

These questions ask students to identify the best explanation for the situation illustrated by the data. To answer these types of questions, the student must first analyze the data to understand the overall meaning. They must then go one step further and use their knowledge of social studies to find a satisfactory explanation for what the data indicate. These types of questions may take any of the following forms:

- The situation illustrated in the cartoon was caused by . . .
- Which factor best explains the events shown on the time line?
- The trend shown in the graph is most probably related to . . .

Conclusion or Generalization Questions

These questions ask students to make generalizations by tying together several elements in the data. These questions may be phrased as follows:

- The main idea of the cartoon is that . . .
- Which statement is best supported by the data in the table?
- Which generalization is best supported by the data in the bar graph?

Prediction Questions

These questions ask students to make a prediction based on the situation illustrated by the data. To answer these types of questions, students must first analyze the data to understand the overall meaning. They must then go one step further and use their knowledge of social studies to make educated guesses as to what will probably happen at some point in the future. These questions may take any of the following forms:

- The writer of the statement would most likely condemn . . .
- Recent Supreme Court decisions about [due process] would probably result in . . .
- Based on the information in the line graph, which is most likely to occur?

(pp. 106–108)

Newmann (1990)

Reading about the Student Locker Searches

This reading presents a court case involving the search of a student locker by a school administrator. Though not an actual case, it is based upon cases presented to the U.S. Supreme Court. You are to be the judge. As you read, think about how you might decide this case.

The Case of *State of New York v. Karen Doctor*

A teacher at a high school in New York discovered Karen, a 16-year old sophomore and her friend smoking cigarettes on school grounds, in clear violation of a school rule. The teacher took them to the principal's office. Karen denied that she had been smoking, saying that she didn't smoke at all. The assistant principal, Mr. Hardy, insisted on seeing the contents of her purse. He found a pack of cigarettes and also a package of rolling papers, which are often used to smoke marijuana. He then decided to search Karen's locker.

With Karen present at the search, Mr. Hardy discovered in her locker a small amount of marijuana, a pipe, a note card with a list of students who owed her money, and two letters that indicated that she was involved in dealing marijuana. He then contacted the police and delinquency charges were brought against Karen. In court, Karen's lawyer argued that the search of her locker violated her constitutional rights and therefore the evidence found in her locker cannot be used. The case should be dismissed. The attorney representing Mr. Hardy argued that the school had reasonable grounds for searching her purse and her locker and therefore the evidence uncovered can be used in the trial. She should be found guilty.

Background Information

The following information is provided to help you think about the case. Please read carefully. You should use this information in writing your argument.

[Background passage deleted]

As *judge*, you are to answer this question: Did the school violate Karen's constitutional rights by searching her purse and then her locker?

Please write an argument to try and convince someone of your position on this question. In your argument, you should

- state your position on the question,
- support your position by giving as many reasons as you can, and
- explain why they are good reasons.

Keep in mind that your position will be most convincing if you include information from the reading and show weaknesses in the opposing position. Good luck!

(pp. 372–373)

Baker, Aschbacher, Niemi, and Sato (1992)

> Imagine that it is 1858 and you are an educated citizen living in Illinois. Because you are interested in politics and always keep yourself well informed, you make a special trip to hear Abraham Lincoln and Stephen Douglas debating during their campaigns for the Senate seat representing Illinois. After the debate you return home, where your cousin asks you about some of the problems that are facing the nation at this time.
>
> Write an essay in which you explain the most important ideas and issues your cousin should understand. Your essay should be based on two major sources: (1) the general concepts and specific facts you know about American History, and especially what you know about the history of the Civil War, and (2) what you have learned from the reading yesterday. Be sure to show the relationships among your ideas and facts. (p. 23)

Sugrue (1994, 1995)

Assessment of Concepts

Example (concept of solution):

Identify which of the following liquids is a solution by placing an X beside it if it is a solution:
_____ 5 grams of salt in 20 grams of water
_____ 10 grams of salt in 20 grams of water
_____ 3 drops of food coloring in 10 grams of water
_____ 3 drops of food coloring in 20 drops of water
_____ maple syrup
_____ a cloudy liquid
_____ a clear red liquid
_____ a clear liquid with no color
_____ a clear mixture of baking soda and water

Give an example of a liquid that is a solution and explain why it is a solution.
Give an example of a liquid that is not a solution and explain why it is not a solution.
Give students a number of liquids, some obviously clear, some cloudy, and ask the students to select (without testing them) the liquids that are most likely to be solutions.
(p. 32)

Assessment of Principles

Examples (concentration/buoyancy principle):

One of the following problems is different from the rest. Indicate which one is the odd one out by placing an X beside it.

____1. Fred wanted to display his model boat floating in a basin of water, but when he tried it the boat sank.
____2. Jamal's vinegar and oil salad dressing would not stay mixed up in the bottle.
____3. Maria wanted to make a sponge take up as much water as possible.
____4. Joan wanted to make a number of colored liquids stay in separate layers in the glass.

(p. 33)

Why is it easy to float on Utah's Great Salt Lake?

A bowl is half full with a solution of lemonade powder and water. An egg is dropped in the lemonade and it floats. What is likely to happen to the egg if water is added to fill the bowl to the top?

(p. 34)

Follow the instructions below, observe the result, and then answer the question at the end.

Instructions:

Pour the maple syrup into the beaker; then pour the colored water in on top of it; then pour the corn syrup on top of that.

Questions:

1. Draw a picture of how the liquids look in the beaker. Label each liquid.
2. Why do the liquids end up in these layers?

(p. 34)

Assessment of Links from Concepts to Conditions and Procedures for Application

Example (concept of concentration):

John needed to test two sodas to see which one contained the most sugar. Some of the following methods will given [sic] him the answer, and some of them won't. Put an X beside any method that will give him the answer.

_____ 1. Use a balance to compare the mass of 100 ml of each of the sodas.
_____ 2. Find an object that will float on one, but not on the other.
_____ 3. Compare the amount of each soda it takes to soak a sponge of the same size.
_____ 4. Boil both liquids and compare their boiling points.

