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The Relationships Between Metacognitive Strategies and Learning Outcomes in an Adult Basic Skills Program

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an Adult Basic Skills Program

by

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Abstract

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This study tested metacognitive strategies accounted for variance in learning acquisition and retention in an adult basic skills population. The study employed the Learning and Study Strategies Inventory (LASSI) to measure metacognitive strategy use, a standardized, individually-accessed basic skills curriculum, and a valid basic skills performance measurement.

The study population was young adult soldiers stationed in South Carolina, California and Hawaii. Sites selection assured uniformity in testing procedures, curriculum and delivery. Multiple sites assured a variety of soldier career fields for purposes of generalization.

Performance measurements were taken at the beginning of instruction, at the end of instruction and a delayed measurement 60 days following the completion of instruction from 96 students who participated in 80 hours of reading and mathematics instruction. The LASSI was administered prior to the first hour of instruction.

The LASSI was found to be significantly predictive of learning acquisition and highly predictive of retention over time. The results suggested that metacognitive strategies, as measured by the LASSI, were positively related to the quality of adult learning of complex skills, and particularly for retention of complex skills.

The study provided insight to the mechanisms of learning decay in the population. The LASSI's ability to account for variance in retention performance suggested that use of metacognitive strategies may improve the durability of learning through linking new information with existing knowledges, monitoring comprehension, employing selection processes to screen out less relevant information, using summary techniques, etc.

The foundations of the research tied to cognitive theory of learning, metacognitive theory, research in application of metacognitive strategies among younger students, and metacognitive research in higher academic and training settings. Applications of the research extend to adult basic education and training programs, particularly in urban environments from which the predominance of the population derived. The criticality of application of the results extends to similar programs within urban areas and has economic implications for both time in training and utility of instruction over time.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

Introduction

Origins of the Study Question

The adult role in learning has dramatically changed in response to changing demands of the workplace. Within competitive economies, concomitant demands for greater efficiency and rapid technological change require that employees continuously update and renew their knowledge and skills. Some of this process is accomplished through formal courses, as employers require employees to individually pursue considerable amounts of self-study and self-development instruction. Current employer training methods increase the emphasis on individually-accessed instruction to develop employee skills.

The concepts of educational preparedness and training have long been linked to individual and organizational performance and productivity. The requirements of today's organizations for a work force with the ability to adapt rapidly to changes in job requirements and acquire new skills demands the review of any process that may enhance training and performance outcomes.

During the past decade, federal and state governments, as well as the popular media, have focused attention on the gap between academic skills of workers competing in the work

force and job marketplace requirements. The President's Commission on Excellence in Education decried problems of basic literacy of high school students, and the inability of those students to function in the workplace (A Nation at Risk, 1983). The Congress, in the Omnibus Trade and Competitiveness Act, affirmed the commission's opinion by linking the decline in national productivity to educational decline (Public Law 100-498). Demographics indicate that 85 percent of workers in the first decade of the next century are adults today; therefore, concentrating on the education of today's youth alone will not solve the literacy gap. Problems of literacy are most demonstrative in the nation's urban populations (Chisman, 1989).

Earlier basic skills education programs for the workplace were designed to meet requirements of civil rights legislation (Rowan an Northrup, 1972). In effect, these programs provided compensatory education to minorities to equalize access to preferred jobs. Although minorities still comprise a disproportionate share of the basic skills deficient population, the problem is growing generally (Workforce 2000, 1988).

Considerable alarm concerning increases in functional illiteracy and innumeracy has led many corporations to establish in-house basic skills training programs. Unfortunately, these programs vary greatly in individual

effectiveness. Employees responded differently to basic literacy and numeracy skills training and often evidenced considerable learning decay over time (Chisman, 1989).

A primary concern of organizational trainers is whether employees have the necessary literacy and numeracy skills required to continue learning. When employers have the opportunity to be selective in hiring practices, many have used tests of general achievement, including literacy and numeracy, to screen potential applicants. While such testing has created legal controversy due to covariance of test results with ethnicity (Albemarle Paper Co. v. Moody, 422 US 405, 1975), there has been a resurgence of achievement testing to demonstrate employee future abilities for learning.

Although skills in reading and mathematics may be necessary prerequisite skills to higher skill attainment, such skills may not be the only variables to significantly affect acquisition of new learning and retention of learning over time. Other variables affecting learning performance and retention, such as motivation, attitude toward the subject, or specific skills employed during the learning process may affect both the acquisition and retention of prerequisite academic skills and job skills (Gagne and Dick, 1983).

Corporations such as General Motors, Polaroid, and AT&T have developed prerequisite skill training programs for entry-level employees and development of current employees through in-house learning centers (Newsweek, 1987). The training programs range from basic skills in reading and mathematics to supervisory programs and highly technical prerequisite skills.

Within the state of Virginia, the training department of the largest industrial organization and private employer, the Newport News Shipyards, a division of Tenneco, describes internal training programs to be between 80 and 90 percent self-directed. Even within the apprentice school operations, most of the training development requirements are placed upon the individual (Jenkins, 1991). The Newport News Shipyard has several specialized learning centers designed to elevate employees' basic and advanced technical skills (Jones and Jenkins, 1990). Learning centers provide access for improvement of workers' academic skills primarily through individualized and self-paced, computer-based instruction.

The largest service organization in the area, the Norfolk Region of McDonalds Corporation, has approximately 85 percent of its operational training as self-directed (Losik, Norfolk, 1992). Although much of the industrial training is computer-based, companies like McDonalds rely on

paper-based modes of delivery of self-development instruction.

The shift from industrial to information and service economies has increased demand for employees who have the learning skills required to adapt to technological change. The impact of these changes are felt most by resident minority populations once dependent upon blue collar jobs. These jobs are being replaced by skilled white collar positions (Kasarda, 1985). Non-resident suburban employees fill many of these new positions, leaving urban minority residents trapped in an environment where their traditional employment base has eroded.

Where requisite skills are lacking in the local population, industry and commerce have the option of relocating to areas where such skills exist or training to the requisite skill level. A relative lack of literacy and numeracy within urban employee markets has encouraged some employers to relocate outside traditional urban areas and others to develop in-house programs of remediation. Either choice has associated costs, and for those employers with capital investments, prerequisite skills training may seem the less expensive alternative. These options are of particular interest to urban communities where industry's migration away from traditional urban bases has been

partially ascribed to a decreasing pool of qualified labor resources (Business Week, 1984).

The Army, as the largest employer of entry-level aged workers in the United States, faces the same problems as private sector employers in acquiring a skilled work force, and upgrading those skills during the life cycle of the soldier. As with most large organizations, initial training concentrates on the fundamentals of the job. As soldiers' careers progress, the requirements for both breadth and depth of knowledge increase greatly.

The burden of acquiring additional knowledges and skills rests upon the individual. Generally, soldiers must acquire this information individually through reading, practicing skills, and through sequences of formal instructional updates. The Army recognizes recommended levels of prerequisite reading and mathematics skills linked to career stages and formal instruction level. Literacy and numeracy alone, however, may not fully empower the learner in the process of turning available information into knowledge.

Training new skills poses several questions. First, how will learning occur? Will the training be dependent upon traditional classroom instruction, tutoring, or some form of self-development through individually-accessed instruction? Second, how much learning will occur? This

question revolves around the ability of the individual to acquire new knowledge from the training provided and is linked to the first question. Third, how long will the training be retained?

All of the questions above involve the criterion of effectiveness of training as a function of cost and productivity. Therefore, the optimization of learning and retention of skills are critical elements in the training environment.

The Choice of the Study Population

A fundamental assumption for generalization of results of this study is that the soldier population within the study faces similar conditions as populations outside the military. From an organizational training perspective, many large organizations in the United States will face similar resource restrictions and heightened needs for employee skills. The need to enhance training outcomes and retention of training, therefore, is a general condition, not limited to the study population, but strongly affecting similar populations in urban environments.

The purpose of selecting a soldier population for study is threefold. First, unlike private sector organizations, the Army does not have an option to move to where requisite basic skills are available in the local population. The

Army consists of a large cross-section of the population with high urban representation. Of the main study group, 95.8 percent of the participants reported having grown up in urban areas as defined as cities of 100,000 or more population. Although this percentage is higher than the overall makeup of the Army, it may be the result of an urban problem of inadequate basic skills represented in the eligible population. Second, the soldiers were more stable and accessible than similar private sector employees. Third, the Army had a large enough common instructional program with valid performance measurements in place.

Existing Conditions Within the Organization

The establishment of the Basic Skills Education Program in 1980 demonstrated the Army's recognition of deficiencies of some soldiers in basic skills. The view of learning accepted by the Army predicted that programmed interventions of literacy and numeracy remediation would affect both basic skills and acquisition of other job-related skills dependent on fundamental literacy and numeracy.

Unfortunately, as Newport News Shipyard, and other organizations have discovered, retention of skills learned, particularly those infrequently used, continues to be poor, especially among those whose educational background was marginal prior to training. The question of how learning

works in terms of turning information into acquired knowledge and factors impacting on the latency of that knowledge prompted this study.

At the time of this study, several forces are acting upon the Army to change its composition and policy direction. In the competition for scarce resources, the Army is experiencing greatly reduced funding. The trend away from a large Army with a massive training base toward a smaller, technologically superior Army with a decentralized training program places more emphasis on the individual's ability to access training materials and self-monitor comprehension and progress.

In the past, the Army has relied upon centralized education and training systems to meet advanced job skill requirements. The Army's centralized school system attempts to transfer a high percentage of required skills and knowledges to soldiers through traditional classroom and field instruction prior to the required use of the skills. The current move toward decentralization of training places more locus of responsibility on the individual soldier.

A primary interest is the capacity of the individual receiving the training to adapt to the new method of delivery. Learning materials initially will be largely paper and pencil. Even with the development of other, more

sophisticated methods of delivery, the individual will be responsible for initiation, self-monitoring, and self-evaluation of learning. Additionally, in self-directed learning, the effects of individual affective conditions, such as motivation, attitude and interest, and anxiety, may limit learning performance more dramatically than in instructor led programs.

The Army appears to be following the same pattern noted earlier among private sector employers by increasing the emphasis on self-directed learning. As soldiers progress in their careers, the learning requirements will not only be more in-depth, but more the responsibility of the individual soldier. The trend away from centralized classrooms is no coincidence. The Army has been studying successful corporate training policies for several years and has incorporated many of the concepts found into their long range plan to decentralize the training function (Distributed Training Plan, 1990).

Individually Accessed Instruction

The continuum of locus of responsibility for learning spans from self-directed learning to other-directed learning. The types of activities representing self-directed learning includes the independent learning projects characterized by Tough (1971). At the other

end of the continuum is lecture format classroom instruction. The curriculum and method of instruction in the current study is closer to self-directed learning on the continuum; however, the soldiers work in a group setting with a monitor present, and therefore are not purely self-directed. The instruction must be accessed by the individual, but the instruction does not adapt itself specifically to the student's needs. This form of linear instruction is the most common in use due to the relatively expensive electronic and programming support required by adaptive methods.

Individually-accessed instructional delivery may act to increase the differences between those who have a strong foundation in learning strategies and those who do not. The locus of responsibility for conveying information in traditional classroom settings is with the instructor. Individually-accessed instruction places dependence on self-monitoring systems, comprehension strategies and other learning strategies that are implicit when the student works alone. Strength in these strategies allows the learner to progress unencumbered by limitations of the traditional classroom. The student may work as quickly or review as many times as necessary those elements he or she feels most critical to work performance.

Trends in Training and Instruction

The recent trend toward more efficient organizations, dependent upon technological advantage, team building, and quick response is a characteristic response to the threat of overseas competition. In line with these changes, corporations and public sector organizations have begun to review their methods of training, with considerable variance in training effectiveness noted (Saari, Johnson, McClaughlin, and Zimmerle, 1988). The review of training has resulted in learning centers becoming the focus of much of the delivery of individually-accessed instruction.

Private sector learning centers utilize a array of electronic programming, to include: simulators, distance learning via television, and hybrid video disk and computer systems designed to provide interactive participation. As with the basic skills intervention in the current study, monitors are present to provide assistance only when required.

However, the traditional use of textbooks and home study guides continues be a primary mode of training delivery. Recently, the Army developed a curriculum designed to increase reading skills in this paper-based mode. Although it is possible to make such instruction adaptive to the needs of the individual learner, most are

linear, requiring the student to take each lesson in turn, thus assuring that all weaknesses are addressed.

Computer-based instruction, that is adapted from paper-based instruction, is generally linear (Heerman, 1988). Adaptive curriculums, with embedded testing of student comprehension, are less common. Programming costs for such curricula can be prohibitively high. New technologies based upon the computer, including multi-media and compact disk delivery systems, offer a more interesting package to the student, with the hope that the students level of concentration may be increased. Authoring systems and expertise in programming remain high in cost, and unless the training is applicable to a large number of employees and relatively stable in content, such curriculums may not be widely available for many occupations.

Effectiveness of Individually Accessed Instruction

Training organizations employ individually-accessed instruction for reasons of economy. In the learning center environment, several students may access different subject matter with only one monitor or instructor present. The monitor or instructor need not be a subject matter expert, since the material itself provides this function. Trainers need not wait for a critical mass of students in a given subject area to employ a subject matter expert for platform instruction. Therefore, students may access training

materials on a just in time basis. With these advantages, however, there are disadvantages to individually-accessed instruction.

Individualized instructional delivery may act to increase the differences between those who have a strong foundation in learning strategies and those who do not. Where the locus of responsibility for conveying information in traditional classroom is with the instructor, individualized instruction places dependence on self-monitoring systems, comprehension strategies and other learning strategies that are implicit when the student works alone. Strength in these strategies allows the learner to progress unencumbered by limitations of the traditional classroom. The student may work as quickly, or review as many times as necessary those elements he or she feels most critical to work performance.

Even the most sophisticated individually-accessed delivery system depends upon the individual student to convey information. Computers or other devices become resources for the learner, but can not take the place of the learner in the learning process. The student must still integrate the information with existing knowledge on the subject area in order to utilize the new information. Those students with requisite skills to make use of individually-accessed instructional materials, either

paper-based or electronic media, perform significantly better than those who do not possess those skills (University of Illinois Technical Report 85-132, 1985).

Metacognition and Learning Skills

In the mid-1970s, J. H. Flavell introduced the global construct of metacognition to collectively define those strategies and skills the learner utilizes to manipulate and monitor the learning process. While Flavell's theory derives from the Piagetian developmental viewpoint, similar theoretical constructs have developed across the range of cognitive theory. Each of these constructs features a management function, directed by the learner to assist in acquiring and integrating new knowledge.

Metacognitive strategies are groups of specific skills that enhance or reinforce the learning process. As the term implies, metacognitive strategies refer to a plan of attack the learner uses to engage new learning material. Metacognitive skills are therefore the specific techniques employed, given the strategy group selected, e.g., summarizing a chapter in a text is a skill of the strategy of elaboration, where the individual selects information and models the description in familiar wording.

Metacognitive strategies encompass a large array of individual learning skills that facilitate the connection of

new information to existing knowledges. The construct of metacognition grew out of behavioral psychology's inability to explain apparently intrinsic learning behaviors. The manipulation of learning, or the person's acting upon learning, could not be easily explained in conditioned response or stimulus-response (S-R) models of learning. Individuals approached learning experiences differently, that they selected information to learn, used different tactics to reinforce learning, applied their own interpretation to new information, and, as a result, varied greatly in their demonstrated performance. These behaviors persisted even under varying learning conditions.

Since the introduction of Flavell's concept of metacognitive processes, educators and psychologists have endeavored to explain how metacognition affects the learning process. Considerable study of children's learning, particularly in reading, has led to development of testing instruments and instructional interventions with encouraging results.

Searching to understand and improve learning, cognitive psychologists have explored conditions of learning in an autonomous environment. Such study has discovered relationships between executive functions of memory and learning and learning strategies. The research of Flavell

(1976), McCombs (1986, 1988), Brown (Brown, A. L., 1982), Glaser (1982, 1989), Gagne (Gagne, R. M., 1962) and Chi (1984) have sought to uncover how learners develop individual learning strategies, manipulate new information within the realm of previously assimilated information and constructs, develop hypotheses based on newly developed constructs, and, retain and recall information for use.

While the concept of metacognition developed out of a need to explain basic learning models for children, a plausible argument exists that metacognitive concepts may be salient to an adult learning model. The adult's preferred learning style of independent exploration may increase his or her dependence on strategy use. Absent outside direction, the adult may require higher skill levels in self-monitoring, elaboration, etc., to effectively learn. A model of adult learning may then draw on metacognitive concepts to account for some of the variance found in adult learning outcomes. The application of the same constructs, adapted to the specific learning needs of the adult population, may yield insight on how to amplify the results of adult learning effort.

The limited view provided in the literature of adult use of metacognitive strategies does not therefore suggest that adults require strategies less, nor that adults are a *priori* fully proficient in their use. Variance in

metacognitive strategy use appears to exist at all ages, and relates to educational level, socioeconomic status, as well as age (Ward, 1986, Alexander, 1986, and Whitt, 1988).

Recently, inquiry into how metacognition may work to enhance learning in high school and college populations has resulted in the development and use of screening instruments for high school and college entry age students (Weinstein, 1986, 1988). However, questions concerning how metacognitive strategies relate to learning outcomes in adult learning have not been fully answered. The constructs of metacognition and general training in the learning literature suggests that unaccounted for variance in adult learning performance may be due to preexisting variance of motivation or learning skills.

Little agreement exists in the field on how to define and differentiate separate metacognitive strategies. Among the several authors cited in the current study, skills and their strategy groupings are not uniform. Since the definition of each strategy impacts on the content of any instrument scale used to measure strategy use, this area requires the attention of psychometrists in the future.

Skills Employed in Learning

The operational definitions of the strategies and skills explored in the current study are confined to the

properties of the inventory used that reports metacognitive strategy use. These strategies and skills include self-testing, time management, information processing, selecting main ideas, test strategies, concentration and use of study aids. In addition, the study controls for the affective variables of motivation, attitude and anxiety by using the Learning and Study Strategies Inventory (LASSI) as the instrument for exploring relationships of variables. A summary of the definitions of each skill or affective measurement from Weinstein (1987) follows:

Self-testing: Self-testing may be better described as self-monitoring for it is a skill of monitoring whether the student comprehends the information presented, and whether the information is consistent with the student's existing knowledge about a subject area.

Time Management: Managing time allocated to study is especially critical in self-directed programs of study, i.e., when no monitoring agent is present. For the adult learner, finding the time to study and keeping to a schedule of study is a practical skill necessary to achieve learning.

Information Processing: Information processing is the skill of connecting new information to what the student already knows. The use of metaphors, or elaborating a concept in terms already known to the student may enhance

the comprehension of the concept and strengthen ties to existing experiential information. Organization of new material into a consistent pattern of information also falls under information processing as a tool to comprehend and connect new information.

Selecting Main Ideas: Selecting Main Ideas is a time-honored reading instructional technique, requiring the student to determine what is essential within the material.

Test Strategies: Test strategies include the skills of test taking and arranging information in a manner that facilitates recall.

Concentration: Concentration is the skill of blocking distracters, both internal and external, that may interfere with the processing of new information.

Study Aids: Well-designed training materials include hints about what information is essential. Salient information may be in bold text, surrounded by more white paper, or illustrated by additional graphs or charts. The skill of identifying these aids, or student-created aids, may increase understanding.

Affective Measures: Motivation, attitude and anxiety are operationally defined by the instrument used in this study. Motivation is the degree to which students desire to achieve. Measurements of motivation include goal setting, preparation for instruction, and accepting responsibility

for learning outcomes. Attitude is a more general measurement of how students relate their studies to their professional and personal goals. Attitude is therefore a metric of how the student perceives the job or learning conditions as relevant to their own needs. Anxiety measures the degree to which the student expresses negative self-reference about his or her abilities or other worries that may interfere with the student's performance.

The above categories of strategies and skills may not include every function of metacognition. However, these categories represent the most comprehensive aggregation of metacognitive strategies and skills. The items of the inventory do not directly measure how the student manipulates information in the learning process, but provides an array of indicators of metacognitive behavior.

Applications for Adult Learning

The methods employed in manipulating new information for storing and retrieving to and from long-term memory accounts for performance differences between expert and novice learners (Glaser, 1982). Metacognitive strategies may directly affect the encoding and decoding processes of learning. The use of metacognitive strategies promote the creation of rules for encoding and decoding information, and expert learners employ these rules to make judgments

concerning like situations and take cognitive short-cuts to solve problems (Glaser and Bassok, 1989). The term novice used by Glaser implies a beginning or young learner. This study substitutes the term 'naive learner' for 'novice learner' to connote that, regardless of age or experience, the learner may not have the acquired skills necessary to effectively attack learning material. In effect, the assumption held is that older students and adult learners can still demonstrate naivete in using metacognitive strategies.

Adult learning theorists (Knowles, 1984, Baker, 1985, 1988, and Knox, 1979), as well as developmental psychologists, e.g., Fromm (1955) and Erikson (1959), have modeled theories of adult learning behaviors in a manner to suggest that individualized learning in an autonomous environment fits adult learning preferences better than traditional classroom instruction.

The trend away from traditional classroom learning toward individually-accessed learning is based on cost. However, if the view of adult learning noted above remains valid in the adult training environment, then individually-accessed learning should achieve higher results than traditional classroom delivery. The caveat to this argument is that the student must possess the necessary skills to attack the learning individually.

The internal processes that assist in the assimilation of new learning, and retention over time, should become increasingly critical as learners leave the other-directed learning mode of secondary education. The self-directed learning mode of adulthood requires the attention of the individual, and implies goal setting. Adult learning theorists suggest that this transition will take place as a function of maturity. Whether the transition is a function of the environment of the young adult, or a developmental process, the question remains whether specific skills or strategies are required for successful learning.

The relative criticality of learning strategies to acquisition and retention of new learning becomes paramount when projecting the degree of success of self-directed learning with the target population. Absent the regular reinforcement of the trained instructor and timely remediation of specific skills, the individual must assume primary responsibility for individually accessing study materials, planning and executing an off-duty study plan, self-testing and reviewing materials, focusing, and selecting main areas of emphasis.

Developing the roles of metacognitive learning strategies and motivation in an adult individual learning model may assist education and training practioners to intervene appropriately with adult learners to maximize

their acquisition, transfer and retention of knowledges and skills. A practical application of this model may lead to higher instructional performance, reduction of remediation time and redundancy, and increased productivity. To the adult learner, the model may help to solve lingering learning problems and associated dissatisficers.

Correlations of metacognitive strategy use and ethnicity suggest that populations with higher minority representation may use metacognitive strategies less effectively or frequently (Borkowski and Krause, 1983). Debra King (1986) and others have argued that the lack of metacognitive strategy skills is the primary reason black students fare less well on standardized tests. Given that metacognitive strategies use is a learned behavior and has been remediated successfully in the past, there is potential utility in using metacognitive strategy remediation to address inequities in minority educational preparation.

Individual Differences

The issue of compensatory learning strategies may require a brief synopsis at this time. The literature is brimming with theories of preferred learning styles and individual learning techniques. Individuals deficient in written language skills may compensate through higher ability in verbal language. Individuals do not employ

specific learning strategies equally well. Individuals may effectively employ a select number of learning strategies and eschew others because of perceptions of ease of use, previous successes or applicability to current learning requirements.

Failure to employ any single learning strategy may result in less efficient learning, but may not preclude learning and retention from taking place. Choice of learning style may be dependent upon previous utility, self-perceptions and comfort more than an innate predilection toward any learning style.

The importance of recognizing compensatory strategies resides in the analysis of variables affecting learning. If the researcher focuses on any single strategy, regardless of task appropriateness, the individual's learning effectiveness may not be clear. When dealing with adult learners, the researcher must understand that patterns of learning, learning experiences and methods employed have developed over time, and the test of a single specific learning strategy may not be equally enlightening with all learners. The choice of an instrument with multiple strategy metrics was critical to the conduct of the study for this reason.

Raising the question of covariance of Intelligence Quotient (IQ) with learning strategies is not an addressable issue of this study. Without discussing the issues surrounding measurement of actual ability and performance as registered on IQ type instruments in depth, it is sufficient to mention that the Information Processing cognitive model suggests that long- and short-term memory switching speed may be the closest indicator of fluid ability (Cattell, 1970), and current IQ tests do not measure this performance directly. The ability indicator relied upon by the military has been the Armed Services Vocational Aptitude Battery (ASVAB) and subtests and combinations of these scores also do not measure the long- and short-term memory switching speed. Rather, the General Technical (GT) score derived from the ASVAB tests only general achievement in reading and mathematical computation. There exists a correlation between GT and IQ scores, since both tests measure the achievement of verbal skills.

Since employment of learning strategies may increase measured achievement, the variables associated with GT and previous achievement performance beyond initial measures of reading and mathematics performance are neither predictor nor criterion variables in the analysis of the data. Inclusion of these variables may induce rich confounding of results.

