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ABSTRACT

This review explores the factors of cognitive processing, style, and metacognitive organization as they contribute to academic success. Specific discussions consider aspects of short- and long-term memory, including how these affect learning and academic performance, and the keys to attaining long-term memory capability by involving redundancy, thinking patterns, and meaning. It is noted that arrangements emphasizing the relationship between ideas and materials enhance learning, and successful learning requires the storage of information in meaningful structures carefully related to learners' prior knowledge and experience. In addition, the article explains how encoding, practice, and cognitive style all work to enhance a student's ability to learn and offers insights on influencing each area to gain the best academic performance from the student. Finally, the process by which the brain organizes and monitors its cognitive resources is examined in relation to using strategies to aid intelligent performance, the success of which depends on the pursuit of the emotional, attitudinal, and motivational orientations promoting academic success. Contains 28 references. A brief Field Notes column (Carole Morning) describes Stress on Analytical Reasoning (SOAR), a program conducted jointly by Xavier University of Louisiana's mathematical, engineering, and sciences departments and designed to promote math and science curricula among selected minority engineering students. (GLR)

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Field Notes

In 1991, HEES assisted California State University at Northridge (CSUN) in instituting a Summer Bridge Program for selected entering minority engineering students to improve their preparation for the demands of college level mathematics, science and engineering courses.

CSUN faculty and administrators considered various models for the program and found the Stress on Analytical Reasoning (SOAR) program, conducted jointly by the faculty of Xavier University of Louisiana's mathematics, engineering and sciences departments, to be particularly effective. According to U.S. News and World Report (Toch, 1990), Xavier places more African-American students into medical school than any other institution, including Harvard, Yale, Columbia or University of Michigan, with the only exception being Howard University, a school four times its size. Twenty percent of Xavier's graduating seniors go on to medical or dental schools, and no less than 55% of Xavier undergraduates major in math, science or engineering. Evaluations of the SOAR approach indicate further that participating students achieve better grades and show greater persistence in the math/science curricula at Xavier than non-participants (Sevenair, et. al., 1987).

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Cognitive Factors in Academic Achievement

To improve the academic performance of students, higher education administrators must consider not only affective issues but intellectual ones as well. To better understand the latter, the true nature of intellectual performance must be understood.

Colleges often depend upon tests that they believe will predict college academic performance for the students tested. IQ tests and their correlates, however, measure only three aspects of intelligence: inherited intellectual ability, content knowledge, and problem-solving skills. Since it is assumed that inherited ability is fixed, most pedagogy in higher education, then, is geared toward increasing students' content knowledge and improving their problem-solving skills.

IQ-type measures do not include the wide variety of abilities with which colleges should be concerned; intelligence is a broader and more complex concept than IQ (Gardner, 1985; Sternberg, 1985). It goes beyond results obtained from pencil-and-paper exercises to include many other cognitive activities — writing, reading, discussion, coping with novelty, forming reasoned judgments, for example, as well as attitudes and emotions as they influence intellectual activities.

Emerging cognitive science research offers new views of intellectual performance that can contribute to more effective educational practices. In the following discussion, intelligence is described as the application of cognitive and metacognitive processes to learning and problem-solving. Cognitive processing depends on brain functions, such as short-term memory, long-term memory, encoding, and practice. Metacognitive processes involve the *management* of cognitive processes, by techniques such as self-steering, thinking strategies, functional principles, and mental preparation involving attitudes and emotions. The interaction of cognitive and metacognitive activities is dynamic and complex, and individual differences appear in every aspect. Nonetheless, it is possible to describe a model of how people think and learn generally, that illustrates how effective academic performance takes place.

Cognitive Processing

Short-term Memory

Short-term memory, or working memory, refers to the capacity for keeping a limited amount of information in a special active state. Conscious mental work is done in short-term memory. Information from the external environment or from memory in general can be used only in this activated state. In fact, the speed of cognitive processing varies directly with the degree of short-term memory activation (Anderson, 1985). When doing intellectual work in short-term memory, relevant information already learned is retrieved from memory, activated, and combined with new information from the environment. Learning depends on this integration of prior knowledge with new information. The accurate, speedy passage of the products of this integration from short-term memory to appropriately structured long-term memory is the neurological correlate of successful learning (Atkinson & Schiffrin, 1968; 1971).

