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Aaron M. Schmidt

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J Kevin Ford
Major professor

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PROMOTING ACTIVE LEARNING: THE EFFECTS OF METACOGNITIVE INSTRUCTION AND TRAINEE CHARACTERISTICS ON LEARNING PROCESSES AND OUTCOMES

By

Aaron M. Schmidt

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ABSTRACT

PROMOTING ACTIVE LEARNING: THE EFFECTS OF METACOGNITIVE INSTRUCTION AND TRAINEE CHARACTERISTICS ON LEARNING PROCESSES AND OUTCOMES

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Aaron M. Schmidt

The resent upsurge of computer-based training has thrust issues of learner control to the forefront. Research on metacognition suggests that those possessing weak metacognitive skills are less able to direct their own learning and, therefore, see less benefit from learner control environments. Learners often fail to adequately and accurately monitor their learning, resulting in sub-optimal decisions concerning how best to direct one's learning. In light of this problem, this study examined two interventions aimed at enhancing metacognitive activity during training. These interventions were placed within a model of self-regulated learning that links training design features (e.g. metacognitive training and prompting), trainee characteristics (e.g. goal orientations, self-efficacy), learning processes (e.g. metacognitive activity, study time), and learning outcomes (e.g. declarative knowledge, post-training self-efficacy, skill-based performance, application performance). Results provided partial support for the model. As predicted, metacognitive training interacted independently with both mastery goal orientation and pre-training self-efficacy in its effects on metacognitive activity throughout training. However, the relationship between metacognitive activity and learning outcomes was equivocal. Implications and directions for future research are discussed.

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INTRODUCTION

In order to meet the demand for quick, effective training, organizations have begun to rely heavily upon new technologies and advancements in training design and delivery. These technologies present new opportunities and challenges for both the trainee and the organization. The resent upsurge of computer-based training, particularly web-based training (WBT), provides a vivid example of the move toward technology-based training systems. WBT offers great flexibility to training designers in terms of content, as well as the organization and presentation of that content (Brown, Milner, Ford, & Golden, in press). WBT also provides the learner the opportunity to take greater control over his or her own learning. Learner control refers to degree to which learners are able to choose the method, timing, practice, and/or feedback during training (Milheim & Martin, 1991). Although the idea of granting the trainee greater control over their learning is not new (e.g. Tennyson, Christensen, & Park, 1984; Steinberg, 1977), web-based training is uniquely suited to this purpose. Thus, the increased utilization of web-based training programs has served to thrust issues of learner control into the forefront.

Research has pointed to advantages of increasing learner control. Among the more frequently cited benefits are trainee attitudes and motivation. Students allowed to choose the content, amount of study, sequencing, as well practice exercises have reported more positive attitudes toward the training (Kinzie & Sullivan, 1989; Milheim, 1989; Morrison, Ross, & Baldwin, 1992). Learner control allows trainees to progress through the training at a comfortable pace, as well as focus on content that is relevant to their specific training objectives, leading to greater training motivation and expectations of success (Milheim & Martin, 1991).

Despite these advantages, increased learner control brings to the table obstacles that may counteract the advantages. Studies on the effects of learner control on post-training achievement have failed to yield consistent results. While some have found that individuals learn more under learner control than program control (e.g. Gray, 1987; Hannafin & Sullivan, 1995; Kinzie, Sullivan, & Berdel, 1988), others have found the opposite (e.g. Tennyson, 1980; Tennyson & Buttrey, 1980; Tennyson & Rothen, 1979).

These inconsistent results may be explained in part by the finding that not all learners are capable of successfully directing their learning, indicating that many learners may fail to make the best use of the control they are given (Steinberg, 1989; Tennyson, Christenson, & Park, 1984). A consistent finding is that individuals are often poor judges of what or how much they need to learn (Tennyson & Rothen, 1979; Tennyson, 1980; Williams, 1993) and, therefore, often either prematurely discontinue instruction before mastery has been attained or continue to focus on material well past the point of mastery (Tennyson, 1980). Given the shift toward web-based instruction, two key questions demand consideration: 1). Why do learners so often fail to identify where to best allocate their time and attentional resources? and 2). What can be done to help learners better utilize their resources in a learner control training environment?

Examination of self-regulation in a learning context may shed some light onto each of these issues. Self-regulation theories seek to explain the process by which goals are translated into action. Two of the more prevalent theories of self-regulation are Bandura's Social Cognitive Theory (Bandura, 1986; Bandura, 1991) and control theory (e.g. Carver & Scheier; Klein, 1989), both of which are built around the concept of the feedback loop. In both social cognitive theory and control theory, the process of self-regulation begins with a goal. One is assigned or chooses a standard by which to compare their performance, behavior, etc. One then monitors their progress toward the standard, examining feedback provided by the environment, as well as that provided by themselves or others. This feedback is utilized to compare one's level of performance to the standard. When a discrepancy is discovered between performance and the standard, one makes judgments about the discrepancy and chooses some action to reduce the discrepancy.

One aspect of self-regulation emerging from educational and cognitive psychology, metacognition, may be particularly informative with respect to self-regulation in learning or training contexts. Most broadly, metacognition refers to "thinking about your thinking" (Flavell, 1979). Although metacognition is a broad, nebulous construct that has been conceptualized and operationalized in a myriad of often incompatible ways, a large portion of the metacognitive literature is focused on what individuals know about the content of their own memories, how they come to acquire this information, the accuracy (or lack thereof) of these assessments, and how this information is utilized to guide subsequent learning. Individuals possessing greater metacognitive skills are frequently found to learn more effectively than those who lack these skills, as they actively monitor their progress, determine where problems exist, and adjust their learning strategies accordingly (Brown, Bransford, Ferrara, & Campione, 1983).

The impact of metacognitive skills on learning effectiveness is unlikely to be uniform across program and learner control environments. Under program control, the extensive guidance built into the training program serves to direct learners and provides a clear, relatively rigid structure under which they are to operate, which may serve to reduce the impact of metacognitive skills. It is not critical that one know what, how, or for how long they should attempt to acquire when these decisions have already been made for the learner. Further, possessing strong metacognitive skills may be irrelevant, or even detrimental, if the training program does not provided the flexibility for trainees to actively pursue preferred learning strategies.

In contrast, when provided the freedom to control their own learning process, it is critical that trainees possess the skills to determine appropriate learning strategies. Those who are unaware of what they do and do not know cannot be expected to make effective decisions concerning how to best progress through the training. Those with strong metacognitive skills are given a venue to fully utilize their skills by structuring their learning experience in whatever manner they deem appropriate.

Although Kanfer and Ackerman (1989) have posited that, by diverting cognitive resources off-task, self-regulatory activity has detrimental effects early in acquisition, these effects should be less problematic under learner control. In many program contexts, learners have pre-specified and limited time available to learn the content of the training. If Kanfer and Ackerman's propositions are correct, trainees have a limited pool of cognitive resources available to allocate to learning activities in any given time period. Thus, time spent engaging in self-regulatory activity reduces the amount of resources spent on-task (on-task resources ≤ total cognitive resources – resources utilized for self-regulatory activities). However, Kanfer et al. (1994) demonstrated that, when given frequent breaks that could be utilized for self-regulatory activities, difficult-specific goals had a positive effect on learning outcomes, rather than the detrimental effects often found on complex tasks. Learner control training contexts allow trainees the freedom to take "breaks" whenever necessary to engage in "off-task" activities such as metacognition without interfering with their focus on the content of the training. That is, trainees can, if needed, devote all resources to training content and self-regulatory activities at separate dedicated time periods. Thus, self-regulatory activities are no longer forced to compete for limited resources during a set period of training – trainees can dedicate distinct blocks of time to focus "on-task" and to self-regulatory activities, in effect increasing the total time and cognitive resources devoted to the training as a whole.

How, then, can metacognition be leveraged to enhance self-directed learning? While pre-existing metacognitive skills have been found to be positively related to training success (e.g. Huet & Marine, 1997; Otero, Campnario, & Hopkins, 1992; Owings, 1980), a strict reliance on pre-existing trainee characteristics is inconsistent with the goals of many training initiatives. Selecting only individuals possessing these characteristics may not always be feasible or desirable for the organization. An alternative is the utilization of metacognitive interventions aimed at increasing metacognitive activity during training. This study is an attempt to examine the utility of metacognition and metacognitive interventions for enhancing learning in a non-academic training course. Although a number of studies have examined the utility of metacognitive interventions for improving learning outcomes, most have focused on children within educational settings. Further, the results of these studies have been equivocal, particularly among studies of adult populations on work-like tasks. Additionally, these studies have largely ignored the role of trainee characteristics, particularly those concerned with trainee motivation. I begin with an in-depth analysis of the existing literature on metacognition and metacognitive interventions. Limitations and implications of this literature are addressed with respect to their applicability to organizational training contexts. Finally a model seeking to address several key limitations of the extant literature is presented and tested.

Metacognition

Although the concept of metacognition has been examined in various forms for many years, Flavell is generally credited with bringing metacognition into prominence in modern psychology. Flavell (1979) conceptualized metacognition as deliberate, planful, goal-directed, and future-oriented mental behaviors that are directed toward accomplishing a task. According to Flavell, metacognition can be divided into four classes of phenomena: metacognitive knowledge, metacognitive experience, goals, and strategies. Metacognitive knowledge refers to one's knowledge and beliefs concerning people as cognitive beings. This knowledge consists of one's beliefs about their nature or the nature of others as cognitive processors, knowledge about the task and its demands, and knowledge about what strategies are likely to be effective in achieving one's goals. Metacognitive experiences are insights or feelings one has concerning their knowledge, such as the feeling that one does not understand. Such insights can lead one to establish new goals or modify old goals, add to one's metacognitive knowledge, and influence the activation of both cognitive or metacognitive strategies. Goals refer simply to the objectives one is attempting to achieve via their cognitive processing. Finally, strategies are the specific actions undertaken to achieve one's goals.