(p. 35)

Describe how you would determine which of two solutions of sugar and water was the more concentrated (without tasting them). (p. 35)

Use the equipment and materials provided to identify which of the liquids in the cups is more concentrated. (Provide the equipment necessary for more than one kind of test that is appropriate.)

Assessment of Links from Concepts to Conditions and Procedures for Application

A soda manufacturer wants its sodas not to freeze in very cold weather. Which of the following methods would be most likely to solve this problem?

_____ a. Decrease the amount of gas in the soda.
_____ b. Decrease the amount of sugar in the soda.
_____ c. Increase the amount of sugar in the soda.
_____ d. Store the soda in bottles rather than in cans.

(p. 36)

Customers in Alaska were complaining that cans of diet cola were freezing and bursting in the cold winter temperatures. Cans of regular cola were not freezing. What would you tell the makers of diet cola to do to stop it from freezing, and why? (p. 37)

You are going on an expedition/journey to the North Pole. You need to bring a supply of liquid to drink during your expedition/journey. You can choose one of the three liquids on the table.

Consider what you know about solution chemistry and perform the tests necessary to select the liquid that will be least likely to freeze during your journey. Then write the answers to the following two questions:

1. What is your conclusion (which liquid is least likely to freeze)?
2. Why?

(p. 37)

Sugrue (1994) indicated that the cognitive functions, planning and monitoring, can also be measured by more than one method. For example, students can be asked to indicate on a scale from 1 to 5 how well the following statements reflected their performance on the test they have just completed.

1. I worked out how much time I should spend on each question and I tried to stick to it.
2. I ran out of time at the end of the test.
3. I spent a long time planning how I would answer the questions.

(p. 40)

Open-ended questions could require students to estimate how much time they spent planning, how they determined their answers were correct, etc. Performance measures could include observations of the time students spend in planning, etc.

Beliefs about one's ability to succeed on the test and enjoyment of it as well as perceptions of test difficulty can be measured with multiple-choice or open-ended questions. Hands-on measures could be raters' observations of time spent and level of persistence and task involvement by students.

Marzano, Kendall, Calamera, Fanning, Grady, Pickering, Sutton, Whisler, & Young (1992)

Supported Deduction

(Students work in cooperative groups for a two week period of time, at the end of which they present a skit and an explanation of the deductive logic of their system of clues.)

Develop the clues to a murder mystery that has at least three suspects. However, your clues must show that one suspect had to be the murderer.

Error Analysis

(Students work in pairs or triads over a three week period of time, at the end of which they present their conclusions in videotape form. They also create and present some aesthetic product that symbolized police work.)

What do policemen really do? Watch at least three television programs about policemen and describe some of the errors about policemen or police work in those shows.

Constructing Support

(Over a two week period of time students work in pairs. At the end of that period of time they present their arguments orally with the aid of graphic organizers.)

We have been studying how great ideas have affected history. Develop an argument for or against the statement, “The pen is mightier than the sword.” Use specific examples in your argument.

(p. 70)

Secured tasks for the reasoning skills are:

Supported Deduction

(Students work independently for a 35 minute period of time, at the end of which they turn in their conclusions on an audiotape. They may use their books and their notes.)

Pretend that you are asked to read a story and are told that is it a fable. Before you begin to read it, what could you conclude must be in the story? Explain why you know these things must be in the story and give an example of each thing you identify.

Error Analysis

(Students work independently for a 25 minute period, at the end of which time they present their reasoning on an audiotape.)

Gabrielle enters 1,585 x 2.7 into her calculator. The display reads 42790.5. Is this answer reasonable? Explain.

Constructing Support

(Students work independently for a 40 minute time period, at the end of which they present their argument on an audiotape. They may use their textbooks and their notes.)

What do you think about using animal fur for coats? Construct an argument for or against their use.

(p. 122)

University of Cambridge, Local Examinations Syndicate (1997b)

1. In recent years, a number of countries have moved away from central planning toward a market economy.
    a. Explain the role of price in a market economy.
    b. What possible disadvantages may follow from this movement toward a market economy?

3. In many countries water, unlike oil, is not treated as an economic commodity and sold at a price that reflects demand and supply conditions. Often it is sold at a price below its total cost.
    a. Explain what is meant by the suggestion that the price of water is often below its total cost.
    b. What might be the possible effects in a country if water were treated like other commodities such as oil?

6. Governments in a number of countries have attempted to limit the use of private transport and encourage the use of public transport.
    a. How may governments attempt to do this?
    b. Why may governments wish to do this? (p. 2)

Sternberg (1985)

Making Inferences about Advertisements

The Avon supermarket advertises “low, low, prices.” Can you be sure that the prices at the Avon supermarket are the lowest prices in town?

a. Yes because otherwise the supermarket could not advertise “low, low prices.”
b. Yes, because the prices are lower than low.
c. No, because the advertisement is not truthful.
d. No, because there is no indication that the prices are the lowest in town.

Completing Standard Number Series

Complete the following number series: 2 3 5 8 12 _____

a. 15
b. 16
c. 17
d. 18

Learning from Context

In the following passage, what does “glick” mean?

> Traffic was heavy, so the glick moved slowly. The driver was carrying almost a ton of fruit from Florida to New Jersey and wanted to make sure that his shipment arrived intact. Thus, he made sure he stopped at red lights and avoided passing cars.

a. truck
b. car
c. orange
d. train

Using Insight to Solve Mathematical and Logical Problems

> I have 5 black socks and 4 blue socks in a drawer. How many socks do I have to take out of the drawer to make sure I have a pair of the same color?

a. 2
b. 3
c. 4
d. 5

(p. 41)

Paul and Nosich (1992)

Following are several abbreviated examples for assessing higher order thinking skills.

- In the following excerpt, mark E for each item that is a piece of empirical *evidence*, mark C for each item that is a *conclusion* based on evidence; mark N for each item that is neither. . . .

- The following is a list of possible findings in relation to the experiment quoted above. For each, say whether it would *support* the author's hypothesis, *oppose* the author’s hypothesis, or be neutral with respect to the author's hypothesis. . . .

- Below is a series of questions. Each question is followed by several reasons. For the purpose of this test, you are to regard each reason as true. The problem is then to decide whether it is a *strong reason* or a *weak reason*. . . .