Short-term memory, however, has a very limited capacity. Only a small amount of information can be active in short-term memory, and this information is lost within 15 to 30 seconds if it is not rehearsed (Reed, 1988). A phone number, for example, is rapidly forgotten unless repeated to oneself to sustain its activation. Experiments indicate that an average short-term memory capacity ranges from 3.4 items for nonsense syllables, to 3.8 for random forms, to 5.3 for geometrical shapes, to 5.5 for words, to 6.4 for letters, to 7.1 for colors, and to 7.7 for digits. Cavanagh (1972) has explained this range with the theory that stimuli are represented or encoded into short-term memory as a list of features. A color or word may be represented in short-term memory by fewer features than a nonsense syllable or random form because more features are needed to specify the more unfamiliar items. Assuming that the processing time for each feature is the same, more items represented by fewer features should require as much time to access as fewer items with more features. In the example above, it should take approximately the same amount of time to search for 3 nonsense syllables as it takes for 7 digits. It turns out that it does take the same amount of time, about one quarter of a second, in each case.

How can all the needed information be processed when short-term memory is so limited? In a famous paper, Miller (1956) found that subjects in recall experiments remember about seven "chunks" of information; "chunks" being clusters of features resulting when individuals divide up an information load into manageable units. Chunking is the primary means of processing conscious material in short-term memory. It enables the manipulation of greater amounts of information and it readies information for entrance into long-term memory. For example, when testing memorization of syllabic strings, the processing load initially is simply the number of syllables. But while subjects can only retrieve *three* nonsense syllables, they can recall a string of *six* monosyllabic words (a doubling of the processing load), and they can remember three four-syllable words (*twelve* syllables - apparently doubling the load again). If mnemonic techniques are used, such as applying a single feature to a set of syllables, larger amounts can be memorized. "Every Good Boy Does Fine" is a single thought that many use to remember the notes E, G, B, D, and F of the treble clef. The reason the processing load limits appear to increase, then, is that it is not simply the number of syllables or discrete unrelated features, but the number of meaningful chunks that counts.

These meaningful groupings are the units of memory, and a chunk can, at one level, subsume a large number of features, and at another level be just one element of a larger whole (Anderson, 1985). One may ultimately memorize a speech by reducing it to a few related chunks representing major concepts, although initially several features per sentence may have been required to represent each point in short-term memory. Thus, when the few chunks that fit into short-term memory each accommodate a large amount of relevant information, and when each of these chunks also relates significantly to others and to relevant prior knowledge, the processing capability of working memory expands. The "design" characteristics of learning, then, are more important than reliance upon the brute speed of neural machinery.

An overly quantitative view of neural functioning has led to the argument that cognitive efficiency is the root of all intelligence and has an extensive genetic basis. The argument is that if intelligence is reducible, in principle, to general physiological factors correlated with neural speed and cellular configuration, then intellectual potential is limited by the genes controlling such factors. However, currently accepted concepts argue against the genetically fixed limits imposed by some general factor theories of intelligence.

For example, the most popular general factor theory today is perhaps the theory of "fluid" and "crystallized" abilities (Catell, 1943;1963; Horn, 1976). "Fluid" mental functioning (Gf) is "a general ability to discriminate relations," while "crystallized" ability (Gc) involves "discriminatory habits long established in a particular field" (Lohman, 1989, p. 339). In terms of this theory, general reasoning ability, often thought of as one's hereditary intellectual ability, correlates with Gf; learned skills and knowledge gleaned from one's experience correlates with Gc. Over time, however, the difference between an inherited fluid ability and a learned crystallized product of education has progressively narrowed. By 1985, Horn (1985, p.289) was saying that "There are good reasons to believe that Gf is learned as much as Gc, and that Gc is inherited as much as Gf." Instead of determining whether intellectual ability derives most from inheritance or from learning, even the quantitative view has led to a more context sensitive theory distinguishing between short-term and long-term applications of cognitive processes:

> Gc and Gf develop through exercise, and perhaps both can be understood as variations on a central production system development (Snow, 1981, p. 360).

