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THE ROLE OF COGNITIVE EFFORT AND LEARNING OUTCOME DEMANDS IN SKILL ACQUISITION AND LEARNING

By

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ABSTRACT

THE ROLE OF COGNITIVE EFFORT
AND LEARNING OUTCOME DEMANDS
IN SKILL ACQUISITION AND LEARNING

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This research was designed to examine how learner awareness of the type of learning outcome, and the amount and type of cognitive effort used during learning, affect performance on knowledge and application tests. The construct of amount of effort was expanded to include off-task attention and mental workload, as well as time on task. Three cognitive learning strategies; rehearsal, organizing and personalizing, were examined. The impact of learning motivation and cognitive ability on effort and performance was also studied. The results indicated that performance on the two learning outcomes was positively related. Amount of effort was found to affect performance on learning outcomes. None of the three hypothesized learning strategies were related to performance, but the working of a sample problem during learning was related to application. Learning motivation affected amount of effort, but did not affect the use of learning strategies. Implications for further cognitive process and learning research are discussed.

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INTRODUCTION

Given the substantial investment in time and resources devoted to training and education every year, psychologists in many disciplines have investigated ways to improve individual learning. Learning is defined as "a relatively permanent change in knowledge or skill produced by experience" (Weiss, 1990, p. 172). Learning is generally recognized to involve an interaction between individual characteristics, such as ability, motivation, attention, and effort, and situational factors, such as the instructor and the material to be learned (Gagné, 1984; Biggs, 1992).

Research investigating the role of attention and effort in learning can be traced back to the days of Ebbinghaus. Using nonsense syllables as material, Ebbinghaus measured the amount of effort, or number of learning trials, required to learn a set of stimuli to a set criterion level. He then had subjects relearn the material at a later date, and calculated a savings score, which was the reduction in effort required to relearn the material (Ashcraft, 1993).

The effort put forth by subjects in Ebbinghaus' experiments was rote memorization, or pure, factual rehearsal. Subjects repeated the nonsense syllables again and again until they remembered them. Cognitive psychologists have investigated the role of rehearsal in memory, and discovered that it serves two primary purposes; retention of material in short term memory, and the transfer of material from short term memory into long term memory (Ashcraft, 1993). It has been generally accepted that rehearsal is a useful way to transfer information into long term memory.

Craik and Lockhart (1972) attempted to distinguish between different types of rehearsal through their depth of processing theory. They claimed that deep, or meaningful, processing was the best way to remember learned material over time. Shallow processing, similar to Ebbinghaus' rehearsal, does not leave a durable memory trace, according to Craik and Lockhart (1972). Thus, the depths of processing theory proposed a 'one best way' view of cognitive processing in learning. Regardless of the stimulus material and demands of the outcome test, the levels of processing theory predicts that deep, intentional processing produces the best retention.

Later research has indicated that there may not be one best way to learn all types of material in all situations. Morris, Bransford and Franks (1978) suggested the notion of transfer appropriate processing. They posited that learning outcomes, or test conditions, must be considered when processing during learning. If the desired outcome is an understanding of a paragraph of text, then Craik and Lockhart's idea of deep processing may still be appropriate. However, if the desired learning outcome is to simply know how many words were in each sentence of the same paragraph, then the traditional deep processing may not be the best mode of processing. Morris, et al., (1978) suggested that the type of processing that is meaningful differs for each learning task, and learning outcomes must be designed to tap what was supposed to be learned.

Effort has been mentioned often in learning and skill acquisition research, but effort is often put aside in favor of abilities or skills as the variable of primary interest. Cognitive effort has typically been conceptualized as time on task, or attention devoted to the task (Mitchell, Hopper, Daniels, Falvy & James, 1994; Kanfer & Ackerman, 1989). The construct of effort will be reviewed as it has been used in motivation and learning research. It is proposed that in addition to the amount of effort put forth by a learner, the type of cognitive effort, or processing, used in a learning situation will affect performance on a learning outcome measure. Theory and research on transfer appropriate processing are reviewed. Individual factors (learning orientation and cognitive ability) and contextual influences (knowledge of the type of learning outcome measure) are proposed to affect the type and amount of effort used by the learner in skill acquisition.

There are two main themes in this proposal. First, it is suggested that the construct of effort as it has been used in training and learning research is incomplete. Effort is typically operationalized as time on task (Kanfer & Ackerman, 1989), or occasionally perceptions of on-task attention (e.g. Paas, 1992). Measures of effort should be used in conjunction with one another, as each measure contributes a unique view of the amount of effort construct. In addition, researchers, instructors, and learners must consider not only the amount of effort allocated toward learning, but also the type of effort used. It is suggested that some types of effort are better suited to particular learning outcomes.

Second, it is proposed that evaluation procedures at the end of learning events, when made known, signal learners to allocate their efforts toward acquiring the knowledge and/or skills which will allow them to perform well on the evaluation. For example, if the objective of a training program is for trainees to learn a skill, a declarative knowledge test would be inappropriate to measure the learning objectives. Hubbard (1994) presented an example of how testing affects students' study behaviors. First, students gather information from the syllabus, former students, and the teacher concerning testing procedures. Students then adjust their study behaviors accordingly. Hubbard (1994) suggested that students will use only the study skills which are required for the expected testing procedures. If a college professor intends students to develop skills that can be used on the job, he or she should orient evaluation procedures to skills, rather than declarative knowledge as demonstrated on a multiple choice exam.

Multidimensionality of Learning Outcomes

Before attempting to determine how people learn, criteria must be specified so "learning" can be measured. Defining learning as a relatively permanent change in knowledge or skill does not directly suggest how one might measure whether or not any learning has taken place. When learning is viewed as a multidimensional construct, the specification of criteria becomes more clear. Kraiger, Ford and Salas (1993) presented a framework which divides learning outcomes into three categories; affective, behavioral, and cognitive. Affective learning outcomes consist of attitudes and motivation which might be desired outcomes of training. Examples of this type of learning outcome include acceptance of diversity, and organizational commitment (Kraiger, et al., 1993). Behavioral, or skill-based, outcomes consist of psychomotor skills one could learn in training. Cognitive outcomes consist of verbal knowledge, as well as higher order knowledge organization and cognitive strategies.

Anderson's ACT* theory presents the acquisition of knowledge and skills as a stage model. This theory posits that the dimensions of learning are arranged hierarchically. The first stage of the model involves the acquisition of declarative knowledge. Declarative knowledge is knowledge about things, such as your mother's maiden name, or the channel Seinfeld is on. Procedural knowledge is knowledge of how to do things, such as drive a car with a manual transmission, or write a grammatically correct sentence. According to Anderson, one cannot learn procedural skills without first having acquired the declarative basis for that skill. Thus, if the ultimate learning goal is skill-based, trainees must first acquire the relevant declarative knowledge before applying that knowledge to proceduralization.

In the declarative stage of skill acquisition, task performance is slow and effortful. The facts about performance must be held in working memory. The learner must verbalize frequently during performance (Weiss, 1991). The second stage of skill acquisition is knowledge compilation. During this phase, the learner begins to build the rules, or production systems, necessary to perform a task. Production systems are arranged in "If: Then" form, and are organized hierarchically according to goals (Anderson, 1982). When the learner is presented with a goal, such as tying one's shoe, there are several sub-goals which must be accomplished in a particular order. Over time, and with practice, the productions are arranged and combined to make performance smooth and easy. When the learner reaches the third stage of skill acquisition, performance requires substantially fewer mental operations than performance in the declarative stage.

Bloom (1956) presented a taxonomy of cognitive learning outcomes which contains six levels. The levels, ranging from the most concrete to the most complex, are knowledge, comprehension, application, analysis, synthesis, and evaluation. The taxonomy was originally developed to aid teachers in designing curriculum and evaluating students. Knowledge is defined as remembering ideas or facts through recall or recognition. Bloom recognized that knowledge is required to perform the more complex objectives. However, the focus in this category is on isolated facts which can be remembered separately. Comprehension is more complex, requiring students to know what is being communicated in a situation, and make limited use of the material. Limited use, in this situation, can include translation, interpretation, and extrapolation. In contrast, application requires students to use an abstraction in a new situation. Thus, the student must not only remember the concept, but use that concept to solve a problem.

The distinction between knowledge and application is similar to that between declarative and procedural knowledge. Both knowledge and declarative knowledge are needed to develop the higher order structures. One important quality of true procedural knowledge is that the learner need not consciously access the declarative knowledge to perform the behavior. In Bloom's taxonomy (1956), no such limitation is placed on application. Application is more likely to occur than proceduralization in the shorter time periods of one class period or one training session. Regardless, the principles of application and procedural knowledge are very similar. Both are higher level knowledge structures, and both require the use of relevant factual knowledge.

Motivation in Learning

Kanfer and Ackerman (1989) present a model of motivational processes within a skill acquisition framework. They discuss motivation as a process in which both distal and proximal motivational processes are used to allocate cognitive resources (i.e. attention and effort). Distal motivation processes involve the choice to use one's resources for a particular task. At this first stage, the individual decides how many resources to allocate for the task at hand. Proximal motivation processes determine the distribution of attention and effort within a given task, once the individual has chosen to engage in the task. Each individual possesses a limited amount of cognitive resources, or ability, which can be distributed. These resources are allocated among three types of behaviors; task related, self-regulation, and off task. The motivational processes that affect resource allocation include goals, incentives, individual personality differences, and metacognitive knowledge. Kanfer and Ackerman (1989) demonstrated that the use of explicit proximal goals in skill acquisition was associated with a decrease in training performance. They contended that effort which was needed to learn the skill was allocated toward goal monitoring.

There are several boundary conditions which must be considered in the motivation-performance relationship. First, the level of skill proficiency affects the amount of cognitive resources needed. Skill acquisition is generally considered to consist of three phases. In the declarative stage, the learner is becoming acquainted with the task, and the demands of the task. The learner must devote substantial cognitive resources to learning the task. In later phases of skill acquisition, knowledge compilation and procedural knowledge, skills become more automatized as the learner performs the task more smoothly, and fewer cognitive resources are required to perform the task.

Second, the resource-dependency of the task must be considered. If the task is considered resource-dependent, performance is at least partially dependent on the amount of attention which is allocated to the task. On a resource insensitive task, however, attention allocation does not impact task performance. Such a task is said to be data-limited, and performance is affected more by task characteristics than by the availability of cognitive resources (Kanfer & Ackerman, 1989). Thus, both the resource dependent task, and the early stages of skill acquisition require high amounts of attention and effort.

Dweck and her colleagues (Dweck, 1986; Dweck & Leggett, 1988) also focus on effort as a primary mechanism linking learning motivation and performance. Dweck and colleagues have suggested that students who are motivated by the task itself do well because they have a healthy attitude towards effort, and can direct all effort towards the task. Individuals who are motivated by the potential for reward or recognition stemming from the learning event tend to perform less well than task motivated students. The performance oriented students do not direct all effort towards the task, as they are concerned with protecting their ego. Thus, the students who are able to direct maximum effort toward the learning task generally perform better.

One limitation identified with the work of Kanfer and Ackerman (1989) is the treatment of all on-task effort as being equal. Kanfer and Ackerman did not investigate *how* the trainees learned. They focused primarily on goal manipulations and ability as determinants of training performance. They refer to variations in on-task effort as only increases or decreases, not as changes in strategy or type of effort. Perhaps the less successful performers were not approaching the task in the most useful manner. The next section investigates the construct of effort, how effort has been measured, and how the treatment of the construct has limited learning research.

Motivation and Effort

Motivation research in Industrial and Organizational psychology has dealt with three primary outcomes of motivational processes; direction of behavior, intensity of action, and persistence of behaviors over time (Kanfer, 1990). *Direction of behavior* typically refers to the choice of a behavior or course of action. However, direction can also be considered within a particular course of action. For example, a student could choose to study for an exam, but the student could then choose different study strategies, such as memorizing a list of terms or paraphrasing class notes. *Intensity of action* refers to how much effort is expended by the individual. For example, a student could study for the exam for one hour, or six hours. Amount of effort, though, may not directly lead to performance improvements. According to Kanfer, "motivational processes may fail to affect performance because effort is misdirected - persons work harder at the wrong things" (Kanfer, 1990, p. 81).

Persistence of behavior has been used less frequently in motivational research, as it is a long-term result of motivation. Our student would display persistence if he studied in a particular way, with a certain amount of effort, over the entire semester, or his entire college career. Because persistence is viewed as a combination of direction and intensity over time (Kanfer, 1991), persistence will not be explicitly considered in this study.

In the Integrated Resource Model, motivational processes direct choices involving the direction of effort and the intensity of effort (Kanfer & Ackerman, 1989). Effort is directed in some combination of on-task, off-task, and self-regulatory activities. Intensity is conceptualized as the amount of effort directed in any of these three directions. In Kanfer and Ackerman's model, direction is not considered *within* a particular course of action. A more fine-grained analysis which looks into specific on-task, off-task, and self-regulatory activities has potential to provide a greater understanding of learning processes. The present paper investigates measurement and conceptualization issues surrounding on-task learning activities.

Measurement of Effort

As suggested above, cognitive effort is comprised of two components: amount of effort, and type of effort. Many researchers have operationalized effort as the amount of time spent on a task (Terborg, 1977; Dweck, 1986), or perceived effort on the part of the learner (Paas, 1992; Wofford, 1990; Hart & Staveland, 1988). Any measure of effort as actual time spent on the task, though, is contaminated. An individual may appear to be working on a task, or thinking about a task, but his/her attention may be focused elsewhere. Kanfer and Ackerman (1989) define effort as the *amount* of attentional resources devoted to the task. Considering the importance of the attentional component to the Integrated Resource Model, it seems useful to determine if the trainee is focusing attention on the task at hand, along with the time spent on the task. For example, a trainee could be working on a problem from 11:00 to noon, but if he thinks about lunch every five minutes, he significantly reduces the actual attentional effort devoted to the problem.

Paas and colleagues (Paas & Van Merrienboer, 1994; Paas, 1992) have operationalized mental effort separately from time on task. According to Paas (1992), mental effort is the amount of capacity that is allocated to instructional demands. Mental effort was measured with a self-report scale on which subjects indicated the perceived amount of mental effort devoted to the task. Time on task did not appear to be related to amount of perceived effort. For example, subjects who studied pre-solved statistics problems spent significantly less time on the task than subjects who actually solved statistics problems. The mean amount of perceived effort did not differ across conditions (Paas, 1992). Paas did not measure the actual mental processes used, but suggested that some mental processes may be more or less relevant to the learning task, and "less effort could be invested in more relevant learning processes" (Paas, 1992, p. 433).

Hart and Staveland (1988) also measured amount of effort by subjective self-report. They define mental workload, as the cost incurred by a person to achieve a given performance level. It is a function of task properties, situational factors, and the skills, behaviors and perceptions of the person. Although mental workload is typically used to describe between-job workload requirements (e.g. Hancock & Caird, 1993), it can also be used to describe between-individual workload expenditures on a given task. Hart and Staveland (1988) suggest that self-report measures of mental workload "may come closest to tapping the essence of mental workload, and provide the most generally valid and sensitive indicator" (Hart & Staveland, 1988, p. 141).

Hart and Staveland (1988) developed a self-report, multidimensional measure of mental workload, the NASA Task Load Index (NASA-TLX). The measure includes items which reference, for example, the mental demand, temporal demand, physical demand, and frustration level of a task. Ratings on individual dimensions were found to correlate highly with global ratings of workload. The scale can be given in many forms, including verbally, paper and pencil, or by computer without appreciably altering the psychometric characteristics of the test. While between subject variability is often considered problematic in human factors research (Hart & Staveland, 1988), it was considered an interesting aspect of self-report ratings of mental workload. With the NASA-TLX, researchers can obtain stable, valid measures of the amount of effort required by a particular task, for a given individual. The mental workload measure addresses one deficiency in the measurement of effort as time on task.

Kanfer and Ackerman (1989) addressed another aspect of the construct of amount of effort. They used a self-report measure of thought content which tapped into the mental activity of the subjects. Subjects were asked to what extent they set goals for themselves, compared their performance to others, or daydreamed. Thus, Kanfer and Ackerman address another deficiency of the effort construct, as they combine the traditional time on task (or number of trials), with information regarding on-task and off-task mental effort.

Each measure of amount of effort discussed above, time on task, mental workload, and on-task/off-task attention, captures a piece of the amount of effort construct. The relationships among these measures should be explored. For example, Paas (1992) has suggested that time on task is unrelated to perceived mental workload. How is on-task/off-task attention related to time on task and workload? Further, what are the relationships among these variables and learning or task performance?

Once the amount of on-task effort has been identified, it is important to discover how the learner spent that time. Terborg (1977) addressed the direction of effort in his model of work performance. Direction of effort was operationalized not through actions of the worker, but through role definitions, or the worker's understanding of the appropriateness of various work related activities. However, most researchers do not directly address the issue of the type of on-task cognitive activities during learning.

While I/O psychologists have found that motivation and intensity of effort play important roles in learning and skill acquisition, many cognitive psychologists would argue that the information processing which occurs during the learning is more important than the goals and motivation of the learner (Anderson, 1983). There is substantial evidence in the cognitive and instructional psychology literatures that the type of processing, or direction of effort within the learning task, during the encoding phase of learning is vital. This literature is reviewed below, with the intention of linking these cognitive processing concepts to on-task activity during learning.

Encoding and Information Processing in Learning

Many cognitive psychologists have investigated the role of processing in the acquisition of information and skills. The consensus view suggests that different types of processing lead the learner to attend to different aspects of the material. Researchers must consider the processes involved in learning - encoding, organization, and retrieval. The accuracy of retrieval processes, such as those necessary for performance on a learning outcome measure, is dependent upon what information is stored, how the information is stored, and how that information matches the subsequent cues for retrieval (Lord & Maher, 1991). It is not just the information itself that is important, but also the organization of the information in memory.