(p. 17)

Multiple-rating items allow any number of answers to a question to be correct or incorrect. Ranking answers according to their plausibility is also possible. Abbreviated examples are given below:

- Here is a list of formulations of the writer's objectives in this excerpt. Rank them from 1 to 5 with respect to which is the most reasonable in the light of the quoted passage. . . .

- Read the excerpt, then, from the following list, identify the most plausible statement of the writer's purpose.

- List A below is a list of various possible statements of the writer's point of view in the quoted passage; list B is a list that includes possible assumptions and implications of those points of view. Match the items on list A with the items on list B. . . .

(pp. 19–20)

Essay items require the student to generate a response. These items can measure higher order skills that multiple-choice or multiple-rating cannot. Directions to the student for answering all the items that follow include a statement of the purpose of the test and eight criteria that would be used in evaluating the answers.

Directions

This test is designed to assess your critical thinking, problem solving, and communication skills. Your answer will be judged for its clarity, relevance, consistency, logic, depth, coherence, and fairness. More specifically, the reader will be asking the following questions:

1. Is the question at issue well stated? Is it clear and unbiased? Does the expression of the question do justice to the complexity of the matter at issue?
2. Does the writer cite relevant evidence, experiences, and/or relevant information essential to the issue?
3. Does the writer clarify key concepts when necessary?
4. Does the writer show a sensitivity to what he or she is assuming or taking for granted (in so far as those assumptions might reasonable be questioned)?
5. Does the writer develop a definite line of reasoning, explaining well how he or she is arriving at his or her conclusions?
6. Is the writer's reasoning well supported?
7. Does the writer show a sensitivity to alternative points of view or lines of reasoning?
8. Does he or she consider and respond to objections framed from other points of view?
9. Does a writer show a sensitivity to the implications and/or consequences to the position that he or she has taken?

Issue #1: Ecology

The nation is facing a variety of ecological problems that have the following general form: An established practice, whether on the part of business and industry or on the part of the public, is contributing to serious health problems for a large number of people. At the same time it would be costly to modify the practice so as to reduce the health problem. People often say that the answer is one of achieving a "balance" between the amount of money we spend to correct the problem and the number of lives we would save by that expenditure. Develop a point of view and some plausible criteria for telling how one would determine this "balance." Make sure you address any dilemmas inherent in your strategies for solving such problems.

Issue #2: Politics

There are a growing number of Americans who do not vote in national and local elections. Many explain their non-participation by saying that their vote would not make a difference. Some go on to argue that this is true because "money plays such a large role in elections that the candidate with the highest paid, and the highest quality, media campaign wins." Most people agree that money sometimes plays an inappropriate role in determining the outcome of elections. Develop a proposed solution to this problem that takes into account the view that people and organizations with money have a right to use that money to advance political causes they believe in. If you like, you may decide to develop a position to the effect that there is no solution to the problem and that we have no choice but to accept the status quo.

Issue # 3: Morality

Sociologist Erving Goffman has pointed out that all social groups, including professions, develop a protective attitude toward members of their group, even when what some of the members do is seen as morally wrong. A sense of loyalty to the group often overrides what they would otherwise deem immoral. Consider the arguments for and against exposing people with whom you are personally close or with whom you have close professional ties. Develop a position on this issue that could serve as a guide for anyone in such a position.

Pennsylvania Department of Education (1997a)

Grade 5 Multiple-Choice

Sharon buys three pencils at 19 cents each, two erasers at 27 cents each and three tablets at 75 cents each. If tax is included in these prices, which of the following is a correct change combination for her if she gives the sales clerk a five-dollar bill?

a. two $1 bills, two quarters, a dime and four pennies
b. two $1 bills, two quarters and six pennies
c. one $1 bill, two quarters, a dime and four pennies (Answer)
d. one $1 bill, two quarters, a nickel and one penny

(p. 18)

Grade 5 Sample Task

Linda is taking a poll to see what kinds of activities the students at Elm Street School would like to have at the school fair. She needs to obtain information which shows what students in all grade levels, including kindergarten, would like. She also needs to interview as many students as possible, but has time to talk to no more than 100 students. The table shows how many students there are at each grade level in the school.

Grade	Number of Students
Kindergarten	106
1	78
2	96
3	92
4	83
5	110
6	114

Make a plan for Linda to use to obtain the information she needs. Explain why your plan is a good one.

(p. 22)

Grade 8 Multiple-Choice

An average of 5000 people enter a certain shopping mall each day. If the shopping mall is open every day of the year, which of the following would be a reasonable estimate of how many people enter the shopping mall each year?

a. 1,500,000 people
b. 2,000,000 people (Correct Answer)
c. 200,000 people
d. 9,000,000 people

(p. 19)

Grade 8 Sample Task

In a city, there are 50,000 cable TV subscribers. Recently 600 of them were randomly surveyed to determine their program preference. The results were as follows: 126 preferred comedy, 225 preferred sports, 193 preferred movies, and 56 named “other” as their #1 TV preference. Using the results of this survey, approximately **how many** of the total cable TV subscribers would be expected to identify **sports** as their program preference?

You must show each step of your math work and write an explanation describing the steps you followed to arrive at your answer and why you chose each step, even if you did mental math or used a calculator.

(p. 34)

Grade 11 Multiple-Choice

In wood shop Gina is going to make a bookshelf. The blueprint for the shelf indicates a scale of 3:8. How high will her bookshelf be if the blueprint measurement for the height is 16.5 inches?

a. 44 inches (Correct Answer)
b. 6.2 feet
c. 4 feet
d. 62 inches

(p. 20)

Grade 11 Sample Task

Mr. Moser is planning to replace the roof of his home. He needs to order packs of shingles. Each pack covers 100 sq. ft. of roof. Without a ladder, Mr. Moser cannot climb to the roof to measure it. Instead, he measures his attic and finds it to be 40 ft long, 24 ft wide and 5 ft high at the peak of the roof which is the center of the house. Although the roof is even with the side walls, he estimates the roof line continues 1.5 feet beyond the front and back walls. How many full packs of shingles should Mr. Moser order to cover his roof?