Kluwe (1987) helped to further refine the construct of metacognition. Kluwe identified two attributes of metacognitive activity consistent with Flavell's (1979) notion of metacognitive knowledge and metacognitive strategies, respectively. First, the thinking subject has some knowledge of their own thinking and the thinking of others. This attribute is based on declarative knowledge, such as the knowledge that one often does poorly in mathematics. The second attribute consists of active monitoring and regulation of one's own thinking, where one is acting as the causal agent of their own thinking, and is characterized as procedural knowledge. Kluwe referred to this latter attribute as executive processes. Executive processes were further subdivided into executive monitoring and executive regulation. Executive monitoring processes are those directed at attaining information about one's thinking process and include such processes as identifying the task, checking and evaluating one's progress, and predicting the outcomes of that progress. Executive regulation involves processes directed at controlling or otherwise influencing the course of one's own thinking. This includes decisions such as where to allocate one's resources, the specific steps to be used to complete the task, and the speed and intensity at which to work on the task.

A key characteristic distinguishing metacognitive thoughts from other cognitive phenomena is that metacognitive thoughts have other thoughts as their target. This raises an interesting paradox of the thinker simultaneously being the one who observes and the target of observation (Comte's paradox: James, 1890). In attempting to resolve this paradox, Nelson and Narens (1990) called on Tarski's (1956) solution to a similar paradox, the Liar's Paradox, by proposing that each process consists of two inter-related levels--an object level and a meta-level. Specifically, they proposed that consciousness is hierarchically organized in such a manner that allows higher levels (meta-levels) to monitor and control lower levels (object-levels).

A critical feature of this object-level/meta-level system is the direction of the flow of information between the two levels. Out of this come the two primary functions of the metacognitive system, consistent with the executive processes identified by Kluwe (1987) -- control and monitoring. Control is interpreted by stating that "the fundamental notion underlying control--analogous to speaking into a telephone handset--is that the meta-level *modifies* the object level, but not vice versa" (Nelson & Narens, 1990, p. 127). This information serves to direct the functioning of the object-level, instructing it to initiate an action, continue an action, or terminate an action.

In order to determine what instructions to give to the object-level, it is necessary for the meta-level to obtain information concerning the current status of the object level. This is achieved via monitoring of the object-level. "The fundamental notion of monitoring--analogous to listening to the telephone handset--is that the meta-level is *informed by* the object level" (Nelson & Narens, 1990, p. 127). This information serves to update the meta-level's model of the situation, which can then be evaluated with respect to the goal the system is attempting to achieve.

The interaction between monitoring and control processes in metacognition represents a negative-feedback loop such as that proposed by theories of self-regulation, such as social cognitive theory (Bandura, 1986; Bandura, 1991) and control theory (e.g. Carver & Scheier, 1982; Klein, 1989). In a learning context, the process of self-regulation begins with the setting of a learning goal. This goal may represents the level to which one seeks to learn the material at hand. These goals may be hierarchical in nature, such that one has goals for particular items or components of the to-be-learned material, as well as goals for the material as a whole. At this point, monitoring may occur in the form of pre-learning judgments of the material. One example of such pre-learning monitoring is ease-of-learning (EOL) judgments, wherein learners make implicit or explicit judgments concerning how difficult the material will be to learn (Leonesio & Nelson, 1990). These and other pre-learning judgments then influence the initial learning strategies utilized by the learner in their attempt to attain the desired level of mastery over the material. During ongoing acquisition, the learner monitors their memory to gauge their current level of knowledge and understanding. By engaging in this online monitoring of comprehension or understanding, often referred to as judgments-of-learning (JOLs), the learner is providing himself or herself with self-generated feedback which may be utilized independently or combined with other sources of feedback. This feedback is compared with the learning goal to determine progress toward the goal. The learner then engages in control processes, wherein they take some form of action, such as changing learning strategies, terminating study of the material, or simply making no changes. It can be seen from the discussion above that a major premise of metacognitive theory is that metacognitive processes can serve as a causal agent in the acquisition of knowledge.

The past two decades have seen increased interest in issues such as consciousness and metacognition, as well as improved methods of assessing such phenomena. This has lead to a wealth of research on cognitive topics such as metacognition, leading to strong evidence of its' causal role in learning. This evidence is presented in the sections that follow, in which I provide a review of the literature on metacognitive monitoring and control. This review begins with a description of metacognitive monitoring processes, including the various metamemory judgments that have been examined and the theoretical mechanisms underlying them. This is followed by an exploration of metacognitive control processes and the link between metacognitive monitoring and control.

Metacognitive Monitoring

Metamemory Judgments

Feeling-of-Knowing. While Flavell (1971; 1979) was responsible for stirring much of the current interest in metacognition, a few studies with relevance to metacognition predate his seminal work. Much of this early work centered on topics relevant to memory monitoring, also known as metamemory. Some of the earliest research on metamemory concerned a metacognitive experience referred to as feeling-of-knowing (FOK). Even after failing to recall previously studied material, individuals are still capable of making judgments concerning the degree to which the information is known. For example, even though one may not currently be able to recall the winners of Super Bowl XXV (New York Giants), they may have a good idea (feeling-of-knowing) of whether they in fact "know" this information and may subsequently be able to retrieve the correct answer from memory. Feelings-of-knowing are closely related to, although less intense, than the tip-of-the-tongue experience. The tip-of-the-tongue experience is the failure to retrieve information from memory, accompanied by a sensation of imminent recall (Brown, 1991). Although the tip-of-the-tongue phenomenon had been discussed at least as early as the 1940's (e.g. Woodworth, 1940), these early investigations were lacking in several respects, most notably in their lack of methodological precision, as well as their failure to examine the accuracy of these experiences.

In 1965, Hart conducted one of the first systematic studies seeking to determine the accuracy of FOK judgments. Undergraduate students were presented with lists of general-information questions, such as "Which planet is the largest in our solar system?" After each question was presented, subjects were given 10 seconds to attempt to recall the answer and write it down. If they were unable to recall the answer, they were asked to make a feeling-of-knowing judgment, indicating whether they believed they knew the answer but were unable to recall it at the moment and would be able to identify the correct answer in a multiple-choice format. After attempting to recall the answer to each question, subjects were presented with a multiple-choice form with the same questions. The results of the recognition test were compared to the subjects' feeling-of-knowing ratings for each item to determine whether the FOK judgments could predict recognition performance. These results indicated that FOK judgments are accurate, albeit imperfect indicators of the content of one's memory. Following up on this initial study, Hart (1967) later found that the FOK judgments increased in magnitude as the number of study trials increased.

In a more recent study, Nelson, Leonesio, Landwehr, & Narens (1986) asked a series of general-information questions to which individuals attempted to recall the answer and made FOK judgments for items not recalled. Each item had previously been normed with respect to both recall probability and FOK judgments, such that Nelson et al. knew the normative probability of recall and subsequent FOKs for each item. It was predicted that the normative probability of recall would be the least accurate predictor of recognition performance, while the individuals' own FOK judgments would be the most accurate, as the individual should be most aware of what they know. Surprisingly, this hypothesis was not confirmed. Rather, the normative probability of recall was the most accurate predictor of recognition, followed by the individuals' own FOK judgments. That the individuals' own FOK judgments were better predictors of recognition than normative FOKs suggests that individuals have some access to their unique, idiosyncratic knowledge. However, the finding that normative recall probability was a better predictor than FOK judgments indicates that this access is somewhat limited.

Many other feeling-of-knowing studies have been conducted using various subject populations (e.g. children: Wellman, 1977; mentally retarded: Brown & Lawton, 1977; older adults: Lachman, Lachman, & Thronesbery, 1979), types of items (e.g. nonsense syllables: Blake, 1973; picture labels: Wellman, 1977; names of entertainers: Read & Bruce, 1982), and criterion tests (e.g. recognition tests: Hart, 1965; cued-recall: Gruneberg, Monks, & Sykes, 1977). The vast majority of these studies have found that FOK judgments are accurate at moderate, but above-chance levels. This leads to the conclusion that individuals have partial, but far from perfect access to their knowledge concerning items for which they cannot immediately recall the answer.

<u>Confidence in Retrieved Information</u>. A second category of metacognitive monitoring is the confidence one has in the answers they provide. In contrast to FOK judgments, judgments of confidence are purely retrospective in that they occur after both acquisition and retrieval of the target information. That is, individuals are making judgments concerning the content of their memory after they have provided an answer.

Confidence ratings have often been obtained in a similar manner as FOK judgments, only for recalled, rather than non-recalled items, as is the case with FOK judgments. More specifically, FOK judgments can be made for omission errors (items not recalled) or commission errors (items incorrectly recalled), whereas confidence judgments are made for correctly recalled items or for commission errors (Narens, Jameson, & Lee, 1994). In the typical study, subjects are first presented with a set of general information questions. For each item recalled, subjects are asked to rate how confident they are that the answer they provided was correct. These ratings can then be compared to recall performance to determine the relationship between confidence and accuracy.