Study Problem

The current study attempts to clarify fundamental relationships between learning strategies, as measured by the Learning and Study Strategies Inventory (LASSI), and learning acquisition and retention of basic reading and mathematics skills as measured by the Test of Adult Basic Education (TABE). The purpose of this exploration is to determine relative utility of metacognitive learning strategies in developing a learning model to assist in understanding the acquisition of a broad range of skills. The relative weight of specific strategies and the impact of affective measures of anxiety, motivation and attitude will also receive examination in the study.

The question posed in this study is whether there is a relationship between adults' preexisting metacognitive strategy use and the amount of knowledge acquired and retained through individually-accessed instruction. The importance of the question concerns both young adults preparing to enter job markets characterized by rapidly changing technologies, as well as adults already in the work force, who must adapt to changes already taking place.

The content of the study problem addresses the relationship of metacognitive strategies and learning outcomes with three specific perspectives. First, as mentioned, the study focuses on a young adult population.

There is little existing empirical research into metacognitive skills and learning relationships in adult learners (Glaser, 1986, McCombs, 1986 and Prawatt, 1989). Second, the study examines the relationship over time, using delayed posttest measurements to capture information on retention of learned material. Third, the study examines the covariant or confounding effects of affective measures, including motivation, attitude and anxiety on performance.

The population in this study group is overly represented by minority students, reflecting an admixture of ethnicity similar to the urban areas of the Tidewater area, and most of the cities of the eastern United States. Although relationships to ethnicity are not part of the current study, there is an ethnic resemblance of the study group to local urban populations.

Should significant relationships exist between scores on the LASSI and acquisition and retention measurements, the inference drawn could be that the existence of specific learning strategies may enhance the outcomes of instruction. Secondly, since instruction to increase strategy use exists and is effective in other environments, the value to the Army or any corporate training department of using similar interventions as prerequisite instruction for specific or general skill curriculums may be high. Such a decision

would require a fundamental understanding of the relative value of learning skills instruction for the target population balanced against the cost of the intervention process.

Of particular interest is the opportunity to explore how metacognitive strategies may enhance the quality of learning to increase its latency. Latency of learning, within the soldier population from which this study draws its participants, is of both organizational and individual significance. Organizations must absorb the costs involved in redundant training efforts and individual inefficiency due to learning decay. Individuals who must continuously review procedural materials because of lack of retention, or who perform poorly on performance measures, will find fewer opportunities for advancement. Accounting for variance in retention due to metacognitive strategies may indicate the potential utility of intervention methods to enhance learning retention of skills. Inclusion of appropriate interventions would potentially increase the efficacy of training systems and results in greater productivity over the life cycle of the employee.

CHAPTER II

A Review of Related Literature

Metacognition has been defined by both passive and active behaviors. Generally, metacognition is an awareness of learning processes as a passive cognitive state. Whereas cognition is thinking, metacognition is thinking about thinking. As an active behavior, metacognition is the manipulation of the process of learning through the active selection and use of specific learned strategies and skills to enhance the learning process.

The definition of metacognition amongst theorists differs. Flavell, who generally is considered a founder of the concept, said, "Metacognition refers to 1) One's knowledge concerning one's own cognitive processes and anything related to them, and 2), The active monitoring and orchestration of these processes" (Flavell, 1976, p. 231). Yussen (1985, p. 253) defined metacognition more broadly by stating that "Metacognition is that mental activity for which other mental states or processes become the object of reflection."

Both of the above definitions suggest that the process of metacognition is a conscious activity. Since theories about metacognition developed out of work with children, the perception of metacognitive activity as a conscious effort is a natural assumption. Children must consciously perform

learning tasks that may seem second nature to the adult learner. However, as the skills of metacognition are perfected, less conscious effort need be placed in the reflection and monitoring of metacognitive activity. Such skill would be seen to reflect automaticity or a skill learned so completely as to require little or no conscious effort to perform it. To the adult expert learner, many metacognitive processes may require so little conscious effort as to become transparent.

Theoretical Derivation and Terminology

One of the great difficulties in describing metacognition's foundation in cognitive literature is the great range of terminology used to describe cognitive and metacognitive structures and processes. The concept of metacognition is common to the three primary theoretical constructs in cognitive theory. The confusion derives from each theoretician's individual terminology, such that, to comprehend the meaning, terms must have operational definitions. The definitions and terms often overlap.

The three primary theoretical constructs of cognition that lead to metacognitive theory are: Piagetian, Information Processing, and the Intrinsic/Self. The construct of metacognition supplements these theories of learning by adding an internal function of control to the learning process.

The Piagetian model, as discussed earlier, provides a basis in a stage-related learning model. In this model, the progress in learning depends upon internal drives for learning as well as upon the child's environment.

Whereas Piaget proposed a developmental model, Information Processing is a model of current cognitive process, using computer-type terms to describe internal processes. The lexicon is more task associated using 'gates' and 'switches' and other mechanisms to metaphorically describe cognitive mechanisms (Garner, 1987).

The Intrinsic/Self model derives from a more phenomenological standpoint. The Intrinsic/Self is a collection of theoretical constructs based on intrinsic motivators to learning. With some commonality to both Piagetian and Information Processing, Intrinsic/Self theoretical constructs owe much to the social-learning and self-efficacy theories of Bandura (1977). Focusing on motivation to learn, the Intrinsic/Self model endeavors to explain cognitive curiosities such as attention and expense of effort. The models have in common a sense of self, self-abilities, and self-evaluation based on individual accomplishment (McCombs, 1988).

The term 'metacognition' came into being based on the work of Piagetian theorists. Information Processing theorists use the terminology of 'executive control'

to refer to the same functions as metacognition describes in Piagetian theory. Intrinsic/Self theorists use metacognition as a separate system of self-regulation strategies and memories. Despite lexical and conceptual differences, however, there is important consensus on what control processes exist and how they function in learning (Garner, 1987).

The use of the term 'metacognition' in this study does not imply ascription to the Piagetian theory of cognitive development. Terminology is based on the observation that metacognition is more popularly identified in the literature with instruction and specific strategies for learning.

One may differentiate model terminology of the three principle models. The comparison below shows the relationship of terms adopted by the three models.

Piagetian Model	Information Processing	Intrinsic/Self
Metacognition	Executive Control	Self-systems
Metacognitive Processes	Executive Control Processes	Metacognitive Processes
Metacognitive Skills	Allocation Policy	Self-Regulatory Processes

The above comparison is not all-inclusive. Some writers have chosen to develop unique terminology to explain events, processes and structures; however, as the comparison demonstrates, there is a basic equivalency of terminology.

Strategies and Skills

The difference in the terms strategies and skills is an important one. As noted earlier, skills refer to specific procedures applied to a learning process. A skill may be outlining a chapter to determine its internal organization. The overall strategy is organization, and several skills may support the objective of organization.

Weinstein and Mayer (1986) developed eight categories of learning strategies. Their strategy categories with examples are summarized in Table 1. The categories may appear to reflect metacognitive strategies normally associated with formal learning conditions, e.g., classroom instruction and learning from a text. In the process of learning in informal conditions, metacognitive strategies may continue to affect the accessing, understanding and retention of new information; however, the practice methods referred to above may not be consciously employed or modified to meet the learning requirements. An apprentice auto mechanic may not consciously use the first two principles of thermodynamics while working on an engine, but may develop a practical mental flow chart for or external consistency and value versus effort may all apply in informal conditions of learning.

Table 1

Metacognitive Strategy Categories and Skills

1. Basic rehearsal strategies--repeating names on list for rote memorization.

2. Complex rehearsal strategies--underlining selected information in a text for the purposes of later review, or, using artificial acronyms or memory aids to memorize material, as is common with medical students.

3. Basic elaboration strategies--forming mental images of relationships between objects or items, reviewing existing knowledge about a subject to determine similarities or relationships to the new learning.

4. Complex elaboration strategies--paraphrasing and summarizing, and using analogies to understand relationships and connections to existing knowledges.

5. Basic organizational strategies--grouping like objects or tasks.

6. Complex organizational strategies--outlining a chapter, creating a flow chart.

7. Comprehension monitoring strategies--checking one's own comprehension by comparing with previously acquired information or others' perception.

8. Affective strategies--mentally reducing external distractions, focusing and maintaining alertness.

History of Theoretical Constructs of Metacognition

The understanding of the need for a methodological system of new knowledge acquisition, classification and ordering of information in an overt manner to promote learning dates back to Aristotle. Aristotle saw the world as too complex to understand by analyzing individual events, or objects without connecting and relating these knowledges. As a solution, he sought to classify observed phenomena based on relatedness to existing knowledge (Adler, 1978). His orderly approach to learning and understanding is now integral to modern instructional methods.

The scientific method of incorporating of new information into the existing framework of knowledge continued with Carolus Linnaeus' system for classification of living things into kingdoms, phylums, orders, genus and species. The purpose of such classification was to connect new things with those already known by determining how the new plant or animal was alike or different from known species. The effect was to bring order from the chaos of information and to allow us to see the relationships of different species to one another. Knowledge of species became more than a collection of information about individuals. Knowledge of the relationships between species adds greatly to the understanding of any one individual.

The process of scientific discovery is one of exploration of what is known, developing hypotheses about what may be expected, given what is known and testing the hypotheses for validity. The scientific process parallels the strategies of elaboration, organization and monitoring, i.e., the essential strategy groups of metacognition listed above.

The scientific processes begun by Aristotle, Linneaus and others was not an artificial set of guidelines, but a natural development of the human desire to bring order and understanding to a confusing environment. The need to understand how things are related, or connected, to other things is not exclusive to the scientist, but essential to everyone who needs to know and understand.

Suggestions of the existence of metacognitive functions as an executive learning process began with Thorndike (1917) and Dewey (viz., 1910). Thorndike's theory of connectiveness postulates that learning requires connecting new information to existing knowledge. Absent this connection, the new learning will not endure.

Piaget (1970) also showed interest in issues related to metacognitive events. Piaget (1952, 1970) constructed a developmental learning model that held that internal factors forced development through specific stages. The fourth and

last of these stages was a self-regulatory process that coordinates maturational, experiential and social factors of development. Flavell (1976) developed Piaget's fourth factor as both knowledge of one's own cognitive process and monitoring of it. He termed this process metacognition.

At about the same time that Flavell conceived the metacognitive model, other cognitive psychologists, e.g., Gagne and Briggs (1977), were developing different terminology to describe similar phenomena. The term for these cognitive strategies was the executive control process. Although conceptual differences yet remain between theoretical branches of psychology, there was a convergence or consensus on the concept of internal control processes that the individual employs to learn.

Flavell (1976) and Brown (1982), working primarily with young learners, determined that the construct was not only viable but practical as a tool for understanding and assisting in the learning process. And more recently, Clark (1988), Weinstein (1988), and McCombs (1986) have applied the theoretical constructs of metacognition to high school and entering college students. The inclusion of motivation and affective measures as an integral part of the metacognitive process began with the work of Baker and Brown (1980) and was greatly embellished by Weinert (1984).

In cognitive and learning theory, Glaser (1984) found reason to incorporate metacognitive processes as method of understanding the more global complexities of learning behavior yet unaccounted for in traditional cognitive models. Glaser's description of metacognition is a control and organizational process that is essential in not only the acquisition of knowledge but also in the organization and subsequent retrieval of information through evaluative association of new knowledge with preexisting knowledges (Glaser, 1989; and Koerkel, 1987). Therefore, metacognitive study skills should have an impact on the assimilation of declarative knowledge, its transfer to new conditions, and latency of learning (Glaser and Bassock, 1989).

Foundations in Cognitive Theory and Research

The failure of behaviorist models to explain unique anomalies of human learning has lead in part to the development and eventual preeminence of cognitive psychology models to explain learning processes. Thorndike (1949) described several experiments where repetition of a task did not ensure its acquisition or retention because the task had no relationship to previous learning. Repetition *per se* does not assure learning. He determined that for learning to occur, the new information must connect to existing knowledge. Thorndike began to use the term 'belongingness'

to refer to the relationship of new and existing knowledge to indicate that the new information must not only be connected but relevant to existing knowledge for learning to occur.

Gagne (1962) provided a theory of hierarchical structure of learning, wherein the success of acquisition of new skills and knowledges is dependent on the success of prerequisite skills and knowledges. The influence of Gagne's theory is seen in modern curriculum structures, particularly in basic and prerequisite skills programs. Gagne served as an advisor in the development of prerequisite skill programs for the Army during the early 1980s; therefore, his influence on the structure of the curriculum intervention used in this study was strong.

The empirical studies of these theoreticians and others began to demonstrate that more was occurring in complex learning conditions than could be explained by a simple stimulus-response model. Learning was more than exposure to a learning condition, coupled with internal or external rewards. Learning required the identification and integration of existing knowledges with the new information.

Declarative and Proceduralized Knowledges

In recent years, cognitive psychologists have explored conditions of knowing or depth of knowledge. Chi, Glaser

and Rees (1984) have differentiated between at least two levels, the most common of which were declarative and procedualized knowledges. These constructs suggested that a qualitative difference existed between knowledges, and those differences resulted in changes in how knowledge may be used and the relative latency of the knowledge.

Declarative knowledge results from the accessing of information on a given subject, and being able to retrieve that information. Proceduralized knowledge is the ability to compare knowledge for the purposes of creating rules. The generation of rules reduces the sequencing of information for problem solving, and allows for more rapid solutions to problems (Glaser and Bassok, 1989).

Referencing rules to solve problems is critical to effective problem solving, and the application of multiple problems to the same rule reinforces and expands the rule's utility. Declarative knowledge may be useful in responding to test questions concerning a specific event, but retention of that knowledge is constrained by a high degree of conscious effort in accessing the knowledge and relatively low retention over time.

Rule-based learning that facilitates proceduralized knowledge is comparable to the elaboration, organization and comprehension monitoring strategies outlined by Weinstein

and Mayer (1986). The requirements of rule-based learning, i.e., the accessing of appropriate existing knowledges, development of analogies or rules, grouping, organizing and monitoring one's comprehension of the learning material fits the requirements of cognitive theory in the development of proceduralized knowledges.

Cognitive Roots in the Behavioral Model

Although cognitive theory is now the dominant force in instructional psychology, much of its present application has its foundations in behaviorist approaches (Glaser, 1982). Behavioristic modeling has demonstrated particular success where tasks are simple and unreliant upon complex relationships to prior learning and experience. Behavioristic modeling begins to lose predictiveness when learning success is predicated on complex task acquisition or acquisition of task groups of a hierarchical or interrelated nature (Glaser and Bassok, 1989). The limited view of internal cognitive relationships existent in behavioristic models excludes internal factors that account for the enhanced predictiveness of more complex cognitive models.

Behavioral modeling may be more appropriate when the conditions of learning include both circumscribed task requirements and available and consistent external

performance monitoring and intervention. Early success of empirical behavioral research was dependent on these conditions. In educational and training situations where skills and knowledges are complex and may include a variety of subroutines, the behavioristic model fails to work well. Task conditions often require independent action exclusive of external performance monitoring. The individual's building and adapting of new subroutines to novel task conditions can not be readily explained by behavioristic modeling. The generalization of rules to situations not characterized in the training condition requires strong rule building skills and the skill to identify analogous situations.

Some researchers have explored the prospect that 'overlearning', or learning new information so completely that recall following learning produces an automatic response. In this way, theorists link overlearning to retention and confidence knowing over time (Nelson, Leonesio, Shimamura, and Landwehr, 1982). While overlearning can enhance specific learning goals, there is little practicality for application to learning material that is complex or infrequently referenced in the job context or living environment. Overlearning appears to have the best results when tasks require motor response, but, may

stereotype responses for proceduralized skills, resulting in inappropriate responses (Gardlin and Sitterly, 1972; Annett, 1979; and Hurlock and Montague, 1982). Specifically, overlearning may increase routine task efficiency, but have little effect on procedualized skills and knowledges.

The majority of tasks and skills required in normal work conditions have a great many subroutines and application of judgments based on previously acquired knowledges and skills. Cognitive models incorporate relationships between knowledges, and take into consideration the internal mechanics of building these relationships. The internal systems identified in cognitive models attempt to account for observed differences in complex learning outcomes.

Skills and Abilities

The question of abilities, or inherent capacities, has plagued psychology since its inception. Cattell (1970) defined intelligence as having two forms: fluid and crystallized. Fluid ability is independent of cultural impact. Crystallized ability includes all learned skill responses to given problems or conditions. Although a correlation exists between these two ability components, Cattell thought it necessary to try to separate fluid from crystallized measurements to create a bias-free measurement

of ability. Such a instrument would focus on items of logical ability and not be dependent on school taught knowledges.

Due to Cattell's own definition, there is reason to conclude that fluid ability represents the individual's theoretical cognitive limitations. Crystallized abilities represent the environmental limitations or opportunities for achievement within the limits of fluid ability.

Current methods of aptitude measurements are largely dependent on crystallized ability measurements (Cattell, 1970; and Douglas, Feld and Asquith, 1989). They are, by Cattell's definition, representative of achievement given environmental limitations. Ethnicity correlations to aptitude tests demonstrate bias. Whether it is possible to determine fluid ability exclusive of achievement, particularly in adults, is not an interest of this study. Of interest, rather, is how metacognitive skills fit into the spectrum of ability versus achievement.

Metacognition and Measured Ability

Weinert (1983) treats metacognitive strategies as an effect of learning as well as having an effect on learning. This circular relationship is descriptive of the integration of monitoring and results achieved. Weinert sees measured "abilities and functioning levels as determinants of individual learning effects" (p. 49).

Successful use of strategies perpetuate their use, or motivates continued successful learning behaviors. Measured ability on achievement tests would then indicate that the individual's ability, as defined by those instruments, would have increased. Weinert's argument was that using instruments to crystallized intelligence is nothing more than measuring an individual's past experience using metacognitive skills.

Kluwe and Schiebler (1983) stated:

> It was demonstrated in developmental psychological research that the repertoire of cognitive strategies expanded the process of cognitive development. If this is the case, then the needs of development, information handling systems (executive processes) increases with the possibility of alternative process choice, evaluation requirements, etc. This requires the ability of flexibly applying one's own personal cognitive facilities (translation by author, p. 34)

Kluwe and Schieber indicate that metacognitive functioning, executive processing and power of intelligence are so interdependent, that it is impossible to separate one from the other. Increases in metacognitive skill functioning would be analogous to increases in intellectual capacity. From a developmental psychology standpoint, their

argument is potentially valid, certainly in terms of the demonstration of intellectual achievement as measured by aptitude tests. However, in skill specific applications common to problem-based adult training and education, the relative effect of metacognitive skill increases may not be as significant on subsequent achievement.

Memory Organization

Significant differences in performance between two soldiers may result given the task of setting a fuse on an artillery round if one soldier understands the use of rulers and gauges and the other does not. If the soldier with the preexisting knowledge applies the understanding of rulers and gauges, then processing the new information, as it conforms to existing knowledges, will be simpler. The soldier will require fewer steps to process both at the time of learning and at the time of recall.

A parallel task condition exists when an apprentice lathe operator would be required to use a micrometer. The steps between the lines of the rotating gauge of the micrometer are similar to the soldier's fuse setting problem above. Based on the skill to use a ruler, albeit more complex, the apprentice's prior knowledge of rulers, together with the identification of this prior knowledge,

will provide a connection between the two knowledges. The connection will not only facilitate the learning of the operation of the micrometer, it will make it resistant to learning decay.

Because of this connectiveness to existing knowledge, the soldier will be able to set the fuse without counting each tick mark and consciously reviewing the direction and interval each time; and, the lathe operator will not constantly reference the subscales on the micrometer. The resulting chunking of the subroutines of direction monitoring and interval counting results in recall and speed performance advantages (Brown and Carr, 1989).

The apprentice lathe operator, after learning the use of the micrometer, may generalize the skill acquired in learning to use the Pi tape, a device to measure the circumference of an object. The skills of ruler reading, micrometer reading and Pi tape reading not only connect to one another, but reinforce each other by expanding and generalizing the rule upon which the learning is based.

The organization and structure of information and the way that knowledge is stored and retrieved for long-term memory may determine much of the differences between experts and beginners when demonstrating skill acquisition (Glaser, 1982). If the organization and structure of the new

information includes keys to other knowledges, particularly those of lower skill level requirement, or makes analogous references that are within the experiential base of the learner, the decoding process of the new information is facilitated.

The encoding of the new knowledge is with the referent information, strengthening both new and old knowledges by connection and utility. The use of magnetized models in chemistry class to illustrate the repulsion of like charged particles lessens the degree of difficulty in decoding information on subatomic particles, provides a visual model for encoding, and reinforces both knowledges.

Use of a prototype solution also assures rule-building. When introducing the Pythagorean theorem, teachers often use the prototypical problem: a right triangle with dimensions of 3, 4, and 5. Over time, the individual may forget that the square of the hypotenuse of a right triangle is equal to the sum of the squares of the opposite sides; however, by squaring 3 and 4, then adding the squares, the product is 25. Knowing that the square root of 25 is 5, the learner may conduct the same process with different dimensions. A prototype is a specific example of any learned experience or concept to which other cases can be compared for similarity (Yussen, 1985).

Skills associated with reading and mathematics commonly reflect two interdependent processes. Decoding represents the lower skill process requiring word and symbol recognition. Decoding processes include the recognition of punctuation, vocabulary, or math symbols, but testing interrelationships of words and symbols.

Reading comprehension requires a higher order skill interlinking conditions established by decoding, e.g., the recognized word may represent an action, and who the actor is may depend on other relationships and sequence of the sentence (Glaser, 1982). Comprehension is the process of building relationships both within the new learning and associating new learning to existing complex relationships. As the complexity of the new task increases, the greater the individual use of experiential relationships in order to solve the problem.

Existing knowledges and rules form general schemata. A schema is an abstract concept derived from repeated experiences with objects or events having one or more similarities to produce an experientially-based set of expectations. The schema is the conceptual slot to integrate new knowledge with existing frameworks of old knowledge. The degree of success of this integration directly impacts not only acquisition and retention, but also transfer to common conditions (Pea, 1987).

The items on the LASSI reflect the use of judgments on learning material as they apply to rules or schemata, e.g., item 47, "I try to relate what I am studying to my own experiences."

Gick and Holyoak (1983) demonstrated that analog problems promote understanding of new problems and transfer of these solutions to other problem-solution conditions. They provided subjects with a problem involving radiation therapy. In the problem, the target tumor was positioned such that the radiation necessary to neutralize the tumor was lethal to the patient. The correct solution was to converge radiation on the tumor from different points to allow sufficient exposure to the tumor without jeopardizing the patient. Without a background in medicine, the subjects were unable to solve the problem. However, when the same subjects were provided analogous situations, i.e., an attack on a fortified position over roads with land mines, and fighting a fire by converging several streams of water, they were able to correctly identify the correct solution to the radiation problem. The problem was not so much one of medical knowledge as one of use of convergence schema.

As the number and strength of experiential prototypes, analogies and schemata increase, individual creation and application of rules governing like situations improves

(Atkinson and Paulson, 1972). Task specific information may lead to task general application. As with the analogies above, generalization of schemata and rules based in analogies and prototypes may cross domains. Development of generalized rules, based on prior knowledge and experiences and organizational skills is the highest level of knowledge management. Application of these rules may result in not only more efficient problem solving, but unique solutions to problems where more than one solution may be found.

Expert and Naive Learners

A difficulty in reviewing literature on metacognition and performance derives from the use of terms such as 'poor readers' and 'low metacognitive ability'. The unfortunate use of qualifiers such as good and bad suggests that the quality is inherent, rather than a transitional condition. Since there is ample evidence to support that metacognitive skills may be taught, and that metacognitive strategies are acquired skills, then use of ability here to denote level of skill is wholly inappropriate.

Learners who utilize metacognitive skills and employ metacognitive strategies to acquire information and integrate that information for future use display expert learning characteristics, or are expert learners (Prawatt, 1989). The failure of a student to use metacognitive

strategies does not denote less metacognitive capacity, but indicates that the learner is naive about such strategy use (Rhinehart and Platt, 1984). The acquired nature of expertise is evident in studies of young learners' inability to use certain metacognitive skills (Baker, 1982). Naive learners, whether they are younger or adult, have yet to learn how to employ certain skills but may be fully capable of doing so.

The expert learning approach is a schema-driven, or rule-based approach. The expert learner's prerequisite skills or knowledge level should be sufficient to allow comparison of the new information with older, relevant information. The expert learner may then employ specific metacognitive strategies to adapt the new information to pre-defined mental models of how it is supposed to work, apply the pre-defined mental model to determine characteristics and judgments concerning the new information, or modify existing models to accommodate persuasive evidence provided in the new information. The strength of the association of new and old knowledge determines the retention and utility of learning (Prawatt, 1989).