[PICTURE OF HOUSE AND MEASUREMENTS]

Show all calculations and explain them. Do all work for this problem in the shaded region below. Remember you must show all steps you used to solve the problem even if you have used a calculator. To receive the highest score, all calculation steps must be shown and verbally explained. Numerical answers must always be labeled.

(p. 54)

Pennsylvania Department of Education (1997b)

Prompt 4: (Narrative/Imaginative)

Imagine that a severe storm has hit your area. Tell what happened.

As you write and rewrite your paper, remember to

- describe what happened that day.
- give details that are specific and relevant to this experience.

- present your ideas clearly and logically.
- use words and well-constructed sentences effectively.
- correct any errors in spelling, punctuation and capitalization.

Prompt 5: (Informational)

Teachers are always looking for ways to help students learn better. If you could help your teacher plan classroom activities that would improve your learning, what would you suggest to them? Write to inform your teacher about your suggestions and how these activities would improve learning.

As you write and rewrite your paper, remember to

- tell what the activities are and how they would help you learn better.
- include enough information and details so that your teacher will understand the activities and why they would help you learn better.
- present your ideas clearly and logically.
- use words and well-constructed sentences effectively.
- correct any errors in spelling, punctuation, and capitalization.

Prompt 6: (Persuasive)

Local leaders are considering building a recycling plant in your community. The only available location for the plant is the community park and recreation area. Do you think the plant should be built? Write to persuade others in your community to agree with your point of view.

As you write and rewrite your paper, remember to

- state your opinion clearly.
- support your opinion with specific details.
- present your ideas clearly and logically.
- use words and well-constructed sentences effectively.
- correct any errors in spelling, punctuation and capitalization.

APPENDIX C: OTHER RESOURCES

Agencies and Groups

Appalachia Educational Laboratory (AEL)
Purpose: The AEL specializes in rural education and serves Kentucky, Tennessee, Virginia, and West Virginia.
Contact: Appalachia Educational Laboratory, Specialty Area: Rural Education, P.O. Box 1348, Charleston, WV 25325-1348; Voice: (304) 347-0400 or (800) 624-9120, Fax: (304) 347-0487; Terry L. Eidell, Executive Director, eidellt@ael.org; Web site/FTP, http://www.hgb.psu.edu/~ekdl.labs.html

California Academic Press (CAP)
Purpose: CAP publishes critical thinking assessment tools based on the American Philosophical Association's Delphi consensus conceptualization of critical thinking (CT), which involves 46 leading theorists, teachers, and CT assessment specialists from several disciplines. These assessment tools have been developed with procedures to establish validity and reliability.
Contact: California Academic Press, 217 La Cruz Avenue, Millbrae, CA 94030; (650) 697-5628; e-mail info@calpress.com., http://www.hgb.psu.edu/~ekdl.labs.html

Dimensions of Learning Network (DLN)
Purpose: The DLN provides structure to network members to share ideas using the Dimensions of Learning model and to exchange information about how to implement the model. Activities include building a bank of lessons, creating a database of users, publishing a member directory, and publishing newsletters.
Contact: Diana Deatherage Pearson, Teacher Consultant, Kenosha Unified School District No. 1, 3600-52nd Street, Kenosha, WI 53144; http://www.mcrel.org/; http://www.hgb.psu.edu/~ekdl.labs.html

Laboratory for Student Success (LSS)
Purpose: LSS specializes in urban education and serves Delaware, Maryland, New Jersey, Pennsylvania, and Washington, DC.
Contact: Temple University, Center for Research in Human Development and Education, 1301 Cecil B. Moore Ave., Philadelphia, PA 19122-6091; (800) 892-5550, Fax: (215) 204-5130, e-mail: LSS@VM.TEMPLE.EDU; http://www.temple.edu/department/LSS/; http://www.hgb.psu.edu/~ekdl.labs.html

Mid-continent Regional Educational Laboratory (McREL)

Purpose: McREL specializes in curriculum, learning, and instruction and provides technical assistance and consultation. The region includes Colorado, Kansas, Missouri, Nebraska, North Dakota, South Dakota, and Wyoming.

Contact: McREL Mid-continent Regional Educational Laboratory, Specialty Area: Curriculum, Learning, and Instruction, 2550 S. Parker Rd., Suite 500, Aurora, CO 80014; Voice: (303) 337-0990, Fax: (303) 337-3005; Tim Waters, Executive Director, twaters@mcrel.org, Web site/FTP, http://www.mcrel.org/; http://www.hgb.psu.edu/~ekdl.labs.html

The National Center for Research on Evaluation, Standards, and Student Testing (CRESST)

Purpose: CRESST conducts research on topics for K–12 educational testing and is affiliated with the Graduate School of Education and Information Studies at the University of California–Los Angeles (UCLA). Materials include media contacts on testing, a parent page with assessment information about K–12 children, research reports, free newsletters about the latest CRESST research.

Contact: Kim Hurst, CRESST/UCLA, 301 GSE&IS, Box 951522, Los Angeles, CA 90095-1522; (310) 206-1532, Fax: (310) 825-3883; e-mail Kim Hurst (kim@cse.ucla.edu), http://CRESST96.cse.ucla.edu/index.htm; requires Netscape 2.0 or later; requires Acrobat Reader (3.0) to read summaries of reports. http://www.hgb.psu.edu/~ekdl.labs.html

North Central Regional Educational Laboratory (NCREL)

Purpose: NCREL specializes in technology and serves as the Regional Educational Laboratory for Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin.

Contact: North Central Regional Educational Laboratory, 1900 Spring Road, Suite 300, Oak Brook, IL 60521; Phone: (800) 356-2735, Fax: (630) 571-4716; Jeri Nowakowski, Executive Director, nowakows@ncrel.org; e-mail: info@ncrel.org, http://www.ncrel.org; http://www.hgb.psu.edu/~ekdl.labs.html

Northeast and Islands Regional Educational Laboratory at Brown University (LAB)

Purpose: LAB specializes in school reform and professional development and serves Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, Puerto Rico, and the Virgin Islands.