The typical finding for confidence ratings is that they are only moderately well calibrated, and generally reflect overconfidence (e.g. Bornstien & Zickafoose, 1999; Koriat & Goldsmith, 1996; Lichtenstein & Fischoff, 1977). The general trend of moderate calibration and overconfidence has been found not only for general knowledge questions and item lists, but for eyewitness accuracy, as well (e.g. Wells & Murray, 1984). A meta-analysis of the confidence and accuracy among witnesses of staged events found that a mere .25 correlation between confidence and accuracy (Bothwell, Deffenbacher, & Brigham, 1987). As in general knowledge domains, the general source of inaccuracy is overconfidence. Bornstein and Zickafoose (1999) directly compared confidence and accuracy across the domains of general knowledge and eyewitness memory. They too found evidence of overconfidence, which was consistent across domains. Interestingly, they found that providing individuals feedback concerning their degree of overconfidence reduced their subsequent levels of overconfidence.

Ease-of-Learning Judgments. A third metamemory judgment is ease-of-learning (EOL) judgments. EOL judgments differ from other metamemory judgments in that they occur *prior* to acquisition, while most other judgments are made at some point *during* or *after* acquisition. These judgments are essentially predictions of how easy or difficult the material will be to learn.

Leonesio & Nelson (1990) found that EOL judgments significantly predicted the rate of acquisition (number of trials needed to attain a given number of correct recalls), with items with higher EOLs requiring fewer trials to learn, although this relationship was only of moderate size (r = -.22). Additionally, a small, but significant correlation was found between EOL and recall, despite the fact that recall occurred four weeks after EOLs and initial learning of the items. Hall and Bahrick (1998) found that EOL ratings had a mean correlation of .24 with final recall performance 5 years after initial acquisition. Despite the long-term relationship between EOL ratings and recall, EOL judgments are most predictive of early performance (Nelson & Leonesio, 1988).

A consistent finding of the EOL research to date is that EOL judgments are moderately accurate predictors of actual rate of learning, as well as subsequent recall performance. This adds further support to the conclusion that individuals have at least partial access to their existing knowledge, which allows them to estimate the ease with which material may be learned. However, the modest size of this relationship points to the fact that the accuracy of individual's monitoring is far from optimal.

Judgments-of-Learning. While much of the early metamemory research focused on the metacognitive experience of feeling-of-knowing, more recently the focus has shifted to judgments-of-learning (JOL) as the primary metamemory judgment of interest.

Judgments-of-learning represent one's perceptions concerning the degree to which currently or recently studied material has been learned and can be retrieved from memory at a later time (Leonesio & Nelson, 1990). Operationally, they are generally assessed prior to a test of retention (generally recall), and are often followed by additional study time. Thus, in contrast to most other metamemory judgments, which generally occur either before (ease-of-learning judgments) or after acquisition (feeling-of-knowing and confidence judgments), JOLs represent *online* monitoring of one's memory, as they occur *during* the process of acquisition.

Like the metamemory judgments discussed above, studies of JOLs typically utilize list learning, such as paired-associates, or general knowledge questions. For example, Arbuckle and Cuddy (1969) asked subjects to learn lists of paired-associates, with each item presented for 3 seconds. Immediately following the presentation of each item, subjects made "Yes" or "No" predictions referring to whether they would be able to recall that item on a subsequent retention test. Subjects were able to predict their recall performance at moderate, but above chance levels. In a study using a similar design, the accuracy of JOLs in predicting recall performance was established for multi-trial acquisition of paired associates as well (Vesonder & Voss, 1985). Using unrelated noun-noun pairs, Leonesio and Nelson (1990) also found that JOL ratings were moderately correlated ($r \approx .30$) with recall performance. Additionally, JOLs significantly predicted the number of trials required to acquire each item to a predetermined criteria.

While most studies of JOLs have examined their relationship with recall performance, they have been demonstrated to predict recognition as well (e.g. Begg, Duft, Lalonde, Melnick, & Sanvito, 1989; Leonesio & Nelson, 1990; Thiede &

Dunlosky, 1994). For example, in the aforementioned study by Leonesio and Nelson (1990), JOLs made after initial item acquisition were correlated over .20 with recognition of items that initially could not be recalled on a previous test, despite the fact that the recognition test took place four weeks after acquisition and the recall test. Theide and Dunlosky (1994) and Begg et al. (1989) also found that JOLs predicted both recall and recognition, but found that JOL accuracy was significantly greater in predicting recall, although correct guessing may contribute to the reduced accuracy of JOLs for recognition tests.

Understanding and Improving Monitoring Accuracy

While overconfidence has been found to be the rule, rather than the exception, some steps have been effective in improving the accuracy of metacognitive monitoring. In attempting to determine the psychological processes underlying inflated post-response confidence ratings, Koriat, Lichtenstein, and Fischoff (1980) suggested that individuals selectively focus on evidence that supports their chosen answer, rather than evidence that may contradict it. To test this hypothesis, subjects were asked to either provide reasons supporting the chosen answer, reasons contradicting the chosen answer, both reasons for and against chosen answer, or no reasons (control condition). Providing contradictory reasons led to greater calibration, whereas providing supporting reasons had no effect, suggesting that this is what individuals do naturally when making confidence ratings. Other studies have found that informing individuals of the tendency toward overconfidence, as well as providing feedback concerning their own overconfidence improve calibration and reduce overconfidence (e.g. Bornstein & Zickafoose, 1999).

While some research has examined the mechanisms underlying and means for increasing the accuracy of one's post-response confidence, much of the attention has been on understanding and improving the accuracy of judgments of learning (JOLs) that one makes during the learning processes. Vesonder & Voss (1985) found that predictions of trial 2 recall were significantly more accurate when subjects had previously made recall predictions at trial 1. Specifically, the general tendency toward overestimating one's learning was reduced for those making JOLs on both trials, leading to increased accuracy. JOL accuracy has also been found to increase when they follow earlier attempts at retrieval (e.g. King, Zechmeister, & Shaughnessy, 1980). For example, subjects who were only presented with study trials prior to a final recall test made less accurate JOLs than did those who alternated between study trials and test trials prior to the final recall test (King, Zechmeister, & Shaughnessy, 1980). However, when presented with a new paired-associates list and study trials only, JOL accuracy between the groups was equivalent, indicating that the increased JOL accuracy during the study-test trial blocks was due to knowledge of previous performance, rather than the development of superior monitoring capabilities. These results indicate that engaging in previous attempts at retrieval is often successful in increasing monitoring accuracy. It is important to note, however, that study time was experimenter controlled and was equivalent across items, the implications of which will be highlighted in the following section on metacognitive control.

In the first of two experiments examining the effects of different kinds of encoding on JOLs and recall, Mazzoni and Nelson (1995) sought to determine whether JOL accuracy for lists of unrelated Italian word pairs was greater as a result of intentional learning in comparison to incidental learning. Subjects in the intentional learning group were instructed to read and learn the items, while those in the incidental learning groups were either asked to rate the pleasantness of each word or report the number of syllables for each word. Although recall was equivalent for all groups, JOL accuracy was greater under intentional learning.

Given the greater accuracy of JOLs following intentional learning, Mazzoni and Nelson (1995) conducted a second study to examine JOL accuracy for general-knowledge items under two types of intentional learning: passive reading and active generation of responses during acquisition. The passive reading group was presented with each item for 3 s, read the answer for 7 s, and then had 7 s to make a JOL. After the 3 s item presentation, the active generation group had 7 s to attempt generate, rather than read, the answer prior to making a JOL for each item. Active generation led to JOLs of significantly greater magnitude, as well as greater recall performance, than did passive reading. These results also point to the advantages, with respect to monitoring accuracy, of active attempts at retrieval.

One of the most robust factors influencing the accuracy of judgments-of-learning is the delay between item study and the JOL rating, known as the delayed-JOL effect. Nelson and Dunlosky (1991) had subjects make JOL ratings for each paired associate either immediately after presentation or after the presentation of eight additional items. When the JOLs were made immediately after presentation, accuracy was moderate at around .35. However, when delayed, JOL accuracy increased for all subjects, and was nearly perfect for most (.80 overall). Thiede & Dunlosky (1994) also compared the accuracy of immediate and delayed JOLs for predicting both recall and recognition of paired associates and found that, for both tests of retention, JOLs were more accurate when delayed, rather than immediate. Connor, Dunlosky, and Hertzog (1994) found evidence of a strong delayed-JOL effect in both young and older adults.

Several hypotheses have been forwarded to explain the accuracy of delayed, in comparison to immediate, JOLs. Based on the finding that a delayed-JOL effect occurs when JOLs are based on the stimulus alone (e.g. "dog-?") but not when based on both the stimulus and response (e.g. "dog-table"), the transfer-appropriate-monitoring (TAM) hypothesis has been proposed (Begg et al., 1989). This hypothesis suggests that the locus of the delayed-JOL effect is the contextual similarity between the JOL and the recall test. Delayed JOLs cued by the stimulus alone are more similar to a cued recall test than are delayed JOLs cued by stimulus and response or immediate JOLs cued by either stimulus alone or stimulus and response. To test this hypothesis, Dunlosky and Nelson (1997) had subjects make either delayed or immediate JOLs cued by the stimulus alone or the stimulus and response and examined the resulting correspondence between these JOLs and a recognition test. In the case of recognition, the stimulus-response cue is most similar to the retention test and thus, the TAM hypothesis would predict, should yield the greatest JOL accuracy. However, the results showed that even when predicting recognition, rather than recall, JOLs cued by the stimulus alone were more accurate than those cued by both the stimulus and response, refuting TAM as a primary cause of the delayed-JOL effect.

The monitoring-retrieval hypothesis states that, when making judgments about their learning, individuals must monitor their memories for information about the item in question (e.g. Dunlosky & Nelson, 1994; King, Zechmeister, & Shaughnessy, 1980;

Spellman & Bjork, 1992). To the extent that the information one retrieves from memory concerning an item is predictive of eventual performance on a retention test, the JOL will be accurate.