Long-Term Memory

While chunking enables groups of features to be manipulated in short-term memory, these clusters are not the stable categories of knowledge making up long-term memory. Physically, long-term memory appears to involve the permanent storage of information along pathways in the brain. From a cognitive science perspective, what distinguishes the expert from the novice in a given area is the retention of a vast store of information efficiently and appropriately structured in long-term memory. *Redundancy, pattern*, and *meaning* are keys to long-term memory capability.

Redundancy was aptly illustrated for cybernetic theorist Warren McCulloch by his aging mother, who called it "keeping a little bit of everything everywhere." Although certain areas of the brain play critical roles (e.g., Wernicke's Area and Broca's Area as speech centers), higher functions and long-term memory generally seem to be stored along pathways throughout the brain. The fact that localized brain damage rarely destroys all traces of higher thinking skills suggests that discrete bits of knowledge are stored permanently in different pathways around the brain and can be linked together in consciousness by the activation of many possible pathways.

Some of the ways ***pattern*** is built into long-term memory include *propositional networks*, and *hierarchical schemas*. In a *propositional network*, meanings are treated hypothetically as words and phrases that can be structured into different arrangements and stored in different parts of the brain. Hence a single thought can be represented as two or more simple sub-statements combined in elementary relationships. Such an analysis creates a network of unit meanings in which the cognitive "distance" between the units is reflected in the structure of the relationships linking them together. In theory, this network structure may also reflect the relative distances along certain pathways linking storage sites in the brain. The theory of propositional networks predicts that the greater the cognitive distance between items in stored knowledge, the longer a search for relationships will take, increasing reaction time. For example, using a particular propositional network, it will take slightly longer for a subject to respond to "Does a hawk have skin?" than to "Does a hawk have feathers?" because the distance "hawk is a bird AND a bird has feathers" is two steps, while thinking "hawk is a bird AND a bird is an animal AND animals have skin" takes three steps (Collins & Quillian, 1969).

If tight propositional networks result in good academic performance, teachers must provide instruction that allows students to process new bits of knowledge in relation to each other and to knowledge already stored in long-term memory. However, the traditional college teaching method, lectures, do not always relate to students' prior network of associations, and this may explain why they often fail to help students connect theory to their lived world. Often in lectures, words and phrases only refer to discipline-specific associations, presenting meanings quite distant from each other and from meanings found already in the long-term memory of the student. In order to relate to or alter a previous network, some sort of scaffolding or series of intermediate structures should be offered to students.

Hierarchical schemas concern even larger units of ***meaning*** than propositional networks. Research shows that people tend to order their perceptions according to idealized models. In one experiment, subjects were left alone in an office and then taken to the next room where they were told to write down everything they could remember about the office. Of the 30 subjects, 29 recalled that the office had a desk, chair, and walls, but only eight remembered a skull on the shelf. Nine "recalled" the presence of books although the office contained none (Brewer & Treyens, 1981). Thus schemas are very powerful, often adding psychological realities to memory: by placing the observed room in the higher conceptual category "office," the ideal models or images in subjects' schemas tended to displace or override actual perceptions.

This does not mean that schemas are always unrealistic or maladaptive. Schemas are specialized, selective filters, key features brought into short-term memory rather than superficial details. Schemas enable people to "file" information into "slots" within an already formed structure, and to predict, infer, and orient themselves even in an unfamiliar situation. For this reason, event schemas, which are a prototypical series of actions, rather than prototypical configurations of object characteristics, are also called "scripts." Knowing the script involved, for example, in eating at a restaurant, enables a diner to get most of the moves right whether ordering burgers or bouillabaisse.

Both scripts and hierarchical schemas, however, may create artificial realities and impair accurate cognition of actual facts.