Contact: Northeast and Islands Regional Educational Laboratory at Brown University, Specialty Area: Language and Cultural Diversity, 222 Richmond Street, Suite 300, Providence, RI 02903-4226; (401) 274-9548, (800) 521-9550, Fax: (401) 421-7650; Philip Zarlengo, Executive Director, Phil_Zarlengo@Brown.edu, lab@brown.edu, http://www.hgb.psu.edu/~ekdl.labs.html

Pacific Resources for Education and Learning (PREL)

Purpose: PREL specializes in language and cultural diversity and serves the United States in the Pacific region.

Contact: Pacific Resources for Education and Learning (includes Hawaii and all U.S. affiliates in the Pacific Basin), Specialty Area: Language and Cultural Diversity, 828 Fort Street Mall, Suite 500, Honolulu, HI 96813; Voice: (808)533-6000, Fax: (808) 533-7599; John W. Kofel, Executive Director, kofelj@prel.hawaii.org, Web site/FTP (n/a), http://www.hgb.psu.edu/~ekdl.labs.html

Southeastern Regional Vision for Education (SERVE)

Purpose: SERVE specializes in early childhood education and serves Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina.

Contact: The Southeastern Professional Development Institute (SERVE, Inc.), P.O. Box 5406, Greensboro, NC 27435; (910) 334-4667; http://serve-line.serve.org/; http://www.hgb.psu.edu/~ekdl.labs.html

Southwest Educational Development Laboratory (SEDL)

Purpose: SEDL specializes in language and cultural diversity and serves Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.

Contact: Southwest Educational Development Laboratory, Specialty Area: Language and Cultural Diversity, 211 East Seventh Street, Austin, TX 78701-3281; Voice: (512) 476-6861, (800) 476-6861, Fax: (512) 476-2286; webmaster@sedl.org; Wesley A. Hoover, President and CEO, whoover@sedl.org, Web site/FTP, http://www.hgb.psu.edu/~ekdl.labs.html

WestEd

Purpose: WestEd specializes in assessment and accountability and serves as the regional education laboratory for Arizona, California, Nevada, and Utah. Headquarters are in San Francisco, with additional offices in Arizona, Massachusetts, and elsewhere in California.

Contact: WestEd (Far West Laboratory and Southwest Regional Laboratory), Specialty Area: Assessment and Accountability, 730 Harrison Street, San Francisco, CA 94107-1242; Voice: (415) 565-3000, Fax: (415) 565-3012; Glen Harvey, Executive Director, dholznag@serve.org, Web site/FTP/Gopher, http://www.fwl.org/; http://www.hgb.psu.edu/~ekdl.labs.html

Thinking Skills Programs

Thinking skills programs have become popular in elementary and secondary education (Cotton, 1997, p. 6). In 1991, 1,700 school districts were using the “CoRT” program, 5,000 schools were using “Philosophy for Children,” and 70,000 teachers were using “Tactics for Thinking” (Crowl et al., 1997, p. 173).

These programs, which do not share a set of central and unifying themes, focus on a variety of skills (Crowl et al., 1997, p. 173). Their successes for student achievement depend on factors such as teacher training, quality of teaching, administrative support, appropriateness of the program, and method of implementation (Cotton, 1997, pp. 7–8).

Thinking skills programs include the following programs, which have appeared in several reports:

1. *Comprehensive School Mathematics Program (CSMP)*—for elementary-level math with a focus on the classification, basic logic, concepts, and development of ideas and the number theory in which children use computers, calculators, geometry models (Cotton, 1997, p. 6).
2. *Cognitive Research Trust (CORT)*—for students of any age or grade level to develop critical, creative, and constructive thinking skills over a 3-year period (Cotton, 1997, p. 6); this program has 63 lessons, each taking about 35 minutes, and uses mnemonics to help students reason, such as CAF for “consider all factors” (Crowl et al., 1997, p. 173).
3. *Higher Order Thinking Skills (HOTS)*—for Chapter 1 and other elementary students to enhance skills in metacognition, inferencing, and decontextualization (transfer of skills) using a computer laboratory context (Cotton, 1997, p. 6).
4. *Institute for Creative Education (ICE)*—for K–12 students to develop creative thinking skills of fluency, flexibility, originality, and elaboration applied to problem–solving activities (Cotton, 1997, p. 6).
5. *Instrumental Enrichment (IE)*—for upper elementary and secondary students to develop active learning processes applied to clusters of problem-solving tasks and exercises (Cotton, 1997, p. 6).
6. *Kids Interest Discovery Study (KIDS) Kits*—for elementary schools to use in conducting surveys of students’ interests and engage students in active, self-directed learning and higher-level thinking around topics related to those interests (Cotton, 1997, p. 6).
7. *Odyssey*—for upper elementary or secondary students to develop the foundations of reasoning, understanding of language, verbal reasoning, problem solving, decision making, and inventive thinking (Cotton, 1997, p. 6).
8. *Philosophy for Children*—for K–12 students to develop thinking and reasoning skills through classroom discussion organized around six novels in which students apply philosophical thinking to their daily lives (Cotton, 1997, p. 6).
9. *Problem Solving and Comprehension*—for students to work in problem-solver-listener pairs to develop decoding skills, vocabulary, basic arithmetic operations, and precise thinking (Cotton, 1997, p. 6).
10. *SAGE*—for gifted elementary students to develop thinking skills through activities, ministudy units, and independent study (Cotton, 1997, p. 6).
11. *SOI*—for development of reasoning organized around 120 intellectual skills based on Guilford’s structure-of-intellect theory (Cotton, 1997, p. 6).
12. *Talents Unlimited (TU)*—for elementary students to develop productive thinking, decision making, planning, forecasting, communication, and knowledge about multiple thinking skills (called “talents”); teachers receive training to instruct students (Cotton, 1997, p. 6).

13. *THINK*—for secondary students to develop problem-solving skills, including rationales that lead to their conclusions, consideration of other points of view, and analysis of various reasoning processes (Cotton, 1997, p. 6).