Much of the research concerning encoding and retrieval processes is based on the encoding/retrieval paradigm of episodic memory research (Tulving, 1983). This paradigm proposes a 2X2 interaction between encoding condition and retrieval condition. In experiments utilizing this paradigm, two encoding conditions are tested with each of two retrieval conditions. The material used is typically the same for each condition, but the focus in encoding and retrieval is varied. For example, a researcher using one list of words could vary encoding condition by instructing subjects to write down the first synonym they can think of for the target word (semantic) or count the number of E's in that same target word (surface-features). Memory tests could be implicit or explicit. Explicit tests involve conceptual, semantic information, while implicit tests are data-driven, and involve physical properties of the stimuli. The usual prediction of the encoding specificity hypothesis is that performance would be superior in the "match" cells, where semantic encoding enhances performance on a free recall or recognition test (Roediger, Weldon & Challis, 1989). A mismatch cell, such as the combination of semantic encoding and an implicit memory test, should result in poor performance. Tulving (1983) contended that the use of this 2 X 2 design was the only way to rule out alternative explanations, and fully test the encoding specificity hypothesis.

Encoding Specificity Research

Earhard (1969), in an attempt to study the independence of memory traces, discovered that subjects could not learn a list of words in one manner, and then recall them in a different manner. She presented the to-be-learned words to subjects in a serial fashion. Some of the subjects were to recall the words in free recall or serial conditions. Others were to recall them alphabetically. The subjects who were to recall the words alphabetically performed poorly, unless they were told before presentation they would be required to recall the words alphabetically. Thus, reorganization of learned words was an extremely difficult task, which became even more difficult as the study time increased. Earhard concluded that it is beneficial to store items in memory according to the retrieval system which will be used (Earhard, 1969).

In another study involving retrieval processes, Thomson and Tulving (1970) had subjects learn a list of words alone, or word pairs of weakly associated words. They tested retrieval of the target words with these learned cues, which they termed "weak," against a cue word which was typically strongly associated with the target word, defined as the "strong" cue. Thomson and Tulving (1970) found that the strong cues worked best when subjects did not learn the word pairs, just a list of target words. The weak cues facilitated performance better than the strong cues when the word pairs had been learned. The authors interpreted this effect as support of the encoding specificity hypothesis, which states, " Specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored" (Tulving & Thomson, 1973, p. 369). According to this principle, test performance will be facilitated to the degree that the test stimulus conditions match the presentation, or learning, stimulus conditions. When there was no cue word learned with the target words, the strong cues facilitated retrieval because they were associated with the target words in everyday speech. Since an experimental association was not learned, the normal cue remained effective.

Tulving and Thomson (1973) further investigated the relationship between encoding and retrieval processes in a study comparing recall and recognition of test words. The typical result of such studies is that subjects perform better on recognition tests than on recall tests. However, Tulving and Thomson found evidence for substantial recognition failure. Subjects studied a set of target words accompanied by a cue word. In the test, subjects could recognize the target word by itself only 24% of the time. However, when given the cue word, the subjects could recall the words 63% of the time (Tulving & Thomson, 1973). This result clearly contradicts the standard notion that recognition is easier than recall in word list memory tests. The authors again called upon the principle of encoding specificity to explain these results. Tulving and Thomson hypothesized that if subjects had been asked to recognize entire word pairs, as had been present in the encoding condition, instead of just the target word, recognition performance would have been much better (Tulving & Thomson, 1973).

The principle of encoding specificity has been demonstrated with pictures as well as with words. Because of the so-called pictorial superiority effect, a theory which hypothesizes that pictures allow dual encoding of stimuli (imaginal and verbal), many researchers believed pictures would lead to better performance than words on any memory test (Weldon, Roediger & Challis, 1989). This hypothesis has been disproven by several researchers. Weldon, Roediger and Challis (1989) showed that pictorial encoding produces low performance on a word-based implicit memory test. Subjects were shown a collection of pictures and words. They were then asked to complete word fragment or word stem completion tests. Subjects were able to complete the items which had been learned as words significantly more often than words which had been learned as pictures. Watkins, Peynircoiglu and Brehms (1984) found similar results. Subjects rehearsed a set of either pictures or words with the same semantic meanings. They were then shown fragments of either pictures or words. Subjects who had studied the pictures were able to identify the pictures more easily, whereas subjects who had studied the words were able to identify words more easily. (Watkins, Peynircoiglu & Brehms, 1984). Performance was best when the mode of study matched the retrieval cue. These results are consistent with the principle of encoding specificity. The pictorial superiority effect is similar to the "one best way" notion of encoding which can be found in Craik and Lockhart's levels of processing idea. The levels of processing theory claims that deeper, or more meaningful, processing during encoding will result in better memory (Ashcraft, 1989).

Transfer Appropriate Processing

Morris, Bransford and Franks (1977) highlighted the importance of the type of cognitive processing in the learning event. This was the first study to use the term "transfer appropriate processing." Morris, et al., among others, were dissatisfied with Craik and Lockhart's (1972) levels of processing theory , which attempted to distinguish between objectively defined meaningful and non-meaningful processing methods. However, as noted by Morris, Bransford and Franks (1977), "many of the results favoring the levels of processing claims may be due in large part to an inherent bias in the way in which memory was tested (p. 521)." They believed that there was no one best way to process information for learning; rather, the best method of processing would depend on the goal of the learning, or the testing situation. The processing task must still be meaningful, but within the specific learning context. They found support for their theory using a simple word task. Subjects performed better on a semantic test when they had used a semantic acquisition task, and performed better on a rhyming test when they had used a rhyme-focused acquisition task.

This series of experiments also showed that the rhyme encoding task allowed superior performance over semantic encoding on the delayed rhyme test. This finding questions the levels of processing idea that deeper processing allows for stronger memory traces, hence longer retention. Thus, Morris, et. al., (1977), concluded that no one learning method is inherently superior in increasing the strength, accessibility, and durability of memory traces. However, the different learning methods can orient the learner towards different types of information. It then becomes very important to encode to-be-learned information in a way consistent with the ultimate learning goal. As demonstrated by both the Morris, et al., (1977) and Roediger, et al., (1989) studies, "the value of particular acquisition activities must be defined relative to particular goals and purposes" (Morris, et al., 1977, p. 528).

Morris, et al., (1977) also highlighted the importance of looking beyond simple input retention as the representation of learning. Depending on the learning situation, individuals must learn from the inputs, rather than learning the actual inputs. For example, if the training is intended to teach assertiveness skills, it is not the actual situation that is important, it is the concepts behind the sample situation. This is an important distinction between the often used verbal learning studies in cognitive and instructional psychology, and the skill acquisition situations found in organizational settings. Under the verbal learning assumption that the outcome will be a test of the retrieval of the list of inputs, the deep processing notion makes sense. When one considers other types of learning outcomes, one also must consider the viability of other types of learning processes.

Barnett, Di Vesta and Rogozinski (1981) investigated the purpose of notes in an academic setting. Study experts usually recommend taking meaningful, or elaborated, notes on lecture material as a way to better remember the material. It was found that the students who elaborated on the material did worse on multiple choice tests constructed by the teacher. Students had not learned the material in the way in which it was tested. When the students wrote their own items, they could answer those much better at a later date if they had done the elaborative processing during note-taking. Barnett, et al., (1981) claimed support for transfer appropriate processing. They also found that the quality of the elaboration mattered. Students had to add conceptual material, not just lengthen the sentences in the notes. This experiment points to the content, or attentional function of the cognitive processes/learning strategies. The elaborations to the notes added material which was not covered on the test. On a teacher constructed multiple choice test, this additional information interfered with the retrieval of the original material. Similar results were reported by McKelvey and Lord (1986), as elaborative note-taking improved memory accuracy only when matched with similar retrieval situations.

Research in encoding and retrieval processes, such as transfer appropriate processing, has highlighted the importance of considering various types of information processing during learning. If a learner uses one type of processing during learning, that knowledge or skill may not be readily available under different retrieval, or test, conditions. Schmidt and Bjork (1992) noted the importance of the overlap of cognitive processes during training (acquisition) and processes necessary for test performance. They suggested that effective training will maximize the overlap between the processes. No single type of processing activities will work for all learning tasks. The following section examines various types of processing which are suggested to be useful in learning.

Cognitive Processes in Encoding

The literature concerning cognitive processes during the encoding and organization of information can be organized into two primary dimensions; a holistic, Gestalt approach, and a specific, detail oriented, data driven approach. Many psychologists have studied encoding processes in reading and arithmetic (e.g. Craik and Lockhart, 1972; Das, 1988; Kirby, 1988, Marton, 1988). Outside of the learning domain, Triesman uses a similar approach to describe encoding of letters (Triesman, 1986). Others have used comparable processes to describe the encoding of scenes and pictures (Henderson, 1992; Biedermann, 1990). Regardless of the perceptual subject, there is great consistency across approaches in the use of part-whole distinctions in the encoding and organization of information. There are many different labels for these dimensions (i.e. simultaneous/successive, holistic/atomistic), but they are essentially instances of these two categories.

Das (1988) described these two types of processing as simultaneous and sequential. In simultaneous encoding of information, separate pieces of information are combined into a meaningful, relational format. In successive processing, each piece of information is considered separately, and the information is placed into a temporally ordered sequence. Das diagnosed the skill levels of subjects on each of these two types of processing, and related their scores to performance on reading and arithmetic tests. Unfortunately, type of processing was not manipulated, and Das could not be sure which type of processing subjects were using during the performance tests. However, students who scored highly on the reading test were skilled at both simultaneous and sequential processing, and students who scored highly on the arithmetic test tended to be skilled in simultaneous processing. Simultaneous processing was strongly related to more advanced reading skills, such as comprehension of conceptual relationships. Das (1988) concluded from these results that sequential processing is less important for arithmetic skills, while both types of processing are needed in reading.

Marton (1988) distinguished between encoding processes described as holistic and atomistic approaches to learning. In the holistic approach, the learner encodes the material hierarchically, considering the material as a whole. Atomistic learners encode the material in a sequential fashion, focusing on the details (Marton & Saljo, 1984; Marton, 1988). For example, a chapter in a textbook may outline a principle, and then offer several instances of that principle. A learner taking the holistic approach would see the hierarchical relationships between the principle and the specific instances. The learner taking the atomistic approach could recall the principle and the instances, but would view them on the same level, as a list of temporally ordered facts with no apparent relationship (Marton, 1988).

These authors suggest that the two primary types of encoding processes are demonstrated across many learning situations. Comparing the ideas of Das and Marton with the findings of the encoding-retrieval interaction paradigm leads us to consider the retrieval situations, or types of learning outcomes, in which these different types of encoding processes might be appropriate. However, these general cognitive processes are difficult to use in an applied setting such as organizational training. These processes can better be thought of as constructs in learning, which can be operationally represented by learning strategies (Schmeck, 1983; Das, 1988). The literature on learning strategies as an operationalization of cognitive encoding processes is reviewed below.

Learning Strategies

Gagné, Briggs & Wager, (1992) define the learning strategy as "an internal process by which learners select and modify their ways of attending, learning, remembering, and thinking" (Gagné, Briggs & Wager, 1992, p. 66). Three categories of strategies directly related to learning are rehearsal, elaboration, and organizing. *Rehearsal* is a forced learning, repetitious procedure. *Elaboration* requires the learner to associate the new material with other, familiar material. *Organizing* strategies require the learner to find similarities and themes within the new material. This strategy differs from elaboration in that elaborative learning links the new material to already familiar material, while in organizing, links are found within the new material. There are also monitoring strategies which relate to goal setting and other activities useful for meeting learning objectives. These monitoring strategies are not directly related to the acquisition of knowledge or skills, and are similar to Kanfer and Ackerman's (1986) self-regulation category.

Gagné (1984) suggests that these categories of learning strategies are differentially useful in the acquisition of various learning outcomes, such as procedural skills or declarative knowledge. For a knowledge outcome such as verbatim reproduction of text, the learner does not go through the stages of learning that are typical for a more complex, or application outcome (i.e. composition and automaticity). The learner could use the rehearsal strategy to acquire the declarative knowledge (Gagné, 1984).

Schmeck defines a learning strategy as a set of procedures for accomplishing learning. While the majority of Schmeck's research has focused on learning styles rather than learning strategies, Schmeck (1983) notes that there are situationally specific factors of learning processes, as well as general tendencies. He suggests that a learning style is a predisposition to use a particular strategy across time and learning domains. Schmeck's (1988) classification of learning strategies is similar to that of Gagné, et al., (1992). Schmeck's categories are conceptualizing, personalizing, and memorizing. The conceptualizing strategy involves dealing with the abstractions in material. With this strategy, the learner focuses on the meaning of the material, as in Gagné's organizing strategy. Personalizing strategies call for integrating new material into personal experience, as with Gagné's elaboration strategy. Schmeck's memorizing strategy is simply the rehearsal of information, focusing on the given attributes and details, as in Gagné's rehearsal strategy.

The three categories of cognitive strategies (Gagné, et al, 1992; Schmeck, 1988) represent the two types of cognitive processing outlined above. Data-driven, detail oriented, sequential processing is represented by the rehearsal/memorization strategy. Learners using this strategy attend to the specific information present in the learning material, and direct their effort towards encoding the material as it is presented. Holistic, simultaneous processing is represented by the integrative, conceptualizing, personalizing strategies. Learners using these strategies are not bound by the material presented. They direct their effort toward understanding how the material fits in the bigger picture, either with previously learned information, or within itself. This structure is similar to the structure needed for proceduralization of skills. The focus is on learning relations among bits of information, rather than the bits of information by themselves.

The bulk of the learning strategy research has been conducted in the instructional psychology domain. Thus, the setting of the learning is traditionally the classroom, and the learning task is verbal. In learning style research, there is usually not a specific learning task; the researcher asks participants to respond to a questionnaire asking about typical learning habits (Biggs, 1993). Thus, learning strategies are differentiated from learning styles with a temporal dimension. The learning style is a tendency to use a particular strategy across many situations (Schmeck, 1983, 1988; Weinstein, 1986).

Many of the authors in the educational psychology literature do not acknowledge the importance of the task specificity of learning strategies. This disregard for task demands in educational psychology could be a result of an assumption of the experimental task; learning the content of a written passage. For example, Marton and Saljo (1976) addressed the issue of defining the learning content space, as what is learned is just as important, if not more important, than how much is learned. However, they attempted to define the content-oriented learning space hierarchically. Marton and Saljo (1976) concluded that "deep" processing is better than "shallow" processing, as the top of the hierarchy was the overall meaning of the passage, not specific details. Some researchers have used problem solving tasks (e.g. Dweck, 1986), but most have instructed subjects to read a passage, and report the content of that passage in one form or another.

Levin (1986) emphasized the "multiple objectives principle," where there is not one best overall learning strategy. Similar to the transfer appropriate processing argument of Bransford, et al., (1977), Levin suggests the 'best' learning strategy depends on the demands of the task. Investigation of learning strategies in the training domain requires the consideration of task characteristics, and Levin's multiple objectives principle. Different learning objectives require different learning strategies.

Learning strategies have been categorized into three main types; rehearsal, personalizing, and organizing (Gagné, et al., 1992; Schmeck, 1988). An individual can use any combination of these strategies in a given learning situation. However, no "one best" learning strategy has been identified across learning situations. The best strategy for a given situation depends on the learning objectives (Levin, 1986; Gagné, 1986). Unfortunately, learners are often unaware of the specific learning objectives. Such lack of clarity may hinder the selection of an appropriate learning strategy. In the following section, factors which affect the learner's selection of a learning strategy are investigated.

<u>Individual and Contextual Factors</u>

This section considers the factors leading to individual differences in the allocation of effort and use of different types of effort. Researchers have found evidence of roles for motivation, learning styles, and other personality constructs in the learning process (Biggs, 1992; Schmeck, 1982; Dweck, 1986; Kanfer and Ackerman, 1989; Kanfer, 1990). Several researchers have called for greater attention towards an interaction perspective on learning (Gagné, 1984; Biggs, 1993), which addresses influences from multiple sources on the learning process. Biggs (1993) also advocates this interactive perspective, cautioning researchers about the dangers of isolating learning in a 'vacuum,' as context aids in the explanation of the effects of learner motivation. Greater specificity in the description of this interaction between the learner and his or her environment will be useful (Gagné, 1984).

In the section below, aspects of both the learner and his/her environment will be reviewed. One individual difference variable which impacts the learning process is learning motivation. Contextually, the impact of the learning orientation and the learners' knowledge of the type of assessment will be investigated.

Learning Motivation

Researchers have identified a variety of motivational states related to the learning process. Dweck and her colleagues (Dweck, 1986; Dweck and Leggett, 1988) have identified two primary learning motivations; performance and mastery. With a mastery motivation, the learner is dedicated to increasing his/her competence with the task. The mastery learner is motivated to learn the task, regardless of the amount of effort required, or how he or she may look on the interim performance tasks. The mastery learner is motivated to actually learn the task, and acquire new knowledge or skills. Similarly, Biggs (1993) describes a learner who takes a deep approach to learning. This learner focuses on the meaning of the task, with the desire to perform the task properly and maximize understanding. Thus, the mastery goal and deep approach are task-focused.

In the performance goal situation, the learner is motivated to perform well. The performance goal learner is concerned about appearing competent at all times (Dweck, 1986). Thus, the performance oriented learner is concerned with non-task functions. Biggs (1993) discusses two types of non-task learning motives. The first is the achieving orientation, which is very similar to Dweck's performance goal. Students or trainees who take this approach to learning are interested in gaining recognition from performance. Biggs' second approach is surface learning, where the learner attempts to satisfice the task demands. The learner who takes this approach will seek to use minimal time and effort on the task, but still meet the requirements of the learning situation. Biggs' achieving and surface learning orientations share a focus on off-task learning motivations. With these orientations, the learner is not attempting to satisfy his/her desire to learn, but rather attain external rewards of recognition and/or evaluation.

These approaches to learning motivation can be summarized into two categories; task/mastery and ego/social (Farr, Hofman & Ringenbach, 1993; Meece, Blumenfeld & Hoyle, 1988). Task/mastery includes the task-focused orientations; Dweck's mastery goal, and Biggs' deep learning approach. The ego/social motivation encompasses Dweck's performance goal, and Biggs' surface and achieving orientations.