One particular case of the monitoring-retrieval hypothesis, the monitoring-dual-memories (MDM) hypothesis, has been widely cited as a major source of the delayed-JOL effect (Dunlosky & Nelson, 1992; Kelemen & Weaver, 1997; Nelson & Dunlosky, 1991). According to the MDM hypothesis, a person monitors information from both short-term and long-term memory in parallel (Wescourt & Atkinson, 1973). When JOLs are made immediately following presentation or study of an item, information about the item is still present in STM, which may interfere with one's ability to make a valid assessment of whether the item has been successfully transferred to LTM. Delaying the JOLs for a period of time allows the item to be cleared from STM. Thus, delayed assessments of the presence or absence of the item in memory are based solely on retrieval (or lack thereof) from LTM. In the case of stimulus-only versus stimulus-response cues for JOLs, providing both the stimulus and response allows both to enter STM, leading one to overestimate their degree of learning of the item, whereas the stimulus alone forces one to search LTM for the response.

Several pieces of evidence support the MDM hypothesis as a major source of the efficacy of delayed JOLs. The longer the delay between item study and JOLs, the greater the accuracy of the JOLs (Nelson & Dunlosky, 1991). Additionally, providing STM interference between item study and JOLs dramatically improves JOL accuracy (Kelemen & Weaver, 1997). Regardless of the explanations, it is clear the delayed-JOL effect is a robust finding with great implications for self-regulated learning.

Metacognitive Control

Metacognitive control refers to activities taken by individuals to influence the course of their own thinking, including initiating, monitoring, and prioritizing mental activities (Mazzoni & Nelson, 1998). This conceptualization of control corresponds to Flavell's (1979) notion of metacognitive strategies, Brown's (1978) metacognitive skills, and Kluwe's (1987) executive regulation. The wide variety of cognitive activities subsumed under the concept of metacognitive control can be roughly divided by the stage of learning to which they are most relevant (Nelson & Narens, 1994). During acquisition, the key control processes are the selection of a mnemonic strategy (i.e. repetition, visualization, etc.), the allocation of study time, both in total and to individual components of the learning material, and termination of study time. Additional control strategies relevant to acquisition are determining the specific steps to be taken to acquire the information (in addition to the mnemonic strategy to be used), as well as the speed and intensity at which one should work at the learning task (Kluwe, 1987). During retrieval, the key control processes include the selection of a search strategy and termination of the search for learned material.

Monitoring Affects Control. It has been demonstrated that individuals are capable of monitoring the content of their memories with varying degrees of accuracy and bias. While the privileged access to one's own memory is an interesting phenomenon in itself, the true value of monitoring, from a training perspective, is in its effects on control processes during learning. Knowledge of one's consciousness plays a critical role in the ongoing acquisition of knowledge and skills. The monitoring-affects-control hypothesis proposes that information gained through monitoring one's memory can be utilized by evaluating it relative to the goal state to determine the actions in which to engage to achieve one's learning goals (Nelson & Leonesio, 1988). Effective self-regulation of learning is predicated on an accurate assessment of what is known or not known (Schoenfeld, 1997).

Many empirical examples support the role that monitoring plays in control processes. Much of this research has focused on the influence of monitoring judgments on the allocation of self-paced study time. In one of the first such studies, carried out by Bugelski and Rickwood (1963), it was found that subjects in a self-paced study condition outperformed those in an experimenter-paced study condition on a retention test. Bugelski and Rickwood concluded that subjects in the self-paced condition were able to allocate additional study time to the more difficult items, which subsequently increased retention. However, only aggregate, rather than item-by-item study time was reported, precluding strong support for this conclusion. Other studies have found that subjects do not allocate study time uniformly across items, but rather allocate more time to some items than others (e.g. Belmont & Butterfield, 1971; Butterfield & Belmont, 1977; Zacks, 1969). This also has been interpreted as evidence of the allocation of more study time to items of greater objective difficulty (as determined by normative probability of recall).

These studies provide indirect evidence that individuals allocate additional study time to items of greater difficulty. Implicit in this conclusion is the assumption that individuals make reasonably accurate, idiosyncratic assessments of item difficulty and/or accurately monitor their learning during acquisition. In turn, subjects are presumed to use these judgments to determine how much study time to allocate to each item. However, these assumptions had yet to be directly examined. Nelson and Leonesio

(1988) provided one of the first such direct tests of the monitoring-affects-control hypothesis. It was predicted that subjects would use both ease-of-learning (EOL) and feeling-of-knowing (FOK) judgments to allocate self-paced study time differentially among the items to be learned. Consistent with their hypotheses, a negative correlation was found between EOL ratings and item-by-item study time, such that items rated as being more difficult to learn were studied longer. FOK judgments were also significantly correlated with study time, with items receiving lower feeling-of-knowing ratings being studied longer.

A surprising finding was that additional study time yielded little gain in terms of performance on the retention tests, a finding that has been labeled the "labor-in-vain" effect. Subjects who were instructed to learn the items as accurately as possible studied up to three times longer across all items than did subjects instructed to learn the items as quickly as possible. However, despite the extra study time, the accuracy group only demonstrated better retention in one of three studies and, even where significant, the difference was minimal. In a similar study examining the role of EOL and JOL ratings on self-paced study time, Mazzoni and Cornoldi (1993) found results that they interpreted as an "item labor-in-vain" effect. Specifically, although both EOL and JOL ratings were negatively correlated with study time, as predicted, items studied longer were not recalled with higher frequency. From these results, the authors concluded that "the effect makes the choice of a correct study time strategy irrelevant" (p.48).

Nelson (1993) provided several alternative explanations for the " labor-in-vain" effect. These explanations centered on an item selection bias, such that items were not initially equivalent with respect to difficulty. Because subjects chose which items to study longer, more difficult items received lower EOL and JOL ratings and were subsequently studied longer. This extra study time may have, in fact, increased the retention of the more difficult items. However, even the extra study time may not have been sufficient to bring the more difficult items up to the same level of retrieval as the less difficult items. Such a situation, where extra study time leads to greater retention than would have been observed otherwise, would represent "labor-and-gain," rather than "labor-in-vain." Labor-and-gain can occur regardless of item retention relative to other items. This hypothesis is known as incomplete compensation, and stands in contrast to the complete compensation (extra study time equalizes retention of all items) and the overcompensation hypothesis (extra study time leads to better retention).

Other studies have also demonstrated a significant relationship between judgments-of-learning and self-paced study time (Bauer, Kyaw, & Kilbey, 1984; Dunlosky & Connor, 1997; Mazzoni, Cornoldi, & Marchitelli, 1990). For example, Mazzoni, Cornoldi, and Marchitelli (1990) found that JOLs significantly predicted study time, with greater study time allocated to items judged to be less well learned. These items were subsequently recalled equally well as were items judged to be easier. Dunlosky and Connor (1997) investigated the utilization of memory monitoring for the allocation of study time among undergraduates and older adults (mean age of 67 yrs). They found that individuals from both age groups utilized their judgments of learning to allocate study time during later study periods.

Surprisingly, relatively few studies have investigated how the allocation of study time is influenced by delayed JOLs. However, Nelson, Dunlosky, Graf, and Narens (1994) provide a notable exception, demonstrating the promise of utilizing delayed JOLs to improve the allocation of study time and subsequent recall. Using a computer-controlled variant of the familiar paired-associates paradigm, participants first learned 36 item-pairs, followed by delayed judgments of learning for each item (based on the stimulus alone: ex. ardhi- ?). After the delayed-JOLs for each item had been made, subjects in a "self-chosen-items" group chose 18 of the 36 items that would later be restudied. This was followed immediately by a self-paced recall test for all 36 items. After the recall test, all subjects were presented with 18 items to restudy. Subjects in the self-chosen-items group restudied those 18 items that had been chosen earlier. In the worst-learned-items group, the computer chose for each subject the 18 items to which they had given the lowest JOLs. In the best-learned-items group, subjects were presented with the 18 items to which they had given the highest JOLs. Finally, in the normatively-most-difficult-items group, subjects were presented with the 18 least recalled items, based on norms from previous studies. This was again followed by a self-paced recall test. Four additional restudy-test cycles followed.

As predicted, the lowest recall across all six test trials resulted from restudy of the "best-learned" items, followed by restudy of the normatively-most-difficult items. The "worst-learned" and self-chosen items groups did not differ in their recall for any of the six trials. The "best-learned" and normatively-most-difficult items conditions failed to utilize individuals' judgments of learning to allocate study time to the items that most needed additional study. Rather, the "best-learned" items condition allocated restudy to items for which their exists the least potential for improvement. That recall was lower for the normatively-most-difficult items condition than the remaining two conditions indicates once again that individuals' are sensitive to idiosyncratic information in memory, and that judgments deriving from these are more useful for guiding subsequent study than is normative information. Taken as a whole, these findings indicate that utilization of delayed judgments of learning during study time allows learners to allocate the greatest study time to the items which need it the most, which can lead to increased memory performance.

While much of the research reviewed to this point has been conducted in laboratory settings, metacognitive monitoring has been implicated as a key causal variable of learning in more naturalistic settings. In a study of class performance among fifth-grade students, Owings et al. (1980) discovered that the more successful students spontaneously and accurately monitored their comprehension as they read and studied and, as a result, were more aware of when they were having difficulty. Further, the successful students allocated greater study time to more difficult stories, whereas less successful students allocated study time evenly across stories, indicating that the successful students utilized their monitoring to regulate their learning. Similarly, Otero, Campanario, and Hopkins (1992) found a strong positive relationship between comprehension monitoring and GPA among 10th and 12th grade students. Huet and Marine (1997) investigated the relationship between metamemory knowledge and memory performance on a simulated table-waiting job. Metamemory knowledge significantly predicted performance on each memory task, regardless of other memory constraints, such as table size and perceptive cues.