Resources

Adventure, Project

Goal: To infuse experiential learning courses by working on specific reality-based tasks or problems in the community and the natural environment

Grades: 6–12

Audience: Teachers and students

Source: Dick Prouty, Project Adventure, Inc., P.O. Box 100, Hamilton, MA 01936; (508) 468-7981. Cindy Simpson, P.O. Box 2447, Covington, GA 30209; (404) 784-9310. Jim Grout, 116 Maple Street, Brattleboro, VT 05301, (802) 254-5054. Ann Smolowe, P.O. Box 14171, Portland, OR 97214, (503) 236-6765, http://www.ed.gov/pubs/EPTW/eptw10/10p.html

ASK to THINK-TEL WHY: A Model of Transactive Peer Tutoring for Scaffolding Higher Level Complex Learning by Lison King

Goal: To provide strategies for using peer tutors to teach higher order thinking skills

Grades: 4–12

Audience: Teachers and students

Source: Alison King, Professor of Education Psychology, California State UniversityB San Marcos, San Marcos, CA 92096; e-mail: aking@mailhost1.csusm.edu

The Bread and Butter of the Internet: A Primer and Presentation Packet for Educators

Goal: To provide simple explanations for the Internet, e-mail, listservs, Telnet, FTP, gopher, and the World Wide Web

Audience: Teachers and educators

Source: Information Resources Publications, Syracuse University, 4-194 Center for Science and Technology, Syracuse, NY 13244-4100; ERIC NO. ED402924

CLIMB Plus

Goal: To improve the performance of all students by integrating reading, writing, study skills, and mathematics through the use of a curriculum framework, procedures for classroom management and implementation, active learning strategies and models, and content reading and study skills strategies

Grades: K–12

Audience: Teachers and students

Source: Barbara Brenner, Director, CLIMB Plus, Middlesex Public Schools, 30 Kennedy Drive, Middlesex, NJ 08846, (908) 968-4494 or (908) 968-2666; Developmental Funding: NJ TEEA R&D and USOE ESEA Title IV-C. JDRP No. 81-44 (1/28/82), Recertified(3/25/93), http://www.ed.gov/pubs/EPTW/eptw10/10b.html

Comprehensive School Mathematics Program (CSMP)

Goal: To develop problem-solving skills and concepts using situational teaching methods; graphic, nonverbal “languages”; colorful and unusual manipulatives; and even fantasy stories for exploring mathematics in the context of the latest standards adopted by the National Council of Teachers of Mathematics

Grades: K–6

Audience: Teachers and students

Source: McREL Resource Center, 2550 South Parker Road, Suite 500, Aurora, CO 80014-1678; http://www.mcrel.org/programs/

Computer-Assisted Diagnostic Prescriptive Program (CADPP) in Reading and Mathematics

Goal: To generate educational plans as the basis for a diagnostic/prescriptive approach to instruction in reading and mathematics

Grades: 3–9, Reading; 3–7, Math

Audience: Teachers and students

Source: Debora J. Roberson, Technology in Education Corporation, Inc., 1844 West 85th Ave., J-266, Merrillville, IN 46410, (219) 769-1712; http://www.ed.gov/pubs/EPTW/eptw10/10c.html

Computers Helping Instruction and Learning Development (Project CHILD)

Goal: To (a) modify the school structure and create classroom conditions conducive for learning with technology; (b) create cohesive units of work that foster strategies for thinking; and (c) realign curriculum for reading, language arts, and mathematics so as to cover legally mandated content while fully integrating computer technology into the curriculum

Grades: K–5

Audience: Teachers and principals

Source: Sarah M. (Sally) Butzin, Daniel Memorial Institute, Inc., P.O. Box 13296, Tallahassee, FL 32317-3296, (904) 385-6985, (800) 940-6985; http://www.ed.gov/pubs/EPTW/eptw10/10d.html

Creating Independence through Student-owned Strategies (Project CRISS)

Goal: To teach students how to learn through reading, writing, talking, listening, and using student-owned strategies

Grades: 4–12

Audience: Teachers and students

Source: Lynn Havens or Carol Santa, Project CRISS, School District #5, 233 First Ave., East, Kalispell, MT 59901, (406) 756-5011, Fax: (406) 756-4510; e-mail: csanta@inet.ed.gov., http://www.ed.gov/pubs/EPTW/eptw10/10e.html

Critical Thinking and Problem Solving Course Overview by Nancy L. Stegall and Lori Abrams

Goal: To provide an introduction to critical thinking and problem solving
Grades: NA
Audience: Teachers
Source: DeVry Institute of Technology, Phoenix, AZ; http://www.primenet.com/~stegall/think.htm

Davis County Indian Homework Centers Program (IHC)

Goal: To increase the achievement scores of Indian students in the Davis County (Utah) School District through a tutoring program
Grades: 1–12
Audience: Students who request and agree to be tutored, tutors, and supervisors
Source: Bruce G. Parry, Project Manager, Davis County Indian Homework Centers Program, 2175 S. 1000 West, Syracuse, UT 84057, (801) 825-6512; http://www.ed.gov/pubs/EPTW/eptw10/10g.html

Gulfport Follow Through: University of Georgia (UGA)

Goal: To use assessment of the cognitive level as a guide for establishing a learning environment that maximizes development of the thinking process by encouraging the student to experiment with problems and discover solutions
Grades: K–3
Audience: Teachers and students
Source: Ronnie Barnes, Director, Gulfport School District, P.O. Box 220, Gulfport, MS 39502-0220, (601) 865-4672; http://www.ed.gov/pubs/EPTW/eptw10/10q.html

Helping with Homework: A Parent's Guide to Information Problem Solving

Goal: To provide parents with information and computer technology problem-solving tools (Big Six Skills) so they can help their children become independent learners
Grades: Not specified
Audience: Parents, teachers, and educators
Source: Clearinghouse on Information and Technology, Syracuse University, 4-194 Center for Science and Technology, Syracuse, NY 13244-4100

History Alive, Six Powerful Teaching Strategies

Goal: To provide teachers with cooperative learning, multiple intelligence, and spiral curriculum strategies that engage students in thinking
Grades: 5–12
Audience: Teachers
Source: Teachers Curriculum Institute, 201 San Antonio Circle, #105, Mountain View, CA 94040

H.O.T.S.: Higher Order Thinking Skills Project

Goal: To provide an alternative approach to Chapter 1 for students in grades 4–6 in which compensatory services consist solely of higher order thinking activities
Note: The program is conducted in a lab equipped with Apple computers (Apple IIe, Apple IIgs, or Macintosh LC), a detailed curriculum, and a teacher trained in Socratic dialog techniques.