Kanfer and Ackerman's (1989) resource allocation model is useful to hypothesize how these learning motivations may affect the effort dedicated to the task, and thus the learning outcomes. Learners with an ego/social motivation allocate resources towards ego maintenance and external recognition as well as skill acquisition. With the task/mastery motivation, all resources are allocated towards skill acquisition/learning. A second distinction between the two goal types is the perception of the role of effort in learning. The ego/social learner believes that effort and ability are inversely related (Dweck & Leggett, 1988). If you have to try hard to learn something, you must have low ability. The task/mastery learner believes that effort and ability are positively related. If you really try hard, you can increase your ability. In terms of cognitive resource allocation, the ego/social learner is at a double disadvantage; not only are cognitive resources removed from the task for ego maintenance purposes, but effort is also decreased because of its perceived relationship with ability (Button, et al., 1994).

Awareness of Learning Outcomes

Learning strategies may be initiated either by internal factors such as learning motivation, or by external factors in the learning environment (Rigney, 1978). Awareness of the type of learning outcome should serve as a signaling factor to the learner. It is an aspect of the task environment which provides relevant information which can direct the learner towards the appropriate learning strategy. Situational demands of the learning environment have been demonstrated to influence learning behaviors (Meece, et al., 1988). In an ambiguous environment, the learner will not have such information, and will rely more heavily on internal factors such as motivation to select the type and amount of effort.

The awareness of the learning outcome may function in much the same manner as advance organizers. As stated by Ausubel (1968), "...the principal function of the organizer is to bridge the gap between what the learner already knows, and what he needs to know before he can successfully learn the task at hand" (p. 148). Advance organizers typically introduce the learner to the content of the to-be-learned material. Knowledge of the learning outcome can orient the learner towards the process necessary to learn the material.

Gagné, et al., (1992) provide an example of how the learning outcome can guide the selection and use of a learning strategy. Suppose the primary learning objective is for trainees to understand the concept of an electric circuit. Two possible outcome measures of this objective are 1) to state verbally what an electric circuit is, and 2) to assemble an electric circuit. Each outcome measure gives some indication of the trainee's understanding of an electric circuit. However, the specific learning objective will require the use of different learning strategies (Gagné, et al., 1992). The verbal statement of 'what a circuit is' would require only declarative knowledge, which could be acquired by rote memorization. The assembling of a circuit would require application, or the *use* of rules concerning current flow, which could better be acquired by organization or conceptualization strategies.

Learning strategies are a useful operationalization of the encoding processes utilized in learning. Rote memorization or rehearsal strategies represent data driven, sequential processing. Personalizing or conceptualizing strategies represent holistic, simultaneous processing. These strategies are differentially useful for acquiring different types of learning outcomes. As suggested by Gagné, et al., (1992), informing the learner of the objective allows him/her to select "particular strategies appropriate to the learning task and its expected outcome" (p. 189).

Summary: The Role of Effort in Learning

Kanfer, Ackerman and colleagues (Kanfer, 1990; Kanfer & Ackerman, 1989; Kanfer, et al., 1994) have expanded our understanding of the role of effort in skill acquisition. The Integrative Resource Model considers cognitive ability and motivation simultaneously, and examines their combined effects on skill acquisition and skill performance. The model posits that cognitive ability limits the amount of effort which can be devoted to any one task, and that proximal motivational processes are used to allocate effort between on-task, off-task, and regulatory processes (Kanfer, 1990). The model suggests that the allocation of attentional effort to regulatory processes such as goal setting early in skill acquisition decreases performance, because goal setting reduces the amount of effort which can be devoted to on-task processes. However, empirical support for the direct role of attentional effort in the acquisition of knowledge and skill is lacking in studies testing this model.

There is evidence that the use of goal manipulations in early skill acquisition reduces complex task performance (Kanfer & Ackerman, 1989). Kanfer and Ackerman (1989) also provide evidence to link cognitive ability and task performance. Few explicit links have been made, though, between attentional effort and performance. In their third experiment, Kanfer and Ackerman (1989) manipulated the type of initial learning of the trainees by providing trainees with procedural or declarative part-learning tasks. The stated intention of this manipulation was to alter the attentional requirements of the training. While the trainees in the declarative part-task condition did have increased knowledge of the rules of the Air Traffic Controller (ATC) task, the training condition did not have a direct effect on either the on-task or off-task attention of the trainees. Kanfer, et al., (1994) reported a significant relationship between goals and attention, and a significant relationship between goals and performance. They reported no evidence directly relating attention to performance.

Thus, something in the ATC task studies other than the amount of attentional effort directed towards the task must have affected the learning outcomes. The transfer appropriate processing literature (e.g. Morris, et al., 1977) suggests that the type of effort applied to the learning task affects performance on learning outcomes. Kanfer and Ackerman have looked at the distribution of effort across general categories of on-task, off-task, and self regulatory processes. It is the author's belief that the investigation of effort in skill acquisition and learning needs to go beyond general categories, and look into the "black box" of on-task effort.

In Kanfer and Ackerman's ATC training task, trainees who had learned with the declarative part-task condition performed better on the knowledge outcome than did trainees in the procedural part-task condition. This result is consistent with the themes of retrieval congruent encoding processes. Research from Tulving (1983), and Morris, Bransford and Franks (1977) has demonstrated the importance of matching encoding and retrieval processes. This paradigm provides suggestions as to why the type of cognitive effort used in learning is important. Two trainees who put forth the same amount of effort, but use different types of encoding processes or learning strategies, may perform differently on measures of learning. Similarly, one trainee may perform differently on two measures of learning because of the type of effort used during learning.

A Motivational Model of Learner Effort

The model of the role of effort in skill acquisition and learning proposed here incorporates elements of Kanfer and Ackerman's (1989) Integrated Resource Model with evidence from cognitive and instructional psychology concerning encoding-retrieval interaction. The conceptual model is presented in Figure 1. Learner effort during the learning process plays a primary role in the model, as both the amount of effort and type of effort are examined. In the instructional psychology literature, there have been several renditions of a systematic model of learning which includes various representations of the learning environment, learner characteristics, and task demands (e.g. Das, 1988; Biggs, 1993).

The primary learner characteristic in the model is learning motivation. The learning environment is represented in the model by learner knowledge of the type of learning outcome. Finally, the type of learning outcome is suggested to be a task demand characteristic which influences learner success.

Learner Effort

The two components of effort in the model are 1) amount of effort and 2) type of effort. Amount of effort is defined as the amount of cognitive, or attentional, resources devoted to the learning task. The type of effort is defined as the form of cognitive processing used during the encoding stage of the learning task. Both the amount and type of effort used by the learner are proposed to affect performance on learning outcomes. Greater amounts of effort devoted to learning are suggested to lead to better performance on a learning outcome. The type of effort suggested to lead to better performance on a learning outcome is dependent on the type of learning outcome. As highlighted by Morris, et al., (1977) and Schmidt and Bjork (1992), the cognitive processing used during learning should match the type of processing required by the learning outcome measure.

Learning Outcomes

Two types of learning outcomes are considered in the model. A knowledge outcome requires the learner to *know* things, such as facts or isolated pieces of information. An application outcome requires the learner to *do* things. This distinction is based on several typologies of training and learning outcomes (Bloom, 1956; Gagné, et al., 1992; Kraiger, Ford & Salas, 1993), as well as Anderson's (1982) ACT* theory.

Antecedents of Learner Effort

Biggs (1993) has developed a systems model of classroom instruction which includes environmental variables such as the teacher, the learning materials and the method of evaluation, and student variables such as interests and motivation. Both environmental variables and student variables are hypothesized to lead to changes in task processing, such as the types of cognitive processes used. Similarly, Das (1988) has suggested that the type of processing used in learning depends on task demands, learner preferences, and an interaction between the two. In the current model, one internal student factor (learning motivation) and one environmental factor (knowledge of learning outcome) will be considered.

Learning Motivation Kanfer and Ackerman (1989) suggest that motivational processes drive the allocation of attentional effort in skill acquisition. Thus, the primary learner or trainee factor in this model is learning motivation, which represents an individual's approach towards learning. With a task/mastery motivation, learners strive to increase their understanding of something new or their competence at a particular activity (Dweck, 1986; Button, et al., 1994). With an ego/social motivation, learners strive to protect their ego by performing well on learning indicators. Thus, the task/mastery motivation is internally focused, while the ego/social motivation focuses on external issues such as appearances.

In the proposed model, a task/mastery motivation is suggested to direct the learner towards strategies which are related to a deeper understanding of new material, such as the personalizing or organizing strategies. The task/mastery motivation is also suggested to cause the learner to devote greater effort to the learning task. Alternately, the ego/social motivation is suggested to direct the learner towards strategies which will allow the learner to perform best on the learning assessment test. The ego/social motivation will also cause the learner to devote less effort to the learning task, as the learner will have increased off-task thoughts. A desire to demonstrate competence through minimal time on task will also reduce the amount of effort put forth by the ego/social learner (Dweck, 1986; Button, et al., 1994).

<u>Awareness of Learning Outcomes</u> The awareness of the type of learning outcome is expected to affect the amount and type of effort put forth by the learner. Biggs (1992) suggests that assessment methods affect learner processing. Students' perceptions of the forthcoming assessment procedures, accurate or not, will alter students' approaches to learning. Gagné, et al., (1992) suggest that the specification of learning objectives allows the instructor to match the instructional approach to the desired learning outcome. The same should hold true for the learner; the specification of the desired learning outcome, and the method of measuring that outcome, allows the learner to adjust his/her approach to learning.

D'Ydewalle and Swerts (1980) instructed students to study short history texts, and informed them they would take either a multiple choice test or a test with open-ended questions. They found that students who took the type of test they had expected performed better than students who received the unexpected test. D'Ydewalle and Swerts (1980) hypothesized that students who had expected the open-ended questions studied "more intensively" than students who had expected the multiple choice test. While both types of tests in this study were forms of declarative knowledge, the findings lend support to the proposed links between awareness of learning outcomes, effort, and performance.

Hypotheses

The hypotheses in this section have been derived from the model presented in Figure 1. In the first section of hypotheses, a moderating role for type of effort is proposed. It is hypothesized that the relationship between amount of effort and learning outcome performance is moderated by the type of learning effort utilized (see Figure 2). The second section of hypotheses details the individual links in the model which affect the amount and type of effort . This operational model of effort in learning and skill acquisition is presented in Figure 3. Third, the mediator relationships implicit in the model are discussed. Finally, the role of cognitive ability in the model is discussed.

Moderating role of type of effort

Research indicates that more time on the task and greater on-task attention lead to higher performance on a learning outcome (e.g. d'Ydewalle & Swerts, 1980). However, this relationship should be moderated by type of effort (see Figure 2). According to Kanfer (1990), motivational processes can fail to affect performance if an individual misdirects his/her effort. In other words, not all effort is equal. A learner must utilize the right type of effort. In the current model, both amount of effort and type of effort are posited to affect performance on learning outcome tasks. The use of the

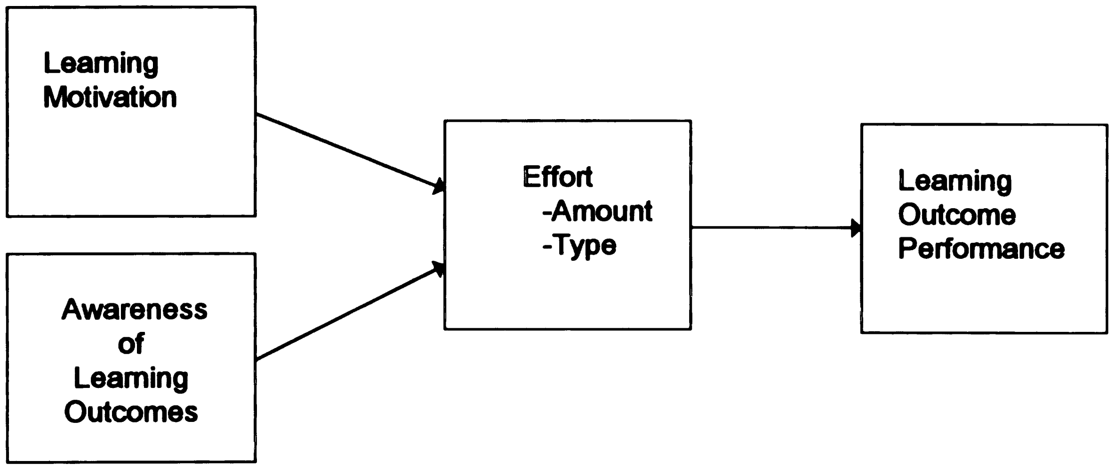

Figure 1: Conceptual Model of the Role of Effort in Learning and Skill Acquisition

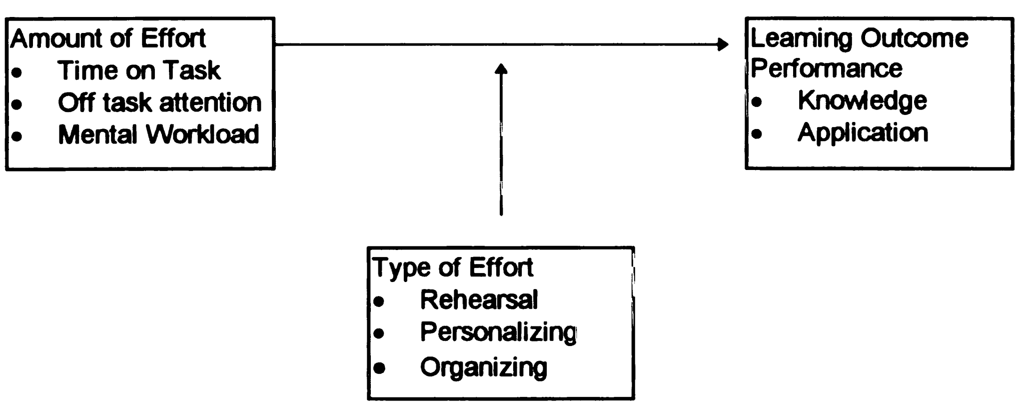

Figure 2. Proposed Moderator Relationship

appropriate, or congruent, type of effort is expected to lead to a more successful learning outcome.

In Anderson's (1982) ACT* framework, rehearsal learning strategies facilitate the acquisition of declarative knowledge. Facts are studied and retained. Further processing is required to facilitate the acquisition of procedural knowledge. The facts, or declarative knowledge, must be compiled into propositions, or knowledge representations which focus on the relationships between facts. The use of rehearsal learning strategies facilitates performance on a declarative learning outcome. For a procedural outcome, the learner must go beyond rehearsal strategies, and incorporate personalizing and/or organizing strategies as well (see Figure 3). It is suggested that the use of rehearsal strategies allows the learner to acquire declarative knowledge, but one or both of the more integrative strategies must also be used to acquire procedural knowledge, or the ability to apply the knowledge. More specifically, high performance on an application outcome requires the use of personalizing and/or organizing strategies. In any learning situation, a learner may use any of the three learning strategies. Only strategies congruent with the learning outcome measure are expected to impact performance on the outcome measure.

Within type of effort, amount of effort is suggested to impact the learning outcome. When a learner uses a rehearsal strategy to prepare for a knowledge test, he or she must devote some amount of effort to the learning task. Users of learning strategies that are congruent with the learning outcome, who exert greater effort towards learning, will perform better than those who exert little effort. Users of incongruent learning strategies will not perform well on the learning outcomes, regardless of the amount of effort.

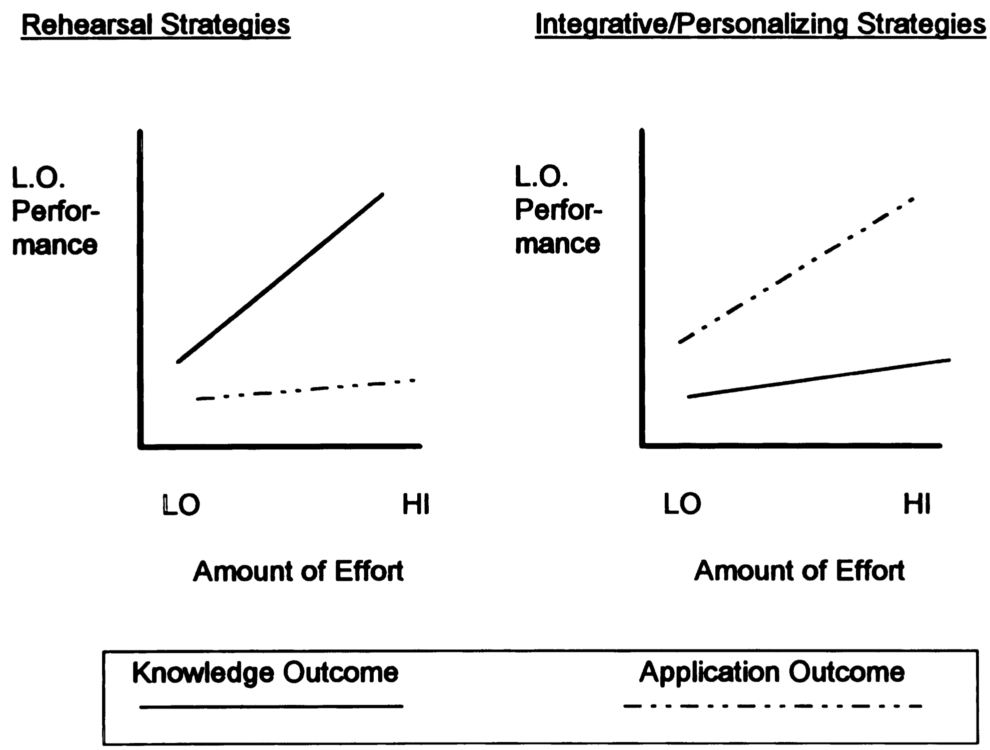

Figure 3: Hypothesized Relationships Among Type of Effort, Amount of Effort, and Learning Outcome Performance

H1: Type of effort is hypothesized to moderate the relationship between amount of effort, as measured by time on task and on-task attention measures, and performance on learning outcomes. Specifically, amount of effort will be strongly related to performance when a congruent strategy is used (i.e. rehearsal strategies for a knowledge test, or personalizing/organizing strategies for an application test). When an incongruent strategy is used (i.e. only rehearsal strategies for an application test), amount of effort will have little impact on performance. When personalizing/organizing strategies are used for a knowledge test, amount of effort will have a moderate impact on outcome performance.