Bovy (1981) demonstrated that expert learners differ from naive learners in that they can independently select an

appropriate learning strategy. Garafalo and Lester (1985) noted that naive math students did not analyze information, monitor progress or evaluate results (both younger math students and naive college level students). Schoenfeld (1981) determined that two sets of metacognitive skills were required in math problems: tactical and managerial. The tactical skills determine the operations to implement, whereas managerial skills are required for selection of rules and frameworks for problem analysis, direction of problem, in-process review, monitoring tactical implementation and reviewing appropriateness of actions. Most applied usage of math skills requires managerial skills, where more metacognitive activity is involved. Lack of metacognitive skills would then lead to critical errors of application. The ability to independently select and monitor an appropriate strategy provides the expert learner a decided advantage in learning new information.

The differences between expert and naive learners in metacognitive strategy usage forms the basis for modeling the learning process in terms of learning outcomes. The differences in behaviors defining the expert and naive learning styles also determines relative expectations of both learning acquisition and retention performance outcomes.

Monitoring Learning

Although there are several models of metacognitive process, consensus on monitoring the process is common to all. The monitoring of learning activities assures not only the comprehension of new material, but the integration of new learning with existing knowledge. Brown (1984) viewed the model of learning as planning, predicting, guessing, and monitoring. Perhaps a more complete view of the learning process based on Yussen (1985, pp. 267-270) would be:

Preevaluating> Identifying> Inprocess Evaluating> Integrating

with monitoring occurring at each step of the process. The monitoring may be a conscious awareness of each step or be an automatic behavior.

Active monitoring does not always mean appropriate choice of learning strategy. An example of inappropriate strategy would be an attempt to rote memorize through rehearsal strategies the names of the chief justices of the United States to answer a question on the selection of Supreme Court justices. One can inappropriately use a strategy, such as underlining a text. At one time, everyone has noticed someone who consistently underlines vast areas of a text, defeating the purpose of selection strategies. However, the naive learner must initially monitor the processes for any hope of understanding their application.

Monitoring, in conjunction with training on appropriate strategy use, assures that strategies are actively employed.

Identification of one's own cognitive activity begins with the questions of "what am I doing here?", "what have I done?", "what does it mean to me?", or "what was my process of thinking?" (Kluwe and Schiebler, 1984, p. 35). The beginning of active monitoring may continue throughout the learning process, particularly when the difficulty level of the material forces reflective monitoring of the learning process.

Internal and External Consistency

Two elements of learning new material are identifying whether the information is internally consistent and whether it is consistent with known facts external to the new information, or preexisting knowledge. Both in-progress evaluation, or checking on understanding, and preview and review of existing knowledge related to the new information are metacognitive strategies.

Conditions of the information, such as sequence of delivery, or matching with established fact may affect some learners more than others (Klahr, 1976). Those readers who employ metacognitive strategies of in-progress evaluation tend to be more sensitive to syntactic manipulation than those who do not (Baker, 1983; and Alexander, 1986). These

studies demonstrate that students with lower metacognitive strategy skills require very clear writing for comprehension. Use of pronouns, or anaphora, will create great difficulty in a reader not actively monitoring comprehension. Readers who monitor external consistency demonstrate more difficulty in understanding passages that are contrary to established fact (Baker, 1983). suggesting an absence of linkage in non-monitoring readers.

Integration of new information requires preevaluation of existing knowledge and monitoring of new information. In math, the preevaluation and monitoring logic sequence is much the same as in reading. The preevaluative question may be "what do I know about this type of problem?" The next step is the identification of salient elements, "what parts or steps in this problem are important?" Internal and external consistency questions are: "Does this problem make sense?" and "Does the process or solution fit what I know?" (Yussen, 1985). The integration of the new information within the framework of existing knowledge demands the learner enquire "does the solution reinforce my existing knowledge or does it require that I alter my view of the solution process?"

Clueing

The use of embedded clues in instruction to prompt metacognitive responses may be especially helpful in working with naive learners. Hurlock and Montague (1982) enhanced learning outcomes through use of memory aids, including contextual clues and mnemonic devices to facilitate organization and interconnection of tasks. Although ideally, learners should learn to independently utilize strategies, initial clues may assist learners in preevaluating the new material's content, and determining what they already know about the subject.

Bartram (1978) determined that even with simple stimulus, providing information on which of two tasks the subjects would be asked to perform greatly enhanced performance over a control group with no prior knowledge. Prior knowledge of test conditions has long been known as a confounding factor in measurement of aptitude (Wagner and Sternberg, 1984). Providing prior knowledge of conditions or concurrent knowledge of results when giving the Stanford-Binet or Wechsler will tend to inflate scores, defeating instrument reliability. With some examinees, it is possible to increase the levels of anxiety with negative performance results. The interaction of prior knowledge and feedback and performance measurements demonstrate variability due to clueing.

Alexander (1986) demonstrated that clueing may impact even advanced readers' comprehension of material. Alexander's study provided specific criteria and general instructions to random groups of advanced college readers prior to introduction of a reading assignment. Those provided specific criterion on what to look for in the reading did not significantly outperform the control group on the first round of questions; however, they tended to review their responses, understood their weaknesses and corrected for response errors significantly better than the group with only general directions.

When clueing is incomplete or misleading, whether intentionally or unintentionally, learners may have difficulty with the material (Clements, 1986). The difficulty with clueing is that if improperly conceived clues are embedded in the learning material, learning outcomes may be negatively affected.

Motivation

The question of how motivation affects learning has long been the subject of considerable controversy. Motivation is, by definition, that which prompts an action or behavior. It is not the behavior itself. Although, in describing a worker or student, one may often say that he or she is motivated, that description is indirect and does not

frequently include the factor that motivates. What is meant by the description of a motivated person is that the behaviors exhibited by that person agree with the values and preconceptions held by the person doing the describing. Since all beings exhibit behaviors, then all are motivated. When these behaviors are productive within the context of performance and social parameters, the ascription of positive motivation may apply.

Motivation, as dealt with in the current study, is the motivation to learn. More clearly, motivation is the set of beliefs, self-concepts and resultant behaviors that affect the learning process (Keeves, 1986). It is logical to assume that positive motivation to learn will result in more effective learning, and thus, motivation has become a frequent subject of study.

Early behaviorist explanations of how environment interacts with behavior attributable to motivation was described by Skinner (1954). Skinner's approach drew from basic behaviorist principles of conditioned response, but included the internalizing of conditioned response. Behaviorism sought to define external variables that could change the response of the individual to the learning condition. This approach is characterized by the study of Fitts and Posner (1967) who suggested that overly enriched learning environments, as well as dull environments pose a

difficulty to learners. Dull environments allow attention to stray. Those overly enriched, i.e., more stimulus than the individual is prepared to accept, may result in stress, or stimulus overload. By providing directions to focus attention, however, much of the stress was alleviated, allowing for greater performance.

Maslow (1954) established the humanist view of motivation with his need theory. Man is driven toward achievement and learning, according to Maslow. While empirical evidence of the validity of need theory came well after Maslow postulated it (Goldstein, 1986), it became the basis for later constructs of motivation that included the goals and requirements of the individual.

Herzberg (Herzberg, Mausner, and Snyderman, 1959) described two sets of motivators: intrinsic and extrinsic factors, that act upon the individual's motivational state. Adherents to Herzberg's theory have included design components to training intended to enhance the intrinsic interest in task learning. Such efforts assume that the intrinsic process may be externally altered.

De Charms also suggested that motivation was separable into two parts, a negative experience from without, and an internal experience wherein the individual feels as though behaviors are self-directed (de Charms, 1968). De Charms

includes the two fundamental views of motivation, behavioral and humanistic, in a construct with both an exterior, behavioristic view of the individual's response to environmental stimuli, and the inner dynamics of a humanistic view of motivation. The latter view of motivation implies that the individual does more than interact with the environment, and, to a large degree, acts upon the environment as an independent agent.

The confusion in defining motivation derives from the theoretical schism on the source of behaviors ascribed to motivation. If motivation is externally defined, changing behavior becomes the process of modification of the external environment. If motivation is an internal process, wherein the individual reacts to internal drives or directs behavior to align with individual goals or individual views of the external environment, then finding and employing a change agent to modify behaviors ascribed to the individual's motivation to learn becomes a more complex problem. The causal attributions of behaviors ascribed to motivation are subject to the interpretation of the theorist.

Keeves identified eight major theories concerning motivation and educational outcomes and grouped theorists by whether motivation was externally or internally derived (Keeves, 1986). Five of the theoretical constructs

associate learning with time and external variables. Included in this group of theorists are Carroll, Bloom, Bennett, Cooley and Leinhardt, and Harnischfeger and Wiley. The time on task principle of these theorists' work is broadly accepted by the Army in determining conditions of tasks. The time on task principle concludes that the amount of time the student allocates to learning a specific task or knowledge is related to the motivational conditions that are under the control of the instructor. In such a paradigm, the instructor should optimize the learning process by (1) specifying the learning objectives; (2) dividing the subject matter into learning units; (3) ordering the learning tasks; (4) using formative tests; and (5) providing corrective feedback. The manipulation of the learning conditions to provide the student with an opportunity to learn is dependent upon the time allotted for each of the learning tasks (Keeves, 1986).

The second group, including Gagne, Glaser and Bruner provide a more intrinsic view of the learning process (Keeves, 1986). The individual's predisposition to learn is the critical element of the learning process, with the instructor facilitating the process by adapting instruction to the learner's own preferred mode of learning.

Although considerable differences exist between the above theorists' views of the ideal conditions to motivate learners to learn, the grouping of theorists into other-directed and inner-directed motivational learning adherents describes clearly the problems with identifying the causal attributions of motivation to learn. Motivation to learn is not a measurable trait of itself, but the aggregate of conditions that represent the individual's state of receptivity for learning. To determine that the individual is positively motivated to learn can be measured. To address the requirements for changing the individual's motivational level presupposes the causal attribution of the motivational state, i.e., whether the motivational state derives from internal or external forces.

The literature supports the intuitively obvious conclusion that measures of preexisting motivational level correlate with learning success (Baldwin and Ford, 1988). Noe and Schmitt (1986), Huczynski and Lewis (1980), and Ryman and Biersner (1975) all found motivation to be a key element of task learning, and later use of learned tasks. In a rare comparison of tested ability and motivation measures to determine which was the dominant variable in learning outcomes, Tubiana and Shakhar (1982) found that several predictors of performance, including motivational measures, were significant in performance outcomes.

Bandura (1977) proposed a theory of self-efficacy where the self not only processes information on efficacy, but evaluates alternative behaviors based upon relative expenditure requirements. McCombs (1986) encapsulated the evaluation and weighing of alternative methods and relative effort and value in what she terms the self-system. The self-system acts with perceptions of ability, competency, personal control and efficacy as a primary screening processor.

The individual's past history in dealing with a given subject, e.g., math, serves as a basis for developing perceptions about self, and about the task. The self-task interaction is a product of actual individual competency and perceptions of competency, and value of the task. Salomon (1981) suggests that tasks falling below or above the individual's perception of competence may negatively affect performance.

Essentially, if a task is perceived as too difficult, then the self-system will attend very little to the task, assuming that the prospects for a positive performance outcome are slim. However, if a task is too easy, the individual will again attend very little to the task, and lose concentration and make errors (Kahneman, 1973). It is the self's prediction of performance that motivates

performance and allocates effort. Salomon suggests that perceived difficulty levels affect performance in an inverted U, where performance is best matched with problems providing a challenge but not an overwhelming one.

Goal setting theory is a direct outcome of this view of motivation (Locke, et al, 1981). Motivation may not be a constant for measurement but may be more a variable associated with the task at hand. The interaction of the individual's initial motivational state and the perceptions of the relevance of the learning material, the level of challenge that the material represents, and the perceived consistency of the learning material with the preconception by the individual about the subject content may all interact with the initial motivational state.

Goal setting on the part of the learner acts to enhance the learning outcome and the persistence of learning over time (Latham and Locke, 1979; Locke, Shaw, Saari and Latham, 1981). Setting goals, coupled with learning that is challenging to the individual, was shown to increase overall performance.

Studies on expectancy of trainees on the perceived applicability of new learning and performance on end of training examinations suggest that the individual's motivation to learn is highly related to the usefulness of

the information. Baumgartel, Reynolds and Pathan (1984) compared perceived usefulness of curricula to curricula construction and found usefulness more critical in determining motivation to learn.

Noe and Schmitt (1986) tested a range of trainee characteristics and determined that individual expectancies, motivation to learn and general conditions of satisfaction and involvement with the job all significantly contributed to learning performance outcomes. Where considerable interaction between the instructor and student exist, the expectancies of both the student and instructor may lead to differences in learning performance. Eden and Ravid (1982) demonstrated that both self-expectancy and instructor-expectancy influenced the individual to perform well in the training; the effort put forth by the student was greater and performance significantly higher.

The question not directly addressed in empirical studies of motivation is whether motivation is an affective or cognitive state. Many theorists have dealt with motivation as a purely logical process of determining goals, or expectancy of personal gain. Vroom (1964) posed the instrumentality theory wherein individuals calculate the potential for accomplishment of secondary or conditional personal goals when determining how much effort to expend in

work or education. Cognitive theorists tend to treat the individual as a highly analytical processor, where emotional response does not affect the motivational state.

Another issue not fully addressed in the literature is the persistence of motivation. If motivation is an aggregate of several preexisting conditions, could some of the parts of the aggregate be more subject to change than others? The possibility that what is ascribed to the general term of 'motivation' is really a complex set of self-perceptions, other-perceptions (feedback), experience, transitory distractions from other areas of the individual's environment, perceived value of learning, perceived value of learning to accomplish deferred goals, drives for conformity, practiced response to conditions of learning, and a variety of other preexisting conditions is not expressed by any one author. Some of these conditions may be more susceptible to change over time than others. In other words, the instruction, instructor, or environment may interact with some conditions for rapid change, while others conditions demonstrate resistance to change.

McClelland (1978), and others who are more commercially oriented, have developed training seminars designed to change beliefs and self-concepts underlying motivational states. Whether such interventions have validity is irrelevant to the current study. The

measurement of the preexisting motivation state is necessary to control for its effects in the current study; however, changing the individual's motivational state is not within the study's purview, and therefore, the study will not address the origins of the motivational states of participants.

Problem-Based versus Process-Based Learning

Adults tend to favor learning environments that have immediate addressable applications (Houle, 1972; and Knowles, 1980). The adult learning preference contrasts to early developmental process-based learning, where learning generalized rules to hypothetical problems prevails. The literature, particularly the developmental reading research, supports the broader impact of metacognitive skills on process-based learning. The differences between adult's preferred learning and children's is below:

Adults	Children
Seek immediate application	Seek foundations and rules
Specific skill application	General skill application
Learns best independently	Teacher-dependent learning
Work is an intrinsic reward	Seeks extrinsic reward
Tends to self-start	Other starter

Selection processes may determine what part of the new information will be absorbed. Selection of new information differs from attention in that selection may be motivated by perceived immediate value. Adult learners tend to select out any new information for which they perceive no immediate gain (Howell, 1982).

Given the preference for individual instruction (Tough, 1979), adults may be more dependent on metacognitive strategies to acquire and retain learning than children. Particularly when the task at hand may appear to not have immediate utility and therefore less motivational, the need for employing metacognitive skills in accessing learning material may be much higher for adults than children.

Metacognitive strategies may operate in lieu of motivators and peer reinforcement in the independent learning situation preferred and most often employed by adults. The practiced use of the strategy domains represented in the LASSI may keep the adult learner focused on the learning material despite the absence of extrinsic reinforcement. In this study, where young men and women were learning basic skills of reading and mathematics, the immediate application of the learning material may have been difficult to deduce. Metacognitive strategy use should therefore be a critical variable to maintain concentration

and enhance the learning outcome in a relativley low motivation environment.

Simple Skill Versus Complex Skill Learning

The information processing cognitive model describes the difference between simple skills or tasks and complex skills or tasks in terms of the number of subroutines required to process the information. This differentiation suffices to define the skills and tasks that students encountered in the instruction. By this definition, vocabulary, or word recognition, is a simpler skill than paragraph comprehension. Vocabulary requires fewer subroutines and therefore require less complex handling by the learner. Computation is simpler than mathematic concepts and problems. Where computation requires a prescribed response to math symbols, concepts and problems require identification of proper procedure, and acquiring and using the proper math symbols.

Metacognitive strategies should act to qualitatively enhance the knowledge acquisition process. In terms of performance, complex skills may be more affected by the qualitative difference in processing complex subroutines, or chunking (Glaser and Bassok, 1989). This chunking of subroutines will result in proceduralized learning, and thus, higher performance in measurements of recall.

As per Chi, Glaser and Rees (1984), qualitative improvement will increase the latency of learning of complex skills. Therefore, existing metacognitive strategy levels should be more predictive of complex skill learning performance and the relationship should continue over time.

Metacognition and Implications in the Urban Environment

As discussed in the introduction, widespread concerns over adult literacy and numeracy exist in the public and private sectors. Lauro Cavazos, former Secretary of Education, addressed the growing number of functionally illiterate and correlations of lower scores on achievement tests with urban environments, low income and ethnicity (Cavazos, 1988, 1989). Urban environment, low income and ethnicity correlate strongly. Cities, with their concentration of social services targeted to lower socioeconomic groups, have reduced resources to compete with suburban educational programs.

Studies involving metacognitive skills and ethnicity (Borkowski and Krause, 1983) and metacognitive skills and socioeconomic status (Manning and Manning, 1984) report a strong relationship between environmentally acquired, or crystallized, abilities and metacognitive skills. Heckhausen (1983) suggests that cultural background may impact on individual perceptions of utility of specific

metacognitive strategies and may affect learning outcomes independent of learning conditions. King (1986), also Wagner and Sternberg (1984), specifically note that black students tend to be more deficit in metacognitive skills than white students, and suggests that achievement score differences are a direct result of this deficiency.

Understanding that metacognitive skills are acquired is important to the understanding of how the individual can reverse conditions of inappropriate or inadequate metacognitive response. In other words, the individual may be able to change demonstrated performance through remediation of specific metacognitive skills or overall metacognitive strategies.

The implications for adult remedial instruction of metacognitive strategies would be greatest in the urban environments. From a macroeconomic view, if metacognitive strategies could significantly impact on adult learning and retention of basic literacy and numeracy skills, the social utility of such training would be obvious. Gary Becker (1975) outlined the effects of better education, not only in terms of increased income and productivity, but also reduced health costs, and reduction in loads on other services.

Individually, the potential for increased trainability, job qualification and productivity associated with higher basic skills may break traditional cycles of poverty and

unemployment common in urban environments. The residual benefit for cities is the increased revenue base provided by not only the worker, whose skills meet the requirements of industry, but also the increase in industrial and commercial base that an availability of qualified workers attracts. The end effect is to increase the resources applied to early educational programming, and increase the capacity of the urban environment to serve all the needs of the resident population.

Summary of Review

The literature strongly suggests that learners who are able to use metacognitive strategies to attack learning situations will learn more and retain more over time. The literature also points to a stronger relationship between complex tasks, e.g., reading comprehension, than simple tasks, e.g., vocabulary, with metacognitive skills (Glaser and Bassok, 1989). Implied in the literature is that just as task skills have a hierarchical order, metacognitive strategies and skills have a hierarchical structure as well. Elaboration strategies are generally more sophisticated than rehearsal strategies, and within elaboration strategies, some skills are more sophisticated than others. Simple elaboration may be forming a mental image of the moon's orbit of the earth. A more complex strategy may be employed

to review the known information on gravitational pull, velocity and specific mass to determine the characteristics of the moon's orbit that prevent decay.

Essentially, the work of Weinstein, Mayer, Glaser and others (cited earlier) suggest that the more complex the learning task, the more sophisticated the appropriate metacognitive skill would be for its solution. Therefore, a strong metacognitive skills repertoire with sophisticated approaches should allow for more complex skill acquisition and retention. The qualitative advantage of metacognitive strategy use should be most evident in the durability of the new learning; therefore, metacognitive strategy use should account for more variance in predicting delayed performance measurement than initial acquisition. Despite the logic of Glaser's and other's conclusions, little research exists on retention and no research exists on relationships of metacognitive strategies and retention in an adult population. This study tested that construct.

The interaction of a range of preexisting conditions, aggregately referred to as motivation, should correlate with learning outcomes. Why and how this process takes place is a question open to debate; however, the several researchers who have employed different approaches to determine the effects of motivation on learning reinforce motivation's

role in learning performance. The measurement and control of motivation as an ancillary variable is critical to understanding learning strategies and their relationships to learning.

Hypotheses

The review of the literature led to the following hypotheses receiving examination in the study:

H_1 = There is a positive relationship between preexisting metacognitive study skills as measured on the LASSI and learning acquisition through individually accessed study as measured on the TABE.

H_2 = There is a positive relationship between preexisting metacognitive study skills as measured on the LASSI and retention of skills learned through individually accessed study as measured on the TABE.

H_3 = Including motivation and affective scores from the LASSI will demonstrate incremental validity, accounting for a significantly higher amount of variance in reading and mathematics skills acquisition.

H_4 = Including motivation and affective scores from the LASSI will demonstrate incremental validity, accounting for a significantly higher amount of variance in retention of reading and mathematics skills.

H_5 = There will be greater relationships between preexisting metacognitive study skills and acquisition of reading comprehension skills than vocabulary acquisition.

H_6 = There will be greater relationships between preexisting metacognitive study skills and retention of reading comprehension skills than vocabulary retention.

H_7 = There will be greater relationships between preexisting metacognitive study skills and acquisition of mathematics concepts and applications than mathematics computation.

H_8 = There will be greater relationships between preexisting metacognitive study skills and retention of mathematics concepts and applications than mathematics computation.

H_9 = There will be a greater relationship between preexisting metacognitive skills and retention of reading and math skills than initial acquisition.

CHAPTER III

Study Design, Methodology and Conduct

Design Considerations

During the course of the study, the Army participated in the Desert Shield and Desert Storm missions in the Middle East. The deployment of soldiers to the war limited both the number of available sites and the number of subjects. The study design took these conditions into account. The study began on August 1, 1990. On August 2, 1990, the Iraqi army invaded Kuwait, demonstrating for purposes of the current study the immutability of Murphy's Law.

The design would have to accommodate existing conditions, accepting a real world situation where random assignment is not always practical. Potential for loss of data and numbers of subjects demanded that research control statistically rather than by design.

The design attempted to generalize results by inclusion of soldiers from three different major commands: Forces Command, Training and Doctrine Command, and Pacific Command. The sites representing these commands were Fort Ord, Fort Jackson, and Schofield Barracks. Analysis of differences between the populations participating at these sites included demographic differences of gender, age, time in service, Military Occupational Specialty (MOS), and education level.

Subjects

The study consists of a main study group, with 96 subjects enrolled in both the reading and mathematics portions of the Basic Skills Education Program (BSEP), the Army's program of remediation of basic literacy and numeracy skills. These soldiers were not randomly selected, nor randomly assigned to treatment groups. The criticality of the BSEP to soldiers' personal careers does not allow for selection out of a treatment group.

A total of 169 soldiers took the LASSI. An additional 26 soldiers enrolled in either reading only or math only, thereby discounting their inclusion in the main study group. These two groups were later compared to the main group to validate main group results for math and reading separately.

Of the initial 169, there were 25 soldiers who participated in some form of instructional activity following the posttest that would potentially confound delayed posttest measurements. These activities included refresher instruction on PLATO (14), attendance at an Army training program (4 in Primary Leadership Development Course, 4 in MOS Improvement Training, and 3 in group MOS training). Of the number of soldiers remaining, 5 left the service, and 17 deployed to other locations. All of these soldiers' data were dropped from the analysis.

The Test of Adult Basic Education, or TABE, was the performance measurement instrument used in the study. The test provides raw, standardized and grade level equivalent scores for reading and mathematics. Reading is comprised of separate vocabulary and paragraph comprehension scores, the composite of which is the reading total score. Mathematics is comprised of computation and concepts and problems scores, the composite of which is the mathematics total score. Separate equivalent forms of the TABE were used for the pretest, posttest and delayed posttest measurements.

The three sites represent considerable differences in mission, and as expected, differences in demographic makeup. Fort Jackson, a training station for non-combat arms MOS, had generally older soldiers with non-combat arms jobs. The majority of female soldiers in the study were also at Fort Jackson, where education levels also tended to be slightly higher. Each of these variables mildly covary in the study population with higher initial TABE scores. However, the variance for initial TABE and subsequent TABE tests between sites were not statistically significant. The comparison of the three sites could therefore be made as a collective group.

Average age for the subject population was 22.8 years old, with the combat arms sites of Fort Ord and Schofield

Barracks slightly younger. The study population was overwhelmingly male, reflecting usual participation data. Only 11 female soldiers were in the study group, making comparisons based on gender difficult. Ethnicity comparisons were not part of the study; however, 52 percent were white, 42 percent were black, 4 percent were English speaking of Hispanic origin, and 2 percent were of other extraction. English as a Second Language (ESL) students did not participate. The majority of subjects (94) were high school graduates, with several reporting postsecondary experience.