Grades: Chapter 1 students in grades 4–6 in both reading and math; also used successfully with Chapter 1 students in grade 7, learning disabled students in grades 4–6, and gifted in grades K–2

Audience: Teachers and students

Source: Christi Estrada or Dr. Stanley Pogrow, University of Arizona, College of Education, Tucson, AZ 85721, (602) 621-9373; Developmental Funding: U.S. Department of Education and Ford Foundation, PEP No. 88-12 (7/13/88); http://www.ed.gov/pubs/EPTW/eptw10/10a.html

HOTStuff: The Unofficial Newsletter of The HOTS Program, Bold New Look—Same Old Pulp, December 1997

Goal: To provide examples of student products, new methods of teaching, web site locations, and related HOTS tips

Grades: Not specified

Audience: Teachers and students

Source: Education Innovations, 2302 East Speedway, Blvd. #114, Tucson, AZ 85719

How Difficult Should a Test Be?

Goal: To provide guidelines for setting a passing score for classroom tests

Audience: Teachers and educators

Source: ERIC Clearinghouse on Assessment and Evaluation, 210 O'Boyle Hall, The Catholic University of America, Washington, DC 20064

Increase Maximal Performance by Activating Critical Thinking Skills (IMPACT)

Goal: To provide staff development for infusing critical thinking with content area instruction using a framework of 22 critical-thinking skills, a model lesson format, and teaching behaviors that activate student use of critical thinking (requires teacher training)

Grades: 6–9

Audience: Teachers

Source: S. Lee Winocur, Ph.D., National Director, IMPACT, Center for the Teaching of Thinking, 21412 Magnolia Street, Huntington Beach, CA 92646, (714) 964-3106; Phi Delta Kappa, Eighth Street and Union Avenue, Box 780, Bloomington, IN 47402-0789, (812) 339-1156; http://www.ed.gov/pubs/EPTW/eptw10/10h.html

Institute for Creative Education (ICE)
Goal: To provide a creative problem solving process that is based in a sequentially ordered curriculum that integrates thinking skill development into a wide variety of subject areas to enable students to respond to problems or tasks more fluently, flexibly, originally, and elaborately
Grades: NA
Audience: Teachers (A two-day teacher workshop required)
Source: Monika Steinberg, Director, Institute for Creative Education, Education Information and Resource Center (ERIC), 606 Delsea Drive, Sewell, NJ 08080, (609) 582-7000, Fax: (609) 582-4206; http://www.ed.gov/pubs/EPTW/eptw10/10r.html

Interdependent Learning
Goal: To use instructional games and pupil self-management methods to teach students traditional academic skills and positive sociocultural attitudes and behaviors
Grades: PreK–6
Audience: Administrators, supervisors, teacher trainers, and support staff
Source: Susan Courtney-Weissman, Interdependent Learning Model, Fordham University, 113 West 60th Street, Room 1003, New York, NY 10023, (212) 636-6494; http://www.ed.gov/pubs/EPTW/eptw10/10s.html

Kids Interest Discovery Studies Kits (KIDS KITS)
Goal: To generate active, self-directed learning and higher levels of thinking, using organized sets of multimedia materials on topics of student interest, problem solving, and career education
Grades: 1–8
Audience: Students
Source: Jo Ann C. Petersen, KID KITS, 3607 Martin Luther King Blvd., Denver, CO 80205, (303) 322-9323, Fax: (303) 322-9475; http://www.ed.gov/pubs/EPTW/eptw10/10i.html

Leflore County (Mississippi) Follow Through Project
Goal: To develop skills in using a framework in which children assume responsibility for their own learning by planning self-initiated activities, carrying out their plans, presenting what they have learned, sharing their experiences with others, and becoming independent decision makers and problem solvers
Grades: K–3
Audience: School administrators, teacher trainers, paraprofessionals, and teachers
Source: Ann Adams, Educational Services Building, 1901 Highway 82 West, Greenwood, MS 38930, (601) 453-8566; http://www.ed.gov/pubs/EPTW/eptw10/10t.html

Literacy Links

Goal: To support teachers in developing instructional, interactive modules in vocabulary, comprehension, and study strategies using the content of their own courses, including familiarization with cooperative learning strategies and activities designed to enable students to organize and apply knowledge

Grades: 5–12

Audience: Teachers

Source: Lynn Dennis, Director, Coeur d'Alene Public Schools, District 271, 311 North 10th Street, Coeur d'Alene, ID 83814, (208) 664-8241, Fax: (208) 664-1748; http://www.ed.gov/pubs/EPTW/eptw10/10j.html

Multicultural Reading and Thinking (McRat)

Goal: To provide a staff development process to help teachers infuse higher order thinking skills and multicultural concepts into existing curriculum for all students and to measure progress through students' writing using direct instruction strategies, modeling, explanation, guidance, and feedback on the use of thinking

Grades: 3–8

Audience: Teachers

Source: Janita Hoskyn, Program Manager, Reading Program, Arkansas Department of Education, Room 401B, #4 Capitol Mall, Little Rock, AR 72201, (501) 682-4232 or (501) 225-5809; http://www.ed.gov/pubs/EPTW/eptw10/10k.html

Multiple Intelligences: Enabling Diverse Learning

Goal: To develop the seven domains of intelligence: (1) logical mathematics, (2) linguistics, (3) musical, (4) spatial, (5) bodily kinesthetic, (6) interpersonal, and (7) intrapersonal

Grades: Young children

Source: Early Childhood Education Journal, Vol. 23 (Summer '96), pp. 249B53; epub@oclc.org; http://gilligan.fs.ded...490028:50:/fsrec50.txt

Need New Problem-Solving Ideas? Take a Trip! by Lynda R. Wiest and Mary Barr Sturbaum