Antecedents of Learner Effort

The following section presents hypotheses regarding the effects of learning motivation and awareness of learning outcomes on both amount and type of effort. The links among these variables are displayed in Figure 4.

Link I: Learning motivation ---> amount of effort

The model posits that learning motivation impacts the amount of effort devoted to the learning task. Trainee learning motivation leads to decisions of how much time will be devoted to a task such as skill acquisition (Kanfer, 1990; Kanfer & Ackerman, 1989). Motivation also affects the distribution of attention between on task and off task activities (Button, et al., 1994). Since an individual's attentional resources are limited (Kanfer & Ackerman, 1989), each learner makes choices concerning how the resources are allocated. A high ego/social motivation will lead to decreased effort because

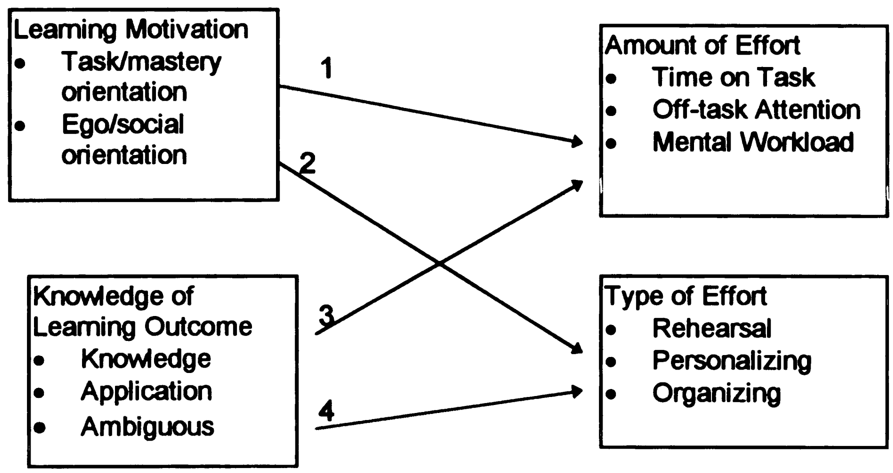

Figure 4: Antecedents of Learner Effort

attentional resources are diverted to ego-protection processes; learners focus on task difficulty and normative evaluations of their performance (Farr, et al., 1993). In addition, a high ego/social motivation is associated with a state notion of ability (Dweck, 1986). While task/mastery motivated individuals believe ability can be improved through effort, high ego/social individuals tend to believe that high effort is an indication of low ability. Therefore, learners with a high ego/social motivation will try to protect the ego by minimizing the amount of effort devoted to the task (see Figure 5).

H2a: Learners with a high task/mastery motivation will be likely to devote high amounts of on-task effort, as measured by time on task, off-task attention, and mental workload. Task/mastery orientation will have a direct, positive effect on amount of effort.

H2b: Learners with a high ego/social motivation will be likely to devote very little on-task effort, as measured by time on task, off-task attention, and mental workload. Individuals with a high ego/social motivation are predicted to have high off-task attention. Ego/social motivation will have a direct, negative effect on amount of effort.

H2c: Learners with low task/mastery and low ego/social motivations are predicted to devote little on-task effort, as measured by time on task, off-task attention, and mental workload. These individuals will not have the positive motivation of the high task/mastery individuals, but neither will they experience the distracting effects of high off-task attention.

H2d: Learners with high task/mastery and high ego/social motivations will be likely to devote a moderate amount of on-task effort, as measured by time on

Ego/social Orientation	Task/mastery orientation: Low	Task/mastery orientation: High
Low	Low effort	High effort
High	Very low effort	Moderate effort

Figure 5. Hypothesized relationships among learning orientations and amount of effort.

task, off-task attention, and mental workload. These learners will devote substantial effort to the task, but will continue to devote resources to ego maintenance. Thus, the net result will be more effort than either of the low task/mastery categories, but not as much as those high in task/mastery orientation and low in ego/social.

Link 2: Learning motivation —> type of effort

Meece, et al., (1988) have suggested that learning motivation can directly influence the selection of learning strategies. Individuals with a high ego/social motivation are primarily concerned with doing well on the learning outcome task, and should be more likely to select a strategy that will lead to high performance on the outcome. With a declarative learning outcome, the ego/social motivated learner will use rehearsal strategies. With an application outcome, the ego/social motivated learner will use primarily personalizing and organizing strategies.

The learner who is motivated primarily by task/mastery, regardless of the awareness of a declarative task, will process deeply because of the overriding motivation to really learn the material. In the ambiguous outcome situation, ego/social motivated learners should use a strategy at which they are competent to protect the ego. Schmeck (1988) suggests that mastery learners are more likely to use conceptualizing and personalizing strategies.

H3a: Task/mastery motivated learners are predicted to use organizing or personalizing strategies. There will be a direct, positive relationship between task/mastery motivation and organizing and personalizing strategies.

H3b: Learners with a high ego/social motivation are predicted to adapt to the demands of the outcome task. With a knowledge outcome, they would focus on rehearsal. With an application outcome, they would use a personalizing or organizing strategy. Thus, there is no direct relationship predicted between the learning strategy and learning motivation for high ego/social learners.

Link 3: Awareness of outcome — amount of effort

Procedural knowledge requires the acquisition of initial declarative knowledge, and then the compilation of that knowledge into proposition form (Anderson, 1983). Thus, acquisition of declarative knowledge should require less effort than acquisition of application type knowledge. From Bloom's (1956) perspective, an application outcome is more complex than a knowledge outcome. Thus, it could be expected to require greater effort to attain the higher level outcome.

H4a: Awareness of an application outcome is predicted to require greater investment of on-task effort, as measured by time, off-task attention, and mental workload.

H4b: The awareness of a knowledge outcome is predicted to require less effort investment, as the learner must only go through one stage of acquisition.

Link 4: Awareness of outcome —> type of effort

It has been suggested that prior knowledge of learning outcomes will allow the learner to utilize a learning strategy, or type of effort, which is congruent with the learning outcome. (Barnett, et al., 1981; Gagné, 1984). Awareness of an application or knowledge test at the end of the training session should allow the learner to orient his or her learning strategies toward that outcome. The learner should use rehearsal strategies to acquire the basic, factual knowledge, as well as an organizing or personalizing approach to create the links between pieces of information. While mastery oriented learners are predicted to always use organizing and personalizing strategies, they may use these complex strategies to a greater extent in the face of an application test. They may also use more rehearsal strategies than they would normally use in the face of a knowledge test.

H5a: Awareness of a knowledge test is predicted to be associated with learner strategies of rote memorization and rehearsal.

H5b: Awareness of an application test at the end of the training session will be associated with the use of rehearsal strategies, as well as an integrative strategy and/or a personalizing strategy.

Mediator Relationships

In the organizing model (Figure 1), learning motivation and awareness of learning outcomes are depicted as affecting outcome performance only through their effects on amount of effort and type of effort. Thus, the effort constructs serve as mediators in the conceptual model. However, type of effort is also proposed to moderate the relationship between amount of effort and outcome performance. Initially, only the mediation role of amount of effort will be tested. The mediation role for type of effort will only be tested if the moderator tests fail. The model presented in Figure 1 likely contains errors of specification (James & Brett, 1984). There are unmeasured variables which potentially are relevant to the model, such as previous experience with, and interest in, the subject area. However, the inclusion of these additional variables is beyond the scope of the present study. Thus, the mediation relationships must be investigated in an exploratory manner, and results interpreted cautiously (James & Brett, 1984).

Cognitive ability

While cognitive ability has not been specifically addressed in the above model or hypotheses, it surely plays a role in the learning process. To eliminate one source of specification error, cognitive ability will be included in this research. Kanfer and Ackerman's resource allocation model suggests that cognitive ability limits the amount of effort available for any given task. Kanfer and Ackerman (1989) found a relationship between ability level and allocation of effort. Specifically, they found that low ability subjects devoted more effort to off-task activities such as spontaneous goal setting and negative self-thoughts. Kanfer and Ackerman have also suggested that cognitive ability is a significant factor in performance during early stages of skill acquisition.

Other researchers have suggested a relationship between cognitive ability and cognitive flexibility. This link would indicate that high ability individuals are more likely to adapt to the situation and use an appropriate learning strategy. In a review of the advance organizer literature, Mayer (1979) concluded that high ability learners did not benefit from the use of an advance organizer because they were already good at assimilative learning, which was deemed most appropriate for the tasks involved in the advance organizer literature. Thus, Mayer suggested that high ability learners are better able to adapt to the demands of the task, and use a more appropriate learning strategy.

However, other researchers (Dweck & Leggett, 1988; Meece, et al., 1988) have found no relationship between cognitive ability and learning goal orientation. In addition, cognitive ability is not related to the experimentally manipulated variable, awareness of learning outcomes, in this study. It is clear that cognitive ability should play some role in the proposed model. However, it could affect several different relationships in the model. Thus, this research will examine relationships between cognitive ability and amount of effort, type of effort, and learning outcome performance in an exploratory manner. Cognitive ability will be covaried out of the regression analyses.

METHOD

Participants

The participants in this study were 121 undergraduate students recruited from the Psychology Department subject pool at Michigan State University. The use of 121 subjects allows for power of .80, with eight independent variables, and alpha level of .05, assuming a medium effect size (Cohen, 1992). The inclusion of three interaction terms in the moderator regression analyses substantially decreases the power of the tests. Due to resource constraints, the sample size was held at 121, and significance tests for the moderated regression will be interpreted cautiously. Effect sizes will also be examined closely due to the low power for these tests.

Independent Variables

Cognitive Ability - The 50 item Wonderlic Personnel Test was used to measure general cognitive ability (see Appendix A). The Wonderlic is an individually administered pencil and paper test with a 12 minute time limit. Test-retest reliability estimates for the Wonderlic range from .82-.94, and the internal consistency reliability (KR-20) is estimated at .88 (User's Manual for the WPT and SLE, 1992).

Learning Motivation - Two 8 item measures of learning and performance goal orientations developed by Button, Mathieu and Zajac (1994) were used to measure learning motivation (see Appendix B). Structural equation modeling evidence supports the existence of two distinguishable dimensions, learning goal orientation and performance goal orientation, between which exists a non-significant correlation. The learning goal, or task/mastery orientation, scale has internal consistency reliability ranging from .79 - .85 (Button, et al., 1994). A sample item from the learning goal orientation scale is: The opportunity to learn new things is important to me. The performance goal, or ego/social, orientation scale has internal consistency reliability ranging from .68 - .82. A sample item for this scale is: I like to work on tasks that I have done well on in the past. A five-point rating scale ranging from (1) = "Strongly Disagree" to (5) = "Strongly Agree" is used for both Learning Motivation measures.

Awareness of Learning Outcomes - Participants were randomly divided into three groups regarding the awareness of the type of learning outcome. One third of the participants were informed at the beginning of the experiment that they would take a multiple choice test after they learned the materials. This was the knowledge, or declarative, condition. One third of the participants were told they would take a test consisting of ten problems. This was the application condition. The remaining third of the participants were simply told they would take a short test on the materials. This was the ambiguous condition, and served as a control.

Amount of Effort - The amount of effort devoted to the learning task by the participants was measured in three ways. First, a measure of time spent learning (in minutes) was taken. Second, a 13 item measure of Off-task Attention, adapted from Kanfer, et. al., (1994) was used to measure the amount of off-task mental effort (see Appendix C). Kanfer, et al.'s (1989) Off-task thoughts scale had six items concerning mental activities such as daydreaming and loss of interest while performing the task. This scale had an internal consistency reliability of .59. The 4 item Affective thoughts scale contained items concerning negative self-evaluations during task performance. This scale had an internal consistency of .78.

The Off-task thoughts and Affective scales were modified for the purposes of this study. The two scales were combined to form the Off-task Attention scale. The distinction between these scales is not relevant in this study, as affective thoughts can be categorized as off-task effort; mental effort not directed explicitly towards learning the materials. Three additional items were written to reflect thoughts about both the learning task and the future performance task, for a total of 13 items. Increasing the number of off-task attention items increased the internal consistency reliability of the measure to .87. A sample item from the Off-task Attention scale is: I took 'mental breaks' while learning. A five-point rating scale ranging from (1) = "Never" to (5) = "Constantly" is used for the Off-task Attention measure.

The third measure of amount of effort is mental workload. This measure was adapted from the NASA-TLX scale (Hart & Staveland, 1988). A six item scale was written to reflect relevant dimensions from the set of ten rating scales used by Hart and Staveland. Items regarding physical effort were discarded, as were items which were conceptually too similar to off-task attention. Relevant dimensions include mental demand, perceived effort, mental fatigue, and an overall rating of perceived workload. Test-retest reliability for the NASA-TLX has been estimated at .83 (Hart & Staveland, 1988). A five-point rating scale ranging from (1) = "Strongly Agree" to (5) = "Strongly Disagree" is used for the Mental Workload measure. A sample item for this scale is "Learning the stock price prediction materials required a lot of mental activity."

Type of Effort - The type of cognitive effort used in the learning task by participants was measured in two ways. First, participants responded to a 17 item questionnaire concerning the learning strategies they used during the experiment (see Appendix D). Each strategy (rehearsal/memorizing, elaboration/personalizing, and organizing/conceptualizing) is comprised of multiple tactics, or specific behaviors which can be used to accomplish the learning objective (Schmeck, 1988; Gagné, et al., 1992). Trainees can accomplish each learning strategy through a variety of specific behaviors.

The Learning Strategy scale for this study was adapted from the Inventory of Learning Processes (ILP), created by Schmeck (1983). Internal consistency estimates for the ILP scales ranged from .58 for the Fact Retention scale to .82 for the Deep Processing scale. Test-retest reliabilities for the ILP scales ranged from .79-.88 (Schmeck, 1983). The ILP includes many items directed toward the general study habits and capabilities of students. These items were not used in this study. Only items pertaining to the "on-line processing" (Biggs, 1993) used during learning were retained. Items from the ILP deep processing factor (Schmeck, 1983) represent the organizing/conceptualizing strategy. Items from the methodical study factor represent rehearsal, and items from the elaborative processing factor represent the elaboration/personalizing strategy. These classifications are supported by Schmeck (1988). Several additional items were added to the Learning Strategy scale based on examples of learning strategies provided by Gagné, et al., (1992).

The Learning Strategy scale contains five items representing rehearsal, or memorizing strategies. This category consists of verbal or mental repetition, with a focus on specific details. A sample item is: I tried to remember exact words or phrases used in the materials. There were six items representing each of the remaining two learning strategies. Activities in the elaboration/personalizing strategy include paraphrasing and generating questions with answers. A sample item is: I created my own examples. Organizing/conceptualizing tactics include organizing material into a chart or diagram, or making lists of related ideas. A sample item is: I made lists of associated ideas. A five-point rating scale ranging from (1) = "Never" to (5) = "Constantly" is used for the Learning Strategies measure. Learning strategies will be treated as three distinct variables. It is possible that one learner could use all three strategies, or limit him/herself to just one of the strategies.

Second, participant learning materials were examined for written evidence of learning strategies used by the participant. A similar method was used by Howard-Rose and Winne (1994), in which traces, or written evidence of particular cognitions, were coded into 10 components with an interrater agreement (Kappa coefficient) of .75. The traces in this study were content coded into only three components; rehearsal, elaboration, and organizing, using a three point scale ranging from 0 (no evidence of this strategy) to 2 (strong evidence of this strategy). Traces were coded by the author and two trained undergraduate students. Work done on the sample problem provided in the learning materials was also coded. If the participant had correctly completed the problem, that was scored as a 2. Attempted but incorrect problems were scored as a 1, while unattempted problems were scored as 0.

<u>Dependent Variables</u>

Knowledge Learning Outcome - The knowledge learning outcome is an 18 item multiple choice test, with five options per item (see Appendix E). This test requires participants to recognize the correct factual response to a question about stock prices or general regression. These items were developed directly from the learning materials, and focus on facts which were found in the text of those materials. A sample item from this measure is: The companies list their stocks on the following stock exchange: a) NYSE b) OTC c) NASDAQ d) CBOT e) AMEX. The knowledge outcome measure was scored in number of correct answers.

Application Learning Outcome - The application learning outcome required participants to predict stock prices of ten fictional companies, using the performance data for each division of each company and the rules for determining the values for beta weights for each term (see Appendix F). These rules forced participants to choose between three possible beta weights for each term, depending on the value of the performance term. Participants were provided with data for the quarterly performance of three divisions of the companies. Participants were then required to apply multiple regression procedures to estimate the future price of the stock. The problems varied in difficulty. Some of the problems required use of only one beta value rule, some problems required use of two rules, and others required use of all three rules. Several problems presented the participant with performance data from four divisions, and he/she was to select the three correct divisions. The application outcome was also scored in number of correct answers.

<u>Learning Task</u>

The learning materials (see Appendix G) were based on the task used by Earley, Connoly and Ekegren (1989). Earley, et al., (1989) asked participants to predict stock prices for 100 fictional companies, given performance data for three divisions in each company. Feedback was given to the participants, in the form of the correct stock price, as they tried to improve their prediction accuracy. In the version of the Stock Price Prediction task used in this study, participants were asked to learn the prediction method (multiple regression) prior to the learning outcome test.

The task required participants to read a one page fictional description of how investment counselors make stock price predictions for their clients. The second page of learning materials details how multiple regression could be used to predict stock prices. Multiple regression is explained in non-technical terms, and a brief example is provided. Both pages include many facts, some of which relate to the actual prediction of stock prices, and others which are to be tested in the knowledge learning outcome.