Grouping all participants was significant, since the participant groups from each site were of different size. The breakout of the total population was Schofield Barracks = 50; Fort Jackson = 30; and Fort Ord = 16. Comparing different sized cells can be problematic due to reduction of associated degrees of freedom.

In addition to demographic analysis and initial TABE analysis, an analysis of variation between participants at the three sites for initial LASSI scores demonstrated statistically insignificant variation. Overall, the variance between sites was primarily accounted for by differences in gender and age composition for LASSI and all TABE scores.

The comparison of the LASSI and pretest, posttest and delayed posttest information from the TABE may operate independently of design considerations of random assignment or other randomization techniques. The primary consideration is whether the population has the exact length of exposure to instruction and identical curricula. Limiting the design to a single location would better assure internal validity but would limit generalization. By monitoring population variables, the design controlled for performance variance that might covary with population characteristics.

Design Limitations of the Study

Potentially confounding variables affecting the outcome of the study may affect the delayed testing portion of the design. The individual soldier's job requirements and environment may impact on the retention of skills (Farr, 1987). The study accounted for any variance in job requirements, i.e., reinforcement of learning outside the control of the experimenter. Comparing variance by job specialties would identify any covariance existing from this source. Because of the number of possible occupational specialities and the limited number of subjects, the practical solution was to identify soldiers as in either combat or noncombat arms job specialties.

There was no attempt to randomly select or assign soldiers to control and treatment groups. Since the curriculum was not the focus of the study and held constant, but rather the relationship between metacognitive study skills and the outcome of instruction, random assignment was not required to demonstrate a relationship and provides feasibility problems to the study.

Selection of Instruments

The use of the TABE as the measurement device for basic skills was predicated on two conditions of the methodology. First, the design attempted to achieve a level of transparency, i.e., the effect of observation, or reactive arrangements (Campbell and Stanley, 1961) were kept at a minimum. Since the TABE was already in use, introduction of an alternate test would have potentially added to the apprehensiveness of both the test administrators and the examinees. Secondly, the TABE has high content and construct validity with the basic skills curriculum. The development of the McFann-Gray series was in fact based on the TABE. The validity of the measurement instrument to the instruction was vital to subsequent measurements of acquisition and retention. Validation information for the TABE is in Appendix A.

The TABE is a general test of literacy and numeracy. The Army has used the TABE since 1980 and adult education programs in the Hampton Roads area also use the TABE. The separate scales for vocabulary and paragraph comprehension allowed for analysis of relationships with basic and complex skills. In the math section, computation was separate from the more complex requirements of concepts and problems, allowing for analysis of basic and complex task relationships with metacognitive strategies.

Several instruments existed to measure metacognitive strategies. Most were targeted to young students, some to remedial students and just two to young adults. The other instrument targeted to young adults was Mueller's (1984) instrument. Inspection of this instrument demonstrated that it was far too generalized for effective utility, including scales on general study attitudes and behaviors, reading and note taking, and test taking. The lack of discrimination of the instrument negated its use in the present study.

A preference for direct measurement of performance variables caused the author to search for an existing performance-based measurement of metacognitive strategies. With none available, a choice was made to identify the best available measurement device applicable for the study population. The course of investigation led to the

conclusion that the Learning and Study Strategies Inventory (LASSI) was the best available instrument to identify variance in existing metacognitive strategy levels among the population. This instrument was the most highly validated tool available for determining individual metacognitive study skills available. Reliability and validation information on the LASSI is in Appendix C.

The utility of the LASSI derived from both its apparent validity to the general model of metacognitive skills and demonstrated validity with similar populations. The LASSI came in two versions. The high school version and college versions were compared for validity to an enlisted population. Interestingly, on close examination, the college version's vocabulary and comprehension requirements were within the range of the study population. The major differences between the instruments were the level of social maturation expected from the examinees. The high school level version concentrated on more of the social learning aspects expected from adolescent students. Few modifications of the college version of the LASSI for a non-academic application were required. Modifications were limited to removal of references to college and replacing those references with "job" or "Army". The modifications were submitted to the author of the LASSI (C. E. Weinstein) and approved (12 February 1991) prior to use.

The LASSI is a self-reporting instrument with scales measuring anxiety, attitude, concentration, information processing (use of elaboration and organization strategies), motivation, scheduling (effective use of time), selecting the main idea, self-testing (monitoring), study aids, and test strategies. The total score of the LASSI provides information on the general state of preparedness for learning. Each scale relates to that overall state, but, overlap of strategies both in source and application, may limit the ability to analyze each scale independently.

The ten scales of the LASSI collectively measure a wide range of metacognitive behaviors. A summary of each scales' primary target of measurement and relatedness to expectations as identified in the literature is at Table 2. In large measure, the scales of the LASSI focus on most of the constructs identified in the literature concerning metacognition. Three scales apply more to affective states than learning strategies: Attitude, Motivation and Anxiety. Each of these scales relate to self-efficacy and general motivation theory and may be associated with negation of learning by prior conditions of discomfort or disassociation with learning objectives. The other seven scales identify specific learning processes.

Table 2

Summary of LASSI Scales and Target of Measurement

Name of Scale	Primary Target of Measurement
Attitude	Measurement of self-perception.
Motivation	Measurement of feelings toward environment and achievement.
Time Management	Measurement of acceptance of responsibility for planning and conducting learning activities.
Anxiety	Measurement of performance concern.
Concentration	Management of distractions.
Information Processing	Measurement of elaboration and organization of learning material.
Selecting Main Ideas	Measurement of identification of main ideas.
Study Aids	Measurement of recognition of available clues in learning materials.
Self Testing	Measurement of inprocess evaluation of comprehension.
Test Strategies	Measurement of the degree to which the individual plans for, and performs on tests.

Note. A more detailed description of LASSI scales and relatedness to cognitive theory is at Appendix B.

The scales do not directly correlate to the previously identified metacognitive strategy groups, i.e., rehearsal, elaborative, organizational, monitoring and affective strategies. If this instrument were used as a prescriptive device based upon the previous grouping, there would be considerable conflict. The LASSI does, however, contain measurements related to all of the previous groups.

Methodology

The study employed a statistical methodology as opposed to a design methodology to establish relationships between metacognitive study skills and learning acquisition and retention. The dependent variables were the posttest on the TABE for initial acquisition of learning, and the delayed posttest on the TABE for retention of learning.

The identification of participants did not vary from established procedures, i.e., soldiers tested on the TABE the week prior to beginning instruction. Soldiers meeting the criteria for both reading and mathematics scores began instruction in both blocks of instruction beginning the following Monday. Those with either deficiencies in reading or mathematics only took that block of instruction only.

Although the instruction is self-paced, reading and mathematics participants were exposed to 80 hours of instruction over a four-week interval. All participants

accessed the same basic skills reading and mathematics curricula, utilizing the McFann-Gray materials developed for the Army. At the end of each block of instruction, the student could review the material prior to proceeding to the subsequent block. Reading only or mathematics only students took 40 hours of instruction.

At the conclusion of the intervention, participants retested on the TABE using a different form of the test. A separate form limited some potential confounding by the effects of testing. Although monitoring instruction ensured the student did not encounter technical problems with the material, the student independently determined the pace of the instruction.

The delayed posttesting, using a different form of the TABE than the posttest, occurred 60 to 67 days following the conclusion of the intervention, providing adequate time for decay of learned knowledge (Farr, 1987). Any unforeseen circumstances that prevented the delayed posttest of an individual, or other environmental conditions that may have affected test scores, resulted in the elimination of the data from the study.

The metacognitive strategy independent variable was operationally defined as the aggregate score of the LASSI. Independent metacognitive variables also included separate

aggregate scale scores for metacognitive learning strategies (Time Management, Concentration, Information Processing, Selecting Main Ideas, Study Aids, Self Testing and Test Strategies scales on the LASSI) and affective and motivational measures (Attitude, Motivation and Anxiety scales on the LASSI).

A limited analysis of individual scale scores of the LASSI as independent variables yielded data on relative contributions to acquisition and retention of the separate scores. Two considerations mitigated conclusions from such analysis. First, as noted, the basic constructs of scales overlapped considerably, creating covariance and confounding interpretations of such analysis. Second, the number of subjects in the study were statistically insufficient to address the entire field of variables.

Initial TABE scores were forced as the first variable in the stepwise regression model. The scores were analyzed as both aggregate reading and mathematics and as component scores, i.e., comprehension and vocabulary for reading and mathematics computation and mathematics concepts and application for mathematics. The multiple regression model determined the amount of covariance accounted for by the initial TABE scores. Metacognitive variables were entered subsequently, using a probability of $F = .05$ criterion for inclusion into the stepwise regression formula. The

multiple regression formula extracted relative contributions, coefficients of determination (R square) and beta weights of the independent variables to account for variance.

The test of the regression model in determining support for the hypotheses was whether inclusion of LASSI score variables for metacognitive skills and motivation and affective measures significantly improved the predictiveness of posttest and delayed posttest scores. Following the analysis of the regression models for skill acquisition and retention, a comparison between the regression values (beta weights for multiple R) for each of the models yielded a description of any differences in the predictive value of measured metacognitive study skills and motivational and affective measures and acquisition and retention scores (Wittman, 1988).

Other variables available for analysis included location, gender, age, years in service, education level and whether the soldier was in a combat arms occupational specialty. No hypotheses were developed in regard to any of these variables, rather, the variables provided a method to test, *post hoc*, for possible confounding effects. Analysis of data was accomplished with the SPSS/PC+ statistical package. Information on the procedures used is available in the SPSS/PC+ Base and Advanced Statistics manuals, 1988.

The conditions of the study were such that two additional groups were available for validation of main group results. Those soldiers taking either math or reading only were evaluated separately. Rather than disregard this data, the study used these smaller data fields to verify the general relationships existing in the primary study group. The reading only group consisted of twelve soldiers, drawn from Forts Ord and Schofield Barracks. These soldiers studied reading for forty hours, half the time allotted for both reading and mathematics. The mathematics only group consisted of fourteen soldiers; again, the study time was forty hours.

The data for both of these groups provided not only a basis of comparison to the primary study group, but controls for the possible confounding effects of instruction in both reading and mathematics in the main study group. The total N for each of the single subject group limited the significance of findings for inclusion of variables into a regression analysis; however, the comparison of correlational data would be able to demonstrate the validity of the relationships of the main study group.

TABE scores were standardized to the D level Form 3 raw scale. Conversion between versions of D level TABE tests were facilitated by considerable documentation of norming available from the publisher.

The selection for participation was, as noted, not random. However, since the study did not compare effects of instruction, but rather the relationships of all participating soldiers' learning outcomes and reported metacognitive skills, the lack of randomness did not negatively affect analysis.

Delimitations of the Study

The availability of suitable subjects and cooperation of key personnel in providing adequate controls for the study were critical. Since the study did not significantly alter existing procedures, it was nearly transparent to the subjects. Subjects were appraised of the nature of the LASSI and that the results of the instrument would not be entered into personnel files.

A concern at the time of the construction of the study was the generalizability of results from a basic skills curriculum to other forms of training and education interventions. There were several considerations for the choice of the curriculum to determine learning relationships to metacognitive skills.

First, the curriculum must have a wide range of exposure. The number participating in the intervention must have been large enough to allow for reasonable expectations

of significant effects within the time for measurement. More importantly for generalization of results, the range of job specialties must have been broad enough to generalize results across the enlisted field.

The BSEP curriculum met both of these requirements. The numbers of soldiers attending BSEP instruction annually made it the most widely used academic intervention within the Army. Although, due to the nature of qualifications for attendance, soldiers with some highly technical job specialties were not part of the BSEP base, all of the highly populated MOS had representation in BSEP instruction. Short of Basic Combat Training, no other Army instruction had such a wide base of attendance.

A second consideration for choice of curriculum was design. The intervention was not the subject of the study. Therefore, the ideal curriculum should have been relatively neutral. Neutrality within the design provided for little interaction between the curriculum and the secondary measurement, i.e., the LASSI. Since the curriculum did not attempt to address the skills measured in the LASSI, the assumption that change may have occurred after the initial measurement could be ignored.

Neutrality also indicates less likelihood of external confounding due to reinforcement following the intervention.

Unlike skill specific instruction that would likely receive reinforcement when the soldier returned to the work site, the opportunity for reinforcing specific learning is highly unlikely with BSEP. The skills are too general in nature to allow supervisory reinforcement. The relative lack of direct reinforcement following the posttest contributed to the opportunity to measure retention over time. Since retention of skills has historically been far more elusive than initial acquisition, and since the metacognitive model suggested that retention over time may be strongly linked to preexisting metacognitive skills, the ability to measure retention through use of BSEP weighed heavily in favor of using BSEP.

BSEP also has a standard method of measurement with both pre- and posttesting. As an existing methodology, the measurements drawn did not change the process and contributed toward minimizing the effects of experimental intrusion. Conveniently, several forms of this nationally normed instrument also allowed for delayed posttesting with an equivalent form.

BSEP possessed similarity to the form of instruction in which soldiers, and employees in non-military organizations, will encounter with individually accessed training. The student individually initiated study and accessed

materials. The independence of action, and the requirement to monitor progress resembled the required activities in other forms of self-directed training.

Controlling the number of hours of exposure to the curriculum provided an experimental advantage over a design using totally self-directed instruction. Pre- and posttest comparisons, and pre- and delayed posttest comparisons would have been richly confounded if the exposure to the instructional intervention was not held constant in time.

Individually Accessed Basic Skills Instruction

The requirement for specificity dictates the use of the terminology "individually-accessed instruction" in reference to the mode of delivery of basic skills in the study. This term will differentiate the instruction from the adaptive, or individualized form inferred by "individualized instruction."

Although common usage refers to any program of instruction that does not depend on traditional teacher/pupil learning relationships as individualized, the generic use of this term is not specific to the conditions existing in the study. The curriculum used in the study did not tailor to specific individual needs as the term individualized instruction implies. Such instruction is generally computer-based and predicated on adaptive testing

techniques not present in the current curriculum. The software engineering for such adaptive testing and prescriptive instruction remains well behind the hardware delivery systems. Although artificial intelligence programming may progressively offer more solutions to the problem of incisively delivering the domain and level correct for the individual student, the costs for such development remain high, particularly on Programmed Logic for Automated Teaching Operations (PLATO) that forms the basis for instructional support for both the Army and several large employers (Ford, General Motors, etc.).

In the intervention mode used for BSEP, the individual received assistance in the selection of the lessons upon which to begin and assumes responsibility for the completion of those lessons and continuance in subsequent lessons. Further, instructional assistance remained available to individuals when specific questions on the material arose.

The primary source of instruction was the McFann-Gray series, developed for the Army in support of math and reading skills for adult learners. The instruction was paper-based with levels and skills separated in workbook form. The monitor selected the appropriate beginning level for each student based on scores of the TABE results. The students progressed through these workbooks, acquired the

next level and continued working throughout the assigned instructional period. Students enrolled in reading and mathematics accessed instruction for eighty hours, forty hours of reading and forty hours of math.

The BSEP curriculum was neither unique nor innovative. It followed basic constructs employed for over two decades to instruct literacy and numeracy. As a curriculum, its relative effectiveness was not a question of this research. Individual variance in the effects of the intervention was the question posed, i.e., why some soldiers outperformed others in acquiring BSEP skill proficiency through instruction and why some soldiers experienced nearly immediate learning decay following the end of the intervention.

Considerations of Pretest, Posttest and Delayed Posttest Comparisons

Several factors obfuscate measurements of difference in pretest-posttest designs. A principle and frequently overlooked problem is the use of gain scores to reflect changes over time. Even using equivalent tests to control for instrumental decay will not alleviate pretest-posttest errors. The problem stems from the internal characteristics of testing.

Educators and trainers have frequently and erroneously interpreted test results based on individual score differences from pre- to posttest. Using normed or criterion-based instruments, they have extracted the difference between results by subtracting one score from the other. An example is the use of normed instruments, similar to and including the TABE, to provide information on the progress of a student. The education specialist reviews the results, e.g., 7.0 grade level equivalent pretest in reading and 7.5 grade level equivalent posttest, and determines that the student has progressed one-half grade level due to the intervening instruction. If the results were independent and true, the conclusion would be correct; however, the score on any instrument measures several factors resulting in dependent and potentially untrue scores.

Each test result includes both the true measurement, a theoretical measurement of the individual's true knowledge, and a standard error of measurement. Even on a very accurate instrument, the error of measurement may be high. If, on the above example scores, the error of measurement was .3 or higher, then the true pretest score may have been 7.3 and the true posttest score 7.2. Thus, the student may have actually decreased in reading ability over time,

perhaps due to the instruction, but possibly due to other uncontrolled factors. As scores are independent, errors are also independent and therefore cumulative.

If the reliability of an instrument is poor, decisions about individual can be more flawed than in the above scenario, leading to inappropriate decisions. It is noted at this time that the use of difference of scores in this study is by cumulative group analysis. Making group assessments does not infer specificity of application back to the individual, and the reliability sensitivity of the decision is greatly reduced (Linn, 1981; and Lord, 1981).

A second issue of possible confounding due to the effects of testing existed in correlating test results of different tests. The reader may refer to Werner Wittmann, "Multivariate Reliability Theory: Principles of Symmetry and Successful Validation Strategies," Handbook of Multivariate Experimental Psychology (1988, pp. 505-557) for a complete examination of the problems associated with test scores or observed variance in score analysis. Wittmann innumerated these factors in accounting for variance: "Observed score variance is an additive function of person-effect, of form-effect, and of a variance component which (sic) confounds variance due to the interaction of person x form and error over person and form (p. 512)."

Since there were two forms, and potentially two form effects and two person x form effects, there existed a possibility of confounding. Again, individual application, i.e., application to a population of one, would have exacerbated potential error. The relationship would only apply when the error term was stable, or when sufficient subjects were grouped for analysis.

A dependent t or Pearson's r may not account for errors of variance observation since the error term does not necessarily derive from all relationships. An ANOVA that does not separate the interaction effect will fail to address within cell replication. Creation of a mixed effect ANOVA to account for each source of variance would have required multiple replication with either person or forms as a fixed factor (Wittman, 1988).

As the sample population score distributions approach normal, the two or more variables representing the test scores may be compared with assumptions of interreliability (Durbin, 1973). The current study tested the population score distributions to examine these assumptions. The study will employ the Durbin-Watson test for this purpose.

The effect of interaction of person and form goes beyond chance differences. Most instruments, including the TABE used in the current study, target a specific level of

performance. In the case of the TABE and other normed interpreters of grade level performance, the accuracy of predicting true scores degrades from the target performance level, i.e., test scores will include higher error measurements in proportion to the movement away from the target level. Publishers recognize this requirement and develop different difficulty levels of normed instruments in an attempt to secure the least measurement error.

Had initial scores deviated too greatly from the target of the TABE form used they would not have been included in the study. Use of the lower level version of the TABE, or TABE E, particularly for soldiers scoring low, is not currently a policy and would force the establishment of a separate cell. Fortunately, no scores fell outside the measurement limits determined by the publishers of the TABE.

As indicated above, the use of gain scores could invalidate observed variance findings. Simply put, the errors of measurement of testing instruments are independent, and therefore, additive. Although several statistical methodologies could control for the effect of independent error, the simplest to conform to the requirements of this study was a stepwise model that has pretest scores as a forced first variable. The stepwise regression model worked much the same as an ANCOVA by selecting out shared variance between individual scores.

The advantage of a regression over ANCOVA was the additional ability to extract information on subsequent variables and test models with and without the contribution of subsequent variables entered. Multiple regression also had two analysis terms, the coefficient of determination, or R Square, and the beta weights of the variables, to explain the complex relationship between each or all variables as a contribution to the predicted measurement.

Utility of the Design

The question arises as to whether the study establishes causality. The study attempts to identify relationships between the measurements of the metacognitive strategies represented on the LASSI and the skill acquisition and retention measured with the TABE. The establishment of causality between metacognitive strategies and learning outcomes requires two conditions. There must be a valid and reliable performance-based instrument to extract real changes in metacognitive behavior, and design including nontreatment and treatment groups using a valid intervention of metacognitive strategy training. Neither of these conditions were obtainable at the time of the study.

The regression model resulting from the current study can, however, determine the relative predictability of LASSI

scores and subscores for skill acquisition, and retention through subsequent model formulation, i.e., if a significant R Square exists between learning strategies and performance on the TABE posttest, then learning strategies are predictive. The suggestion of causality derived from such predictions would require additional research. However, as Schmidt and Hunter demonstrated (see Schmidt, F. L., Hunter, J. E., and Pearlman, K. ,1979), a correlation coefficient, or R value can be developed into an utility analysis to determine the value of inclusion of learning strategy instruction in the skill instruction cycle. The reader may note the replacement of Schmidt and Hunter's use of Pearson's product moment correlation coefficient with a regression term, i.e., coefficient of determination. Such replacement would be valid and would enhance the understanding of the relationship.

Therefore, although the present research did not establish causality in the clearest sense of the term, it provided potential practical utility. Further, the study's results provided strong evidence to support of the development of performance-based metacognitive measurements and interventions validated for adult training and education use.

The study's use of the LASSI had secondary benefits in that the instrument includes both learning strategies and affective measures. Several studies, including many sponsored by the Department of Defense (notably Naylor and Briggs, 1961; and Schendel, Shields and Katz, 1978) have examined motivation as a contributor to learning acquisition. Although effects were not particularly strong in some of these studies, some relationship was noted. If learning strategies are to be considered as preconditions of higher learning performance, then it would follow that absent these skills, motivation to learn alone would not significantly increase learning. Conversely, learning skills absent motivation may not increase learning.

The review of the literature showed that the combination of metacognitive study skills and motivation has not received empirical examination in an adult population. As stated above, without controlling for the effect of motivation/affective conditions, the results may be obfuscated. The review of the literature showed that the definition of motivation to be imprecise, and that several factors, including self-perception and expectancy may be related or a function of motivation. The Attitude, Anxiety, as well as the Motivation scales of the LASSI refer to behaviors and beliefs that the literature connects to the

aggregate construct of motivation. Combining these scales under the title of affective measurements provides a fairly broad sampling of responses for motivation measurement. Affective measurements described the preexisting context that participants brought to the learning situation, i.e., how the participant felt about his or her participation in a learning situation (Anxiety scale), how the participant viewed the job environment beyond the context of the present learning experience (Attitude scale), and the participant's self-perception (Motivation scale).

Although the content of the scales grouped as affective measurements includes goal setting and other logical processes not usually defined as affective, the response of the participant to the learning situation can be termed affective, thus the distinction from learning strategies. The LASSI affective measurements together address the majority of conditions, factors, behaviors and beliefs that the review of the literature refers to as motivation.

CHAPTER IV

Results of the Study

General and Descriptive

Several unexpected results occurred from the conduct of the study noted in detail below. The first of these was the apparent wide range of discrimination of the LASSI. The frequency distribution of LASSI scores is in Table 3. The descriptive data for the LASSI, total pretest TABE, LASSI learning strategy score total and affective score total, total TABE posttest score and delayed posttest score are in Table 4.

Table 5 shows the descriptive data by the ten LASSI scale scores. All LASSI scale scores have a range of 8 to 40, with the exception of Selecting Main Ideas (SMI). SMI has an abbreviated scale due to the limit of five items. All other scales have eight items. The process for defining these items and developing the LASSI scales may be found in Learning and Study Strategies, Weinstein, Goetz, and Alexander, 1988 (pp. 25-39).

The histogram of LASSI scores in Table 6 represents an interesting condition of the subject population. The approximation of a Gaussian Curve is apparent, with the mean and mode of the distribution equivalent. The distribution is not significantly skewed, and only mildly leptokurtic.