Goal: To provide ways to use actual or planned travel experiences for constructing realistic, challenging, and interesting problem-solving tasks, with examples of how teachers and students can create travel problems for elementary, secondary, or postsecondary classrooms

Grades: Elementary, secondary, and postsecondary classrooms

Audience: Teachers and students

Source: School Science and Mathematics Abstracts, Vol. 96, No. 4; http://science.cc.uwf.edu/ssma/abs/SSMV96N4.htm

Philosophy for Children

Goal: To provide a program that offers conceptual and cultural enrichment while providing skill improvement in comprehension, analysis, and problem solving by developing specific reasoning competencies

Grades: 3–7

Audience: Teachers

Source: Mathew Lipman, Professor of Philosophy and Director, Institute from the Advancement of Philosophy for Children, Montclair State College, Upper Montclair, NJ 07043, (201) 655-4277, Fax: (201) 655-5455; e-mail: lipman@saturn.montclair.edu; http://www.ed.gov/pubs/EPTW/eptw10/10l.html

Questioning and Understanding to Improve Learning and Thinking (QUILT)

Goal: To increase and sustain teacher use of classroom questioning techniques and procedures that produce higher levels of student learning and thinking through the use of effective questioning

Grades: K–12

Audience: Teachers and local facilitation teams (Teacher training required)

Source: Sandra Orletsky, Project Director, Appalachia Educational Laboratory, P.O. Box 1348, Charleston, WV 25325, (304) 347-0400 or (800) 624-9120, Fax: (304) 347-0487; http://www.ed.gov/pubs/EPTW/eptw10/10m.html

Strategies for Technical Communication, A Collection of Teaching Tips by Meg Morgan, John McNair, and Deborah S. Bosley

Goal: To provide guidelines and examples on teaching students how to prepare technical reports with visuals, tables, graphics, acronyms, technical descriptions, and e-mail

Grades: Various

Audience: Teachers

Source: Society for Technical Communication, 901 N. Stuart Street, Suite 904, Arlington, VA 22203-1854

Student Team Learning

Goal: To provide instructional techniques in which students learn to master basic skills presented by the teacher using three major strategies: Student Teams Achievement Division (STAD), Teams-Games-Tournaments (TGT), and Jigsaw II

Grades: 3–12

Audience: Teachers and students

Source: Anna Marie Farnish, Director of Training Projects, Center for Social Organization of Schools, 3505 North Charles Street, Baltimore, MD 21218, (410) 516-8857, Fax: (410) 516-8890; http://www.ed.gov/pubs/EPTW/eptw10/10u.html

Study Skills Across the Curriculum
Goal: To improve students' study skills
Grades: 5–8
Audience: Teachers, parents, and students
Source: Patricia S. Olson, Director, ISD 197- Study Skills across the Curriculum, 1897 Delaware Avenue, West, St. Paul, MN 55118, (612) 681-0844, (612) 898-3002, Fax: 612/681-0879; http://www.ed.gov/pubs/EPTW/eptw10/10n.html

Systems Approach to Individualized Instruction (SAII)
Goal: To provide a systematic instructional program in reading and mathematics using criterion-referenced tests and learning modules
Grades: 1–6 and in other settings for 7–8
Audience: Teachers
Source: Charles L. Barker, Josephine County School District, P.O. Box 160, Murphy, OR 97533, (503) 862-3111; http://www.ed.gov/pubs/EPTW/eptw10/10v.html

Talents Unlimited
Goal: To develop skills in using a teaching/learning model that integrates creative and critical thinking skills in any classroom curriculum
Grades: 1–6, also being used in 7–12
Audience: NA
Source: Brenda Haskew, Talents Unlimited, 109 South Cedar Street, Mobile, AL 36602, (205) 690-8060,
Fax: (205) 344-8364; http://www.ed.gov/pubs/EPTW/eptw10/10o.html

Teacher's Handbook of Practical Strategies by Susan H. Hawley and Robert C. Hawley
Goal: To provide practical strategies and examples for how to teach thinking, including activities and behaviors to promote thinking and checklists for planning and teacher evaluation
Grades: K–12
Audience: Teachers
Source: ERA Press, Education Research Associates, Box 767, Amherst, MA 01004

Toolkit98 Developed collaboratively by all 10 Regional Educational Laboratories
Goal: To define expectations for performance for students, encourage student self-reflection and self-assessment, and assist classroom teachers in assessing student learning
Grades: NA
Audience: Professional development of staff and teachers
Source: McREL Resource Center, 2550 South Parker Road, Suite 500, Aurora, CO 80014-1678, http://www.mcrel.org/
Note: The cost of Toolkit*98* is $66.50, which includes UPS ground shipment.

Transforming Ideas for Teaching and Learning Mathematics by Carole B. Lacampagne

Goal: To provide teaching and learning strategies for creating and transforming four congruent shapes and ways for including nonroutine problems in the development of higher order skills

Grades: K–8

Audience: Students

Source: United States Department of Education, Office of Educational Research and Improvement, 555 New Jersey Avenue NW, Washington, DC 20208-5641; http://www.ed.gov/pubs/StateArt/Math/covpg.html

Transforming Ideas for Teaching and Learning to Read by Ann P. Sweet

Goal: To provide 10 interrelated ideas for transforming literacy instruction in the classroom

Grades: K–8

Audience: Teachers

Source: United States Department of Education, Office of Educational Research and Improvement, 555 New Jersey Avenue NW, Washington, DC 20208-5641; http://www.ed.gov/pubs/StateArt/Read/covpg.html

Using the California Critical Skills Test in Research, Evaluation, and Assessment by Peter A. Facione

Goal: To access core college-level critical-thinking skills based on validation studies

Grades: NA

Audience: Administrators and teachers

Source: California Academic Press, 217 La Cruz Ave., Millbrae, CA 94030; cited at http://rice.edn.deakin...roj/Mt Annan/home.html

Writing Multiple-Choice Test Items

Goal: To provide guidelines for the task of constructing multiple-choice tests

Audience: Teachers and educators

Source: ERIC Clearinghouse on Assessment and Evaluation, 210 O'Boyle Hall, The Catholic University of America, Washington, DC 20064