This task provided several desirable conditions for testing the hypotheses in this study. First, the participants in this study, undergraduate psychology students, were unlikely to be familiar with the content area of the task. They should not have been able to answer the knowledge items or successfully predict stock prices from prior knowledge. Thus, in accordance with the earlier discussion of boundary conditions for skill acquisition tasks (see page 7), the Stock Prediction task should have placed the participants in the early stages of learning. Second, the stock prediction task allowed for variance in both amount of effort and type of effort. Each participant was free to use whatever methods of learning he/she desired, and spend as much time on the learning segment as he/she desired. The task was considered to be resource-dependent, where success on the learning outcome task depended to some extent on the effort allocated to the learning portion of the task.

Third, there were clear distinctions between the knowledge and application learning outcome measures. In the knowledge outcome, the participants recognized a variety of simple facts concerning stock prediction and multiple regression. In the application outcome, participants selected relevant information using a series of rules, and performed multiple regression on performance data from fictional companies. Thus, high performance on the application outcome required use of the rules found in the learning materials in a new situation. Stock price prediction is a higher order rule as described by Gagné, et al. (1992). Successful prediction requires a combination of several simpler rules, i.e. the rules for a regression equation, beta weight selection and relevant performance data. It is one thing to recognize the answer to a question about the definition of a beta weight. It is quite another matter to know and apply the rules, or relations among facts, to produce an accurate stock price prediction.

Experimental Procedure

Participants first took the Wonderlic Personnel Test, and the Learning Orientation Questionnaire. Participants were then placed in rooms individually, and were instructed to take as much time as they needed to learn the Stock Prediction Task materials. Isolating participants from one another during the learning portion of the experiment was intended to reduce the chances of contamination of amount of effort as measured by minutes spent learning. If the participants were in a group setting during learning, they could have taken cues from one another concerning time spent learning. Keeping participants separate at this point was intended to increase the between subjects variance on amount of effort. Participants individually indicated when they felt they had sufficiently learned the material. The length of time elapsed during learning, in minutes, was recorded for each participant.

Upon completion of the learning portion, subjects completed the Off-task Attention measure, the Learning Strategies measure, and the Mental Workload measure. Completion of the effort measures at this time was intended to allow the participants to most easily and accurately report their thoughts and mental processes during the learning of the stock prediction materials. In addition, participant reactions to the Learning Outcome measures could not affect participant motivation to respond accurately to the effort measures. Following the effort measures, participants were given the learning outcome measures.

Awareness of Learning Outcome Conditions

Participants were informed prior to beginning the task that upon completion of the learning segment, they would either 1) take an 18 item multiple choice test (knowledge condition) 2) predict stock prices for 10 companies (application condition) or 3) take a short test (ambiguous condition). All participants were given both tests; the order of the tests depended on the experimental condition. In the knowledge and application conditions, the announced test was be given first, followed immediately by the other test. In the ambiguous instruction condition, the order of the tests was randomly counterbalanced across the participants in that cell.

Pilot Study

A pilot study was conducted prior to the full study. Participants were 38 undergraduates recruited from the Psychology Department subject pool at Michigan State University. The pilot study was conducted in three groups of approximately 10-15 subjects. All subjects in each group were assigned to the same experimental condition. Subjects in the pilot study were not asked to complete the Wonderlic Personnel Test or the Learning Motivation questionnaire. In addition, three subjects in each group were randomly selected to participate in a structured interview after the learning outcome measures had been completed.

The pilot study was used primarily to investigate the strength of the Awareness of Learning Outcome manipulation, and the degree to which the manipulation affects participants' attitudes toward the second learning outcome. It is possible that asking participants to complete a second learning outcome, one that is not the type of test for which they had prepared, could create negative affect and reduce motivation to perform well on the second Learning Outcome measure. Data collected in the post experimental interviews indicated this was not the case. None of the interviewees indicated any negative reactions to the two tests.

The pilot study was also used to evaluate the completeness of the Learning Strategy questionnaire. It is possible that participants would use specific learning tactics which were not listed on the questionnaire. While there is an open-ended question on the Learning Strategy questionnaire, the author believes participants are more likely to respond to an item listed on a questionnaire than write in their own response. As a result of the pilot study, several items were dropped because of low variability, and two additional items were written for the rehearsal subscale.

As a result of the pilot study, additional material was added to the task, and items were added to the knowledge outcome. A fifth distracter was also added to each item. The application outcome appeared to be an adequate measure, so no changes were made. Results of the pilot study are presented in Appendix I.

RESULTS

The results of this study are reported in two parts. First, the adequacy of the measures is examined. This includes factor analyses, reliability of the measures, content coding of relevant variables, and intercorrelations of the variables. Second, the hypotheses of the study are tested using a series of univariate multiple regression procedures.

Adequacy of Measures

Factor Analyses. Factor analysis was performed on the measures of learning orientation and type of effort. The learning orientation measure was hypothesized to contain two distinct factors; task/mastery motivation and ego/social (performance) motivation. A common factor analysis (Principal factors extraction, Oblimin rotation) supported this structure. The eigenvalues and factor loadings are presented in Table 1. The results of the factor analysis support the hypothesized two factor structure of the orientation measures. Factor 1 represents ego/social orientation, and Factor 2 represents task/mastery orientation. A third factor had an eigenvalue of less than 1.00 (.96), and was discarded.

The type of effort questionnaire is hypothesized to measure three different learning strategies; rehearsal, personalizing, and organizing. Thus, three factors are expected. No specific pattern of correlations is expected among the three factors. A common factor analysis (Principal factors extraction, Oblimin rotation) supported this structure. The eigenvalues and factor loadings are presented in Table 2. The results of the factor analysis supports the three factor structure of the learning strategies questionnaire. Factor 1 primarily represents the personalizing strategy. One item from the organizing strategy loads most highly on this factor, but none of the loadings for the item are strong. Factor 2 represents the rehearsal strategy. Factor 3 represents the organizing strategy. A fourth factor was discarded because the eigenvalue was less than 1.00 (.88).

The two self-report measures of amount of effort, Mental Workload and Off-task Attention, were factor analyzed. Given the strong correlation between the variables, it is possible that these two measures are tapping into the same construct. A common factor analysis (Principal factors extraction, Oblimin rotation) supported the existence of two separate constructs. Eigenvalues and factor loadings are presented in Table 3.

The first factor has an eigenvalue of 6.1, and measures Off-task Attention. The second factor has an eigenvalue of 1.97, and represents Mental Workload. A third factor has an eigenvalue of 1.48. By Kaiser's rule of retaining all factors with eigenvalues over 1.00, this third factor should be retained. This third factor would contain five items from the Off-task Attention scale; items 6, 7, 8, 9, and 10. These are all items which deal with thoughts completely unrelated to the experimental setting. The Off-task Attention scale was intended to capture any non-learning related thoughts. No distinction was made between test-related thoughts and daydreaming, for instance. The factor analysis demonstrates that the Off-task Attention items are distinct from the Mental Workload items. The two factor solution presented in Table 3 reduces the number of negative factor loadings, and is a more parsimonious solution. Thus, the two factor solution will be retained for the purposes of this research.

Table 1

Factor Loadings for Learning Orientation Scales

	Factor 1	Factor 2
Eigenvalue	3.9	2.9
Learn9	.73	.03
Learn12	.72	-.12
Learn16	.71	.03
Learn14	.70	-.12
Learn11	.69	-.12
Learn10	.65	.03
Learn13	.63	-.14
Learn15	.50	.08
Learn5	-.02	.74
Learn6	.08	.68
Learn7	-.20	.67
Learn1	-.04	.65
Learn3	.25	.61
Learn8	.07	.57
Learn4	-.21	.48
Learn2	-.11	.32

Note:
Items Learn1 to Learn8 were intended to measure Task/mastery orientation, and items Learn9 to Learn16 were intended to measure Ego/social orientation.

Table 2

Factor Loadings for Learning Strategy Scales

	Factor 1	Factor 2	Factor 3
Eigenvalues	3.5	1.88	1.3
P6	.74	.05	-.02
P2	.73	.03	.23
P5	.72	.05	.03
P1	.52	-.01	-.09
P4	.48	-.11	-.32
P3	.45	-.09	-.25
O1	.27	.05	-.21
R5	-.05	.76	.03
R1	.03	.64	-.04
R2	-.13	.59	-.11
R4	.10	.53	.09
R3	.04	.48	-.04
O3	-.14	.14	-.87
O4	-.11	-.05	-.84
O5	.15	.12	-.38
O2	.12	.03	-.38
O6	.16	-.01	-.27

Note:

R = item from rehearsal scale
O = item from organizing scale
P = item from personalizing scale

Table 3

Factor Loadings for Off-task Attention and Mental Workload Scales

	Factor 1	Factor 2
Eigenvalue	6.1	1.9
A12	.68	-.09
A7	.68	.19
A8	.67	-.12
A10	.66	.02
A9	.62	.06
A2	.57	.09
A1	.54	.04
A4	.53	-.17
A3	.51	-.06
A5	.48	-.01
A11	.48	-.39
A13	.46	-.19
A6	.30	-.19
WL6	-.01	.81
WL2	-.14	.76
WL3	.06	.70
WL4	-.17	.68
WL5	.14	.63
WL1	-.28	.57

Note:
A = item from off-task attention scale
W = item from mental workload scale

<u>Intercorrelations and Reliabilities.</u> Correlations among all independent and dependent variables are presented in Table 4. Summed scale scores were used to calculate correlations. All scales are coded such that a high score reflects a larger amount of that construct. Internal consistency reliabilities (coefficient alpha) for all scales appear on the diagonal of the matrix. All reliabilities were in the acceptable range (above .70) with the exception of the knowledge test. The reliability of this 18 item, dichotomously scored test was .65. There is no reliability estimate for the measure of time. The reliability for the cognitive ability measure, the Wonderlic, was based on information from the test publisher ("Wonderlic Personnel Test," 1992).

While it was expected that the two dependent variables, knowledge and application tests, were distinct learning outcomes, the two measures were positively correlated ($r = .36$, $p<.01$). The reliability of the knowledge test was also less than desirable ($\alpha=.65$). The correlation corrected for this unreliability increases to .47. The correlation was not significantly attenuated by partialling out cognitive ability ($r = .32$, $p<.01$).

Correlations among the amount of effort variables ranged from .02 to -.48. Off-task attention and workload were most strongly related, while time and workload were unrelated. Correlations among the type of effort variables ranged from .07 to .40. Personalizing and organizing were most strongly related, while rehearsal and personalizing were minimally related.

Cognitive ability was associated with few of the variables of interest. Cognitive ability was negatively correlated with time spent learning, and positively related to mental workload, but was unrelated to off-task attention. It was positively correlated with performance on both the knowledge test ($r = .27$) and the application test ($r = .23$).

Cognitive ability was not related to task/mastery or ego/social orientation, nor was it related to the use of learning strategies.

Content Coding. In addition to the self-report measures of learning strategies, four measures were coded from the participants' learning materials. First, rehearsal, organizing and personalizing strategies were coded from the markings made by the participants on their materials. The interrater reliability of these measures with three raters was acceptable (rehearsal .89, organizing .91, and personalizing .74). However, these measures did not demonstrate acceptable construct validity. The coded measures correlated much more highly among themselves than with the corresponding self-report measures. The correlation matrix is presented in Table 5. In addition, the patterns of correlations with other variables differ substantially. For example, the knowledge test correlates positively with the self-reports of both organizing and personalizing, and does not correlate with rehearsal. In contrast, the knowledge test is moderately correlated with the rehearsal trace, and not significantly correlated with organizing or personalizing. It appears that the trace measures may be tapping a different construct, such as tendency to write while learning. Because of the lack of evidence for validity as cognitive learning strategies, these measures were not used in further analyses.

The final measure of learning strategies was the coding of completion and accuracy of the sample problem. Working the sample problem was positively associated with performance on the application test. It was not associated with any of

Table 4: Scale Intercorrelations and Reliabilities:

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Perf Orient	31.5	4.81	(.82)											
2. Mast Orient	32.8	3.31	-.10	(.73)										
3. Time	13.6	4.48	-.10	.13	---									
4. Off-task atten	30.5	8.31	.34*	-.17*	-.15	(.87)								
5. Workload	20.3	4.81	-.11	.21*	.02	-.48	(.87)							
6. Rehearsal	17.9	3.40	.23*	.10	.08	.17	-.06	(.73)						
7. Organizing	15.4	4.13	.03	.14	.36*	-.17*	.13	.20*	(.71)					
8. Personali-zing	12.9	4.86	-.20*	.29*	.10	-.20*	.18*	.07	.40*	(.80)				
9. Worked Sample	1.33	.79	.03	-.07	.20*	-.13	.22*	.09	.11	.05	---			
10. Knowledge Outcome	13.7	2.76	-.18*	.35*	.31*	-.35*	.35*	.01	.24*	.24*	.11	(.65)		
11. Application Outcome	4.6	3.06	-.08	.06	.09	-.33*	.39*	-.12	.05	.17	.40*	.36*	.89)	
12. Cog Ability	26.4	5.16	.04	.08	-.22*	.02	.18*	-.11	-.09	-.01	.21*	.27*	.23*	---

Internal consistency estimates (coefficient alpha) are presented in the diagonal. Estimates are not available for time or worked sample problem, as they are single item measures. Starred correlation coefficients are statistically significant at the .05 level.

Table 5

Correlation Matrix for Learning Strategy Traces and Self-reports

	1	2	3	4	5	6	7	8
1. Organize								
2. OTrace	.25*							
3. Personalize	.40**	.15						
4. PTrace	.48**	.57**	.18*					
5. Rehearsal	.20*	.06	.07	-.01				
6. RTrace	.17	.61**	-.05	.44**	.10			
7. Knowledge	.24*	.14	.24*	.15	.01	.19*		
8. Application	.05	.07	.17	-.10	-.12	-.00	.36*	

n=121

** significant at .01
* significant at .05

the other learning strategy measures, nor was it related to performance on the knowledge test.

Hypothesis Testing

Moderated Regressions. Hypothesis 1 suggests that the type of effort will moderate the relationship between amount of effort and learning outcome performance. Specifically, amount of effort was not expected to impact learning unless that effort was congruent with the cognitive demands of the learning outcome. Separate regressions were performed on each dependent variable; knowledge outcome and application outcome. First, to control for the effects of cognitive ability on performance, cognitive ability was entered as a covariate. Type of effort and amount of effort were entered on the second and third steps. Type of effort consists of four variables. Rehearsal, personalizing, and organizing strategies are treated independently. Working the sample problem was included as a learning strategy. Amount of effort consists of three variables; time on task (measured in minutes), off-task attention, and mental workload. Finally, the product terms of amount of effort (3 variables) and type of effort (4 variables) were entered, for a total of 6 direct effects and 8 product terms. Off-task attention was not included in the interaction terms. Theoretically, off-task attention should have no effect on the strategies used. It is not effort applied to the task. Thus, it could not interact with the strategies to affect the outcomes.

For the application outcome, cognitive ability was entered in the first step, and produced a significant R^2 of .05 ($p<.01$). In the second step, the four learning strategies (type of effort) were entered, and produced a significant change in R^2 of .17 ($p < .01$). Only Sample resulted in a significant final standardized beta weight (.30, $p< .01$). In the third step, the three amount of effort variables were entered, and produced a significant change in R^2 (.09, $p<.01$). Workload (.21, $p < .05$) and Off-task attention (-.15, $p < .05$) had significant final standardized beta weights. In steps four and five, the interactions were entered. The product terms account for an insignificant amount of unique variance. It should be noted that the standardized beta weights for personalizing X workload, and rehearsal X time, were significant at the .10 level. However, there is little evidence for the proposed moderator relationship. The full results are presented in Table 6. The total amount of variance accounted for was .39.

For the knowledge outcome, cognitive ability was entered in the first step, and produced a significant R^2 of .07. In the second step, the four learning strategies (type of effort) were entered, and produced a significant change in R^2 (.09, $p<.01$), although none of the beta weights were individually significant. In the third step, the three amount of effort variables were entered, and produced a significant change in R^2 (.19, $p<.01$). Each of the three variables made a significant contribution. In steps four and five, the interactions were entered. The product terms account for no unique variance. Thus, there is no evidence for the proposed moderator relationship. The full results are presented in Table 7. Hypothesis 1 is not supported regarding the knowledge outcome. The total amount of variance accounted for was .39.

<u>Antecedents of Effort.</u> To investigate the antecedents of both amount of effort and type of effort, regression analyses were performed using amount of effort and type of effort as separate dependent variables. Cognitive ability was entered first in the analyses as a covariate. Learning motivation and knowledge of learning outcome were entered on the second step. Learning motivation was treated as two independent variables, task/mastery orientation and ego/social orientation. Knowledge of learning

Table 6

Moderated Regression Analysis Results on Application Outcome

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	.13	.23	.05	.05**
Step 2:				
Organize	-.07			
Personalize	.11			
Rehearsal	-.09			
Sample	.30**	.47	.22	.17**
Step 3:				
Workload	.21*			
Time	.05			
Off-task Atten.	-.15#	.56	.31	.09**
Step 4:				
O X W	.01			
P X W	-.97#			
R X W	-.14			
S X W	-.08	.59	.35	.04
Step 5:				
O X T	.42			
P X T	-.84			
R X T	1.13*			
S X T	-.19	.62	.39	.04

n=121

Note: Standardized Beta weights are used

** significant at .01
* significant at .05
# significant at .10

Table 7

Moderated Regression Analysis Results on Knowledge Outcome

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	.36**	.27	.07	.07**
Step 2:				
Organize	.04			
Personalize	.11			
Rehearsal	.07			
Sample	-.12	.41	.17	.09*
Step 3:				
Workload	.18*			
Time	.34*			
Off-task Atten.	-.22*	.60	.37	.20**
Step 4:				
O X W	.06			
P X W	-.62			
R X W	.90			
S X W	.06	.62	.39	.02
Step 5:				
O X T	-.17			
P X T	-.21			
R X T	.44			
S X T	.12	.63	.39	.00

n=121

Note: Standardized Beta weights are used

** significant at .01
* significant at .05
# significant at .10

Hypotheses H2a-H2d suggest several relationships between motivation and amount of effort. Specifically, a task/mastery orientation will be positively related to amount of effort, while an ego/social orientation will be negatively related to amount of effort. An interaction between the two orientations was also hypothesized, which suggested that the matched cells (high-high or low-low) would result in more moderate amounts of effort (see Figure 5).