Table 3. Frequency Distribution of Learning and Study Strategy Inventory (LASSI) Scores

Value	Freq	Percent	Cum%	Value	Freq	Percent	Cum%
167	2	2.1	2.1	254	3	3.1	57.3
179	1	1.0	3.1	255	1	1.0	58.3
184	1	1.0	4.2	256	1	1.0	59.4
186	2	1.0	6.3	257	1	1.0	60.4
191	1	2.1	7.3	259	1	1.0	61.5
198	1	1.0	8.3	260	1	1.0	62.5
200	1	1.0	9.4	261	1	1.0	63.5
201	2	2.1	11.5	262	1	1.0	64.6
202	1	1.0	12.5	263	2	2.1	66.7
205	1	1.0	13.5	264	1	1.0	67.7
206	1	1.0	14.6	265	1	1.0	68.8
207	1	1.0	15.6	266	1	1.0	69.8
211	1	1.0	16.7	270	1	1.0	70.8
212	1	1.0	17.7	271	1	1.0	71.9
217	1	1.0	18.8	272	1	1.0	72.9
219	1	1.0	19.8	274	1	1.0	74.0
221	1	1.0	20.8	276	1	1.0	75.0
222	3	3.1	24.0	282	1	1.0	76.0
224	2	2.1	26.0	283	2	2.1	78.1
226	1	1.0	27.1	284	1	1.0	79.2
227	1	1.0	28.1	285	2	2.1	81.3
229	2	2.1	30.2	287	1	1.0	82.3
231	4	4.1	34.4	288	1	1.0	83.3
238	1	1.0	35.4	289	1	1.0	84.4
239	1	1.0	36.5	292	2	2.1	86.5
240	1	1.0	37.5	293	1	1.0	87.5
241	2	2.1	39.6	294	1	1.0	88.5
242	2	2.1	41.7	299	1	1.0	89.6
243	2	2.1	43.8	304	1	1.0	90.6
244	1	1.0	44.8	308	1	1.0	91.7
245	1	1.0	45.8	311	1	1.0	92.7
246	1	1.0	46.9	318	1	1.0	93.8
247	1	1.0	47.9	322	2	2.1	95.8
248	1	1.0	49.0	323	1	1.0	96.9
249	1	1.0	50.0	329	1	1.0	97.9
250	1	1.0	51.0	332	1	1.0	99.0
251	2	2.1	53.1	360	1	1.0	100
253	1	1.0	54.2	Total	96		

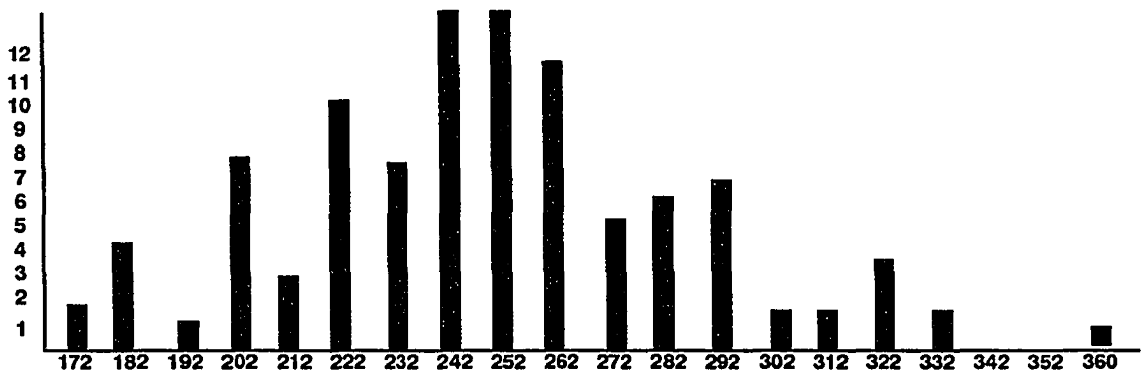
Table 4. Descriptive Data For All TABE, LASSI, Learning Strategy and Affective Scores

Variable	Mean	Std Dev	Min	Max	N
TABE Pretest	112.02	12.86	72	141	96
TABE Posttest	141.81	18.18	87	182	96
TABE Delayed Test	129.20	20.59	76	173	96
Total LASSI	250.86	39.36	167	360	96
Affective Total	83.43	11.67	59	109	96
Learning Strategies	167.28	31.18	103	251	96

Table 5. Descriptive Data of LASSI Scales

Variable	Mean	Std Dev	Min	Max	N
Attitude (ATT)	29.18	5.17	18	40	96
Motivation (MOT)	30.22	5.66	13	40	96
Time Management (TMT)	25.03	6.22	13	40	96
Anxiety (ANX)	24.24	5.33	10	40	96
Concentration (CON)	26.00	6.38	12	40	96
Information Processing	25.50	7.62	12	39	96
Selecting Main Ideas (SMI)	16.82	4.61	7	25	96
Study Aids (STA)	22.95	6.05	12	38	96
Self Testing (SFT)	26.09	6.98	12	39	96
Test Strategies (TST)	25.95	5.66	12	39	96

Table 6. Histogram of LASSI Score Frequency



The distribution of LASSI scores among the sample population indicates a probability of generalization back to the parent population, i.e., basic skills eligibles. The sample size of N=96 is sufficient to draw general conclusions about the population group; however, the sample does not necessarily represent the entire population, i.e., all soldiers, since other populations, e.g., United States Military Academy graduates, may respond to the items on the LASSI significantly differently than a basic skills eligible population.

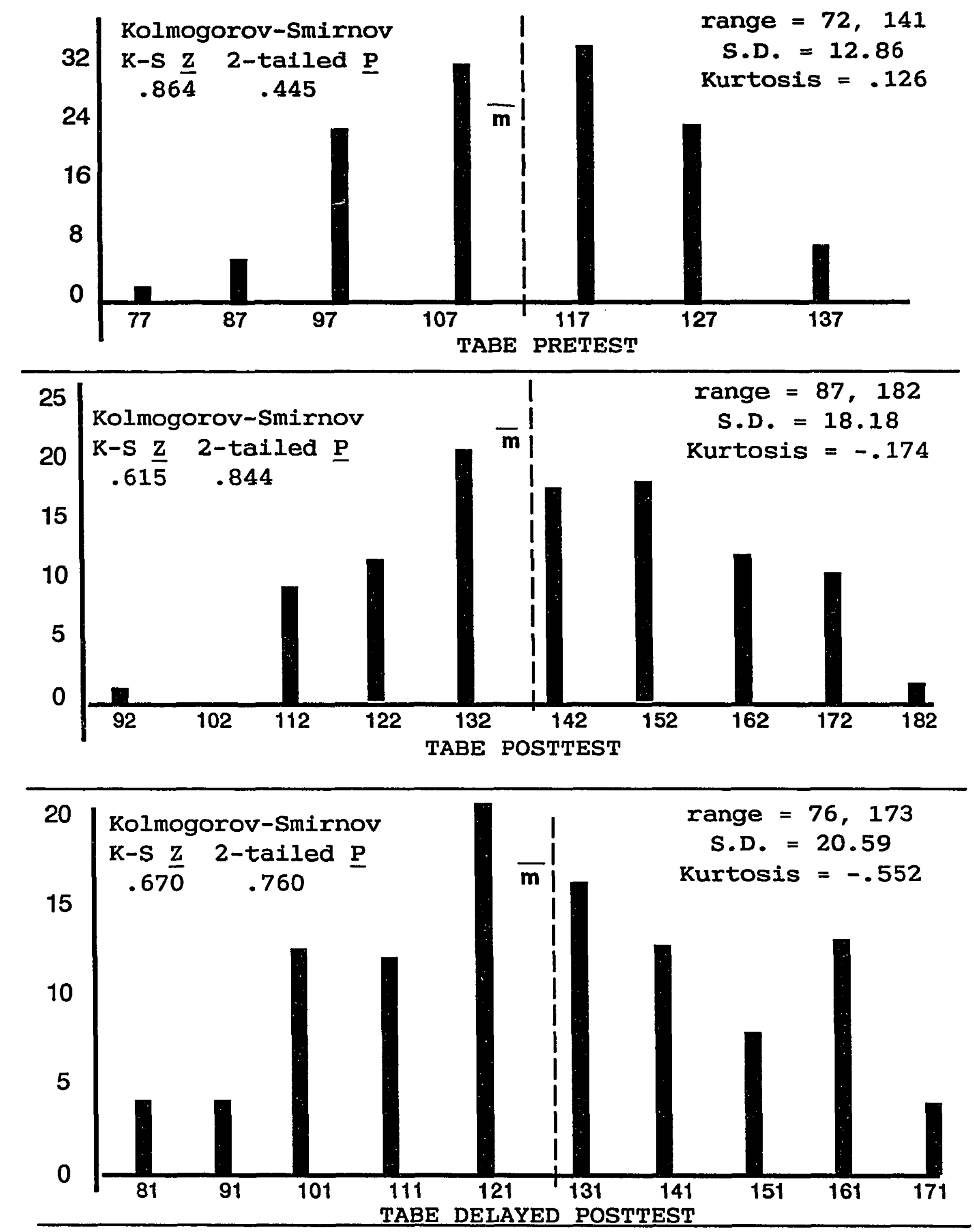
The histogram draws attention to outliers, particularly to the LASSI score of 360. Analysis of outliers, including methods of extraction was performed, but controversy concerning such methods, together with the limited error caused by such variance in the present study determined a more conservative approach and outlying data remained in the study (Barnett and Lewis, 1984).

Histograms of TABE scores were nonessential to the study hypotheses, since their inclusion would infer analysis of instructional outcomes. However, with different tests, assumptions of autocorrelation must be tested. These histograms are in Table 7. The TABE pretest distribution nearly approximates a Gaussian curve. However, subsequent posttests and delayed posttests expand the base of the curve, demonstrating a condition of range and variance expansion. As a training outcome, such expansion would be an unacceptable result.

Given the conditions of the instruction, however, such expansion may be explainable. The increase in reading and mathematics proficiency may be assigned, based on the literature and this study's findings, to soldiers' abilities to independently access information and process learning. Variance in strategy choice and use should account, as hypothesized, for variance in posttest and delayed posttest performance. Initial variance in strategies, as measured by the LASSI and positively correlated to initial TABE scores, may then explain the training's lack of effectiveness in enhancing the homogeneity of the training group. The inference of a lack of homogeneity will be discussed later.

Within the regression analysis, all variables included in the regression, with the exception of the forced entry of

Table 7. Histograms of TABE Pre-, Post-, and Delayed Posttests



TABE pretest, must survive the probability of $F = .05$ for entry. Relevant post hoc analysis (Hotelling's T) is included with the regressions to determine the significance of inclusion of the variable in accounting for variance in performance. The F ratios associated with this procedure are also provided to illuminate relationships and assure congruency of outcome (Williams, 1974; and Ferguson and Takane, 1989).

All nine of the hypotheses were supported by the results; however, constraints on implications of results were noted specifically for hypotheses 3, 4, 7 and 8. The potential for deriving incorrect conclusions concerning the exact source of variance for these hypotheses is described with the results of those hypotheses.

Overall, scores on the LASSI had a greater effect on retention than initial acquisition, in support of the last hypothesis; however, the significance and power of the relationship uncovered was not expected. In all analyses, the predictive value of the LASSI scores outweighed the predictiveness of the initial TABE scores for determining the delayed posttest scores of the individual.

A sampling of TABE scores and available soldiers' General Technical (GT) scores demonstrated a significant correlation (Pearson's $r = .882$, $N=50$). The TABE results were consistent with test score predating entry into

service, suggesting that TABE pretest scores were not anomalous.

Metacognitive Strategies and Learning Acquisition

Results in support of the first hypothesis is in Table 8. The first hypothesis anticipated positive relationship between preexisting metacognitive study skills as measured on the LASSI and learning acquisition through individually accessed study as measured on the TABE. The zero order correlation in Table 8 shows the LASSI score did not correlate as highly to the TABE pretest as the posttest, i.e., the level of initial metacognitive skills, as reported on the LASSI, did not as strongly correlate to existing basic skill levels (.343) as to learning acquisition (.683).

The TABE pretest alone predicted performance at a relatively high level (R square = .533). When the LASSI follows as the second variable in the equation, performance prediction increased (R square = .745). The beta weight for the LASSI included as the second variable in the stepwise regression is .491, significant at the .001 level. The added knowledge of LASSI scores therefore availed higher predictiveness than the individual's pretest performance alone.

Table 8. Regression Analysis of Total LASSI and Learning Acquisition (TABE posttest)

Zero Order Correlations:

	LASSI	TABE 1	TABE 2
LASSI	1.000	.343	.683
TABE 1	.343	1.000	.730
TABE 2	.683	.730	1.000

R Square without LASSI = .533

Regression with LASSI as second variable

Multiple R	.863	
R Square	.745	
Adjusted R Square	.740	
Standard Error	9.275	Durbin-Watson = 1.78

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	23404.977	11702.489
Residual	93	7999.647	86.017

<u>F</u> = 136.047 Significance of <u>F</u> < .001

----------Variables in the Equation---------

Variable	B	SE B	Beta	T	Sig T
TABE Pretest	.794	.079	.562	10.08	< .001
Total LASSI	.227	.026	.491	8.81	< .001
(Constant)	-3.985	9.018		-.44	.659

Although TABE pretest scores yielded higher beta weights than LASSI scores in determining the TABE posttest score in the regression analysis, the difference was less than expected. The evident capacity of the LASSI to account for variance in performance outcomes was significant. The variance accounted for by the addition of the LASSI score substantially enhanced the understanding of the relationships between metacognitive skills, as reported on the LASSI, and subsequent learning outcomes.

A second relationship represented in Table 8 is the relatively low standard error of the regression coefficient (B) for the LASSI, as compared to the TABE. The low standard error suggested that although the regression coefficient for the LASSI represented a less direct relationship to the TABE posttest, as would be expected, there existed greater opportunity for error in the TABE. A review of the histograms of the TABE pretest and posttest may amplify this relationship. The outcome of the BSEP intervention was to both increase performance of the group mean score, and to increase the standard deviation. Therefore, relationships between the pretest and posttest included the resultant error.

A regression showing the contribution of individual LASSI scales is in Table 9. The LASSI significantly

improved predictions of learning acquisition in Table 6 as total score. Through stepwise analysis of sub-scores on the LASSI, there was evidence that specific individual scales more strongly predicted initial acquisition than did others.

Analysis of all the variables associated with the LASSI, i.e., all ten sub-scores, may have created some confusion in the regression itself due to the number of potential variables in the equation versus the number of N available in the study. Table 9 only begins to analyze the possible relationships to learning performance; but, the regression shows that by including only the Information Processing, Attitude, Study Aids, and Anxiety the resulting equation had a lower standard error and a higher R square than using the total LASSI score. The LASSI was therefore not only predictive of learning performance, but some scales of the LASSI appeared to be more predictive than others.

The relative predictiveness of sub-scales of the LASSI to performance, as shown later, varies with the type of learning, and whether the measurement is of learning acquisition or retention. Although a regression equation accounting for variance of TABE posttest places Information Processing as the second variable, subsequent separate analysis of reading and math acquisition generate equations in which the second variables are other sub-scores.

Table 9. Stepwise Regression Predicting TABE Posttest
Stepwise selection for inclusion of all LASSI Scales

Multiple R	.880
R Square	.774
Standard Error	8.873

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	5	24319.08	4863.82
Residual	90	7085.54	78.72
F = 61.78	Significance of F < .001		

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
TABE Pretest	.879	.075	.623	11.72	< .001
Information Processing	.478	.162	.200	2.96	.004
Attitude	.770	.180	.219	4.27	< .001
Study Aids	.665	.208	.221	3.19	.002
Anxiety	.467	.178	.137	2.62	.010
(Constant)	-17.861	9.772		-1.83	.071

Table 10. Regression of TABE Pretest and LASSI to Delayed Posttest Score

Multiple R	.916	Durbin-Watson =	1.884
R Square	.839	R Square Change	.324
		F Change	187.409
Standard Error	8.343	Signif F Change	< .001

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	33784.26	16892.13
Residual	93	6472.98	69.60
F = 242.70	Significance of F < .001		

Summary Table

Step	MultR	Rsq	Variable	Beta In
1	.718	.515	TABE 1	.718
2	.916	.840	LASSI	.606

Later discussion attends to possible domain specificity of the LASSI sub-scores. For now, it is sufficient to point out that the results of the first regression did not necessarily support a strategy of focusing only on the four scales included in the regression. The complexity of the relationships of learning functions and retention to metacognitive skills did not appear to warrant such a simplified model. Secondly, the covariance due to overlapping constructs between scales promoted using the LASSI as a total score despite possible prediction advantages of using separate scales.

Metacognitive Strategies and Retention

The second hypothesis held that there is a positive relationship between preexisting metacognitive study skills as measured on the LASSI and retention of skills learned through individually accessed study as measured on the TABE. The results of this study strongly support this hypothesis. Table 10 shows a much higher contribution or predictiveness of total LASSI scores to delayed performance measures than the TABE pretest. The increase in the coefficient of determination was from .515 to .839. The F ratio change in this analysis was highly significant and demonstrated the robustness of LASSI scores in predicting delayed posttest performance.

Comparing Table 8 with Table 10 shows that the coefficient of determination for TABE pretest to delayed posttest (R square = .515) was less than for pretest to posttest (R square = .533). While TABE pretest scores were less predictive of retention, the LASSI score accounted for the remaining variance. With the LASSI, the coefficient of determination increases from .745 posttest prediction to .839 for the delayed posttest prediction equations. The inclusion of LASSI scores allowed better prediction to performance over time.

The variance accounted for in the regression analysis and the strength of the relationship of LASSI scores and retention was not an expected result. The LASSI's power as an instrument, due to its relatively short length and being a self-reporting instrument, together with concerns about population variance, led to expectations of less significant results. Since this relationship could not logically exist by chance alone, and since covariance of initial TABE scores is extracted in the methodology, the observation must be that the measurements of the LASSI were strong and consistent predictors of retention of learning.

As with the first equation demonstrating the relationships of the LASSI and posttest results, the regression with the availability of all scales provided the opportunity for some interesting questions and conclusions.

Table 11. Stepwise Regression of all LASSI Scales and TABE Delayed Posttest Retention Measurement

Multiple R	.935
R Square	.874
Adjusted R Square	.865
Standard Error	7.558

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	6	35172.75	5862.12
Residual	89	5084.49	57.13

F = 102.61 Significance of F < .001

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
TABE Pretest	.899	.066	.562	13.70	< .001
Selecting Main Ideas	.708	.222	.158	3.19	.002
Attitude	.551	.164	.138	3.56	.001
Information Processing	.616	.155	.228	3.97	< .001
Concentration	.575	.147	.178	3.90	< .001
Study Aids	.613	.177	.180	3.47	< .001
(Constant)	-44.244	8.036		-5.51	.001

Summary Table

Step	MultR	Rsq	Variable	Beta In
1	.718	.515	TABE Pretest	.718
2	.877	.769	Self Testing	.534
3	.903	.815	Select Main Ideas	.257
4	.917	.840	Attitude	.165
5	.926	.857	Info Processing	.215
6	.931	.867	Concentration	.127
7	.936	.876	Study Aids	.147
8	.935	.874	*Remove* Self Testing	

Building the regression equation shown in Table 11 took eight steps. The first variable included in the equation after the forced entry of the TABE pretest was the SFT (Self Testing) scale score; however, at step eight, the SFT score was removed. The power of the stepwise regression process began to demonstrate itself by illustrating quite a bit about the SFT scale's dynamics in the regression model. Although SFT was clearly the strongest of all stepwise entered variables, other scales covaried sufficiently to force the variable out at step eight. Again, the number of subjects helped in making such analysis, since reaching the critical threshold for inclusion of the other variables allowed for the observation of the removal of SFT.

The Self Testing scale appeared to measure those activities also referred to in the literature as self-monitoring. In terms of powers of performance prediction, the covariance between SFT and other variables entered later strongly suggested that other variables measured some of the same factors as SFT. Simplified, self-monitoring was a partial function of all variables entered later in the equation.

Selection out of the equation, rather than reducing SFT's overall accounting for variance, enhanced SFT's

apparent place as the most potent scale of measurement for the prediction of learning retention. With larger numbers of subjects, other dynamics of the model could become apparent, but, the primary relationships demonstrated here would probably continue. The analysis of separate scales was not part of the initial hypotheses; however, the results of such analysis were presented here to enrich the understanding of the relationships and stimulate further inquiry.

Table 12. Zero Order Correlation of LASSI and TABE Pre-, Post-, and Delayed Posttests

Correlations of primary measurements (two-tailed significance)

	TABE Pretest	TABE Posttest	TABE Delayed
Total LASSI	.343*	.683*	.781*
TABE Pretest	1.000	.730*	.718*
TABE Posttest	.730*	1.000	.937*
TABE Delayed Posttest	.718*	.937*	1.000

* Level of significance: **p < .001

The zero order correlation in Table 12 demonstrates the fundamental relationships between the LASSI and TABE scores. The strength of the correlation grows from .343 for pretest to .683 for posttest, and .781 for delayed posttest measures. The metacognitive measurements of the LASSI showed greater relationships to learning over time.

Questions concerning the predictiveness of the LASSI when only posttest scores are known are answered in Table 13. Discounting the effects of the BSEP intervention and individual differences existing at the beginning of BSEP, a regression of posttest to delayed posttest provided a simple regression of retention. LASSI scores remain significant in predicting delayed posttest results of the TABE.

Affective Measures and Incremental Validity

The third hypothesis stated that including motivation and affective scores from the LASSI would demonstrate incremental validity, accounting for a significantly higher amount of variance in reading and mathematics skills acquisition. As noted in the earlier discussion, the relationship of overall LASSI scores and initial acquisition was significantly less than with retention.

The support for this hypothesis was split between total TABE scores and separate reading and math scores. For total TABE acquisition (reading and mathematics posttest) scores, affective measures were significant as the third variable after initial TABE and learning strategies with a significance of T of .04 (Table 14). Thus, although affective measures account for the least variance of the variables, the inclusion of affective measures provided incremental validity to the equation at a statistically significant level.

Table 13. Stepwise Regression: TABE Posttest as First Independent Variable. Included, TABE Pretest and LASSI-Dependent: TABE Delayed Posttest

Adjusted R Square	.913	Multiple R	.956
Standard Error	6.088	R square	.914

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
TABE Posttest	.856	.047	.756	18.19	< .001
LASSI	.138	.022	.264	6.36	< .001
(Constant)	-26.858	4.992		-5.38	< .001

------------Variables not in the Equation---------

Variable	Beta In	Partial	Min Toler	T	Sig T
TABE Pretest	.179	.397	.255	4.14	< .001

Table 14. Contributions of Affective and Learning Strategies Measurements for Acquisition Performance on TABE Posttest

Regression Analysis: Entered on Step One, TABE Pretest

Multiple R	.730
R Square	.533
Adjusted R Square	.528
Standard Error	12.493

Entered Stepwise on Step Two, Total Learning Strategies

Multiple R	.856
R Square	.732
Adjusted R Square	.727
Standard Error	9.508

Entered Stepwise on Step Three, Affective Measures

Multiple R	.863
R Square	.744
Adjusted R Square	.736
Standard Error	9.341

--------------Variables in the Equation------------

Variable	Beta	T	Signif T
TABE 1	.562	9.99	< .001
Learning Strategies	.395	5.76	< .001
Affective Measures	.137	2.08	.039

Table 15. Contributions of Affective Measurements to Aquisition Performance on Reading Posttest

Multiple R	.850
R Square	.723
Adjusted R Square	.717
Standard Error	5.656

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
TABE Pretest	.876	.091	.554	9.47	<.001
Learning Strategies	.162	.020	.474	8.10	<.001
(Constant)	-5.372	5.000		-1.08	.285

------------Variables not in the Equation---------

Variable	Beta In	Partial	Min Toler	T	Sig T
Affective Measures	.029	.043	.607	.415	.679

Correlations:

	Read 1	Strategies	Affective	Read 2
Read 1	1.000	.363	.306	.727
Strategies	.363	1.000	.598	.675
Affective	.306	.598	1.000	.471

For reading separately, affective measures did not significantly account for variance in the equation (Table 15) despite correlating at .471 with reading posttest. After learning strategies were selected into the equation, the significance of entering affective scores greatly diminishes. For reading acquisition, therefore, learning strategies and affective measurements covaried sufficiently to have kept affective measures out of the regression.

Similarly, the regression for math acquisition did not include affective measurements (Table 16). Therefore, if the analysis of whether inclusion of affective measures demonstrates incremental validity in the acquisition of both

Table 16. Contributions of Affective Measurements to Aquisition Performance on Mathematics Posttest

Multiple R	.736
R Square	.542
Adjusted R Square	.533
Standard Error	6.945

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
Math Pretest	.611	.078	.564	7.78	< .001
Learning Strategies	.114	.024	.351	4.83	< .001
(Constant)	18.934	5.148		3.68	< .001

------------Variables not in the Equation---------

Variable	Beta In	Partial	Min Toler	T	Sig T
Affective Measures	.120	.143	.612	1.38	.170

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	5316.06	2658.03
Residual	93	4485.17	48.23

F = 55.11 Significance of F < .001

taken separately, the apparent covariance of learning strategies and affective measures obscured the contribution of affective measures to predictions of posttest reading and math performance.

The predictiveness of affective measures of the LASSI to retention (Table 17) measurements was less than with

Table 17. Contributions of Affective Measurements for Retention Performance on TABE Delayed Posttest

Multiple R	.919
R Square	.844
Adjusted R Square	.840
Standard Error	8.222

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
TABE Pretest	.805	.070	.503	11.49	< .001
Learning Strategies	.404	.029	.612	13.99	< .001
(Constant)	-28.577	7.680		-3.78	< .001

------------Variables not in the Equation---------

Variable	Beta In	Partial	Min Toler	T	Sig T
Affective Measures	.071	.145	.590	1.40	.164

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	33970.60	16985.30
Residual	93	6286.64	67.60

F = 55.11 Significance of F < .001

acquisition (Table 14). Affective measures' beta weight in the acquisition equation was .137 acquisition and in the retention equation in Table 17, the beta weight for affective measures was .071. Most significantly, affective measures did not remain in the retention equation. Affective measures entered the stepwise regression for acquisition with a significance of .039, while left out in the retention formula with a significance above the level allowable for inclusion (.164). No statistically significant place existed in the regression analysis between affective measures and separate measures for reading and math delayed posttests (Tables 18, 19), despite highly significant correlations shown in the zero order correlations in Table 12. The deduction was that the affective measures of the LASSI were measuring similar or associated constructs to those measured by the items of the learning strategies scales. This redundancy of measurement fell out of the analysis through the regression process.