Different cultures can have schemas that incorporate different emotions or attitudes as well as other concepts. For example, among Asian Americans help-seeking behavior often operates in terms of a schema that might be expressed as follows:

(1) student and teacher form a complementary dyad that is both intellectual and affective: students give teachers respect and deference and in exchange teachers give students nurturance and responsive authority;
(2) teachers recognize good students;
(3) good students will be supported or helped by teachers.

Given this model, when good Asian American students need recommendations to advance their educations, they might expect their teachers to offer this support without prompting. If this does not happen, the students may feel that for some reason they have not merited their teacher's nurturing and responsive intervention. There have been qualified high school Asian Americans who missed applying to college because their schema never anticipated that a good student would need to solicit recommendations.

Schemas are deeply embedded in cultures through individual human minds. They affect the frameworks in which information is viewed. To access and modify such structures, elaborate or deep processing is required. In college, this involves intense engagement in course material and handling information in a wide variety of relevant activities. Successful learning results when new material is integrated with information already stored in a student's long-term memory. Accurate, elaborated structures of knowledge facilitate rapid recall and effective application to problem situations.

Deep or elaborate processing can be promoted by using creative formats to present new information. Thus music, drama, and associated physical activity involve multi-sensory input that can increase redundancy, pattern, and meaning. Richly symbolic and graphic representations also facilitate long-term storage because they unite emotions with the knowledge to be acquired. The power of such unions is attested to by the perseverance of myths, oral heritage, and epic narrative.

In sum, chunking, propositional networks, scripts, schemas, and informational format all affect learning through the structures of long-term memory. Arrangements emphasizing the relationship between ideas and materials enhance learning, and successful learning requires the storage of information in meaningful structures carefully related to learners' prior knowledge and experience. Students who possess fewer relevant schemas to which material can be connected will have greater difficulty learning unless given help in building appropriate schemas.

Encoding

Robert Sternberg, a major contributor to current cognitive theory, defines encoding as the first stage of information processing "in which individuals represent the task problem in working memory and retrieve from long-term memory information that may be relevant to problem solution" (1979, p. 329). Encoding, required for both representation and retrieval, is therefore closely tied to schema-induction, and so forms a critical link between short-term and long-term memory. It is different encoding practices, and the resulting schemas, plus the gains resulting from practice (see below) that explain much of the performance differences between experts and novices in a given area. Therefore, it is important for teachers (experts) to appreciate that students (novices) have not yet developed the schema necessary for quickly and accurately encoding problems.

Research on the encoding differences of experts and novices shows that experts make qualitative judgments based on a wide variety of general principles that they know. For example, physics experts are not distracted by superficial features of problems; they apply correct equations that will lead to the solution of the problem, and before working out the exact answer they often know the rough result. Novice physics students tend to classify problems superficially, concentrating on whether the problem involves levers, pulleys, or inclined planes, and then identifying which equations go with each problem type. This is a strain on working memory avoided in expert schemas by recognizing or encoding a problem situation as an instance of a general physics principle, however disguised by circumstances (Chi, Glaser & Rees, 1982).

Practice

From a cognitive science perspective, there is an energy cost associated with retrieving and holding information in working memory. If this energy cost of activation is reduced, considerable gains in overall cognitive performance result. Practice, or automatization, reduces the cost. Processing automaticity is achieved when it occurs without intention, does not give rise to conscious awareness, and does not interfere with other mental activities (Posner & Snyder, 1975). When a skill becomes automatic, as driving a car is, the cost of activation energy has been "saved" and working memory is free for other concurrent tasks.

Properly spaced practice can profoundly affect the amount of practice time needed. For example, during World War II, intensive Morse code training was given to students for up to seven hours a day. But students who spent four hours a day in training, with longer periods off-task, developed just as rapidly as the seven-hour subjects, who were effectively wasting three hours a day (Anderson, 1985).