Limitations of Metamemory Research

Generalizability. Among the most salient limitation of the metamemory research concerns issues of generalizability. Despite the substantial empirical support for the positive impact of metacognition on learning, one must question whether similar results can be expected in real-world training settings. Much of the concern over the generalizability of the results is driven by the simplicity of the learning tasks utilized in the vast majority of the metamemory studies. Much of the metamemory research has relied on list-learning as the vehicle to examine individual's monitoring of their own memories. Some have used lists of general knowledge items (i.e. "What is the capitol of Finland?"), while the majority have used lists of paired associates, such as English-Swahili equivalents for a given concept (i.e. "Soil-Adhir").

In a 1995 address, Kraiger highlighted differences in task complexity as a key difference between cognitive and I/O psychology paradigms, noting that the reliance on simple tasks is often consistent with the goals of basic cognitive research. For cognitive researchers studying learning, the focus is on fundamental learning mechanisms that are assumed to be active across individuals and contexts. Therefore, tasks are chosen that allow a clean test of the hypotheses without interfering with the mechanisms or practice conditions under investigation. In contrast, I/O psychology is concerned with learning mechanisms and practice conditions only in so far as they are relevant in real-world training and/or performance contexts. Therefore, greater concern is given to the fidelity of the task, the extent to which it mirrors critical elements of the target.

Given the goals of cognitive psychology, the use of simple learning tasks by metamemory researchers is neither surprising nor unjustified. However, such tasks ignore differences in prior knowledge, environmental factors, are often of short duration, etc., making attempts to generalize the findings to more complex tasks tenuous (Kraiger, 1995). While the list-learning/paired-associates paradigm may resemble some of the requirements for some jobs in which memorization of lists of information are a critical aspect of the job, such as that of table waiting, by and large, list learning represents a very narrow sample of the type of knowledge, skills, and abilities that must be acquired to perform effectively in most jobs.

Coinciding with its focus on relatively simple learning tasks, much of the existing research on metacognitive monitoring has evaluated the impact of monitoring using a narrow range of criteria, most often consisting of performance on a recall and/or recognition test occurring immediately following the presentation and study of the list. While this is understandable, given the tasks generally utilized in such studies, it serves to compound the difficulty of generalizing the findings to more complex settings and criteria. It has been convincingly demonstrated that individuals are capable of accurately monitoring their memories under paired-associate learning tasks and that this monitoring can influence control processes, which allow for better performance on recall and/or recognition tests immediately following study. However, such indicators of immediate learning or training performance may not reflect the degree to which training will be successful in the long-term. It has been found that interventions which introduce greater difficulty to the learner may slow acquisition and result in lower performance during training, yet often yield substantial long-term gains relative to interventions maximizing speed of acquisition and performance during training (Bjork, 1994; Schmidt & Bjork, 1992). From this finding, it is clear that immediate training performance is insufficient to capture the long-term utility of a training intervention. While a few studies have linked metamemory judgments with long-term retention (e.g. Hall & Bahrick, 1998), the distal effects of metacognitive monitoring have gone largely unexamined.

In addition to focusing primarily on immediate indicators of learning, the criteria of choice have almost exclusively been measures of verbal or declarative knowledge. Many theories of knowledge acquisition agree that declarative knowledge must be attained before higher-level development can occur (e.g. Ackerman, 1987; Anderson, 1982). Because declarative knowledge generally serves as a foundation for further high-order cognitive development (Anderson, 1982) and are most sensitive during the early stages of knowledge acquisition (Kraiger, Ford, & Salas, 1993), the placement of recall or recognition tests immediately following study is serendipitously well timed. However, it is in their reliance on immediate declarative knowledge as the <u>sole</u> measure of learning that the metamemory literature has missed the mark.

Because declarative knowledge may not discriminate between learners at higher levels of cognitive development (Kraiger, Ford, & Salas, 1993), simply re-assessing declarative knowledge at some later point during or after training is not sufficient to capture the full range of cognitive development. A valuable addition would be measures assessing skill-based and affective learning outcomes. During initial skill acquisition, performance tends to be slow, error-prone, and resource-dependent (Weiss, 1990). However, as skill development progresses, performance becomes faster, less error-prone, and approaches automaticity, freeing up cognitive resources which can then be directed toward additional tasks or to the development of more elaborate task strategies. In addition, during the latter stages of skill development, learners become more adept at determining the appropriate situations for skill use (Gagne & Medsker, 1996), allowing them to adapt their skills when necessary. Skill-based learning outcomes represent an important criterion for organizational training programs, yet the role of metacognitive monitoring in skill development remains largely unexplored.

Motivation. Another limitation of the current metamemory research is that it has failed to examine the extent to which individuals vary in their use of metacognitive monitoring, or the ability of motivational learner characteristics to explain or predict this variability. The design of most metamemory studies is such that all individuals are required to make monitoring judgments before they can proceed to the next stage of the study. Under such controlled experimental conditions, individual differences in general, and those that influence motivation in particular, are less able to affect the frequency with which individuals engage in monitoring. However, even under these limited conditions, one might expect individual differences to influence aspects of metacognition such as the accuracy of monitoring and the extent to which individuals use the information gained by monitoring to guide their learning via control processes.

The failure of metamemory researchers to examine the effects of motivation or other individual differences is consistent with the goals and assumptions of much of the cognitive literature (Kraiger, 1995). Because the processes under examination are generally assumed to be common to all individuals, individual differences are regarded as error, hence, experiments are strategically designed to minimize this source of "error variance." However, in less tightly controlled environments, as more accurately reflects most real-world learning environments, there is likely to be great variability in the extent to which individuals monitor their learning, as well as in the way they use the information that monitoring provides. This variability in monitoring may result from any number of differences between individuals--thus individual differences represent important sources of variance that applied researchers must take into consideration.

Motivationally relevant individual differences may heavily influence the extent to which individuals engage in metacognitive monitoring, as well as their reactions to and utilization of this monitoring to influence the course of their learning. For example, when monitoring reveals that one's current level of learning is below the desired level of learning, some individuals may view this feedback as diagnostic, whereas others may view this information as an indication of a lack of competence. This reaction, in turn, may determine whether one utilizes this information productively, by allocating additional study time, changing strategies, etc., or counterproductively, such as ignoring, discontinuing monitoring of one's learning, or physically or psychologically disengaging from the task as a means of avoiding further negative feedback.

Metacognitive Interventions

Given the conceptual and empirical support for the benefits of metacognition in enhancing learning, research efforts have been aimed at enhancing metacognition during learning. Much of this research has examined the utility of metacognitive interventions for improving learning outcomes among young children within academic settings. In a study by Meloth (1990), 3rd-grade students were instructed in a manner intended to improve their knowledge of cognition. The training resulted in modest changes in students' knowledge of cognition over the course of a year, although this knowledge was strongly associated with strategy use and reading comprehension. Short and Ryan (1984) taught low-skill fourth-grade students a strategic plan (i.e. asking who, what, when, where, and why) that was intended to aid the less-skilled readers in the monitoring of their reading comprehension. As predicted, strategy training increased the poor readers comprehension up to the level of the skilled readers (who did not receive strategy training), as assessed by free and probed recall. Also working with fourth-grade students, Weed, Ryan, and Day (1990) provided some students with instructions on process monitoring, which focused attention on interdependencies among the to be learned material, on their use of strategies, and on how much of the material they were remembering. Memory monitoring was significantly related to post-test recall of nonsense syllables and position probes. Payne and Manning (1992) taught 4th-grade students comprehension monitoring strategies for use during guided reading lessons. Compared to a control group, students receiving the comprehension monitoring training demonstrated greater reading comprehension, knowledge about reading strategies, and more positive attitudes toward reading.

The efficacy of metacognitive skills training has been examined with older populations as well. Volet (1991) sought to develop students' metacognitive skills over the course of a 13-week introductory computer science course by teaching a metacognitive strategy tailored specifically to computer programming that included planning, monitoring, and evaluation components. Of seven assessments of computing performance, the trained group only significantly outperformed the control group in their ability to apply their knowledge to solve new problems. A significantly greater number of trained than control students passed a follow-up computing course.

Murphy, Schmitt, Caruso, and Sanders (1987) examined differences in metamemory in older and younger adults and its effects on recall of black and white pictures. Young adults instructed to remember as many pictures as possible rehearsed longer, recalled more, and spontaneously self-tested more than did older adults. Older adults who were instructed to monitor their memory by self-testing prior to indicating readiness to recall showed improved short-term recall and generalization as compared to older adults instructed only to remember. Because no young adults were instructed to monitor but rather were only instructed to remember as much as possible, it is not possible to determine from this study whether self-testing instruction is beneficial for younger adults as well.

Among of the more successful metacognitive interventions have been those teaching learners question generation strategies as a means of monitoring their comprehension. Bean et al. (1986) examined the effects of question generation and graphic organization strategies on text recall of 10th-grade history students. The comparison group received instruction on outlining, while two groups received instruction on the use of graphic organizers, with one of the two graphic organizer groups receiving previous training on question generation, which consisted of selecting or creating statements to organize the text, writing questions based on these statements, and evaluating the responses generated. No differences were found between the three groups on the first five of six 15-item quizzes. However, on quiz six and on written recall protocols, the group receiving both question-generation and graphic organization training significantly outperformed the two other groups. Because this group also outperformed the graphic organizer only group, this suggests that the locus of its effectiveness was in the question-generation strategies rather than graphic organization, although a more rigorous experimental design is in order to test this assumption.