The product of the above analysis suggests that the LASSI scales of Attitude, Motivation and Anxiety may in fact measure either the same things as the items of the learning scales, i.e., Time Management, Concentration, Information Processing, Selecting Main Ideas, Study Techniques, Self Testing, and Test Strategies, or, that the direction of

Table 18. Contributions of Affective Measurements to Retention on Reading Delayed Posttest

Multiple R	.908
R Square	.825
Adjusted R Square	.821
Standard Error	4.804

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
Reading Pretest	.839	.077	.508	10.91	< .001
Learning Strategies	.215	.017	.591	13.68	< .001
(Constant)	-19.288	4.247		-4.54	< .001

------------Variables not in the Equation---------

Variable	Beta In	Partial	Min Toler	T	Sig T
Affective Measures	.046	.088	.607	.85	.398

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	10096.91	5048.45
Residual	93	2146.58	23.08

F = 218.72 Significance of F < .001

response to these items are associated with each other, or perhaps associated with a third trait or condition not measured by the LASSI. Internal covariance can be extracted through the regression process, thus limiting confounding; however, covariance with an external variable not measured in the population might confound results.

To test these possibilities required separation of the individual scales of the LASSI. At Table 20, the stepwise

regression of all scales to reading acquisition demonstrated that four scales or variables from the LASSI survive the probability of F to enter. Selecting Main Ideas, Study Aids, Test Strategies, and Time Management all fit the equation. None of these scores are affective measures. The regression for math, the results of which are in Table 21,

Table 19. Contributions of Affective Measurements to Retention on Math Delayed Posttest

Multiple R	.822
R Square	.675
Adjusted R Square	.668
Standard Error	6.744

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
Mathematics Pretest	.618	.076	.495	8.10	< .001
Learning Strategies	.203	.023	.542	8.86	< .001
(Constant)	-3.579	4.999		-.72	.476

------------Variables not in the Equation---------

Variable	Beta In	Partial	Min Toler	T	Sig T
Affective Measures	.091	.129	.612	1.24	.217

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	8797.80	4398.90
Residual	93	4229.82	45.48

F = 96.78 Significance of F < .001

Table 20. Stepwise Analysis of Reading Acquisition With LASSI

Multiple R	.862
R Square	.743
Adjusted R Square	.729
Standard Error	5.534

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
Reading Pretest	.867	.088	.560	9.82	< .001
Selecting Main Ideas	.440	.148	.191	2.97	.004
Study Aids	.372	.107	.212	3.48	< .001
Test Strategies	.304	.116	.162	2.62	.010
Time Management	.232	.102	.136	2.69	.026
(Constant)	-8.473	5.046		-1.68	.097

Table 21. Stepwise Analysis of Math Acquisition With LASSI

Multiple R	.760
R Square	.578
Adjusted R Square	.565
Standard Error	6.703

------------Variables in the Equation-------------

Variable	B	SE B	Beta	T	Sig T
Math Pretest	.623	.076	.575	8.23	< .001
Study Aids	.526	.118	.313	4.48	< .001
Attitude	.439	.133	.224	3.30	.001
(Constant)	12.500	5.835		2.14	.035

showed only two variables from the LASSI entered into the equation: Study Techniques and Attitude.

Since attitude was an affective score and fit into the equation where affective scores grouped together did not,

then an apparent third solution to the problem of affective covariance was provided by viewing the variables not in the equation. Motivation had both the lowest beta in value and the lowest t score, suggesting that when it was grouped with the Attitude scale, it increased the cumulative error of affective measures.

At this point, it should be pointed out that there is a difficulty in describing behaviors that may be inherently linked. A respondent's answers for items on the Time Management scale may correspond to answers for Attitude. An example of this linkage would be the items of "I find it hard to stick to a study schedule" for Time Management, and, "I only study tasks I like" for Attitude. Although the intent of the items may be different from a construction point of view, their very wording suggests the possibility of covariance.

The covariance of individual scales should be expected in constructing a instrument that is designed to measure a wide range of strategies and skills. The wider the range, the greater the likelihood of overlapping measurements. There was evidence that similarity of item wording, and associated conditions, e.g., respondents with a good attitude finding it easier to concentrate, accounts for much of the evident covariance between affective and learning strategy scores. Additionally, there were but three

affective scales. Fewer items, as a result, could have increased the overall error of measurement allowing the learning strategy group score to be dominant in regression comparisons.

The analysis demonstrated that although affective scores demonstrated incremental validity, that validity was uneven, with some affective scores more valid than others and not equally valid as predictors of performance with reading as with math. For both hypotheses three and four, therefore, affective measures provided more incremental validity to the regression analysis for math than for reading. Of the affective measurement scales, Attitude was the most predictive. Motivation, despite its relatively high correlation with posttest and delayed posttest results, did not significantly contribute to the predictiveness of the regression equation, and Anxiety was relatively neutral in predictiveness, significant only in predicting TABE total posttest scores.

There was conditional support for hypotheses three and four. Given the failure to separate reading and mathematics in the initial hypotheses, the conclusion must be that such support be recognized for its limitations.

Metacognitive Strategies and Simple and Complex Skills

The fifth hypothesis suggested greater relationships between LASSI scores and acquisition of reading

comprehension skills than vocabulary. The basis for this hypothesis was that complex skills required more sophisticated metacognitive strategies. Vocabulary, for example, may depend largely on rehearsal strategies that constitute a less complex strategy. Higher LASSI scores should indicate a larger repertoire of skills and be more predictive of more complex skills such as comprehension.

Aggregate LASSI scores demonstrated a higher coefficients of determination for paragraph comprehension than for vocabulary (see Tables 22/23). The difference in R square for predictiveness was .17. A Hotellings T^2 in Tables 22/23 demonstrates that the difference was significant. The difference was anticipated by the correlations. Paragraph Comprehension correlated more highly for both the pre- and posttest scores with the LASSI.

The relationships between preexisting learning strategies and retention of reading were found to be greater with comprehension skills than vocabulary acquisition, supporting the sixth hypothesis. The coefficient of determination was again .17 higher for Paragraph Comprehension than Vocabulary. Post hoc Hotelling's T^2 confirmed the significance of the difference (Tables 24/25).

Table 22/23. LASSI Relationship to Paragraph Comprehension (PC) and Vocabulary (VOC) Acquistion

Paragraph Comprehension		Correlation:	PC-1	LASSI	PC-2
Multiple R	.816	PC Pretest	1.000	.391	.696
R Square	.667	LASSI	.391	1.000	.665
Adjusted R Square	.659	PC Posttest	.696	.665	1.000
Standard Error	3.542				

versus

Vocabulary		Correlation:	VOC-1	LASSI	VOC-2
Multiple R	.709	VOC Pretest	1.000	.228	.553
R Square	.503	LASSI	.228	1.000	.558
Adjusted R Square	.493	VOC Posttest	.553	.558	1.000
Standard Error	4.076				

Hotelling's T Value = 50.883; Significance of F = .016

Table 24/25. LASSI Relationship to Paragraph Comprehension (PC) and Vocabulary (VOC) Retention Comparison

Paragraph Comprehension		Correlation:	PC-1	LASSI	PC-3
Multiple R	.885	PC Pretest	1.000	.391	.706
R Square	.784	LASSI	.391	1.000	.767
Adjusted R Square	.779	PC Delayed Posttest	.706	.767	1.000
Standard Error	3.306				

versus

Vocabulary		Correlation:	VOC-1	LASSI	VOC-3
Multiple R	.784	VOC Pretest	1.000	.228	.606
R Square	.615	LASSI	.228	1.000	.623
Adjusted R Square	.606	VOC Delayed Posttest	.606	.623	1.000
Standard Error	3.431				

Hotelling's T Value = 49.239; Significance of F = .001

The seventh hypothesis anticipated a greater relationship between learning strategies and mathematics concepts and problems posttesting than computational posttesting. A higher coefficient of determination for Concepts and Problems was confirmed by post hoc Hotelling's T^2 (Table 26/27). This hypothesis depended on the condition of the Concepts and Problems score requiring a higher level of metacognitive strategies than simple computation.

The eighth hypothesis sought to test the same comparison for retention measures. Tables 28/29 show a higher correlation and resultant higher coefficient of determination for Concepts and Problems than for Computation. Post hoc again held the difference as significant.

For hypotheses five through eight regarding the higher relationships expected between metacognitive strategies and more complex skills, sufficient support existed to accept these hypotheses. Metacognitive strategies, as defined by the LASSI, better predicted complex skill acquisition and retention.

Although there was definitive support for both the seventh and eighth hypotheses, it may be premature to draw definitive conclusions about the application of the results. First of all, the overall results of the study demonstrated

Table 26/27. LASSI Relationship to Concepts & Problems (CP) and Computation (COMP) Acquistion

Concepts & Problems		Correlation:	CP-1	LASSI	CP-2
Multiple R	.766	CP Pretest	1.000	.256	.668
R Square	.587	LASSI	.256	1.000	.534
Adjusted R Square	.578	CP Posttest	.668	.534	1.000
Standard Error	3.720				

versus

Computation		Correlation:	COMP-1	LASSI	COMP-2
Multiple R	.702	COMP Pretest	1.000	.167	.668
R Square	.493	LASSI	.167	1.000	.325
Adjusted R Square	.482	COMP Posttest	.668	.325	1.000
Standard Error	4.553				

Hotelling's T Value = 61.919; Significance of F = .011

Table 28/29. LASSI Relationship to Concepts & Problems (CP) and Computation (COMP) Retention Comparison

Concepts & Problems		Correlation:	CP-1	LASSI	CP-3
Multiple R	.843	CP Pretest	1.000	.256	.704
R Square	.711	LASSI	.256	1.000	.629
Adjusted R Square	.704	CP Delayed Posttest	.704	.629	1.000
Standard Error	3.517				

versus

Computation		Correlation:	COMP-1	LASSI	COMP-3
Multiple R	.787	COMP Pretest	1.000	.167	.697
R Square	.636	LASSI	.167	1.000	.498
Adjusted R Square	.628	COMP Delayed Posttest	.697	.498	1.000
Standard Error	3.847				

Hotellings T Value = 47.608; Significance of F = .002

that the LASSI was more predictive of reading performance than of math performance. A simplistic conclusion that the differences between Concepts and Problems and Computation relationships to the LASSI was due entirely to differences in levels of sophistication of math skills may not be completely true. The TABE test of Concepts and Problems required some reading and the differences may be partly due to the confounding effect of reading and math together.

The conclusion appropriately drawn about hypotheses seven and eight was that the data supports the expected results of greater relationships to Concepts and Problems than to Computation; however, the potential confounding effects of the reading skills required in the former could not be extracted from the data, and cannot be discounted as an additive effect.

Metacognitive Strategies and Retention Versus Acquisition

The ninth hypothesis stated that there would be a greater relationship between preexisting metacognitive skills and retention of reading and math skills than initial acquisition. Of the hypotheses investigated, the ninth and final hypothesis proved to be the most interesting. In review of the data, the relationships of metacognitive skills to delayed test results was far greater than for posttest results. Although metacognitive strategies

demonstrate a strong relationship with initial learning, the effect seemed to strengthen over time. Poor metacognitive strategies, as reported on the LASSI, related to very poor retention of learning, independent of the initial performance on the TABE pretest, and, as discussed below, independent of other selected demographic variables.

The strength of the ninth hypothesis is demonstrated throughout the results tables, in product moment coefficients, beta weights and coefficients of determination. A review of these results and Hotelling's T^2 are in Table 30. A standardized residual probability plot is also in that table, demonstrating cohesion of prediction with LASSI included in the equation.

The weight of evidence for all comparisons supported that metacognitive skills have more to do with retaining information than with initially acquiring information. Some quality about the learning process must interact using the strategies tested to transform information into durable knowledge. In the later discussion of results, this mechanism will be explored more fully.

In testing the regression equations, consideration was given to the assumption of autocorrelation between variables. To test this assumption, the Durbin-Watson test was applied to each regression. The actual results

Table 30. Review of Major Relationships Between Metacognitive Strategies and Learning Acquistion/Retention

TABE Posttest Prediction Regression Analysis:

		R Square	Beta In	T	Sig T
Step One:	TABE Pretest	.533	.730	10.35	.001
Step Two	LASSI Stepwise	.745	.491	8.81	.001

Standard Error before LASSI: 12.49; and, after LASSI: 9.27
Difference in R Square: .212. Beta Weight Advantage: .322

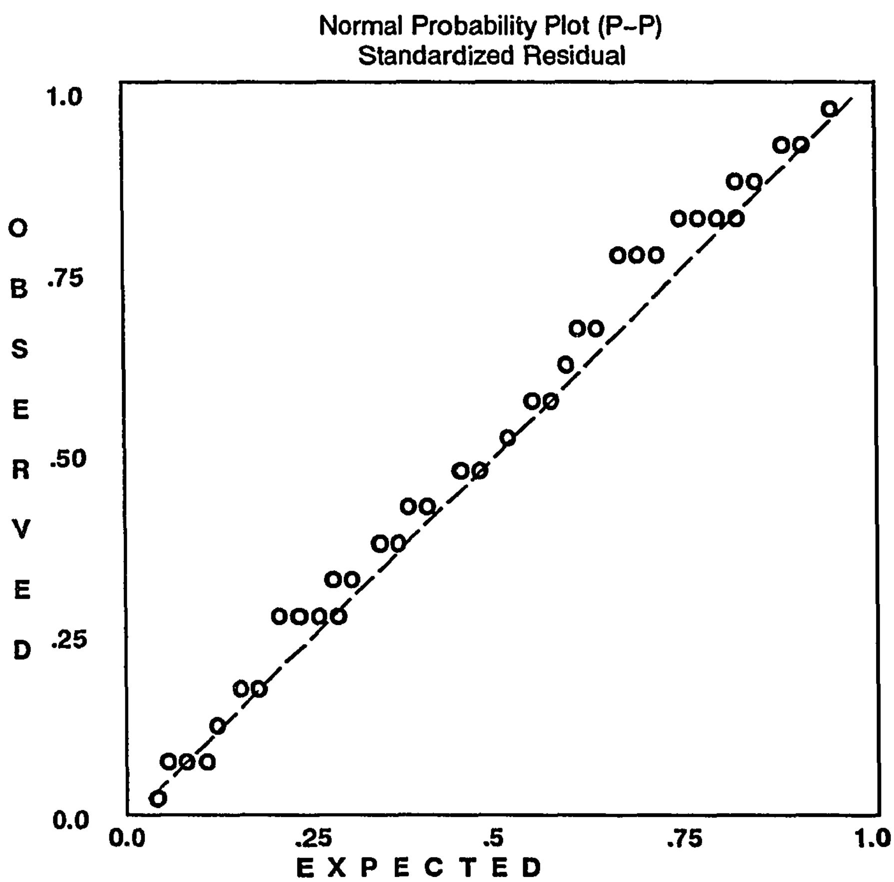
TABE Delayed Posttest Prediction Regression Analysis:

		R Square	Beta In	T	Sig T
Step One	TABE Pretest	.515	.718	9.99	.000
Step Two	LASSI Stepwise	.839	.606	13.69	.001

Standard Error before LASSI: 14.41; after LASSI: 8.34.
Difference in R Square: .324. Beta Weight Advantage: .398.

F ratio change: 187.41; Significance of F change: p < .001

Predictiveness to Retention with Pretest and LASSI



confirmed that the Durbin-Watson score did not vary more than .11 from the expected 2.0 perfect autocorrelation score. Therefore, the simple regressions used in this study were valid in their assumptions of autocorrelation.

Demographic Variables

No hypotheses were adopted concerning the impact of demographic variables on the outcome of learning. First, there was no evidence in the literature that age or education level would have a direct effect. There was support in the literature, as noted earlier, that ethnicity and metacognitive strategies would correlate; however, that relationship was beyond the interest of the current study, and, after reflection, it was determined that ethnicity would not be a factor independent of metacognitive strategies in determining either acquisition or retention.

The first variable for consideration was the location of the subjects. Differences in pretest scores particularly could confound the previous analysis. The data on this analysis is in Table 31 and clearly demonstrates that while some variance existed, it was far from significant. Variance in TABE pretest scores was in fact due to another variable, the Military Occupational Specialty (MOS). A deliberate endeavor to gather data from different sites also resulted in differences in MOS normally found at those

Table 31. Demographic Data: Differences Between Sites

Summaries of Initial TABE Test Scores by Location

Variable (location)	Mean	Std Deviation	Cases
Entire Population	112.02	12.86	96
Schofield Barracks	112.18	12.50	50
Fort Jackson	116.23	14.21	30
Fort Ord	103.63	10.71	16

ANOVA: Criterion Variable=Location by Initial TABE

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	71.67	52	1.38	.837	.732
Within Groups	70.83	43	1.65		

Eta = .709 Eta Squared = .503

Summaries of Total LASSI Scores by Location

Variable (location)	Mean	Std Deviation	Cases
Entire Population	250.86	39.36	96
Schofield Barracks	243.44	34.21	50
Fort Jackson	256.90	44.95	30
Fort Ord	262.75	40.94	16

Kruskal-Wallis 1-way ANOVA: Chi-Square: 5.39 (sig=.068)

ANOVA: Criterion Variable = Location by Total LASSI Score

Source	Sum of Squares	DF	Mean Square	F	Sig. of F
Location	6109.22	2	3054.61	2.01	.139
Residual	141072.02	93	1516.90		

Correlations:	Ed Level	Age	Years in Service	Gender	MOS	Location
TABE Pretest	.185	.141	.190	-.094	-.239*	-.100
TABE Posttest	.123	.160	.145	-.083	-.204*	-.054
TABE Delayed Posttest	.168	.139	.145	-.123	-.212*	-.016
Total LASSI	.161	.158	.151	-.076	-.184	-.204

* Indicates significant correlation

sites. Schofield Barracks consisted of mostly combat arms soldiers while Fort Jackson consisted primarily of combat support and combat services support soldiers. Three other variables covaried with location: age, gender and education level. As noted, the older soldiers were at Fort Jackson, with younger soldiers in the combat arms at Schofield and Fort Ord.

The second test of differences between locations was the LASSI scores of each installation. Again, differences existed but were statistically insignificant. The Analysis of Variance (ANOVA) was performed prior to all other analysis to assure that all subjects could be in the same group for regression analysis.

At the time of administration of the LASSI, specific information on the soldiers' background was acquired. This information included education level, age, MOS, gender, and time in service. A correlation sufficed to determine to what degree the demographic data may explain results, or mitigate relationships of LASSI scores in the regression analysis.

Education level was a dummy variable with 1 = less than high school, 2 = high school completion, and 3 = more than high school. Given the population, it was unnecessary to discriminate further. The age variable grouped soldiers at

<21 years, 21-23 years, and 24+ years. MOS was either combat arms (1) or non-combat arms (0).

The only significant correlations to performance on the TABE was by MOS. The negative correlation reflects that non-combat arms specialties tended to have higher initial TABE scores, and that relationship held constant for posttest and delayed posttest scores. Since there was no significant change in terms of acquisition or retention, this variable was moot in describing confounding.

In learning acquisition, age, MOS, and education level had moderate relationships to outcomes. Correlation levels were low and statistically insignificant. Older soldiers and those soldiers with more years in service performed slightly better in acquisition of skills.

A closer inspection of age and years in service partially explained the variables strength of relationship. The variables correlate not only with each other, but also with the affective measures of the LASSI. Since earlier examination of LASSI predictiveness to acquisition of learning demonstrated that affective scales, particularly the Attitude scale, increased predictiveness to TABE posttest scores, a dual relationship emerged. Older soldiers in this sample had better attitudes, and, better attitudes were predictive of better initial performance (particularly in math). No causal relationship between

these independent variables should be inferred; however, there may be grounds for closer examination of these relationships in the future.

Analyzing fixed or demographic data in populations of the current study's size is tricky and potentially misleading. In any case, demographic elements were not particularly illuminating in explaining the strength or direction of the relationships under scrutiny.

Validation Through Separate Analysis

A number of soldiers took that LASSI and did not fit the criteria for inclusion into the main study group. Of these, 26 took either reading or math only instruction. In the case of reading only, 12 students provided an opportunity to partially validate the results of the reading portion of the main group's relationships.

Run as an independent cell, the results of the reading only group's correlation and stepwise regression coefficients with LASSI scores demonstrate the similarity of outcomes (Table 32). Use of Analysis of Variance procedures to compare regression results to the main study group was not feasible due to the extreme differences in group size. However, even with 12 students, there was a significant relationship of LASSI scores to retention.

Table 32. Reading Only BSEP Group: Correlations to LASSI

Number in Group = 12

Baseline correlations:	Reading Pretest	Posttest	Delayed Posttest
Total LASSI	.121 (p= .36)	.278 (p= .19)	.542 (p= .03*)

Acquisition: Forced entry Reading Pretest, LASSI stepwise

Variables in the equation:	B	SE B	Beta	T	Sig T
Reading Pretest	.648	.172	.771(.727)	3.83	.003

Variables not in the equation

	Beta In	Partial	Min Tolerance	T	Sig T
Total LASSI	.187(.468)	.292	.986	.92	.383

Retention: Forced entry Reading Pretest, LASSI stepwise

Variables in the equation:	B	SE B	Beta	T	Sig T
Reading Pretest	.621	.127	.721(.501)	4.88	.001
Total LASSI	.187	.038	.455(.584)	3.08	.013

Beta weight values of main study group shown in parenthesis.

Table 33. Math Only BSEP Group: Correlations to LASSI

Number in Group = 14

Baseline correlations:	Math Pretest	Posttest	Delayed Posttest
Total LASSI	.059 (p=.27)	.179 (p=.42)	.542 (p=.08)

Acquisition: Forced entry Math Pretest, LASSI stepwise

Variables in the equation:	B	SE B	Beta	T	Sig T
Math Pretest	.515	.124	.768(.654)	4.16	.001

Variables not included	Beta In	Partial	Min Tolerance	T	Sig T
Total LASSI	.203(.366)	.312	.968	1.09	.299

Retention: Forced entry Math Pretest, LASSI stepwise

Variables in the equation:	B	SE B	Beta	T	Sig T
Math Pretest	.517	.143	.685(.501)	3.61	.004
Total LASSI	.120	.043	.525(.543)	2.77	.018

Beta weight values of main study group shown in parenthesis.

The correlations in Table 32 of the LASSI scores to reading pretests, posttests and delayed posttests mirror the main group in their progressive nature of strength of correlation over time. The results suggest that the study results would be reproducible and that reading acquisition and retention results of the main study group were not confounded by mathematics instruction.

In the math only group, 14 soldiers participated. The progressive nature of correlations from pre- to delayed posttests continued. Again, as in the reading only analysis, the posttest regression equation does not include LASSI. This, in all likelihood derives from the small sample size and the lesser relationship of LASSI to initial acquisition than to retention over time. The retention equation included the LASSI at only slightly less a significance than with the reading only group (Table 33).

Reliability of the LASSI Scale With the Study Population

In Table 34 is the reliability data provided by the publisher of the LASSI. To assure the consistency of the current study with the results of the LASSI's initial reliability data, the author of the LASSI was contacted, and using an identical process of reliability testing, i.e., Cronbach's Alpha, the reliability for the study group was obtained.

Reliability data comparing the current study with publisher's data using Cronbach's alpha is at Table 34.

Table 34

Reliability of Learning and Study Strategies Inventory in Study Group

Results of study population LASSI reliability testing, using Cronbach's alpha. N = 169, the total LASSI available for scoring, including those not included for study analysis for reasons as stated in the study.

	Cronbach's Alpha (n=169)	Publisher's Scale Coefficient Alpha
Attitude	.643	.72
Motivation	.774	.81
Time Management	.799	.86
Anxiety	.796	.81
Concentration	.801	.84
Information Processing	.910	.83
Selecting Main Ideas	.748	.74
Study Aids	.742	.68
Self Testing	.763	.75
Test Strategies	.821	.83

Similarities of study results to publisher's data was remarkable with two exceptions. The Attitude scale alpha results on the study group were somewhat less than reported by the publisher, and the Information Processing scale alpha was somewhat higher. Some variance was anticipated, due to differences in group size and composition. The publisher's data derives from a population of over 800, while the study's accessible population was 169. Secondly, the original reliability measures were from a college student population, not active duty soldiers.