Mastery orientation and workload are positively correlated ($r = .21$), and a negative relationship was found between mastery orientation and off-task attention ($r = -.17$). These two correlations support H2a. Correlations also indicate a positive relationship between ego/social orientation and off-task attention ($r = .34$), supporting H2b. Separate regression analyses with the amount of effort measures as dependent variables indicated that an ego/social orientation was a significant predictor of off-task attention ($b = .33$, $p < .01$) and mastery orientation was a significant predictor of workload ($b = .19$, $p < .05$). The interaction terms were not significant for any of the three measures of amount of effort. Thus, there were only direct effects of learning orientation on amount of effort.

The third set of hypotheses (H3a & H3b) suggests several relationships between motivation and type of effort. Specifically, high task/mastery orientation will be directly associated with the use of organizing and/or personalizing strategies, while ego/social orientation will interact with the awareness of learning outcome to predict use of learning strategies. Correlations between the variables indicate positive relationships between performance orientation and rehearsal ($r = .23$) and mastery orientation and personalizing ($r = .29$). A negative relationship was found between ego/social orientation and personalizing ($r = -.20$).

Table 8

Regression Analysis Results on Off-task Attention

Variable	Beta	R	R^2	R^2 Change
Step 1: Cognitive Ability	.01	.02	.00	.00
Step 2: Performance orientation (P)	.33**	.34	.12	.12**
Step 3: Mastery orientation (M)	-.15	.37	.14	.02#
Step 4: Knowledge Condition	-.04			
Application Condition	-.03	.37	.14	.00
Step 5: P X M	-.14	.37	.14	.00

n=121

** significant at .01
* significant at .05
# significant at .10

Table 9

Regression Analysis Results on Time

Variable	Beta	R	R^2	R^2 Change
Step 1: Cognitive Ability	-.24*	.22	.05	.05*
Step 2: Performance orientation (P)	-.07	.24	.06	.01
Step 3: Mastery orientation (M)	.12	.27	.07	.02
Step 4: Knowledge Condition	-.21*			
Application Condition	-.12	.33	.11	.03
Step 5: P X M	-.24	.33	.11	.00

n=121

** significant at .01
* significant at .05
# significant at .10

Table 10

Regression Analysis Results on Workload

Variable	Beta	R	R^2	R^2 Change
Step 1: Cognitive Ability	.16#	.17	.03	.03*
Step 2: Performance orientation (P)	-.10	.22	.05	.01
Step 3: Mastery orientation (M)	.18*	.29	.08	.03*
Step 4: Knowledge Condition	-.08			
Application Condition	-.07	.30	.09	.01
Step 5: P X M	.65	.26	.07	.00

n=121

** significant at .01
* significant at .05
# significant at .10

outcomes was treated as two variables, dummy coded for the analysis. The results of these regressions are presented in Tables 8-14, and are discussed below.

Separate regression analyses with the type of effort measures as outcome variables indicated that mastery orientation ($b=.28$, $p<.01$) and ego/social orientation ($b= -.18$, $p<.01$) significantly predicted personalizing, and the beta weights are in opposite directions. Ego/social orientation also predicted use of rehearsal strategies ($b=.24$, $p<.01$). These findings support Hypothesis 3a. Hypothesis 3b is not supported. No interaction effects were found regarding ego/social orientation; only direct effects were found. The full results are presented in Tables 11-14.

The fourth set of hypotheses (H4a and H4b) suggests several relationships between awareness of learning outcome and amount of effort. Awareness of a knowledge outcome was expected to be negatively associated with amount of effort, while awareness of an application outcome was expected to be positively associated with amount of effort. Separate regression analyses with the amount of effort measures as outcome variables indicated that the knowledge test condition significantly predicted time spent studying ($b= -.23$, $p<.01$), providing partial support for H4b. No other regression terms were significant.

The fifth set of hypotheses (H5a and H5b) suggests several relationships between knowledge of learning outcomes and type of effort. Awareness of a knowledge outcome was expected to be associated with the use of rehearsal strategies, while awareness of an application outcome was expected to be associated with the use of personalizing or organizing strategies. Separate regression analyses with the type of effort measures as outcome variables indicated that awareness of the knowledge condition was weakly associated with the use of rehearsal strategies ($r =.17$,

Table 11

Regression Analysis Results on Rehearsal

Variable	Beta	R	R^2	R^2 Change
Step 1: Cognitive Ability	-.14	.11	.01	.01
Step 2: Performance orientation (P)	.24**	.26	.07	.06**
Step 3: Mastery orientation (M)	.13	.30	.07	.02
Step 4: Knowledge Condition	.17#			
Application Condition	-.01	.34	.12	.03
Step 5: P X M	.46	.35	.12	.00

n=121

** significant at .01
* significant at .05
# significant at .10

Table 12

Regression Analysis Results on Organizing

Variable	Beta	R	R^2	R^2 Change
Step 1: Cognitive Ability	-.11	.08	.01	.01
Step 2: Performance orientation (P)	.05	.09	.01	.00
Step 3: Mastery orientation (M)	.15	.18	.03	.02#
Step 4: Knowledge Condition	-.04			
Application Condition	-.08	.19	.04	.00
Step 5: P X M	.06	.19	.04	.00

n=121

** significant at .01
* significant at .05
# significant at .10

Table 13

Regression Analysis Results on Personalizing

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	-.01	.00	.00	.00
Step 2:				
Performance orientation (P)	-.18*	.20	.04	.04*
Step 3:				
Mastery orientation (M)	.28**	.34	.11	.07**
Step 4:				
Knowledge Condition	.07			
Application Condition	.04	.34	.12	.00
Step 5:				
P X M	1.09	.36	.13	.01

n=121

** significant at .01
* significant at .05
# significant at .10

Table 14

Regression Analysis Results on Worked Sample Problem

Variable	Beta	R	R^2	R^2 Change
Step 1: Cognitive Ability	.21*	.21	.04	.04*
Step 2: Performance orientation (P)	.01	.21	..04	.00
Step 3: Mastery orientation (M)	-.08	.22	.05	.01
Step 4: Knowledge Condition	-.10			
Application Condition	.03	.25	.06	.01
Step 5: P X M	.45	.26	.07	.00

n=121

** significant at .01
* significant at .05
# significant at .10

p<.10), but the change in R^2 at this step was not significant. Awareness of the application test was not associated with the use of any strategy. Hypothesis 5a is somewhat supported, but H5b was not supported.

Mediator Analyses. As there was no support for the moderator relationship, two mediator analyses were performed. Both the role of amount of effort and type of effort were tested as mediating the relationship between learning motivation and performance. Mediator tests were appropriate only for the relationships involving the knowledge test, as the application test was not correlated with either motivation scale or the awareness of learning outcome. The awareness of learning outcomes was included only in the mediator analysis involving amount of effort, as there was no direct relationship between awareness of outcomes and type of effort.

The mediator relationships were tested with hierarchical regression analyses using the knowledge test as the dependent variable. Correlations (see Table 4) demonstrate the existence of relationships among the learning orientations and the knowledge outcome. Relationships were also demonstrated between the knowledge outcome and all three measures of amount of effort, as well as organizing and personalizing strategies. However, in the mediated regression analysis, there was no evidence for mediator relationships. With cognitive ability controlled for, significant direct effects were found for the learning orientations after entering effort into the equation. A small effect was also found for knowledge of declarative condition. Results of the mediated regression analyses are presented in Tables 15 and 16.

Full regression equation. Given the lack of support for either the mediated or moderated models, regression analyses were performed which included only direct effects for all variables, with the application and knowledge tests as the dependent variables. In the final equation, working the sample ($b=.29$, $p<.01$) and workload ($b=.23$, $p<.05$) significantly predicted performance on the application outcome. Knowledge of the application outcome was not a significant predictor, but the beta weight was in the predicted direction ($b=.15$, $p = .11$). Results of the regression are presented in Table 17. The total variance accounted for in the application outcome was .33.

For the knowledge outcome, cognitive ability ($b=.33$, $p<.01$), time ($b=.33$, $p< .01$) and task orientation ($b=.19$, $p<.05$) were significant predictors. Again, the beta weight for experimental condition was not significant, but was in the predicted direction ($b=.15$, $p=.10$). Several other variables nearly reached significance in the predicted direction, including off-task attention ($b=-.16$, $p<.10$) and workload ($b=.17$, $p<.10$). Results of the regression are presented in Table 18. The total variance accounted for was .42.

Table 15

Mediated Regression Analysis Results on
Knowledge Learning Outcome through Learning Strategies

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	.27**	.27	.07	.07**
Step 2:				
Organize	.21*			
Personalize	.04			
Rehearsal	.01			
Sample	.05	.41	.17	.09**
Step 3:				
Mastery Orient.	.28**			
Perf. Orient.	-.17*	.52	.27	.10**

n=121

Note: Final standardized Beta weights are presented.

** significant at .01
* significant at .05
# significant at .10

Table 16

Mediated Regression Analysis Results on
Knowledge Learning Outcome through Amount of Effort

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	.30**	.27	.07	.07**
Step 2:				
Workload	.16*			
Time	.33**			
Off-task Atten.	-.16*	.57	.33	.26**
Step 3:				
Mastery Orient.	.22**			
Perf. Orient.	-.07	.62	.38	.05**
Step 4:				
Knowledge condition	.16*			
Application condition	-.03	.64	.41	.03#

n=121

Note: Final standardized Beta weights are presented.

** significant at .01
* significant at .05
# significant at .10

Table 17

Direct Effects Regression Analysis Results on Application Learning Outcome

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	.15#	.23	.05	.05*
Step 2:				
Knowledge Condition	.09			
Application Condition	.15	.27	.07	.02
Step 3:				
Mastery orient.	-.02			
Perf. orient.	.03	.29	.08	.01
Step 4:				
Organize	-.07			
Personalize	.12			
Rehearsal	-.10			
Sample	.29**	.49	.24	.16**
Step 5:				
Workload	.23*			
Time	.08			
Off-task Atten.	-.15	.58	.33	.09**

n=121

Note: Final standardized Beta weights are presented.

** significant at .01
* significant at .05
# significant at .10

Table 18

Direct Effects Regression Analysis Results on Knowledge Learning Outcome

Variable	Beta	R	R^2	R^2 Change
Step 1:				
Cognitive Ability	.33**	.27	.07	.07**
Step 2:				
Knowledge Condition	.15#			
Application Condition	-.02	.31	.09	.02
Step 3:				
Mastery orient.	.19*			
Perf. orient.	-.07	.48	.23	.13*
Step 4:				
Organize	.06			
Personalize	.05			
Rehearsal	.03			
Sample	-.06	.53	.28	.06#
Step 5:				
Workload	.17#			
Time	.33**			
Off-task Atten.	-.16#	.65	.42	.14**

n=121

Note: Final standardized Beta weights are presented.

** significant at .01
* significant at .05
# significant at .10

DISCUSSION

The purpose of the present study was to examine the role of both amount of effort and type of cognitive effort in learning. The effect of learner awareness of the type of learning outcome on effort was also investigated. The discussion is divided into three sections. First, the findings of the study are presented. As several of the hypothesized relationships were not supported, alternative explanations are explored. Second, limitations of the study are discussed, as well as the possible impact of those limitations on the results. Finally, opportunities for further study of issues concerning effort in learning are explored.

Summary of Findings

Learning Orientation. The data support the notion that task/mastery orientation and performance, or ego/social, orientation are two distinct constructs, rather than endpoints on a continuum. The correlation between the two variables was non-significant ($r = -.10$). In the factor analysis, all items loaded as hypothesized on two factors.

The hypotheses regarding learning orientation stated that high task/mastery orientation would lead to greater effort and use of more complex learning strategies. It was suggested that high ego/social orientation would lead to less on-task effort and the use of simpler learning strategies. Hypotheses were also made concerning patterns of effort for the interaction among these two variables. The study provided partial support for the direct effects of learning orientation on effort. Task/mastery orientation was positively associated with perceived mental workload and personalizing strategies, and negatively related to off-task attention. Ego/social orientation was positively associated with off-task attention and use of rehearsal strategies, and negatively correlated with personalizing. In general, the direct effects were consistent with the hypotheses. The hypotheses concerning the interaction between the orientations were not supported. Thus, the orientations affect effort independently of one another. However, using off-task attention as an example, the patterns of effort predicted by the regression equation are consistent with the hypothesis. Recall that a high value on the off-task attention scale is interpreted as less effort. If an individual is high on task/mastery orientation and high on ego/social orientation, the prediction for amount of off-task attention is slightly positive. Low scores on both would result in a negative standardized off-task attention score. With high task/mastery and low ego/social orientation, the equation would predict a negative value. With high ego/social and low task/mastery orientation, the equation would produce a high negative value (see Table 19). Regardless, the interaction term for this particular effect produced zero change in R^2.

As the hypothesized mediator relationships were not statistically significant, the direct effects of learning orientation on outcome performance can be examined. Neither orientation was directly related to the application outcome. However, task/mastery orientation was positively related to performance on the knowledge test, and the ego/social orientation was negatively related to performance. Finally, the results of the study agree with the work of Dweck and colleagues, as there were no significant relationships between cognitive ability and learning motivation.

Table 19

Prediction of Off-task attention from Learning Orientation

Regression equation (from Table 8): A = .33 (P) - .15 (M)

<u>Low Mastery-Low Perf</u> A = .33 (-2) - .15 (-2) A = -.66 - (-.3) **A = -.36**	<u>High Mastery-Low Perf</u> A = .33(-2) - .15(2) A = -.66 - .30 **A = -.96**
<u>High Perf-Low Mastery</u> A = .33(2) - .15 (-2) A = .66 - (-.30) **A = .96**	<u>High Perf-High Mastery</u> A = .33(2) - .15(2) A = .66 - .30 **A = .36**

Note: Standardized regression weights are used. Variable values are 2 standard deviations above and below the mean. Positive values indicate high off-task attention; negative values indicate low off-task attention.

Awareness of Learning Outcome. The hypotheses regarding awareness of the learning outcome (knowledge vs. application) suggested that participants would adjust their learning strategies and amount of effort depending on the test they expected. The data show limited support for the importance of informing learners of the type of learning outcome they can expect. While none of the relationships were statistically significant, a few of the hypothesized relationships were nearly significant. Participants who were told they would receive a knowledge based outcome tended to spend less time learning ($b = -.21$, $p < .05$), however, the change in R^2 associated with this beta weight was non-significant. Participants who were told they would receive a knowledge based outcome were also more likely to use rehearsal learning strategies ($b = .17$). In each case, awareness of a knowledge based outcome test was associated with reduced effort on the part of the learners. This effect should be further examined, given the limitations of the study. Perhaps the two outcomes were too similar, as both were pencil and paper. The lack of support for these hypotheses could also be a result of study habits. Students at large universities are accustomed to taking multiple choice tests. The participants may simply have used the same study strategies they would use in a typical classroom learning situation.

Amount of Effort. The data suggest many interesting relationships among measures of amount of effort. These constructs are related, but are not identical. Time was not highly related to the self-report measure of mental workload. Off-task attention and perceived mental workload are inversely related. Participants who were thinking of things other than the task while learning felt the learning required less effort. As expected, time and off-task attention were not related. These relationships reinforce the need to measure amount of effort in multiple ways.

Each of the measures provided valuable information regarding one or more hypotheses. Amount of effort was hypothesized to be indirectly related to the learning outcomes. It was suggested that the amount of effort expended would only matter if the learning strategies used were congruent with the learning outcome. For example, regardless of the amount of effort devoted to learning, the use of rehearsal strategies should not affect the application outcome. However, the mediated model was not supported. All three measures of amount of effort were directly related to performance on the knowledge outcome. Time was positively related to performance on the knowledge test, suggesting that time on task is an important factor in memorization. In contrast, off-task attention was negatively related to both the knowledge and application outcomes. This suggests that regardless of the learning outcome, concentration is important, and focusing on external issues detracts from learning. Similarly, workload was positively related to both tests. If participants felt they had devoted a great deal of mental effort to the task, they tended to perform well on the outcome tests. In general, participants who worked harder performed better on the learning outcomes. This result is consistent with the position of Kanfer and Ackerman (1989), that mental effort, or the devotion of attentional resources, is related to learning and task performance.

Learning Strategies. Learning strategies were hypothesized to positively affect congruent learning outcomes. Use of rehearsal strategies was expected to lead to high performance on the knowledge outcome, while high performance on the application outcome was expected to require the use of organizing or personalizing strategies.

These hypotheses were not supported. In the final regression equation, none of the cognitive learning strategies were significant predictors of the knowledge outcome, although both personalizing and organizing strategies were positively correlated with the knowledge outcome. Working the sample problem was a significant predictor of performance on the application test. Rehearsal strategies may have been unrelated to performance because of low variance ($x = 17.9$, $sd = 3.4$).

The construct validity of the learning strategy measures must be considered. The self-report measures correlated in the expected pattern; rehearsal and organizing had a low to moderate, positive correlation ($r = .20$, $p<.05$); rehearsal and personalizing were not correlated; and organizing and personalizing had a strong, positive correlation ($r = .40$, $p< .01$). The trace codings of learning strategies were more strongly correlated with one another than with the corresponding self-report measures, displaying little discriminant validity. Thus, the self-report measures of the learning strategies appear to have greater use in distinguishing among the three types of strategies. The trace codings of the strategies may be measuring a different construct, such as tendency to write while learning. This is a separate learning strategy than the ones which were examined in this study. Writing while learning may be considered a specific learning tactic, rather than a cognitive learning strategy.