This spacing effect can be understood using the idea of encoding variability. Time between practices makes it more likely that the practice context and the learner's encoding will be slightly different each time. Also, as time between practice sessions leads to variety in practice, it is more likely that there will be an overlap between one of the contexts in which a skill is practiced and the context in which it is required. Therefore, when spacing is not possible, repetition over short lags can still benefit from encoding variability if the practice context is changed often. That is, if study sessions cannot be spaced, the location for studying or the perspective taken on the material can be varied (Anderson, 1985).

Cognitive Style

The amazing performances attainable through practice raise the issue of whether cognitive styles can be viewed as results of practice rather than as fixed, inherited learning dispositions. Cognitive styles have been defined as "a person's typical modes of perceiving, remembering, thinking, and problem solving" (Messick, 1970, p. 188). Since a style is an individual's personal, characteristic, consistent manner of processing and organizing their thoughts, it is separate from measures of intelligence or knowledge, reflecting simply the mode of performing. Styles have been given labels such as reflective, impulsive, field-independent or field-dependent — labels that come from experimental settings. Rose (1988) has argued that if cognitive styles are simply different modes of learning and doing, then both reflective and impulsive styles, for example, should display the same average level of achievement, and it should be just as likely to find high performance in a field-dependent student as in a field-independent one. In fact, however, cognitive typing does not seem to be neutral with respect to achievement in Western cultures; reflectiveness and field-independence tend to correlate with academic success, so that impulsiveness and field-dependence may eventually be carelessly used as no more than a euphemism for low achievement.

It may be more useful to see cognitive styles as products of practice. Baron (1985) has suggested that cognitive styles can be systematized by relating them to three underlying search processes that form any intellectual performance: search for possibilities, for evidence, and for goals. Each of these searches is affected by the cognitive processes covered above in the discussions of storage and retrieval of information from short- and long-term memory. A reflective style implies that the length of search for evidence is relatively long, while the same search is rather short in an impulsive style. Field-independence may mean that the search for possibilities is more often extended beyond the immediate context; field-dependence might translate into a search for goals that adjusts to the purposes of the group or emphasizes text cues in formulating an answer. When students habitually practice these search characteristics and use their associated strategies, they could well become largely automatic (Baron, 1985).

If cognitive styles are interpreted as constellations of automatic processing activities reinforced by practice, then students can be trained to adjust their cognitive style to suit different situations. An essay assignment in history may require emphasis on the search for evidence, but the problem of providing for the survival of astronauts stranded on the moon may require more emphasis on the search for possibilities or goals. Thus, students should be encouraged to draw on the strengths of appropriate cognitive styles rather than limiting learning to contexts of the one that they feel most comfortable using and usually employ.

Metacognitive Organization

Metacognition refers to the processes by which the brain organizes and monitors its cognitive resources. It involves planning, monitoring, and evaluating solutions to achieve cognitive control and to improve the effectiveness of thinking. Sternberg (1987) has called the direction of attention and formulation of actions necessary to skilled performances, "executive processes." In Sternberg's formulation, metacognition is represented by six steps (1987, p.200-201):

(1) define nature of problem,
(2) select components or steps,
(3) select strategy for ordering components or steps,
(4) select a mental representation of information,
(5) allocate mental resources, and
(6) monitor solution.

Consideration of the structure of memory leads to an important caution connected with metacognitive strategies: they themselves may overload working memory. In teaching for cognitive development, it is important that the strategies meant to aid intelligent performance not interfere with the processing of the facts and vice versa. Among the recommendations of Bauman, Wdowiak, & Loomis (1979), drawn from the Mathematical Preparation for Physics course developed for enhancing student thinking, is a simple but profound dictum: "ask hard questions about easy material." Doing this allows students to focus on methods for solving the problem without getting bogged down with problem parameters. In this way strategies and the appropriate conditions for their use are more readily automatized.

Perkins (1985, p.340-341) has summarized important points of the argument for metacognitive instruction in these words:

(1) IF you understand general cognitive-control strategies
AND
IF you are habitually ready to apply them
THEN you can be intellectually competent.
(2) A few good cognitive strategies, being highly general, are more important than specific knowledge.
(3) Cognitive strategies are teachable.