In a series of studies, King and colleagues investigated the efficacy of self-questioning strategies for enhancing lecture and reading comprehension (King, 1989; King, 1992; King & Rosenshine, 1993). The interventions consisted of an introduction to the basic concepts and purposes of metacognition, followed by presentation of generic question stems that require learners to fill in the blanks (i.e. "How does... affect ... ?"). After the instructor had taught and modeled the question generation strategy, students were instructed to utilize these strategies during practice sessions, with the question stems displayed on an overhead screen to reduce cognitive load. Students using these generic question stems have generally been found to demonstrate greater lecture comprehension, metacognitive process, strategy use, and knowledge structure (King, 1989; King, 1992; King & Rosenshine, 1993) than controls, as well as students taught other learning strategies such as note taking and summarizing. In one study with college students, those taught a summarization strategy recalled more than those taught question generation immediately following the lecture (King, 1992). However, self-questioners outperformed the summarizers on a retention test one week later.

A recent meta-analysis of self-questioning interventions provides further support for the utility of generic question stems as a means of improving comprehension (Rosenshine et al., 1996). Twenty-six question generation interventions were further divided into five types: 1). those based on signal words, such as who, what, when, where, why, and how, 2). those focusing on the identification of main ideas, 3). those focusing on the identification of types of questions they were being asked, 4). those teaching students to generate questions about key story grammar categories, such as setting and main characters for reading comprehension, and 5). those utilizing generic question stems that require learners to fill in the blanks (i.e. "How are... and ... alike?"). While the findings for main ideas, question types, and story grammar categories were somewhat equivocal, signal words and generic question stems consistently led to large increases in comprehension among average, below average, and above average students. These interventions were particularly effective for college students, as opposed to younger students. It is also worth noting that, at least among those interventions examined in this meta-analysis, the most effective interventions were easy to learn and use, provided guidance and focus, but did not demand strong cognitive skills or an extended period of time to utilize effectively.

The list of studies attempting to train metacognitive skills outside the context of the classroom is all too brief. Lorenc et al. (1992) instructed 30 stroke patients to ask themselves if they understood the information in each section immediately after reading it. Those given the self-questioning instructions performed significantly better on a stroke knowledge test than did the control patients. Unfortunately, other attempts to apply metacognitive interventions outside the classroom have been less successful. Weissbein (1996) provided instruction on planning, monitoring, and evaluation of learning aimed at enhancing trainees' learning and performance on a radar-tracking simulation. Contrary to the hypotheses, metacognitive training did not lead to greater metacognitive activity, declarative or procedural knowledge, or task performance, although post-hoc content analysis of metacognitive activity ratings revealed a relationship between metacognition and many key study variables. Using the same radar-tracking task, Smith (1996) provided instruction on what it means to plan, monitor, and evaluate task strategies, coupled with three levels of discovery learning. While the results with respect to discovery learning were intriguing, metacognitive training only had a significant effect on verbal knowledge and adaptive transfer, and only when coupled with a pure discovery learning environment. Finally, in another study using the radar-tracking task, Brown et al. (1997) provided subjects with strategic instruction, which included choosing, evaluating, and modifying task strategies. However, Strategic Instruction did not lead to improvement in learning outcomes, as the only significant predictor of knowledge, strategy use, or task performance was cognitive ability.

Overall, interventions aimed at increasing metacognition among learners have been relatively effective at increasing both metacognitive activity and learning outcomes such as recall and test performance. This has been particularly well demonstrated among young children in academic settings. Fewer studies have attempted to apply metacognitive interventions to adult learners. Those that have generally have concluded that metacognitive interventions can be effective for adult learners as well as children (Volet, 1991; Murphy et al. 1987; King, 1992). Particularly promising are interventions that facilitate self-questioning during learning (Rosenshine et al., 1996). Among such self-questioning interventions, the use of generic question stems seems to be particularly effective, resulting in an average increase of over one standard deviation in multiple-choice and short-answer test performance across the four such studies included in the Rosenshine et al. meta-analysis.

Limitations of Metacognitive Intervention Research

Generalizability. With the exception of generic question stems, many of the interventions reviewed above are often taught over time spans ranging from several weeks to an entire academic year. Such extended time requirements for metacognitive interventions reduce the feasibility of utilizing these interventions in employee training programs. From an employee training perspective, the time required for metacognitive interventions to be effectively implemented can have implications for both short and long term gains in learning outcomes. In order for such interventions to have a positive impact on learning during training and lead to greater transfer of training to the job, they must be feasibly implemented within a reasonable time frame.

There are several potential explanations for the extended time required for most metacognitive interventions. First, as already mentioned, most of these interventions take place as part of other academic courses, which are generally relatively extended in time. Because they are coupled with a long-term process of learning, brevity and time efficiency of the interventions are less of a concern. Second, most metacognitive interventions have sought to teach multiple components of metacognition, such as planning, monitoring, and evaluation, within a single intervention. Such a holistic approach to metacognitive training makes sense given the interrelatedness of the various components of metacognition. However, as the complexity of the metacognitive intervention increases, so too do the cognitive requirements to effectively acquire the training. This translates into a flatter learning curve for most learners, wherein a larger period of time is required to effectively master and utilize the content of the intervention. In contrast, some of the more effective interventions, such as generic question stems and signal words, focus on a limited range of metacognitive phenomena. By simplifying and better focusing the intervention, such interventions can be more quickly acquired and assimilated into the learning process.

Within the metacognitive intervention literature, few attempts have been made to generalize the results beyond the classroom. Further, the results of those that have are less positive than one might expect. However, it is too early to conclude that metacognitive interventions are ineffective outside the academic context. Studies that have attempted to enhance metacognition in non-academic settings have suffered from several limitations that may, at least in part, account for the tepid findings. First, Weissbein (1996), Smith (1996), and Brown et al. (1997) all attempted to train multiple aspects of metacognition in a single intervention that was placed within a study lasting four hours. Such short time periods may be insufficient for trainees to acquire such extensive metacognitive interventions. This may be compounded by the fact that subjects were also attempting to learn and master a complex radar-tracking task, a process in which the metacognitive skills training was intended to assist. This may have represented a dual task load, as subjects were expected to acquire both the metacognitive skills and the skills necessary for effective performance of the radar-tracking task. If one assumes a limited pool of cognitive resources, such a dual load may have exceeded subjects' available cognitive resources. Under such an assumption, acquisition of metacognitive skills, task-specific skills, or both are likely to suffer. Given that the radar-tracking task was the most salient and emphasized aspect of the study, and in some cases was explicitly rewarded monetarily (Brown et al., 1997), it seems likely that subjects would focus their available resources on the task itself. Because those with greater cognitive ability are assumed to have a greater pool of cognitive resources (Kanfer & Ackerman, 1989), a reasonable expectation resulting from this discussion would be an interaction between cognitive ability and metacognitive training, such that those with greater cognitive ability would more successfully acquire the metacognitive training, leading to increased learning outcomes. However, none of the three studies reported any test of this interaction.

Motivation. Another explanation for inconsistent findings across metacognitive interventions centers on subjects' motivation to acquire and/or apply their metacognitive skills to the task. Because metacognition is an effort intense process, those lacking sufficient motivation will likely fail to acquire the metacognitive skills taught in the interventions, or apply the skills that they have. Trainee characteristics may play a key role in affecting the extent to which trainees acquire or utilize the knowledge and skills targeted by the interventions.

For example, self-efficacy has been posited to play a role in determining the extent to which individuals engage in metacognitive activity (e.g. Paris & Winograd, 1990). Those who believe they are incapable of acquiring the training content may have little motivation to learn, much less monitor and regulate their learning. Other constructs, such as goal orientations and conscientiousness, may have an equally important role in the extent to which individuals engage in metacognitive activity. Given insufficient motivation to engage in metacognitive activities, interventions aimed at increasing this activity will likely have little or no effect. Little research in metacognition has examined the moderating effect of motivational characteristics. While all three of the radar-tracking studies have included motivational variables such as mastery and performance goal orientations, they have not reported test for interactions between these variables and the metacognitive interventions.

Prompting vs. Training. An implicit distinction among metacognitive interventions is the issue of training metacognitive skills as opposed to prompting their use. This distinction reflects assumptions concerning the locus of metacognitive skill use during learning. Studies that have sought to train metacognitive skills are based on the assumption that the learners lack key metacognitive skills, and that this lack of skill underlies the failure to actively engage in metacognition. To remedy this situation, they seek to train subjects in the use of metacognitive skills, after which they are expected to utilize the skills in the acquisition of the target material. Rather than extensively train learners in the use of metacognitive skills, other studies have simply prompted trainees as to when to engage in particular skills. This reflects an assumption that, while trainees may have the metacognitive skills in question, they will not utilize these skills effectively unless given explicit structure and guidance for their use.

This distinction has both practical and conceptual implications. From a conceptual standpoint, it is important to determine whether sub-optimal engagement in metacognition is the result of a lack of skills, or a lack of the knowledge or motivation to utilize these skills. If it is the former underlying these deficits, than our attention is best directed toward understanding and enhancing the fundamental strategies and skills underlying metacognition. If it is the latter, attention should be shifted to understanding the factors that influence the use of the metacognitive skills that learners possess. Metacognitive skills training will be ineffective if individuals do not use the skills that they acquire. In all likelihood, some combination of knowledge of metacognitive skill and the use of existing metacognitive skills underlies the eventual use of metacognition during learning. Understanding the nature of this relationship is critical to advancing our understanding of metacognition at large.