The limited resources of the study proscribed a test-retest validation. To gain the information in this study, 18,381 data points were entered and evaluated. To properly conduct a test-retest validation, the extended efforts and time of the field in acquiring the data and the additional entry and analysis were deemed too extensive and inappropriate for the goals of the research.

CHAPTER V

Conclusions and Implications of Results

General

The results of the study supported the nine hypotheses tested. Metacognitive strategies, as described in the LASSI held a strong relationship to learning acquisition, both for reading and mathematics together and for reading and mathematics separately. The relationship intensified when the LASSI entered the regression model for learning retention, supporting the second and the ninth hypotheses.

The addition of affective measures of the Attitude, Motivation, and Anxiety scales of the LASSI provided incremental validity to the model; however, these scales were limited in their impact and demonstrated some domain specificity in their power to affect the basic relationships established by learning strategies. Further, the ability of these scales to account for variance diminished over time, i.e., they were not as strongly related to retention as to initial acquisition of learning. Affective measures, within the context of the LASSI items, appeared to screen learning initially, while learning strategies, e.g., information processing and monitoring, had the greatest effect over time.

The complexity of the task related to metacognitive strategy use for both reading and mathematics. The more

complex the learning task, the more critical the function of the strategies and skills represented on the LASSI appeared to be. For complex tasks requiring integration of several steps, metacognitive strategies may have qualitatively altered the learning process to the degree that learning acquisition and retention were strongly affected. The more circumscribed the learning task, the less necessary were strategies. The discrimination level between simple and complex tasks available with the performance instrument used was not adequate to generalize this relationship to other task conditions; however, for practical application of this research, the use of metacognitive interventions to embellish learning of simple tasks would not be appropriate.

Discussion of Results

The results of the current study pointed to the utility of metacognitive strategies in facilitating the learning process and reinforcing latency of learning. The expectations of initial value of metacognitive strategies, as reported on the LASSI, with acquisition of the complex skills of reading and mathematics were fully realized. More importantly, the question that plagues many trainers and educators concerning the latency of skill training found a partial answer in the results. The question can be

formulated in two parts: the observational, and the operational. The observational question is, "Why do some students forget learning rapidly after training, and others do not?" and the operational question is, "How can we reinforce the learning process to increase latency of learning?"

When the results of this study were related back to the cognitive theory from which it ensued, the explanation of the observational form of the question was found in the specific strategies supporting a dynamic learning process. A dynamic learning process postulates that individuals act upon learning rather than learning environments acting upon the individual. The individual transforms the learning material into a personalized arrangement of concepts and contents. This chunking (Glaser and Bassok, 1989), rearranging and reconnecting of learning material is critical to understanding and retaining learning.

Initial learning states of prior knowledges and prerequisite competencies impact on initial learning, but how the individual attacks the learning process may have more impact on how the learner performs over time than the quantity of prior learning. The active engagement of the steps of the learning process, preevaluating the learning material for difficulty and value, identifying known rules

and schemata, evaluating and monitoring one's own understanding, integrating new information with existing knowledges, and assimilating the combined knowledges into an individual repertoire, require tools to enhance the performance of each step. The process of selection of the proper metacognitive tool for the job may lead to a good fit, and therefore enhanced learning, or a bad fit, and poor learning. The qualitative difference between enhanced and poor learning becomes more demonstrative over time.

The individual's collection of metacognitive skills is a tool box with which to take learning experiences apart, analyze and reassemble them to meet their own needs. The metacognitive strategies of the subjects in the current study, as reported, directly related to their subsequent performance. Those lacking the tools, or the knowledges to use them, fared significantly worse in recalling information over time. Those students reporting an understanding and history of metacognitive strategies use and skills fared significantly better. Initial affective measures contributed far less to long term retention performance than one might expect. It was the student's understanding and history of specific rehearsal, elaborative, organizational and monitoring skills that predicted performance over time. Therefore, to answer the observational question, the

students' individual differences in metacognitive strategies appears to explain much of the variation of retention performance.

The behavioral model suggests that repeated and continued reinforcement will assure learning. Secondly, the better the initial learning, the better the retention will be. For conditions of learning where tasks are very simple and may have no relationship to prior learning experiences, this model is generally supported in the literature. However, the results of the current study suggested that when tasks were complex or when continuous reinforcement was unavailable or infrequent over time, the behavioral model did not fit. Conditions of cognitive state and metacognitive performance better predicted performance both in acquisition of complex skills and tasks and retention of learning over time.

For those simple tasks and skills that find immediate and frequent reinforcement within the work environment, it may not be as necessary to identify either cognitive state or metacognitive performance. Use of the behavioral model will assure reasonable success. Unfortunately, large numbers of tasks and skills incorporated in adults' jobs may be complex or infrequently accessed.

To answer the operational question posed of how to reinforce the learning process to assure latency of skills, the relationships demonstrated in this study implied that improving strategy use and metacognitive skill development may have a greater impact on retention performance than any method of simple reinforcement. Earlier references to training of metacognitive skills indicated that the utility of employing either a separate metacognitive training program, embedding metacognitive clues in curriculum or doing both could be feasible and highly productive. The results of this study suggested that such actions would reduce redundant training and frequency of errors.

Since the variance accounted for by metacognitive variables entered into the regression analyses as significant variables, there is evidence of strong positive relationships between metacognitive strategies as reported on the LASSI and learning and retention of basic skills. Further, these relationships existed exclusive of preexisting levels of basic skill competencies, or prior learning. The conclusion drawn is that the knowledge of metacognitive strategies scores derived from the LASSI greatly enhances the understanding of the model of learning and suggests an elaborate system of judgment, identification and evaluation in the process of learning.

While learning may occur exclusive of metacognitive strategies and skills, the study strongly points toward an enhancing of learning and retention. Particularly with retention, the relationships of strategies and skills with performance outcomes is striking. Therefore, with the increase in accounted for variance from posttest to delayed posttest, the apparent strength of metacognitive strategies and skills is in enhancing the quality of the learning, thereby increasing its durability.

Covariance of Scales in LASSI

Some of the analysis attempted to derive whether some of the scales of the LASSI were more predictive of results than others. This search was partially based on a false premise: that the scales measured separate or separable strategies and skills. The covariance between scales indicated that the separation between measurements was not clearly articulated in the instrument. The regression of individual scales provided for insightful analysis of both the covariance of scales and for the apparent domain and time related specificity of the scales. As noted, some scales appeared to have significant relationships in math acquisition, but not reading, or, in math retention.

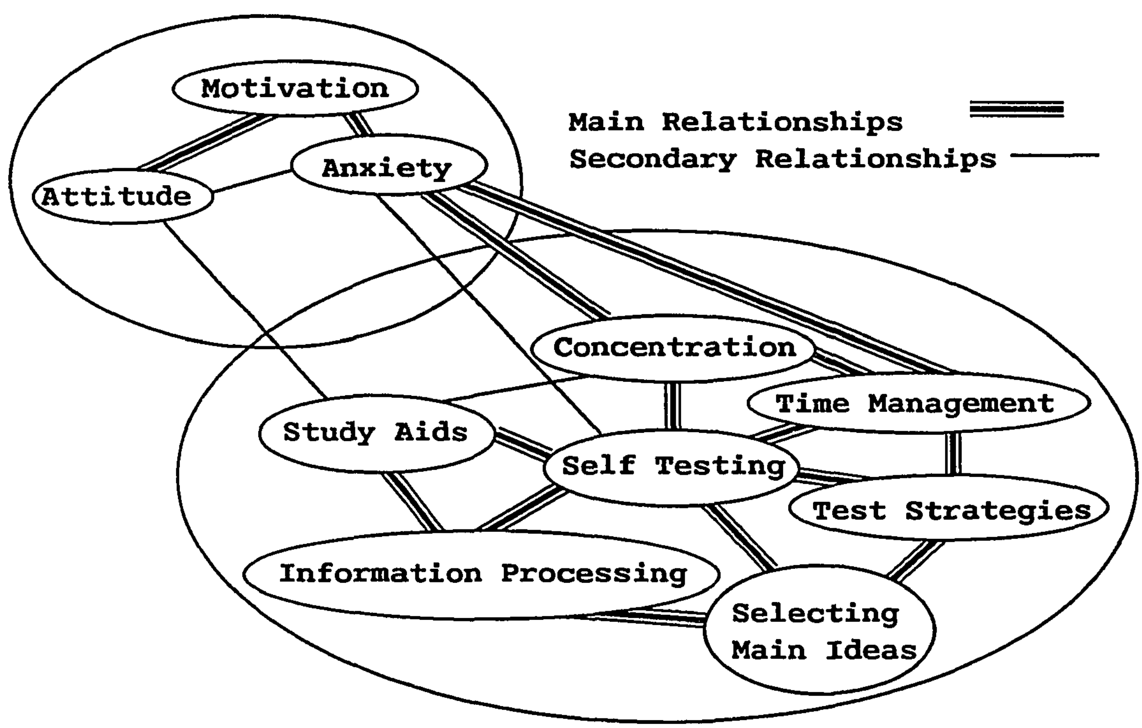
In generalizing the results to other domains or time relationships, it would appear that the specificity of the scales will continue. In effect, the complexity of the task, and the time between learning and performance measurement may be critical to the selection of the metacognitive strategies employed.

An interesting relationship developed when comparing the LASSI scales' internal correlations and resulting covariance. The interrelatedness of separate scales could mean that the scales are in fact measuring the same thing, or that the scales are related to some outside variable, not directly measured by the LASSI itself. While there is some overlapping of constructs associated with the scales of the LASSI, the possibility of relatedness to an outside variable cannot be discounted.

The basic relationships found between the LASSI scales are described in Figure 1. There was a definite pairing of most scales with secondary relationships representing slightly less remarkable correlations. Some of these relationships were intuitively obvious with the description of the scales' intended measurement. When relating the scales back to the literature, the basis for other relationships became apparent.

One possible solution to the covariance of scales is that the scales relate to points along the learning process. The third variable not measured by the LASSI is time. Assuming a linear process for the purposes of clarity allows us to see a time relationship with the separate steps of the learning process. The steps involve the preevaluation of learning material, linking the learning material to existing knowledge, inprocess evaluation, integrating the new knowledge with preexisting schemata and assimilating the newly integrated knowledge for future use. The process could be compared to the Hegelian dialectic, wherein the

Figure 1 Relationships of LASSI Scales



thesis is challenged by new information (antithesis) and the resulting synthesis forms the basis for a new thesis. More often, the process is additive, however, with new knowledge complementing old and expanding its utility for the learner.

The determination critical metacognitive strategies for specific training tasks may be more of a research issue than a practical consideration. As noted, there exists considerable covariance, or overlap, between scales. Even a performance based instrument may possess this quality. To apply a rigorous definition to the strategies in an effort to separate their domain impact may be both costly and counterproductive to such an instrument's main intent. Over time, the application of a construct and content valid instrument may provide adequate validity measures to determine domain specificity criteria.

Implications for Metacognitive Models

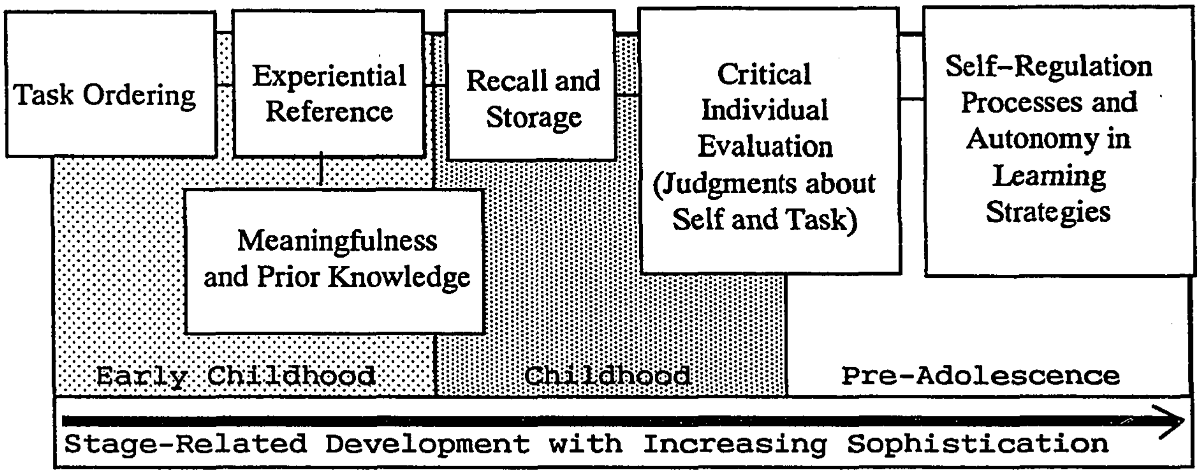
Three metacognitive models were introduced in Chapter 2, i.e., Piagetian, Information Processing and the Intrinsic Self. Although this study did not seek to test any model of metacognition, the basis for construction of the principle instrument, the LASSI, was based upon a conceptualization of metacognition that included elements of all three metacognitive models (Weinstein, 1988).

The study demonstrated that some form of interaction occurred between existing levels of reported metacognitive strategy use and learning acquisition and retention in the study population. One element of the models found support in the results of the study, i.e., some form of regulatory process existed that enhanced learning outcomes.

A Piagetian model of metacognition would not have been entirely appropriate with the study population. As a developmental model, adult variance in metacognitive strategy knowledge and use was beyond the model's basic structure. A simplification of the Piagetian model is in Figure 2. The Piagetian model did not extend to adult populations, and therefore, did not explain the naive adult learner.

Information processing models supported a cyclic learning process. Models associated with information processing used gates, switches and other conceptual mechanisms to describe the learning process. The critical features of information processing models were the executive control and allocation policy that provided regulation of incoming information. A simplified information processing model is in Figure 3. As in the Piagetian metacognitive model in Figure 2, the information processing model represents an amalgam of critical elements found in the

Figure 2. Piagetian Metacognitive Model



literature, not a comprehensive description of all complex relationships.

Barbara McCombs' (1986) model in Figure 4 provided the best example of the Intrinsic/Self view of metacognitive learning. McCombs expressed the heuristics of the model in terms of self-systems. The elegance of the model was in its cyclic quality, suggesting that the path from self-system processes, through self-regulation, and self-reinforcement effects a change in the self-system. McCombs incorporated domain specificity and affective screening. This model more closely represented these aspects of the results of the study than either the Piagetian of information processing models.

Figure 3. Information Processing Model

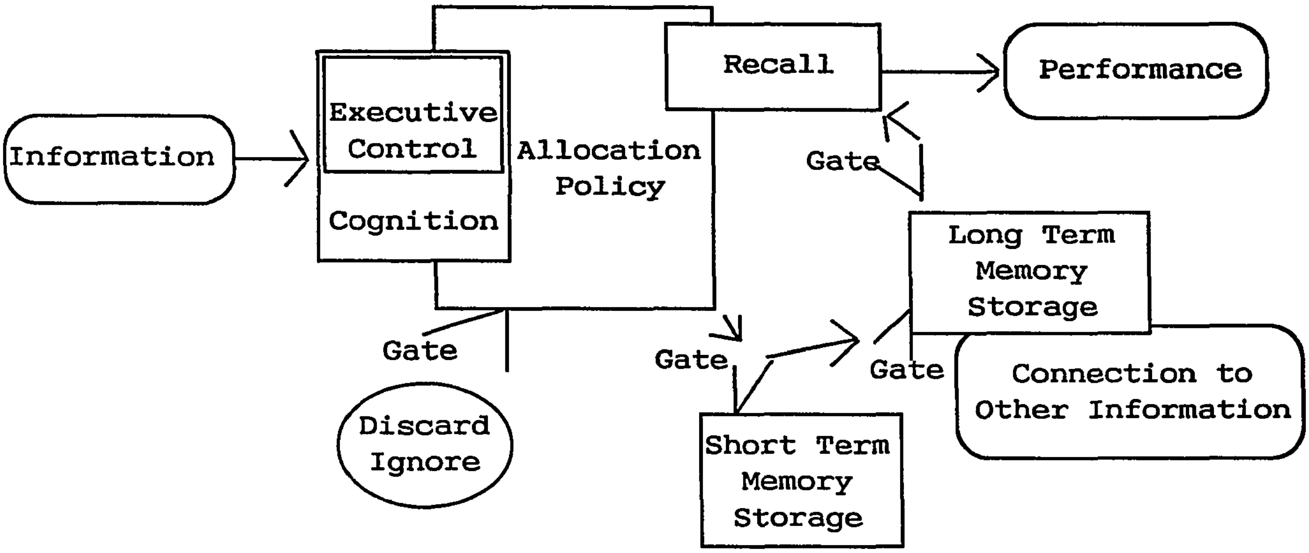
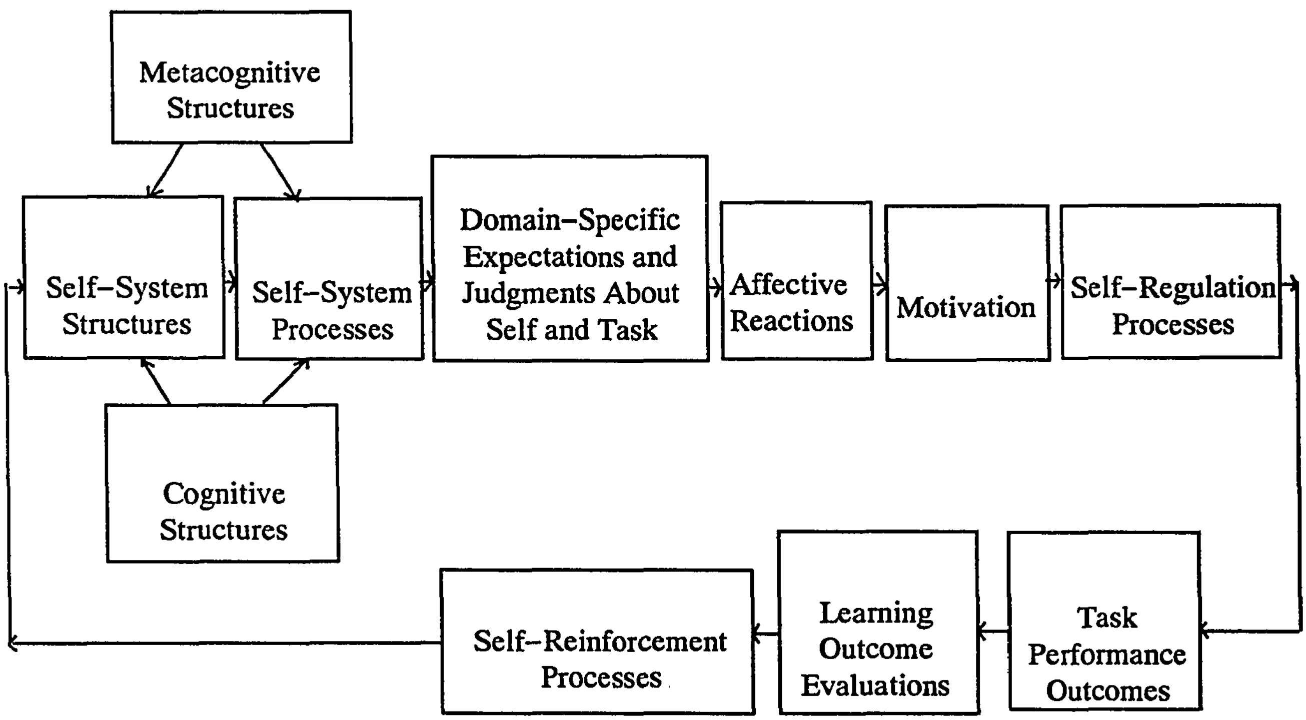


Figure 4. Self-System Evaluation Model*



*Adapted from Barbara L. McCombs, "The Role of the Self-System in Self-Regulated Learning", Contemporary Education Psychology, 1986, Volume 11, 314-332.

Several aspects of the McCombs model did not fully represent the learning model emerging from the results of the current study and existing cognitive theory. The process of attacking learning, and stages and transitions that may occur from the point of introduction of the material to using the material learned, were not present in the McCombs model. To be clear, McCombs did not represent her model to demonstrate a learning process, but rather, the role of the self-system in the process.

The literature and the results of this study converged on a concept of learner actively taking apart information for their own use. A model of learning that might have best represented the results of this study would have been considerably more complicated than those illustrated in Figures 2, 3 and 4. Such a model would have incorporated selected metacognitive strategies at several stages of an individual learning experience. The resulting learning model would have represented a learning event, wherein the individual approaches a single concept, acts on that concept to transform it to a usable form by linking the information with existing rules and schemata to form an expanded or modified rule and schemata set.

Although none of the existing models provided a complete explanation of the learning process consistent with

the results of the study, common critical elements of intrinsic judgment and control seem to have fit the overall results. Any new model should incorporate more clearly the creation of rules and schemata, and address specifically the properties essential to durability of learning.

Implications of Research

This study tended to support the contention that learning strategies may alter, elaborate, magnify, or simplify basic cognitive encoding processes associated with learning as presented by Weinstein and Mayer (1986). The utility for the individual learner's use of strategies may have resulted from the improved retrieval capacity over time. Particularly useful were those elaboration strategies that improved reference to existing knowledges. Cognitive linkage of new information to existing knowledges appeared to have reinforced the likelihood of retrieval of the new knowledge and refreshed existing knowledges. The results implied that a curriculum that reinforces information through the use of parallel examples, metaphors or analogies may enhance rule-based knowledge applications.

An explanation of the phenomena of linkage may be found in the corollary structures of cognitive pathways. A simple explanation of elaborative reinforcement is that the recall of existing knowledge makes that knowledge more recently

accessed, or fresher. The association of knowledges provides more opportunity to access any linked knowledge from another. The more linkage, the more points of access the individual may have. To use an analogous explanation, using elaboration in encoding and recall is much like a relational data base, wherein one file is accessible through connectivity to another. Instead of searching through a mass array of disconnected memories and information, the active association between files allows more rapid access and higher likelihood of recall.

Any strategy that either increases knowledge path strength (rehearsal and organizational), connects to other knowledges (elaboration), increases the preparedness to learn and perform (affective strategies), or actively involves the learner in evaluation of learning (monitoring strategies) has an effect of increasing learning performance.

Winn (1983) suggested that through development of metacognitive skills, learners can adapt to instruction rather than adapting instruction to the level of the learner, i.e., reducing instructional level and mode of delivery to learners' achievement level and preferred learning style. Strategy training, including development of metacognitive skills, and training on when best to employ

particular skills might then allow students with lesser achievement levels to successfully compete with higher achievement students. There are logical and common sense limits to adapting students to instruction. One would not place high school level math students in a matrix engineering course; however, Winn's proposal offered much in practical terms to a training organization where small variance in prerequisite skills may lead to the lower achieving students falling irrevocably behind or the pace of training must slow to meet the students' needs. Reducing the difficulty to compensate for individual's with weak metacognitive skills may also reduce the mental effort invested for all students and lessen the overall possibility for success (Kahneman, 1973). If the difficulty remains high, commensurate with the training requirements of the organization, then two viable courses of action remain: either include metacognitive clues within the curriculum (embedded metacognitive training), or screen students on their metacognitive skills to provide those deficient strategy training. The optimal course may be a combination of these two actions.

The young adults in the current study demonstrated the benefit of metacognitive strategies for acquisition and retention of learning. Some of these students would have

undoubtedly continued to experience learning decay, therefore requiring remediation at a future date. Naylor and Briggs (1961) determined that practice effect alone is limited in determining the level of retention. At some point, additional practice will decrease in its rate of impact on retention.

There were few precedents for using strategy training to offset this cycle in an adult population. Rush and Milburn (1986) introduced a self-monitoring strategy in a welding training program at a community college. The study results were confounded through effects of instrumentation; however, sufficient evidence was available to conclude that long-term retention was enhanced by the strategy training.

McAleese (1985) described some of the problems associated with knowledge representation systems on computers. The role of the information provider, must be expanded, McAleese argued, to expand the learners understanding of the new knowledge in context with existing skills.

Shenkman (1986) described a metacognitive skills instructional program called LETME. LETME is an acronym of the program's macrostrategic components: Linking to existing knowledge, Extracting major concepts, Transforming

material into organized summary for storage, Monitoring self-awareness, and Extending the process to review and evaluation. The forced organization required by the LETME system provides not only for analysis of internal and external consistency and identification, but also promotes a more serial or chunking (Glaser and Bassok, 1989) method of encoding new information. By organizing learning items, the individual tests and employs various schemata during the organizational process, thus enhancing connectivity, and prearranges items to meet internal consistency criteria.

Utility

The utility of LETME is encouraging. Computer-based programs for younger learners such as LOGO have already demonstrated strong effects on metacognitive processes (Clements, 1986). Future developments in Artificial Intelligence may lead to more effective methods of identifying, and adapting learning strategies and skills to applied conditions of learning (Glaser and Bassok, 1989). A question concerning the relevance of developing systems to teach arises, however, in the order of development of effective metacognitive strategy enhancement.