Perkins' arguments raise a number of issues. First, knowing *what* strategy to use and *when* to use it is critical to successful mental functioning. For example, Larkin (1979), investigating differences between expert and novice approaches to problem solving, identified automatized, immediate responses as important to expert strategies. She called the automatic responses "condition-action pairs." One such pair is "seeing a red light and stopping the car."

> When we teach students useful actions we should be conscientious about teaching the conditions under which these actions are useful. Perhaps students' most common complaint about their problem-solving ability is that they "don't know how to get started" or "don't know how to decide what to do."...When students don't learn *appropriate* conditions, they too often learn *inappropriate* ones. For example, not infrequently, physics

> students think that principles describing circular motion are applicable to motion along any curved path; and so they try to use these principles to describe the flight of baseballs! (Larkin, 1979, p. 112).

Experts have a multitude of condition-action units stored in long-term memory, and thus they are able to categorize a problem in order to decide whether it can be simplified and a shortcut can be found.

> Using general principles in simple situations can result in work which is clumsy and error prone...[But] skilled persons avoid needlessly cumbersome applications of general actions by recognizing special conditions under which simpler actions do as well. By judiciously exposing learners to selected, special cases, one might...help them acquire the skilled person's economy in applying actions appropriate to the complexity of the situation (Larkin, 1979, p. 112).

A second issue, especially for teachers, is how to infuse appropriate thinking skills into courses without unduly sacrificing class time for presenting factual material. Asking of hard questions about easy material is a valuable approach here, as is compressing necessary facts into a memorable form. Like the ABC song of youngsters, formulas can be quickly learned and accessed through a rhythmic or musical format. Current models of cognitive instruction also urge that only highly relevant and effective strategies be taught, that they be well-matched to the actual tasks and materials presented in a course, and that only a few good strategies be taught at a time and be taught well (Pressley, 1990).

Rushing to cover too much new material may also be unwarranted since it is the possession of key knowledge structures that enables learners to acquire new information rapidly. At the same time, new material may easily fall into disuse unless connections between the new material and previously given concepts are made. According to Larkin's description of experts, they utilize "Large Scale Functional Units" that make available in a coherent fashion "bits of information which are often used together... Individual items or slots in the structure can be changed as the structure is used, but many parts of the large unit simply remain as they were stored in memory" (1979, p. 113). This suggests that cognitive strategies training should help students understand and acquire the schemas and scripts that subject experts have developed for encoding and reasoning. Instruction on problem-solving should be very explicit and aimed at aiding students to consolidate day-to-day factual and theoretical bits into functional units. The practice of grouping students into pairs or teams so that they must articulate their thinking can provide an environment for such development of explicit procedures.

The goal of articulating explicit and specific methods must be balanced with a concern for flexibility and qualitative insight. According to Larkin, it is clear that for experts "low detail, qualitative, often vague reasoning is crucial to problem-solving" (1979, p. 116). Typically such reasoning involves making a qualitative representation of the problem (e.g., a labeled sketch), tentatively selecting a method to make qualitative statements about the situation, checking the qualitative statements to see if any intractable difficulty would result, and only after all this, proceeding to calculating the precise solution. The lesson for metacognitive instruction is clearly that it model and re-model strategies, showing in all the rough and tumble of real practice exactly what happens in application (Pressley, 1990).

A third issue concerns the indirect benefits of cognitive skills training. From his extensive work in creative thinking, Perkins points out that textbook problem-solving is only one use for cognitive strategies. Useful cognitive instruction should include both problem-finding, not just problem-solving, and procedures that help students acquire further knowledge. An example appears in the description given by Simon and Simon (1979) of the two different approaches taken by two experts presented with a complex word problem involving astronauts stranded on the moon. While one solved the immediately given problem of irrigating soil to grow food, the other assessed the entire situation and produced a manifold solution providing for shelter, water, oxygen, and food supply, along with a plan for identifying and meeting survival needs. The latter approach derived benefit from an executive, metacognitive perspective enabling the integration of many goals and methods in a life-like manner. This kind of learning transfer, often involving "rough drafts" and estimates, suggests that strategies that are simple, but possibly not the most efficient, may be preferable because the student can use them as a basis for elaboration. In other words, directly teaching strategies should not preclude indirect teaching through which students become used to thinking widely, and develop an awareness and reflectiveness that go far beyond items in test-measured performance (Perkins, 1985).