The practical implications of this distinction are more obvious but no less critical. If utilization of metacognition hinges on the knowledge of the key skills involved, than interventions aimed at reaping the benefits of metacognition would do best to work toward increasing the learners' knowledge of these skills. Such training may be extensive, or may be more focused in nature, but the aim would be to increase learners understanding of various metacognitive strategies and skills that will have a positive influence on learning outcomes. In contrast, if it is an issue of skill use rather than a lack of the skill itself, than metacognitive interventions would be most effective if they focus on encouraging learners to use their skills at appropriate points during learning. Prompting metacognition presents the most direct means of achieving this goal.

As stated above, it is most likely the case that metacognitive skill use hinges on a combination of possessing the necessary skills and a willingness to use these skills effectively. This suggests that some combination of metacognitive skill training and prompting would provide the most beneficial results, as such an intervention would increase the skills and provide structure and guidance for their use. However, depending upon the type of prompts used, the skills themselves may play less of a role. For example if the prompts are very directive the learner may not need to know the skills underlying the prompt. Simply by following the prompt, the learner may acquire the necessary understanding of their present state of knowledge and may be directed in the use of optimal learning strategies. However, such prompting without knowledge of the metacognitive skills and strategies underlying them may not lead one to utilize metacognition when not explicitly prompted.

Model and Hypotheses

The literature review above identified a number of limitations of existing theory and research on metacognition and metacognitive interventions. Although it is not feasible to address all these limitations, this study attempts to address several of the key limitations of this research. The first limitation concerns the generalizability of the findings to organizational training and various learning outcomes. While most studies of metamemory have relatively simple tasks, such as word pairs, this study attempts to apply principles derived from this literature to a complex training task similar to those utilized for organizational training. The generalizability of metamemory findings is also uncertain due to reliance on relatively simple criteria, such as immediate tests of recall and/or recognition of word lists. The present study evaluates training effectiveness by utilizing knowledge-based, skill-based, and affective criteria, consistent with Kraiger, Ford, and Salas' (1993) taxonomy of training outcomes.

Questions of generalizability plague studies of metacognitive interventions as well. The vast majority of metacognitive interventions have been applied to and evaluated on children in educational settings. The present study explores the effectiveness of metacognitive interventions for improving adult trainees' mastery of non-academic content. Previous studies attempting to generalize to this population and context have achieved limited success. This may be, in part, due their reliance on extensive interventions that attempt to teach several components of metacognition concurrently. Given the limited time and attentional resources present in brief training programs (i.e. 3-4 hour) such as those utilized in these studies, trainees may not be able to acquire and apply extensive interventions of this sort in addition to the primary training content. This issue is addressed by providing simplified, focused interventions aimed at improving metacognitive monitoring rather than the broad range of metacognitive activity utilized in previous studies.

Another category of limitations to be addressed in this study is the limited consideration of the role of motivationally relevant trainee characteristics in metacognition. Studies of metamemory have largely ignored the impact of individual difference or motivational variables, instead choosing to minimize this source of variance. Studies of metacognitive interventions have likewise given limited consideration to the role of motivation. This study attempts to fill this gap by examining the role of mastery goal orientation, self-efficacy, and conscientiousness in the success of the metacognitive interventions.

A final limitation to be addressed concerns the implicit distinction among metacognitive interventions between training and prompting. This distinction reflects underlying assumptions regarding whether sub-optimal metacognition during training is the result of a lack of metacognitive skills, a failure to utilize these skills, or some combination of the two. This distinction may underlie some of the inconsistent results associated with metacognitive interventions. This study will address this question by examining two separate interventions aimed at training or prompting the use of metacognitive skills.

These limitations serve as the impetus for the present study. Next, a heuristic model is presented incorporating the relevant study variables and specific hypotheses are described.

Overview

Baldwin and Ford (1988) have generated a framework for understanding factors affecting learning and transfer of training. Three general categories of training inputs identified as critical for learning, retention, generalization, and maintenance of training were trainee characteristics, training design, and the work environment. Trainee characteristics are ability, skill, motivation, and personality factors that influence the learning process and subsequent transfer of training to the job. Training design factors refer to the learning principles embedded in the training, the sequencing of training, and the content of training itself. Work environment factors are those related to the conditions under which one is expected to apply the KSAs acquired in training and includes factors such as support and opportunity to perform trained skills. Work environment characteristics are beyond the scope of this study, which is concerned with factors that come into play during the training itself to affect learning outcomes.

Figure 1 presents a model for understanding factors influencing metacognition as well as the outcomes of metacognition, based on an input-process-output framework. Consistent with Baldwin and Ford (1988), the input factors include trainee characteristics and training design factors. These inputs are assumed to influence the learning process, with the focal process in this study being the extent to which the trainee engages in metacognitive activity. These learning processes should lead to learning outcomes,

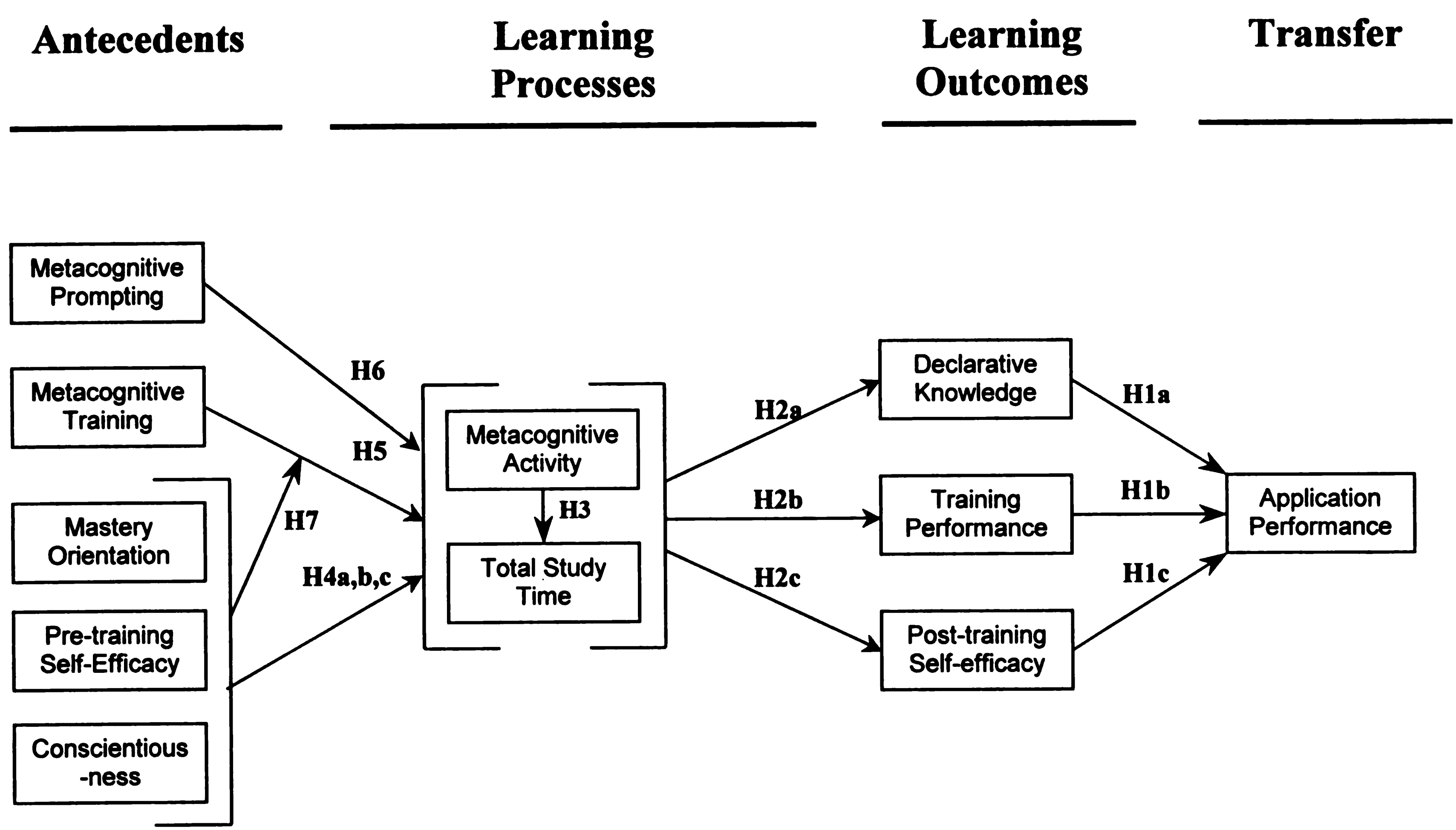


Figure 1. Conceptual model

including knowledge, skills, and affect. These outcomes, in turn, should positively impact performance on a task requiring application of the training content. In the section that follows, each of these components will be discussed in detail, and specific hypotheses will be posited regarding relationships among the model components.

Transfer

Transfer has been defined as the extent to which trainees apply the knowledge, skills, and abilities acquired in training back to the job (Baldwin & Ford, 1988). Early learning theorists held that transfer was predicated on the existence of identical elements between two tasks (Thorndike & Woodworth, 1901), a position behaviorists have also forwarded in the guise of stimulus-response pairings (Butterfield & Nelson, 1989). This approach led training designers to focus on how best to structure the learning environment, in terms of reinforcement schedules, stimulus variability, etc. With the cognitive revolution in psychology, such simplistic views of learning and transfer have given way to greater focus on the role of the learner during the learning process.