The training organizations of many large companies measure their training capacity in terms of the number of classrooms, computer stations and available course ware.

At the center of plans to enlarge capacity and improve training performance is technology. Stand alone and integrated computer work stations, distance training with video remote technology, and high tech simulators seem to promise a future training environment with all the bells and whistles imaginable. In appearance, these systems suggest a great advantage to traditional, text-based training. The seduction of fitting metacognitive training into this future world vision is strong.

The reality of training is that it is an often mundane, rigorous, and highly repetitive function that demands a wide range of resources and materials. In the real training environment, jobs change frequently to meet changing requirements, equipment and conditions. Training criteria and training materials must remain evaluable and able to change. Even if the text-based materials are translated to electronic media, the basic requirements involved with accessing training materials will remain much the same as it is now.

Training programs that include basic skill competencies, or that require basic skill competencies, will likely prosper from the inclusion of metacognitive strategy training. No one has suggested that future electronic programs will remove the responsibility of the individual to access, evaluate and integrate learning.

In the end, it is not the electronic devices that are the capacity of the training organization, but the people who are to be trained. Developing within this resource the capacity to be expert learners should be a prime consideration of a training organization. The expert learner will be able to attack new information, apply strategies, break apart the learning material, compare the new material with his or her existing knowledges, rules and schemata, integrate that knowledge and apply it. The expert learner can operate independently of continuous monitoring to transform information into knowledge. The expert learner also adapts to the method of presentation, transcending mode of delivery to extract the information relevant to the tasks at hand.

Mikulecky and Ehlinger (1985) studied electronics technicians to determine differences in organization, monitoring and focusing (concentration scale on the LASSI) strategies between superior performing (expert) technicians and trainees. Superior job performers not only used organization and focusing strategies on the job site, but were far better able to articulate their strategy use. The high level of articulation was attributed to an awareness of strategies and monitoring of performance. The results illustrated that metacognitive strategies are not only a function of expert learning, but also expert doing.

Utility for Training

Application of a form of motivational skills training, as a separate affective strategy, has already been tried in a military study. McCombs (1988) conducted a study at the Army Electronics Communication School introducing a program designed to raise self-efficacy. The program achieved part of the objective of the training, i.e., it aided individual development of intrinsic motivation; however, the results and recommendations were never put into practice.

The utility of strategy training has been demonstrated across a broad range of performance levels. Average and above average young readers demonstrated performance growth after metacognitive monitoring training (Miller, 1987). Embedded preevaluative clues assisted both low/average and high aptitude undergraduate students in determining information from a map (Gilbert, 1986). Engineering students benefited from sophisticated metacognitive strategy training at the University of Minnesota (Smith, 1987). Although the sophistication of the strategy may differ, the evidence supports utility of metacognitive training at every level of learning.

Learning Decay and Curriculum

As noted, learning is most effective when integrated into rule-based learning constructs. One of the questions

that plagues education personnel is why students seem to forget math skills so quickly. If math is rule-based learning, it should follow that the retention of math would be higher than reading. The common explanation of the difference is that reading skills are more frequently accessed than math, therefore decay should occur more with math than reading. In the current study, only 60 days between posttest and delayed posttest demonstrated slightly higher rates of decay of math than reading. Although the difference was statistically insignificant, the scores suggested that rule-based math skills decay more rapidly than cognitive theory might suggest.

Resnick (1987) sheds light on why some rule-based learning decays. Speaking to mathematical rules, Resnick's observation is applicable to other sets of rule-based learning, e.g., graph, map and chart reading. Resnick observed that formal school instruction tends to teach rules of mathematics independent of real world conditions. Absent external referents, students are unable to interrelate rules with other information and experience. Standing alone in the cognitive framework, rules are easily lost or misapplied when recalled over time.

Resnick uses the terms "buggy arithmetic" and "malrules" to describe syntactic math errors. Such errors of application result from a lack of foundation in how the

rule developed from real world applications. Practical applications, as opposed to symbolic operations, may enhance initial comprehension, but, more importantly, enhance retention over time.

Any curriculum that does not emphasize practical application, real world problems and reasons for operations may fail to induce quality rule-based learning. The need for practical application is highest when dealing with adult learners whose problem-based focus demands immediate utility for learning to be deemed useful.

Equally, analogies referring to more commonly grasped concepts, and even metaphors, can expand the schema-driven and rule-driven problem solving of the learner (Paris, 1988). Whenever possible, the curriculum should reflect the student's experiential reality.

Curriculum may be more successful when clues to instruction (desired learning outcomes) immediately precede the text content. Questions about what the student already knows about the next subject will aid in identification and linkage to existing knowledge. Questions or clues to important elements of the text will alert the reader and enhance the probability of retention. Renolds and Shirley (1988) studied probing behaviors in reading and comprehension. Probing is the slowing down and reflecting

on specific elements of text in progress of reading. When probing occurs, comprehension and retention increase sharply. The embedding of clues in the text to trigger probing activity may greatly enhance learning outcomes, regardless of the learning level of the reader.

Frequent periodic testing within the curriculum should include feedback on performance and provide immediate knowledge of results. Both probing and feedback reinforce the evaluation step of the transformational learning model. The more frequent the feedback, the more closely the process may act as an externalized monitoring system. The externalized monitoring system would mimic internal monitoring strategies. Knowledge of results will enhance subsequent learning performance (Hurlock and Montague, 1982).

Exercises that force summary responses, as opposed to short answer or multiple choice, will simulate elaboration strategies. Exercises in reorganizing and outlining information from training materials will assist organizational strategy development. For rote memorization of sequence procedures, or other sequential memory tasks, mnemonic clues or other rehearsal strategies may be embedded in the curriculum.

Overall, the use of embedded clues and directions may not replace separate and independent metacognitive strategy

training for enhancing learning performance. Based on the literature, however, a great potential exists for enhanced learning using embedded clues to reinforce learning processes and increase retention.

Generalization of Results

The generalization of the study's results was most appropriate to adult basic skills learners. The study used a military population of limited age range; however, these students were within the age and maturity range of what we traditionally call adults. The learning conditions were not entirely independent. Generalizing these results to older adult learners operating independently of teachers or monitors may seem difficult. The strength of generalization beyond the study population and conditions may lie in the apparent robustness of the relationships demonstrated.

A requirement of the study's construction was an intervention of complex procedural learning that would evidence decay (Farr, 1987). The general model based on the study's results operate independently of specific conditions of interventions, populations and performance. Given the decay criterion, metacognitive strategies should account for retention performance variance with any training intervention. The result is an inference of generalization

to other complex skill training. Therefore, the case for generalization to like conditions will be strongest, and to unlike conditions less so.

The LASSI provides information on general strategies and employment of certain subsets of metacognitive skills. As an indicator of general metacognitive performance, the LASSI should associate with any desired learning outcome requiring a wide array of strategies. Some job-related learning requirements may be appropriately linked to only one strategy, and other learning requirements to two or more. As with BSEP, the more general the instruction, the greater the opportunity is to generalize results from one curriculum to others.

The study demonstrated that several different scales may be appropriately linked to different subsets of learning requirements, i.e., the scales are domain specific. As the training task and skill vary, so may the metacognitive strategy most critical to acquiring and retaining that skill. It is important to anyone attempting to apply the results of the current study to a model of learning that the spectrum of metacognitive skills is no more important than the appropriateness of strategy selection. To use the analogy of a tool box, one who has the knowledge of the tools' uses but a limited number of tools in the box may

outperform another with a larger selection of tools but limited knowledge of their use.

Using a general instrument, like the LASSI, to assess metacognitive preparedness for learning a specific skill may not be wholly appropriate. Individual LASSI scales proved to be domain specific as predictors of learning results. One would have to know which scale or scales were predictive of that specific skill learning performance. However, over a broad range of skills, such a general instrument could prove to be highly predictive.

The results of the current study pointed to a generally higher predictiveness of reading performance than to mathematics performance. The amount of research in reading and metacognitive strategies and the LASSI's authors own emphasis on reading may have weighed the instrument in favor of reading related strategies. Where mathematics skill preparedness and proficiency is critical to performance, the instrument should reflect more of those strategies that directly reinforce the mathematics learning process.

Individual Preparation for Learning

The literature represents that ideal individual preparation for learning exists when 1) the level of task difficulty nearly matches the competency of the student, yet

provides challenge, 2) the student possesses the minimum prerequisite skills required by the task: writing, mathematical, reading and referencing (chart, table, diagram or scale reading), 3) as described in the current study, the student possesses metacognitive skills and the strategic knowledge to employ them, and 4) the affective state promotes learning behavior appropriate to the task, or, the student is motivated to learn.

Options for ideal individual preparation to learn vary. As addressed earlier, the level of task difficulty can be adjusted to the level of individual competence in the task domain. Some form of competency testing is required for the prescriptive start points for instruction, or, absent this identification, learning material must be directed toward the lowest competency level of the targeted population. The second option creates a host of problems, particularly if one accepts the validity of Salomom's (1981) and Bandura's (1977) explanation of the relationship of effort and performance.

Reading and mathematics skill learning may offer different problems within the context of metacognitive interventions. For reading, sentence complexity and vocabulary determine grade level difficulty. Monitoring and looking up the meaning of words may offset initial deficits.

However, math is a rule-based discipline, and, as such, requires application of specific rules to solve problems. The results of this study, particularly the lesser supported hypothesis that mathematics concepts and problems are more highly related to metacognition than simple computational skills, suggest that metacognitive strategies may not fully compensate for lack of initial math knowledge for new math learning to be successful.

Recommendations for Metacognitive Measurements

Determination of metacognitive strategy levels in this study was by way of the LASSI. The evidenced success of this instrument in prediction of learning performance may lead a practitioner of education or training to adopt the LASSI as the instrument of measurement for future learning models. However, the LASSI is a self-reporting instrument, and as such, is subject to not only normal test errors, i.e., errors of measurement, but also rater errors.

Rater errors stem from bias, internal screens, or hidden agendas and tend to obscure 'true' ratings. In the case of self-reporting instruments, the rater and the one rated are the same. Some of the usual effects demonstrate themselves, e.g., halo effect, leniency effect, and errors of central tendency, plus errors associated with self-disclosure, e.g., how the rater wants others to see him

or her. At best, self-reporting instruments are measurements of perceived performance, and therefore, indirect and potentially inaccurate. At worst, the individual may willfully subvert the goals of the instrument by misrepresentations.

The success of the study's use of the LASSI may have been due in part to a deliberate attempt to put subjects at ease with not only the instrument but with the knowledge that their results of the instrument would not be disclosed to any other than themselves. Secondly, rater errors that obscure results of self-reporting instruments for individual application may have been far less dangerous in analyses of groups. Use of the LASSI as a screening device in an organization that employs the individual and makes decisions about the individual's future role may limit the utility of the LASSI as demonstrated in this study.

Two requirements exist to clearly define metacognitive measurements. First, as noted throughout the examination of the literature, metacognitive strategies must be clearly defined as behaviors. The confusion in the literature on what metacognitive strategies are will limit development of an instrument of measurement. Secondly, a valid, performance-based instrument is needed to limit rating bias and misperceptions noted above.

Recommendations for a Clearly Defined Learning Model

Several findings of the present study suggested that a different form of learning model may be appropriate for adult learners and metacognitive processes. Results of the first two hypotheses supported the position that in the population study group, metacognitive strategies related strongly to learning outcomes. The third and fourth hypotheses anticipated incremental validity of affective measures in the model. The hypotheses were supported; however, the strength of the relationship lessened with the delayed posttest measurement. Secondly, the relationship with mathematics was stronger than for reading.

Affective measures appeared to have the greatest impact in short term, or upon initiation of learning. Either the quality of the affective measures were fluid, or the learning process involved in the intervention has effected the affective state of the student. Since the intervention has no attitudinal or motivational content or intent, it would seem unlikely that it could have affected the student's attitude, motivation or anxiety.

To discover what mechanisms affective measures may relate to, one should refer to the theoretical constructs of Bandura and Salomon. Self perceptions, derived from previous experience may alter how the student perceives the

learning process and the learning material specifically. Previous experience will include how much effort was previously expended and to what gain. Effort versus value estimates may affect the student's level of attention and interest in the learning material; hence, the student's performance in acquiring knowledge may be linked to past memories of similar instruction.

Over time, with individually-accessed learning materials, the student may learn to compensate for initial misgivings about the learning process or the content of the material. Successes in learning, then, may lead to a renewed attitude about the subject, independent of any separate intervention. The key to understanding the relationships demonstrated in the present study may be the impact of affective state on mathematics. Where affective measures on the LASSI were low, students performed poorly on mathematics. This relationship did not hold for reading.

Memories of unsuccessful experiences with mathematics, or as it is unhappily referred to as math anxiety, apparently affected students more than with reading. Students frequently lament that they are just not good in math. This self perception of mathematics ability may be more difficult to alter than whether the student is feeling good about studying on that day.

The results of the fifth through the eighth hypotheses were illuminating as well. The strategies and skills levels required of tasks of higher complexities differed from those required of simpler tasks. Here, the level of sophistication in strategy choice and skill application may have caused the difference in relationships between metacognitive strategies and learning outcomes. Strategies such as elaboration and organization, as reflected in the Information Processing, Selecting Main Ideas, and Study Aids scales of the LASSI, have several levels of sophistication and a wide range of specific skills associated with them. Concentration and testing strategies to focus on select information for retention require practiced use to be effective.

Where tasks are complex, the student must determine what strategy is most appropriate and use that strategy at that particular phase of the learning process. A single learning experience may require the use of more than one strategy and several skills. Overall, the monitoring of this process, whether conscious or automatic, may have the greatest determination of retention of the learned information over time.

The ninth hypothesis anticipated a greater relationship of metacognitive strategies to retention than to acquisition

of skills. The results of the testing of this hypothesis strongly supported the premise laid down by Glaser that there a qualitative difference in learning exists between expert and naive learners. The monitoring and elaborative strategies of the expert learners allowed for longer retention of the material over time. Far from being a two-stage process of perception and storage, the results of this study supported that learning was a process of individual judgments that serve to manipulate, modify and amplify learning material to fit the needs of the learner. The metacognitive strategies employed assist the learner in this transformation of information into knowledge.

The active role of the learner in the learning process may not be the sole domain of the adult learner. Brown (1982) and others have suggested that the process of employing metacognitive strategies to manipulate the learning process begins quite young. The foundation of adult learning theory is that adults must actively engage in the learning process. It is the adult learner's nature to transform information for his or her own purposes, and to integrate that learning with existing constructs or schemata.

The development of a learning model that approximates the processes that adult learners employ would assist in the

development of metacognitive measurements, direction of future research and focusing on adult learners' metacognitive strategy requirements. Such a model would stress the principle role of the learner in accessing and evaluating information and integrating the information into existing schemata. Existing pedagogical metacognitive models focus on external influences of teachers as principle agents of learning. While external influences exist in the adult world of learning, particularly in motivational aspects, the adult model should be primarily concerned with the internal processes as principle agents of learning.

Recommendations for Further Study

The apparent direct relationship between complexity of task and utility of strategies requires further research. Researchers should attempt to reveal how performance is dependent upon existing metacognitive strategies for training in simple and complex procedural tasks, rule-based learning and applications and evaluative or inferential tasks. Simple and complex procedural tasks represent a large part of manufacturing, commercial and technical job components. Rule-based tasks, such as those required in basic skills education programs, constitute a higher order of skill learning and application. Evaluative or inferential tasks require the individual to identify and solve problems when no single rule applies and the

individual must concurrently evaluate the application of several rules to solve a single problem. The formal metacognitive strategies and skills tested in the present study may not be as useful where learning conditions and expectations are wholly procedural and not rule-based. An instrument that concentrates on rehearsal strategies might be more appropriate in these cases.

A second recommended course of research stems from affective measures' relationships to learning acquisition and retention in the present study. Research on whether motivation plays less of a key role in learning than earlier literature suggests would aid in the development of metacognitive strategy interventions. If motivation is secondary to specific learning strategies and skills, then the current emphasis on motivation programs may be incorrect. Another form of research might center on why learning mathematics was apparently more dependent upon motivation and other affective measures than was reading.

To test a metacognitive learning model, researchers may replicate parts of earlier research, e.g., studies on monitoring internal and external consistency, to evaluate the congruency of the process. Or, following the model, develop internal (embedded) and external interventions for specific learning materials and test whether performance is

enhanced with the addition of metacognitive intervention. Either process may be complex and potentially confounded by processes beyond the control of the experimenter.

Instruction on how to select a strategy and employ specific skills to enhance the learning process should, given the results of this study, increase the latency of learning, and may, according to self-efficacy theorists, increase general motivational factors in the population. Therefore, the practical question of raising metacognitive strategy knowledge and use may also be appropriate for examination in subsequent study. Although successful metacognitive training programs exist and may be adaptable to adult use, the direction and value of these programs should be considered in view of adult requirements. Some metacognitive processes may have more utility than others and should therefore have more emphasis in programs oriented to increasing job performance. The development of a baseline set of metacognitive strategies should find its basis in the instrument used to determine proficiency.

Embedded metacognitive prompts, as noted, may enhance metacognitive activity and thus retention. Curriculum should be developed incorporating appropriate metacognitive prompting to assure optimal learning performance. The development of such a broad base of curriculum may take a

great deal of time. Costs of such development would force the stretching of embedded metacognitive training curriculum to occur over time, perhaps waiting for curriculum to become obsolete for other reasons before replacing it with an embedded training form.

Urban Research Requirements

The research question remains as to whether, given an adult basic skills population and a methodology to remediate deficient metacognitive strategies, a training intervention in metacognitive strategies will increase learning performance. The criticality of the question was prefaced in Chapter 1, wherein a demonstrable need to upgrade basic literacy and numeracy in the adult population still exists.

The study population did not mirror the urban adult basic skills population in three specific ways. First, the adults in the study were all employed; that condition certainly does not exist in the general urban adult basic skills population. Second, the study population was young adults and variance in age was limited. While this characteristic lessened possible confounding due to age differences, an urban adult basic skills population would have greater variance in age and may therefore demonstrate age unique learning characteristics. Third, the variance in starting literacy and numeracy was limited in the study

population, both by selection into the Army, and by the pretesting on the TABE. Again, basic skills programs in urban areas may expect to see a greater variance in beginning literacy and numeracy.

While the study design may account for greater variance in an adult basic skills program, particularly where large numbers of participants may be available for study, specific controls for curriculum and uniformity of attendance may be lacking. The pure approach would be to replicate the current study in the urban basic skills environment to demonstrate whether the strength of relationships found here continues in the alternative environment. However, given the practical aspects of the construction of such a study, and the likelihood of confounding through those conditions listed above, a more pragmatic approach would be to assume generalization from the current study and institute a study of various forms of metacognitive intervention to test for the utility of such interventions.

A study to determine the effects of metacognitive interventions could include groups with no intervention, pre-instructional metacognitive strategy training, embedded clues in the curriculum, and a combination of embedded clues and pre-instructional metacognitive strategy training. The groups may exist intact, or students may be randomly

assigned to each of the groups. Problems in experimental mortality would have to be addressed prior to running the study. The obvious advantages of random assignment may be overcome by experimental mortality or may be overwhelmed by logistical disadvantages.

Additionally, metacognitive strategies' relationship to other training and instruction would be appropriate, particularly in training programs sponsored in whole or in part by public sector funds. Recent moves in retraining the available work force in urban areas using federal and local funds could provide an available study population.

Other Research Suggested by the Study

The significance of the current study's findings suggest that a study of metacognitive strategy instruction should be undertaken with another population sample. If the use of the LASSI would be appropriate, and no other performance-based measurement of metacognitive strategies exist at the time of the study, care should be taken to institute instruction that conforms to the instrument in order to measure change.

A long term study could derive from the current study's results. Given that variance exists in metacognitive strategy knowledge and use in the adult population, and that forms of metacognitive strategy instruction are in use,

research to test the latency of metacognitive strategy knowledge and use would be appropriate. The researcher could test for metacognitive learning decay. This research is predicated on the assumption that metacognitive strategy learning is subject to the same types of decay evidenced in other learning. Such research would focus on the latency of learned metacognitive behaviors following a metacognitive training intervention.

Summary

This study explored a wide range of literature associated with learning and performance. The literature pointed conclusively to a problem of training and a potential answer, i.e., why do some individuals acquire and retain information better than others. The construction of the design allowed for examination of the basic question within existing conditions to limit confounding while limiting impact on the ongoing processes of current training systems. The results of the study point to variance in specific metacognitive strategies as related to skill acquisition and retention performance over time.

The study was correlational, however, and as such, raises questions of causality. In this study, no intervention of metacognitive training was used to determine whether changes in metacognitive strategy proficiency would

result in direct changes in learning acquisition and retention. Secondly, as expressed, the conditions of the instrument to measure metacognitive strategy performance opens questions on true versus reported metacognitive strategy proficiency. Most importantly, is the problem of generalizability to other adult training functions and populations. However, the results of the current study demonstrate strong relationships that should hold when applied to other training regimen, and other adult population groups.

Results of the study were demonstrable, and satifactorily answer the observational question of why some students learn and retain learning better than others. The study also indicates a high potential for application to the real and pervasive problem of skill acquisition and learning decay. It suggests the operational solution of metacognitive training, either as a stand alone or embedded curriculum as a solution to the problem of latency of learning. Implications for application should not be enacted exclusive of further inquiry, but should be considered as a possible, plausible direction for further development.

Appendix A.

Reliability and Validity Information on the Tests of Adult Basic Education

Publishers: CTB\McGraw-Hill, 2500 Garden Road, Monterey, California 93940, 1987.

The TABE scale reports a raw score and a reading grade level equivalent (RGL) and mathematical grade level (MGL). Grade equivalents are based on the CAT E and F standardization administration for October (.1) and May (.8). Other grade equivalents are mathematically interpolated. For purposes of statistical clarity, only raw scores will be used in the study. Additionally, RGL and MGL does indicate, even with the above measures, a sequential and equivalent interval of measurement.

The TABE was validated against a population of 4,800 vocational/technical school enrollees and adult and juvenile offenders. The standard error of measurement increases at the high range (RGL and MGL > 11.0) and at the low range (RGL and MGL < 7.0). The coefficient alpha is reported at .87 for reading and .83 for mathematics.

Appendix B.

LASSI Scales and Relatedness to Cognitive Theory

Scale Code	Name of Scale	Primary Target of Measurement & Relatedness
ATT	Attitude	Affective measurement of self-perception. Related to self-efficacy theory, expectancy theory, and preevaluation of learning material.
MOT	Motivation	Affective measurement of feelings toward environment and achievement. Related to motivation theory, need achievement theory, and expectancy theory.
TMT	Time Management	Learning strategy measuring individual's acceptance of locus of responsibility for planning and conducting learning activities. Related adult learning theory, motivation theory, and pre-evaluation of learning material.

Appendix B Continued

Scale Code	Name of Scale	Primary Target of Measurement & Relatedness
ANX	Anxiety	Affective measurement of performance concern. Related to self-efficacy theory.
CON	Concentration	Learning strategy measuring management of distractions. Related to monitoring and in-process evaluation.
INP	Information Processing	Learning strategy measuring elaboration and organization of learning material. Related to theories of cognitive association, chunking and cognitive metaphor. Applies to both identification of and integration with existing schemata.
SMI	Selecting Main Ideas	Learning strategy measuring identification of main ideas. Related to theories of cognitive association, and selection. Applies to both identification of and integration with existing schemata.

Appendix B Continued

Scale Code	Name of Scale	Primary Target of Measurement & Relatedness
STA	Study Aids	Learning strategy measuring recognition of clues in learning materials, and creation of aids to study. Related to theoretical constructs of clueing, and elaboration and memory organization. Applies to evaluation and assimilation of learning material.
SFT	Self Testing	Learning strategy measuring inprocess evaluation of comprehension. Related to internal and external consistency, monitoring and comprehension checking. Applies to in-process evaluation and assimilation of learning material.

Appendix B Continued

Scale Code	Name of Scale	Primary Target of Measurement & Relatedness
TST	Test Strategies	Learning and performance strategy measuring planning for, and performance on tests. Related to theories of declarative and proceduralized knowledges, and monitoring. Applies to preevaluation of learning material.

Appendix C.

Reliability and Validity Information of the Learning and Study Strategies Inventory

Publisher: H & H Publishing Company, Inc., 1231 Kapp Drive, Clearwater Florida 34625, 1987. Author: Claire E. Weinstein.

Each of the ten scales of the LASSI have individually been reliability tested and validated against a population of over 800. The coefficient alpha and test-retest correlations are below:

Scale	Coefficient Alpha	Test-Retest Coefficient
Attitude	.72	.75
Motivation	.81	.84
Time Management	.86	.85
Anxiety	.81	.83
Concentration	.84	.85
Information Processing	.83	.72
Selecting Main Ideas	.74	.78
Study Aids	.68	.75
Self Testing	.75	.78
Test Strategies	.83	.81

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