Intelligence, unfortunately, continues to be viewed as unmodifiable not only by many educators, but by many students as well. However, a fourth metacognitive issue is that students can, in fact, be helped to "become smarter" through assistance with non-intellectual development as well as through cognitive training. Like any other educational practice, teaching metacognitive tactics takes place against the background of learners' prior knowledge and predispositions. The benefits of learning strategies may not be apparent to students hardened in the belief that they cannot learn well; their attitudes can, thus, compromise the teachability of cognitive methods. Metacognitive instruction, therefore, cannot be undertaken apart from the equally important effort to pursue the emotional, attitudinal, and motivational orientations promoting academic success.

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References

Anderson, J. R. (1985). *Cognitive psychology and its implications.* New York: W. H. Freeman & Co.

Atkinson, R. C., & Schiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 2). Orlando FL: Academic Press.

Atkinson, R. C., & Schiffrin, R. M. (1971). The control of short term memory. *Scientific American, 225,* 82-90.

Baron, J. (1985). What kinds of intelligence components are fundamental? In S. F. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Research and open questions* (Vol. 2). Hillsdale NJ: Lawrence Erlbaum Associates.

Bauman, R. P., Wdowiak, T., & Loomis, I. (1979). Teaching for cognitive development. In J. Lochhead, & J. Clement (Eds.), *Cognitive process instruction: Research on teaching thinking skills.* Philadelphia: Franklin Institute Press.

Brewer, W. F., & Treyens, J. C. (1981). Role of schemata in memory for places. *Cognitive Psychology, 13,* 207-230.

Catell, R. B. (1943). The measurement of adult intelligence. *Psychological Bulletin, 40,* 153-193.

Catell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology, 54,* 1-22.

Cavanagh, J. P. (1972). Relation between the immediate memory span and the memory search rate. *Psychological Review, 79,* 525-530.

Chi, R., Glaser, S. & Rees, M. (1982). Expertise in problem solving.In R. J. Sternberg (Ed.), *Advances in the Psychology of Human Intelligence* (Vol.1). Hillsdale N.J.: Lawrence Erlbaum Associates.

Collins, A. M., & Quillian, M. R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior, 8,* 240-247.

Gardner, H. (1985). *Frames of mind: The theory of multiple intelligenecs.* New York: Basic Books.

Horn, J. L. (1976). Human abilities: A review of research theory in the early 1970s. *Annual Review of Psychology, 27,* 437-485.

Horn, J. L. (1985). Remodeling old models of intelligence. In B. B. Wolman, (Ed.), *Handbook of intelligence.* New York: John Wiley & Sons.

Larkin, J. H. (1979). Information processing models and science instruction. In J. Lochhead & J. Clement (Eds.), *Cognitive process instruction: Research on teaching thinking skills.* Philadelphia: Franklin Institute Press.

Lohman, D. F. (1989). Human intelligence: An introduction to advances in theory and research. *Review of Education Research, 59*(4), 333-373.

Messick, S. (1970). The criterion problem in the evaluation of instruction: Assessing possible, not just intended, outcomes. In W. C. Wittrock & D. E.Wiley (Eds.), *The evaluation of instruction: Issues and problems.* New York: Holt, Rinehart & Winston.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63,* 81-97.

Perkins, D. N. (1985). General cognitive skills: Why not? In S. F. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Research and open questions* (Vol. 2). Hillsdale N.J.: Lawrence Erlbaum Associates.

Posner, M. I., & Snyder, C. R. R. (1975). Attention and cognitive control. In R. L. Solso (Ed.), *Information processing and cognition.* Hillsdale N.J.: Lawrence Erlbaum Associates.

Pressley, M. (1990). *Cognitive strategy instruction.* Cambridge, MA: Brookline Books.