However, there were clearly between-person differences on the traces. Many of the learning materials were clean, while others were filled with writing. All three traces were positively related to performance on the knowledge test, with the correlation with rehearsal traces reaching significance ($r = .19$, $p<.05$). In addition, the organizing and personalizing traces were positively related to task/mastery orientation. This result is consistent with the notion that task/mastery oriented individuals will use the more complex strategies. The traces were not related to performance on the application test. Working the sample, which was the other learning strategy coded from the learning materials, was a strong predictor of performance on the application test.

The data also point to the amount of effort required for the different types of learning strategies. The use of organizing strategies was associated with greater time spent learning, and less off-task attention. Personalizing was associated with less off-task attention, and greater perceived workload. Not surprisingly, performance oriented individuals tended to use more rehearsal strategies, and fewer personalizing strategies. In contrast, mastery oriented individuals tended to use more personalizing strategies. The mastery oriented individuals put forth more effort during learning, and chose strategies which were more complex.

The study did not provide a great deal of explanation for why participants used a particular learning strategy. The percentage of variance explained in these variables was low, ranging from .04-.13. Only cognitive ability was a significant predictor of working the sample problem ($b = .26$, $p < .01$). Much of the literature regarding learning strategies focuses on how to teach various strategies to students. Perhaps the participants in this study did not know how to use strategies other than rehearsal, which many of them used. Ability to use particular strategies was not measured.

<u>Working Sample Problems.</u> This study has also highlights the importance of working sample problems when faced with a performance or application test. Participants who successfully worked the sample problem included in the learning materials tended to score much higher on the application outcome test. Working the sample problem had no effect on knowledge test performance. More simply stated, practice on the required behavior while learning improves post-learning performance.

Since the knowledge test required recognition of facts concerning regression and stock price prediction, rather than use of the regression formula, one would not expect practice on a sample problem to improve knowledge test scores.

This result concurs with Anderson's most recent data on the proceduralization of skills (Anderson & Fincham, 1994). Anderson suggests that examples can provide a direct linkage to proceduralization, without ever learning a declarative representation of the concept. Additionally, Paas (1992) suggested that the type of sample problem affects outcomes of learning. He found that learning from already worked or partially worked sample problems was positively related to test performance. Test problems ranged from identical to the sample problems but with different numbers, to more complex, less structured problems than the sample problems. Unfortunately, in the current study, participants who did not work the sample problem were not asked if they had studied the solution to the problem on the next page.

Role of cognitive ability. Cognitive ability was positively related to performance on both outcome measures. This result supports the notion of general cognitive ability - individuals with more g will perform better on a range of cognitive tasks. In contrast to Kanfer and Ackerman's suggestion that cognitive ability is negatively related to off-task mental activities, cognitive ability was not related to off-task attention. Cognitive ability was negatively related to time, and positively related to mental workload. Individuals with high cognitive ability, as measured by the Wonderlic, spent less time on the learning task, but perceived using more mental effort. However, time and workload were not related in the sample as a whole. Perhaps because these high ability individuals concentrated their effort in a shorter period of time, they perceived that it required more mental effort.

Study Limitations

The limitations of the study are discussed in relation to: (1) participant characteristics, (2) measures used, (3) low power to detect significant effects, and (4) tradeoffs associated with cognitive research.

Participant characteristics. The participants in this study were recruited through the undergraduate subject pool at a large university. Thus, the participants were relatively homogeneous in age, race, and background. The motivation of the participants, however, varied widely. Many proceeded through the experiment as quickly as possible. Receiving credit for the experiment was not contingent on their performance in the experiment. Some wrote on their materials that this was the most boring thing they had ever done. Others were stimulated to learn more about the stock market, while still others remained after the experiment for several minutes to argue about their scores, or apologize for poor performance. Informing participants at the beginning of the experiment that their tests would be scored was intended to increase the motivation of all participants to perform well. Clearly, it was not effective for everyone.

Toward the end of the experiment, it was discovered that an unknown number of subjects were cheating by writing relevant information on the tables in their individual rooms. It would have been interesting to include cheating behaviors as a variable in the study, both to covary cheating out of the performance measures, and to relate cheating to learning orientation. It seems likely that participants high on ego/social orientation would be more likely to cheat.

Measures Used. While it was expected that the two learning outcome measures, knowledge and application, were distinct learning outcomes, the two measures were positively correlated ($r = .36$, $p<.01$). The reliability of the knowledge test was also less than desirable ($\alpha=.65$). The correlation corrected for this unreliability increases to .47. The correlation was not significantly attenuated by partialling out cognitive ability. Thus, the two measures may have been tapping the same construct, to a degree. The two tests did cover the same general content area, and both were paper and pencil tests. These similarities likely contributed to the correlation. In support of the distinction between the tests, the patterns of correlations between the tests and other variables were quite different. For example, the knowledge test was positively correlated with task/mastery orientation, and negatively correlated with ego/social orientation. The application test was not significantly correlated with either orientation.

Several of the effort measures used were written for this study. The Learning Strategy measures, for example, were based on Schmeck's (1983) Inventory of Learning Processes (ILP). These scales had not been widely pretested. Thus, there is little evidence supporting construct validity of these scales. In addition, the internal consistency reliability was somewhat low for the Rehearsal (.73) and Organizing (.71) subscales.

Power to Detect Significant Effects. Given the number of independent variables and interaction terms entered in some of the regression analyses, the number of participants ($n=121$) was too small to provide adequate power for detecting significant effects. Indeed, several effects were in the predicted direction, but missed the traditional significance levels. One of these effects was the manipulation of awareness of learning outcome type. The awareness of the knowledge outcome displayed effects in the predicted direction on several occasions, but generally failed to reach significance. Similarly, none of the tests for interactions found significant results. Unfortunately, the number of participants was limited by available resources.

Tradeoffs Associated with Cognitive Research. The study may have been affected by several trade-offs which were made during the planning process. One of these trade-offs was the type of task used. A task with greater complexity may have produced results more similar to the hypotheses. Perhaps participants were not challenged enough by the task to use complex learning strategies. Perhaps the task did not allow the use of complex learning strategies. Cognitive ability may have an even greater impact on more complex tasks. However, a relatively simple task was chosen to reduce the time required by the participants.

The nested nature of types of learning outcomes makes it difficult to separate the effects of the knowledge and application measures. If knowledge is required for application, perhaps it should be covaried out of analyses. Clearly distinct testing may help to separate the effects. A trade-off was made in the current study to measure both types of outcomes using paper and pencil tests.

A third problem inherent in the study of cognitive processes is the lack of clear definitions in the literature. While several concepts were consistent across authors and studies, often the name and intricacies of the constructs varied widely. For instance, the difference between examples of learning styles, learning strategies, and learning tactics was not always clear. This lack of consensus among previous researchers increases the difficulty of writing scales which accurately reflect the nature of the construct in question.

Future Research Opportunities

First, future research could address some of the limitations discussed above. Regarding the learning outcome measures, the knowledge test could be pencil and paper, but the application test could be a role play or physical performance of a task. A greater distinction between the tests may increase the effects of awareness of learning outcome on learner effort. Learners may not distinguish between two pencil and paper tests as they approach the learning task.

Further work should be conducted exploring the construct validity of the cognitive learning strategy measures. Verbal protocol analysis during learning could give a more objective indication of what the learners are actually doing. Fischer (1993) analyzed videos of students in small group interaction to measure cognitive processes, examining written transcripts of the learning situation. Current self-report measures of strategies rely on not only participants' honesty, but also their accuracy. There is much debate concerning how accurately people can use introspection to report their mental processes. Adding to the difficulty of identifying one's own mental processes is the delay in completing the scales. In the current study, participants waited several minutes before recording their processes. Mental processes may be more accurately reported as they are occurring. Participants were not informed prior to the learning that they would be later asked to report their processing during learning. Informing people in advance may improve the accuracy of self-reported mental processes.

The trace codings of strategies used in the present study did not appear to measure three different learning strategies. However, the use of repetitious writing may certainly be a valid learning method. Three fairly general, cognitive learning strategies were examined in the study. Rather than attempting to measure the cognitive processes behind learning, a direct focus on the behaviors may be more fruitful. The domain of specific learning tactics, which comprise general learning strategies (Schmeck, 1983), should be further examined. The coding of whether or not the participants had correctly completed the sample falls closer to a specific learning tactic, rather than a cognitive learning strategy. Perhaps a focus on learning behaviors would be a useful direction for further research. A well-defined domain of learning tactics may lead to better specification of the general learning strategies.

In addition to work on the measurement of learning strategies, the ability to select and use certain learning strategies should be studied. The process used to select learning strategies may vary across learners. The current study did not substantially advance our understanding of this area. Selection of learning strategies has been considered a specific cognitive skill in itself, within the realm of metacognition (Gagné, et al., 1992; Kraiger, Ford & Salas, 1993). The inclusion of various metacognitive skills in future research may better predict which learning strategies will be used. Another avenue of research regarding strategy selection might be additional individual characteristics. The learning orientation measures and cognitive ability were the best predictors of strategy use in this study. All learners may not have access to the same learning strategies. Perhaps participants did not use personalizing strategies because they were not aware it was an option. Schmeck (1983, 1988) has suggested that people have different learning styles which are consistent across situations.

Teaching learning strategies could increase flexibility of strategy use across situations. Schmeck (1988) suggests that students should be taught a range of learning tactics, as they will likely encounter a range of learning outcomes. However, students must also be taught when to use these strategies. Schmeck (1983) refers to a training program which taught various strategies, but was not effective, as students did not know when to apply these strategies. Relationships between learning style and use of specific learning strategies could be investigated further.

The relationships among task/mastery orientation, ego/social orientation, and additional learning variables should be further examined. Interest in these constructs has increased dramatically in I/O psychology in the past few years (e.g. Button, et al., 1994; Boyle & Klimoski, 1995; Smith, Ford, Weissbein, & Gully, 1995). Smith, et al., (1995) discovered that learning orientation was related to self-efficacy, which impacted training performance. Boyle and Klimoski (1995) treated learning orientation as both state and trait variables. The trait orientation was measured in the current study, but perhaps participants took on a different state orientation as a result of the specific task, and this change went undetected. Similar to learning style, the malleability of learning orientation should be studied. It may be that individuals who are more flexible in their approach to learning are more successful in learning.

Finally, the long term effects of the amount and type of effort used during learning must be considered. High performance on a test at the end of a learning experience is irrelevant if that learning is not transferred to other situations at other times. It has been suggested that the same cognitive processes are not involved in successful training performance and successful transfer of training (Schmidt & Bjork, 1992). An extension of the current study could consider the difference between the learning outcome at the end of training, and the test conditions present in the transfer environment. It follows that cognitive processes required for the test at the end of training should be as similar as possible to those processes required at transfer.

Future research on learning motivation and learner effort must address transfer of learning as well as initial learning.

APPENDICES

APPENDIX A

Wonderlic Personnel Test

WONDERLIC

PERSONNEL TEST

FORM V

NAME .... Date ....
(Please Print)

Social Security Number

READ THIS PAGE CAREFULLY. DO EXACTLY AS YOU ARE TOLD.
DO NOT TURN OVER THIS PAGE UNTIL YOU ARE
INSTRUCTED TO DO SO.

PROBLEMS MUST BE WORKED WITHOUT THE AID OF A CALCULATOR
OR OTHER PROBLEM-SOLVING DEVICE.

This is a test of problem solving ability. It contains various types of questions. Below is a sample question correctly filled in:

PLACE ANSWERS HERE

REAP is the opposite of
1 obtain, 2 cheer, 3 continue, 4 exist, 5 sow .... [5]

The correct answer is "sow". (It is helpful to underline the correct word.) The correct word is numbered 5. Then write the figure 5 in the brackets at the end of the line.

Answer the next sample question yourself.

Paper sells for 23 cents per pad. What will 4 pads cost? .... [ ]

The correct answer is 92¢. There is nothing to underline so just place "92¢" in the brackets.

Here is another example:

MINER MINOR — Do these words
1 have similar meanings, 2 have contradictory meanings, 3 mean neither the same nor opposite? [ ]

The correct answer is "mean neither same nor opposite" which is number 3 so all you have to do is place a figure "3" in the brackets at the end of the line.

When the answer to a question is a letter or a number, put the letter or number in the brackets. All letters should be printed.

This test contains 50 questions. It is unlikely that you will finish all of them, but do your best. After the examiner tells you to begin, you will be given exactly 12 minutes to work as many as you can. Do not go so fast that you make mistakes since you must try to get as many right as possible. The questions become increasingly difficult, so do not skip about. Do not spend too much time on any one problem. The examiner will not answer any questions after the test begins.

Now, lay down your pencil and wait for the examiner to tell you to begin!

Do not turn the page until you are told to do so.

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CATALOG #P-3

1. In the following set of words, which word is different from the others?
   1 copper, 2 nickel, 3 aluminum, 4 wood, 5 bronze ....
2. Which word below is related to bear as calf is to cow?
   1 chick, 2 cub, 3 fawn, 4 trout, 5 fox ....
3. Most of the items below resemble each other. Which one is least like the others?
   1 July, 2 February, 3 April, 4 Tuesday, 5 June ....
4. In 20 days a boy saved one dollar. What was his average daily saving? ....
5. HYPOCRITE HYSTERICAL—Do these words
   1 have similar meanings, 2 have contradictory meanings, 3 mean neither the same nor opposite?.
6. Are the meanings of the following sentences: 1 similar, 2 contradictory, 3 neither similar nor contradictory? Look before you leap. Think today and speak tomorrow. ....
7. Assume the first 2 statements are true. Is the final one: 1 true, 2 false, 3 not certain? The flute is in tune with the harp. The harp is in tune with the viola. The viola is in tune with the flute. ....
8. In the following set of words, which word is different from the others?
   1 beef, 2 mackerel, 3 veal, 4 bacon, 5 hot dog ....
9. Are the meanings of the following sentences: 1 similar, 2 contradictory, 3 neither similar nor contradictory? Never look a gift horse in the mouth. You cannot make a silk purse out of a sow's ear ....
10. Most of the items below resemble each other. Which one is least like the others?
    1 suspicion, 2 unbelief, 3 doubt, 4 resolve, 5 misgiving ....
11. SUPPORT is the opposite of
    1 maintain, 2 sustain, 3 cherish, 4 desert, 5 prop ....
12. Assume the first 2 statements are true. Is the final one: 1 true, 2 false, 3 not certain? These puppies are normal dogs. All normal dogs are active. These puppies are active. ....
13. How many of the five items listed below are exact duplicates of each other? ....

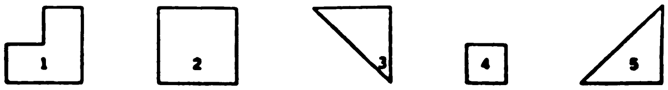
7362	7363
62738	63738
527182	527182
918264	918264
1628357	1638357

14. Wire is 12.5 cents a foot. How many feet can you buy for a dollar? ....
15. DECEPTION is the opposite of
    1 falsehood, 2 trickery, 3 frankness, 4 finesse, 5 fabrication ....
16. Assume the first 2 statements are true. Is the final one: 1 true, 2 false, 3 not certain? All red-headed boys like candy. Charles is red-headed. He likes candy. ....
17. A dealer bought some televisions for $2500. She sold them for $2900, making $50 on each television. How many televisions were involved? ....
18. ABSURD ACCEDE—Do these words
    1 have similar meanings, 2 have contradictory meanings, 3 mean neither the same nor opposite?.
19. Two of the following proverbs have similar meanings. Which ones are they? ....
    1. You catch more flies with honey than with vinegar.
    2. The squeaking wheel gets the grease.
    3. A fly follows the honey.
    4. Sweet appears sour when we pay.
    5. Too swift arrives as tardy as too slow.
20. In the following set of words, which word is different from the others?
    1 little, 2 small, 3 tiny, 4 spacious, 5 precise ....
21. ADORN is the opposite of
    1 garnish, 2 ornament, 3 embellish, 4 bedeck, 5 deface ....
22. Are the meanings of the following sentences: 1 similar, 2 contradictory, 3 neither similar nor contradictory? Words are always bolder than deeds. Stab wounds heal, but bad words never. ....
23. Two of the following proverbs have similar meanings. Which ones are they? ....
    1. Once bitten, twice shy.
    2. No one is happy all his life long.
    3. Hitch your wagon to a star.
    4. Fortune favors the brave.
    5. All men have the same share of happiness.
24. A rectangular bin, completely filled, holds 640 cubic feet of grain. If the bin is 8 feet wide and 10 feet long, how deep is it? ....
25. ANGER is the opposite of
    1 fury, 2 vexation, 3 forbearance, 4 displeasure, 5 resentment ....
26. Assume the first 2 statements are true. Is the final one: 1 true, 2 false, 3 not certain? These boys are normal children. All normal children are big eaters. These boys are big eaters. ....
27. A boy is 10 years old and his sister is twice as old. When the boy is 16 years old, what will be the age of his sister? ....
28. Are the meanings of the following sentences: 1 similar, 2 contradictory, 3 neither similar nor contradictory? All comedies are ended at marriage. The man who expects comfort in this life must be born deaf, dumb, and blind. ....

29. In the following set of words, which word is different from the others?
1 odor, 2 scent, 3 sour, 4 spice, 5 fume ....

30. ABSCOND ABSENCE—Do these words
1 have similar meanings, 2 have contradictory meanings, 3 mean neither the same nor opposite?.

31. Four of the following 5 parts can be fitted together in such a way as to make a triangle. Which 4 are they? ....



32. RETREAT RETRIEVE—Do these words
1 have similar meanings, 2 have contradictory meanings, 3 mean neither the same nor opposite?.

33. Which number in the following group of numbers represents the smallest amount?
.999 999 .9 1 2 .88 ....

34. Are the meanings of the following sentences: 1 similar, 2 contradictory, 3 neither similar nor contradictory? A friend in need is a friend indeed. A faithful friend is a strong defense. ....

35. When the price of gasoline increased from 16.4 cents to 20.5 cents, what was the percent increase in cost of the gasoline? ....