Reed, S. K. (1988). *Cognition: Theory and applications.* Pacific Grove, CA: Brooks/Cole Publishing Co.

Rose, M. (1988). Narrowing the mind and page: Remedial writers and cognitive reductionism. *College Composition and Communication, 39,* 267-302.

Simon, D. P., & Simon, H. A. (1979). A tale of two protocols. In J. Lochhead & J. Clement (Eds.), *Cognitive process instruction: Research on teaching thinking skills.* Philadelphia: Franklin Institute Press.

Snow, R. E. (1981). Toward a theory of aptitude for learning: Fluid and crystallized abilities and their correlates. In M. P. Friedman, J. P. Das, & N. O'Connor, (Eds.), *Intelligence and learning.* New York: Plenum Press.

Sternberg, R.J. (1979). The nature of mental activities. *American Psychologist, 34,* 214-230.

Sternberg, R. J. (1985). *Beyond IQ: A triarchic theory of human intelligence.* Cambridge, MA: Cambridge University Press.

Sternberg, R.J. (1987). Teaching intelligence: The application of cognitive psychology to the improvement of intellectual skills. In R.J. Sternberg & R. J. Baron (Eds.), *Teaching thinking skills: Theory and practice.* New York: W. H. Freeman, & Co.

Field Notes

(continued from page 1)

Xavier's success is owed to strategies grounded in cognitive science research, begun in its precollege summer programs and continued in the undergraduate curricula. They include: 1) laboratories utilizing an inductive, Piagetian-based approach to improve specific components of general problem-solving ability; 2) instruction designed to improve verbal reasoning skills required in understanding textbooks, answering exam questions and scoring well on standardized tests; 3) instruction in quantitative problem-solving skills typically required by standardized tests; 4) systematic building of general, rather than scientific, vocabulary; 5) development of peer group support systems based on academics; and 6) motivational activities designed to involve students in their chosen careers.

Because of the well-documented success of SOAR, the CSUN Bridge Program borrowed many of its techniques. Twenty African-American and Latino students, considered to be "at risk" because of their underpreparation for college engineering, were selected to participate in the six-week residential experience. Dr. Jacqueline Fleming, a developmental psychologist noted for her research on African-American college students was provided by HEES to design and teach the problem-solving component, with advice from cognitive scientist Dr. Jack Lochhead, co-author of the course text, *Problem Solving and Comprehension* (Whimbey & Lochhead, 1986).

To assess the effectiveness of the pilot program, the Fall academic performance of Bridge students was compared to the performance of a control group of 66 non-Bridge minority engineering students. In addition, Bridge students were administered pre- and post- measures of various cognitive skills and motivation.

The evaluation of the CSUN Summer Bridge program indicates that:

1) Participation in the Summer Bridge program had a positive impact on Fall academic performance. Bridge participants achieved higher grades in math and overall grade point average than the control group of nonparticipants.
2) The grades received by students in the Bridge Problem-Solving course significantly correlated with a number of indicators of Fall academic performance, including math performance.
3) Bridge students showed significant improvement in their problem-solving skills as measured by the Whimbey Analytical Skills Inventories (WASI). The degree of improvement correlated with students' SAT-M score. In addition, the degree of improvement in problem-solving skills correlated with students' effort (i.e. grades in Summer Bridge courses), which is distinctly different from SAT measured aptitude.
4) As for many minority students, the SAT was not useful in predicting Fall grades. In fact, among Bridge students, the SAT was a negative predictor of Fall grades, and among students in the control group, the SAT did not predict at all.

Course refinements are under way in preparation for offering the course on other campuses.

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References

Sevenair, J.P., Carmichael, J.W., Bauer, J., Hunter, J.T., Labat, D., Vincent, H. & Jones, L.W. (1987). SERG: A model for colleges without graduate programs. *Journal of College Science Teaching*, March/April, 444-446.

Toch, T. (1990). Teaching science the hard way. *U.S. News and World Report*. May 28, 60-61.

Whimbey, A. & Lochhead, J. (1986). *Problem Solving and Comprehension*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

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