36. APPEAL is the opposite of
1 beseech, 2 entreat, 3 request, 4 deny, 5 invoke ....

37. Two of the following proverbs have similar meanings. Which ones are they? ....

1. Every effect becomes a cause.
2. The cautious seldom make mistakes.
3. Two dogs will kill a lion.
4. A threefold cord is not quickly broken.
5. Water falling day by day wears the hardest stone away.

38. Suppose you arrange the following words so that they make a complete sentence. If it is a true sentence, mark (T) in the brackets; if false, put an (F) in the brackets.
always Lightning follows thunder ....

39. A clock was exactly on time at noon on Monday. At 8 P.M. on Tuesday it was 64 seconds slow. At that same rate, how much did it lose in ½ hour? ....

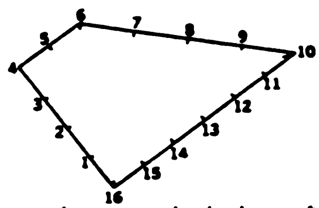
40. ENDURE is the opposite of
1 allow, 2 bear, 3 suffer, 4 sustain, 5 foil ....

41. If 3½ bags of seed cost $35, what will 4½ bags cost? ....

42. Are the meanings of the following sentences: 1 similar, 2 contradictory, 3 neither similar nor contradictory? Politeness is excellent, but it does not pay the bill. Cash is virtue. ....

43. Which number in the following group of numbers represents the smallest amount?
222 .9 .73 2 4 .49 ....

44. This geometric figure can be divided by a straight line into two parts which will fit together in a certain way to make a perfect square. Draw such a line by joining 2 of the numbers. Then write these numbers as the answer. ....



45. Three individuals form a partnership and agree to divide the profits equally. X invests $6500, Y invests $2000, and Z invests $1500. If the profits are $3000, how much less does X receive than if the profits were divided in proportion to the amount invested? ....

46. What is the next number in this series? 16 4 1 .25 ....

47. Two of the following proverbs have similar meanings. Which ones are they? ....

1. No one is wise all the time.
2. A word to the wise is sufficient.
3. The doors of wisdom are never shut.
4. 'Tis wisdom sometimes to seem a fool.
5. The greatest good is wisdom.

48. ADROIT ADEPT—Do these words
1 have similar meanings, 2 have contradictory meanings, 3 mean neither the same nor opposite?.

49. In printing an article of 24,000 words, a printer decides to use two sizes of type. Using the larger type, a printed page contains 1200 words. Using the smaller type, a page contains 1500 words. The article is allotted 17 full pages in a magazine. How many pages must be in the small type? ....

50. One number in the following series does not fit in with the pattern set by the others. What should that number be? 1/1000 1/100 1/10 0 1/10 10 ....

APPENDIX B

Learning Orientation Scales

This set of questions asks you to describe how you feel about each of the following statements. Please use the scale shown below to make your ratings.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

1. The opportunity to do challenging work is important to me.

2. I do my best when I'm working on a fairly difficult task.

3. I try hard to improve on my past performance.

4. When I have difficulty solving a problem, I enjoy trying different approaches to see which one will work.

5. The opportunity to learn new things is important to me.

6. The opportunity to extend the range of my abilities is important to me.

7. I prefer to work on tasks that force me to learn new things.

8. When I fail to complete a difficult task, I plan to try harder the next time.

9. The things I enjoy the most are the things I do the best.

10. I feel smart when I can do something better than most other people.

11. I like to be fairly confident that I can successfully perform a task before I attempt it.

12. I am happiest at work when I perform tasks on which I know that I won't make any errors.

13. I feel smart when I do something without making any mistakes.

14. I prefer to do things that I can do well rather than things that I do poorly.

15. The opinions others have about how well I can do certain things are important to me.

16. I like to work on tasks that I have done well on in the past.

APPENDIX C

Off-task Attention Scale

Please respond to the items below with the following scale:
1 = Never 2 = Seldom 3 = Occasionally 4 = Frequently 5 = Constantly

While I was learning the Stock Price Prediction Task material:

1. I thought about how much time I had spent learning the material

   1————————2————————3————————4————————5

   Never Constantly

2. I wondered about my performance compared with others

   1————————2————————3————————4————————5

   Never Constantly

3. I wondered how well others have done on the test

   1————————2————————3————————4————————5

   Never Constantly

4. I thought about how hard the material was to learn.

   1————————2————————3————————4————————5

   Never Constantly

5. I wondered about how hard the test might be

   1————————2————————3————————4————————5

   Never Constantly

6. I took 'mental breaks' while I was learning

   1————————2————————3————————4————————5

   Never Constantly

7. I daydreamed while I was learning

1——————2——————3——————4——————5

Never Constantly

8. I lost interest in learning the material for short periods of time

1——————2——————3——————4——————5

Never Constantly

9. I thought about other things that I have to do today

1——————2——————3——————4——————5

Never Constantly

10. I let my mind wander while I was learning the materials

1——————2——————3——————4——————5

Never Constantly

11. I became frustrated with my ability to learn the material

1——————2——————3——————4——————5

Never Constantly

12. I thought about how well or how poorly I was doing

1——————2——————3——————4——————5

Never Constantly

13. I got mad at myself while I was learning the material

1——————2——————3——————4——————5

Never Constantly

APPENDIX D

Learning Strategy Scales

Please respond to the items below with the following scale:

1 = Never 2 = Seldom 3 = Occasionally 4 = Frequently 5 = Constantly

While I was learning the Stock Price Prediction Task material:

1. I tried to memorize the facts. ______
2. I focused on remembering the details of the material. ______
3. I repeated certain words or phrases to myself. ______
4. I repeated the regression formula to myself. ______
5. I tried to remember exact words or phrases used in the materials. ______
6. I created my own examples. ______
7. I related the regression equation to other formulas I knew. ______
8. I tested myself on the material using my own questions. ______
9. I tried to express things in my own words. ______
10. I thought of similar concepts to which the material was related. ______
11. I learned new ideas by associating them with words and ideas I already knew. ______
12. I tried to relate facts to other pieces of information found in the material. ______
13. I looked for conflicts or inconsistencies between pieces of information. ______
14. I made lists of associated ideas . ______
15. I made simple charts or diagrams to help relate ideas to one another. ______
16. I tried to organize the material. ______
17. I searched for general ideas in the material. ______

APPENDIX E

Mental Workload Scale

Please respond to the following items concerning the stock price prediction materials using the scale below.

1. I felt mentally tired and worn out after learning the stock price prediction materials.

1————————2————————3————————4————————5
Strongly Agree Strongly disagree

2. Learning the stock prediction materials was a difficult and complex task.

1————————2————————3————————4————————5
Strongly Agree Strongly disagree

3. The overall mental workload I felt while learning the stock prediction materials was low.

1————————2————————3————————4————————5
Strongly Agree Strongly disagree

4. Learning the stock price prediction materials was easy.

1————————2————————3————————4————————5
Strongly Agree Strongly disagree

5. Learning the stock price prediction materials required a lot of mental activity.

1————————2————————3————————4————————5
Strongly Agree Strongly disagree

6. I had to work very hard to learn the stock price prediction materials.

1————————2————————3————————4————————5
Strongly Agree Strongly disagree

APPENDIX F

Stock Price Prediction Learning Task

Instructions (Application condition)

Take as much time as you need to learn the material on the following pages. You may use any method you choose to learn the material. After you have learned the material, you will be asked to predict stock prices for ten companies. Later we will score your test so you know how well you have done on the test.

Instructions (Knowledge condition)

Take as much time as you need to learn the material on the following pages. You may use any method you choose to learn the material. After you have learned the material, you will be asked to take an 18 item multiple choice test on the material. Later we will score your test so you know how well you have done on the test.

Instructions (Ambiguous condition)

Take as much time as you need to learn the material on the following pages. You may use any method you choose to learn the material. After you have learned the material, you will be asked to demonstrate your learning on a short test. Later we will score your test so you know how well you have done on the test.

The following task focuses on how an investment counselor makes stock recommendations to a client. During the course of this session, you will be asked to learn how an investment counselor might make decisions about stock values.

More specifically, you will learn about making estimates concerning the behavior of the stock for a variety of similar large multi-national corporations based in the United States. The current market value of each company's stock as listed on AMEX is $80 per share. The stock price for a given company will rarely fall below $10 per share, or rise above $150 per share. In addition, the performance of each company is independent. That is, the performance of company #10 does not influence the performance of company #11.

Stock prices can be predicted from performance data about each company. Three divisions of each company are considered in the prediction of stock prices; 1) marketing, 2) research and development, and 3) production. Each division reports quarterly performance levels, measured in millions of dollars gained or lost. A positive value reflects a profit, while a negative value reflects a loss. Information concerning quarterly performance can be found in each company's shareholder disclosure reports.

The shareholder disclosure reports also contain information such as the previous annual dividend and the change in company profits. The previous annual dividend gives an indication of how much money was paid to investors during the previous year. The change in company profits indicates how much money the company as a whole made during the previous year. The relationship between the previous annual dividend is positive but low, usually a correlation of .15.

The prediction of stock prices is somewhat uncertain. In a given year, the average fluctuation of stock prices is $25. Investment counselors cannot always perfectly predict the prices of stocks. In fact, they usually succeed only 65% of the time. The stock market is affected by many factors outside of organizational performance, such as interest rates, political events, and economic cycles.

Investment counselors also track the trends of stock prices. Short term stock trends refer to the movement of the stock price over the past three months. Long term stock trends refer to the general movement of stock prices over a longer period of time, usually a year or more. These trends allow counselors to give stock ratings. An A+ is the top stock rating, while a C- is the lowest possible rating.

Multiple regression is a statistical technique which can be used to predict one number from a weighted combination of other numbers. The goal in multiple regression is to reduce, or minimize, the errors one makes in prediction.

Multiple regression is based on the general linear model. Thus, the basic equation for multiple regression is similar to the equation for a line:

$$y = a + b_1 x_1 + b_2 x_2$$

y is the number you want to predict
a is the intercept term, or the place where the line crosses the y axis
b_1 is the weight given to the first number that you know
x_1 is the first number that you know
b_2 is the weight given to the second number that you know
x_2 is the second number that you know

For example, you could predict the weight of children (y) from the number of hours of television watched (x_1) and their age (x_2).

Assume that $b_1 = 2$, and $b_2 = 7$. Assume also that $a = 8$, because that is the average weight of a newborn. If a child spends 7 hours a week watching TV, and is 10 years old, then the equation will look like this:

$y = 8 + (2 \text{ X } 7) + (7 \text{ X } 10)$

$y = 92$

Thus, one would predict that this child weighs 92 pounds.

Multiple regression can be used to predict stock prices from performance data, and can be used with any number of x terms.

⇒ The b value for each term can change depending on the performance level of each division. If the quarterly performance for one division is between 0 and 50, b=.5. If performance is between 51 and 100, b = .2. If performance is between 101 and 150, b = .1. If the performance value is negative, use the absolute value (remove the negative sign) to determine the b value.

⇒ The a value will always be the current price of the stock.

Two examples of the use of regression in predicting stock prices are on the next page.

Example 1

At Bob's Kreme Filling, Inc., the following quarterly performance data were reported:

- Marketing 20
- Research and
  Development -60
- Production 100

The regression equation for predicting the stock price of Bob's Kreme Filling, Inc. is:

y = 80 + (.5) 20 + (.2) -60 + (.2) 100

y = 80 + 10 - 12 + 20

y = 98

Example 2:

At Mike's International BrewPub, the following performance data were reported:

- Marketing 70
- Research and
  Development 10
- Production -20

Feel free to practice predicting the stock price for Mike's International BrewPub in the space below. The completed regression equation is displayed on the next page.

Feel free to look over any portion of the Stock Prediction materials until you feel you have learned the materials. When you are finished learning the material, please raise your hand and the experimenter will collect your materials.

Answer to Example 2:

- Marketing 70
- Research and Development 10
- Production -20

$$y = 80 + (.2)\ 70 + (.5)\ 10 + (.5)\ {-20}$$

$$y = 80 + 14 + 5 - 10$$

$$y = 89$$

APPENDIX G

Knowledge Learning Outcome

In this part of the session you will be asked to choose the correct answer to the 18 multiple choice items below. Please circle the correct answer.

1. The divisions of a company an investment counselor uses to predict stock prices are:
a) marketing, sales, and human resources
b) marketing, research and development, sales, and production
c) finance, customer service, and research and development
d) marketing, research and development, and production
e) production, sales, and customer service

2. When evaluating how well a division has done, the investment counselor looks at:
a) percentage of goal met
b) profit/loss
c) receivables
d) market share
e) stock ratings

3. Predicted stock prices generally range from:
a) $20 - $200
b) $10 - $150
c) $80 - $150
d) $10 - $80
e) $25 - $150

4. The investment counselors make predictions about:
a) chemical companies
b) large auto supply companies
c) a wide range of companies
d) large multi-national companies
e) large financial companies

Continue on to the next page

5. Performance is measured for each division in the companies:

a) yearly
b) monthly
c) weekly
d) quarterly
e) bimonthly

6. External influences on the stock market include:

a) seasons, weather, and mergers
b) interest rates, political events, and economic cycles.
c) Supreme Court decisions, acquisitions, and the Fed
d) major holidays, product cycles, and inflation
e) the global economy, elections, and downsizing

7. Multiple regression is based on:

a) the weighted geometric model
b) the general linear model
c) Euclidean geometry
d) vectors and angles
e) the factor analytic model

8. Investment counselors are correct about stock price predictions:

a) half the time
b) very rarely
c) two-thirds of the time
d) always
e) one-fourth of the time

9. The primary goal in multiple regression is to:

a) choose between several options
b) maximize the value of the stock price
c) reduce the amount of information needed
d) minimize errors in prediction
e) find the absolute value of performance

Continue on to the next page

10. The b value in a regression equation is:

a) the number you are trying to predict
b) the place where the line crosses the y axis
c) one of the numbers that you know
d) the weight given to one of the numbers that you know
e) the current value of the stock

11. In the first multiple regression example, we were trying to predict:

a) the weight of an average newborn
b) a child's age
c) a child's weight
d) the amount of time a child watched TV
e) the number of Twinkies eaten by a child each week

12. The companies list their stocks on the following stock exchange:

a) NYSE
b) OTC
c) NASDAQ
d) CBOT
e) AMEX

13. The current value of each stock is:

a) $50
b) $80
c) $10
d) $25
e) $100

14. Performance information for each firm can be found in:

a) the annual report
b) the Wall Street Journal
c) shareholder disclosure reports
d) Business Week
e) the business section of any newspaper

Continue on to the next page

15. The average annual fluctuation of stock prices is:

a) $10
b) $80
c) $25
d) $50
e) $15

16. The lowest possible stock rating is:

a) C
b) E
c) C-
d) F
e) D-

17. If the performance value for the research and development division of a company is 50, the b value for that term is:

a) .1
b) .2
c) .3
d) .4
e) .5

18. The relationship between change in company profits and previous annual dividend is:

a) high and positive
b) moderate and negative
c) low and positive
d) low and negative
e) zero

Please raise your hand to let the experimenter know you are finished.

APPENDIX H

Application Learning Outcome

In this part of the session, you will play the role of an investment counselor. After examining the performance of several divisions for each of the ten companies listed below, you should estimate the price of the stock for that company.

Write your prediction in the box labeled "Predicted Stock Price." You should try to predict as close as possible to the actual stock price each time.

You will be provided with a calculator to assist in the math.

If you have any questions at this time, please feel free to ask the experimenter.

Please begin the test now.

Company 1:

- Marketing 20
- Research and Development 10
- Production 40

Predicted Price [ ]

Company 2:

- Marketing 110
- Research and Development 120
- Sales 70
- Production 130

Predicted Price

Company 3:

- Marketing 70
- Research and Development 50
- Production -30

Predicted Price

Company 4:

- Marketing 140
- Research and Development 110
- Sales 50
- Production 40

Predicted Price

Company 5:

- Marketing 80
- Research and Development 60
- Production 90

Predicted Price

Company 6:

- Marketing 140
- Research and Development 80
- Sales -20
- Production -60

Predicted Price

Company 7:

- Marketing 100
- Research and Development 120
- Production 120

Predicted Price

Company 8:

- Marketing -110
- Research and Development -70
- Production 40

Predicted Price

Company 9:

- Marketing 20
- Research and Development -70
- Sales 40
- Production 30

Predicted Price

Company 10:

- Marketing -70
- Research and Development 90
- Production -80

Predicted Price

APPENDIX I

Pilot Study Results

The following are the item means and corrected item-scale correlations for the items on the knowledge outcome measure used in the pilot. The coefficient alpha reliability for the scale was .38. In an effort to correct the high means and low item-total correlations, an additional distracter was added for each item. Three items were also added.

Item	x	$r_{i\text{-}s}$
1.	1.00	—
2.	.71	.06
3.	.92	-.22
4.	.58	.12
5.	.95	.11
6.	.95	.11
7.	.92	.11
8.	.89	.12
9.	.89	.02
10.	.82	.08
11.	.82	.40
12.	.97	-.25
13.	.66	.32
14.	.47	.29
15.	.68	.37

The following are the item means and corrected item-scale correlations for the items on the learning strategy measures used in the pilot. As a result of these data, several items on the rehearsal and organizing scales were rewritten.

Rehearsal (α = .33)			Organizing(α =.60)			Personalizing(α = .70)		
Item	x	$r_{i\text{-}s}$	Item	x	$r_{i\text{-}s}$	Item	x	$r_{i\text{-}s}$
1	3.97	.14	7	1.52	.71	13	3.29	.27
2	2.60	.13	8	4.31	-.01	14	2.52	.38
3	1.89	.04	9	1.81	.32	15	1.76	.63
4	3.92	.43	10	2.81	.19	16	1.55	.62
5	4.44	.00	11	2.58	.52	17	3.28	.37
6	2.81	.21	12	2.71	.45	18	3.86	.32

Note: The modified versions of all scales are presented in the Appendices.

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LIST OF REFERENCES

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