For training to be considered successful, it is not enough that individuals acquire the knowledge, skills, affective outcomes targeted by the training--trainees must be able to apply what they have learned to complex situations for which the training was ultimately intended to address (Baldwin & Ford, 1988). Successful application of training is contingent upon acquiring the basic declarative knowledge that underlies task completion. Trainees must also possess the skill-based knowledge required to effectively and efficiently execute critical task functions. Finally, trainees must be able to cope with and persevere through the increased complexity encountered when attempting to apply what was learned to a more complex situation. The current study operationalized and examined transfer of training as the extent to which individuals were able to apply the knowledge and skills of the training program in a complex task that mirrored the situations to which the training was intended to apply.

Learning Outcomes

Kraiger, Ford, and Salas (1993) recently criticized I/O psychologists' tendency to view learning and transfer as a unidimensional construct, often focusing simply on behavioral outcomes as an index of learning and transfer. Taking a construct-oriented approach to learning, they drew from a broad base of literature from cognitive, instructional, and industrial/organizational psychology to develop a multi-dimensional and conceptually based classification scheme of learning, consisting of cognitive, skill-based, and affective outcomes. Examples of cognitive outcomes include verbal/declarative knowledge, knowledge organization, and cognitive strategies. Skill-based outcomes include skill compilation and automaticity. Finally, examples of affective outcomes include attitudes and motivational outcomes such as self-efficacy.

Examples of research taking just such a multi-dimensional approach to learning and transfer have recently begun to emerge. For example, Kozlowski et al. (1995) examined a model linking individual differences and training design features to a variety of learning outcomes as well as adaptive transfer. It was found that declarative knowledge, training performance, and self-efficacy all added independent prediction of performance on an adaptive transfer scenario. Ford et al. (1998) also found that declarative knowledge, training performance, and self-efficacy were positively related to transfer performance in a learner control training environment. In this study, it is expected that the training outcomes of declarative knowledge, training performance, and self-efficacy will lead to greater transfer performance.

Declarative knowledge refers to knowledge concerning the "what" of training and serves as a foundation for further high-order cognitive development (Anderson, 1982). Many theories of knowledge acquisition posit that declarative knowledge is most sensitive during the early stages of knowledge acquisition and must be attained before higher-level development can occur (e.g. Ackerman, 1987; Anderson, 1982; Kraiger, Ford, & Salas, 1993). Individuals with greater knowledge and understanding of the training content should be better able to apply those skills. Said differently, without the requisite declarative knowledge, individuals will have little to apply to the transfer task. Models of transfer of training often posit knowledge-based outcomes as mediating the relationship between training and transfer (e.g. Baldwin & Ford, 1988). Thus, knowledge of the training content is expected to be positively related to performance on the application task.

<u>Hypothesis 1a</u>. *Declarative knowledge will be positively related to transfer of training.*

During initial skill acquisition, performance tends to be slow, error-prone, and resource-dependent (Weiss, 1990). However, as skill development progresses, performance becomes faster, less error-prone, and approaches automaticity, freeing up cognitive resources which can then be directed toward additional tasks or to the development of more elaborate task strategies. In addition, during the latter stages of skill development, learners become more adept at determining the appropriate situations for skill use (Gagne & Medsker, 1996) and adapting their skills when necessary. Thus, the skill-based outcome of training performance is a valuable index of learning, which is expected to be related to success on the transfer task.

Hypothesis 1b. *Training performance will be positively related to performance on the application task.*

Self-efficacy has been defined as an individual's belief in their ability to perform a specific task (Bandura, 1977). Self-efficacy has been posited to play a key role in the self-regulatory process (e.g. Bandura, 1991). Those with high self-efficacy generally set higher goals and demonstrate greater persistence than do those with low self-efficacy (Bandura & Cervone, 1986). The persistence resulting from high self-efficacy may be critical in transfer, as the greater complexity that often accompanies transfer situations introduces new challenges and difficulties that must be overcome to succeed. In the absence of such efficacy beliefs, the learner is likely to cognitively or behaviorally withdraw from the task, with resulting decrements in performance. Kraiger et al. (1993) highlighted research indicating the criticality of self-efficacy beliefs for the application of knowledge and skills. Thus, self-efficacy is expected to demonstrate a positive relationship with application performance.

Hypothesis 1c. *Post-training self-efficacy will be positively related to performance on the application task*

Learning Processes

A large body of research provides conceptual, along with empirical support for the key causal role of metacognitive processes in learning (e.g. Dunlosky & Connor, 1997; Mazzoni, Cornoldi, & Marchitelli, 1990; Nelson & Leonesio, 1988). Metacognitive monitoring allows the learner to gain awareness of their current state of knowledge and the effectiveness of their learning strategies. Self-generation of feedback may be particularly critical in learner control environments, where little external structure or feedback is given to guide the learner. Rather, the learner is charged with progressing through the training content in whatever fashion they see fit. By engaging in metacognitive monitoring, learners can then make informed decisions about how to best progress in their learning.

The learning processes of metacognitive activity and study time are expected to influence the learning outcomes declarative knowledge, training performance, and post-task self-efficacy. Meloth (1990) found that students trained in the use of comprehension strategies demonstrated greater reading comprehension than did control students. King (1989) found that students who utilized metacognitive strategies to guide their learning performed better on measures of declarative knowledge of lecture content. Further, research in cognitive psychology has demonstrated that those who utilize the feedback gained through monitoring by allocating additional study time to less-well known material demonstrated greater recall of the training content (Nelson, Dunlosky, Graf, & Narens, 1994). Therefore, learning processes are expected to influence the acquisition of declarative knowledge.

Hypothesis 2a. Learning processes will be positively related to declarative knowledge.

By engaging in learning processes, individuals are expected to develop a better understanding of how to apply the skills being trained. Volet (1991) found that individuals trained in the use of metacognitive skills in a computer programming course demonstrated significantly greater computing performance. Thus, individuals who engage in more learning processes should demonstrate better training performance.

Hypothesis 2b. Learning processes will be positively related to skill-based training performance.

Ford et al. (1998) recently examined the relationship between metacognition and self-efficacy, with self-efficacy conceptualized as a learning outcome influenced by metacognition. Consistent with their hypotheses, the results indicated a .38 correlation between metacognition and self-efficacy. Like Ford et al., Winne (1995) noted that positive feelings of efficacy will likely result from monitoring one's comprehension.

Hypothesis 2c. Learning processes will be positively related to post-training self-efficacy.

It is expected that metacognitive activity will positively influence the total time spent on the training material. Those who engage in greater metacognitive activity are expected to allocate more study time to material judged to be less well learned. Because the process of monitoring one's knowledge, along with the allocation of greater study time to less well known material are time consuming processes, it is expected that metacognitive monitoring will result in more total time spent on the training material.

Hypothesis 3. Metacognitive activity will be positively related to study time.

Trainee Characteristics

Goal Orientation

A motivational construct with relevance for metacognition is mastery goal orientation. A high mastery goal orientation is associated with developing competence relative to oneself (Dweck, 1986), belief that ability is dependent upon effort, a preference for challenging tasks, setting of difficult goals for themselves (Bandura & Jourden, 1991), persistence when faced with challenges, and a tendency to view feedback as diagnostic rather than evaluative. Mastery orientation contains elements that can be classified as metacognitive knowledge, which Flavell defined as knowledge or beliefs about yourself or others as cognitive processors. For example, a mastery orientation is associated an incremental view of intelligence, a belief that intelligence is not fixed, but rather can be improved through effort. An outcome of this belief is that mastery orientation is generally associated with a willingness to devote greater effort in the face of challenges.

Those with a high mastery orientation should be willing to devote the effort necessary to monitor their knowledge, as effort is believed to lead to eventual gains in knowledge and skills, which such individuals view as the end goal, rather than task performance per se. Further, a high mastery orientation should lead one to view the outcomes of metacognitive monitoring as diagnostic of their current state of knowledge and its relationship to the desired state of knowledge. When monitoring reveals large discrepancies between current and desired states of knowledge, self-efficacy should be relatively unaffected, as should future engagement in monitoring.

Some support for these propositions can be found in the existing metacognitive literature. Schraw et al. (1995) found that those high on mastery orientation reported greater strategy use and metacognitive awareness, which consisted of knowledge of cognition and regulation of cognition. Ford et al. (1998) also examined the relationship between goal orientations and metacognition in a training environment characterized by high learner control. As hypothesized, mastery orientation was positively correlated with a measure of metacognition, which reflected self-monitoring, planning, and evaluation of progress. Wolters (1998) also found a positive relationship between mastery goal orientation and both metacognition and use of specific learning strategies.

Hypothesis 4a. *Mastery goal orientation will be positively related to learning processes.*

Self-Efficacy

While *post*-training self-efficacy is hypothesized to be influenced by metacognition, research suggests that *pre*-training self-efficacy may also influence self-regulated learning activities. Schunk (1995) has suggested that self-efficacy has effects on self-regulated learning activities, independent of problem solving skill. Those with high self-efficacy may utilize self-regulatory skills, even if their skills are deficient or otherwise faulty. At the same time, those with low efficacy beliefs may minimize self-regulatory learning activities even if their skills are, in fact, effective. Palmer and Goetz (1988) have likewise proposed that students who perceive themselves as incompetent may be less prone to engage in cognitive strategies. Both control theory (Carver & Scheier, 1982; Klein, 1989) and social cognitive theory (Bandura, 1991) of self-regulation indicate that a lack of efficacy should lead to behavioral or mental disengagement from the task. Monitoring is likely discontinued as a result of such disengagement.

Additional support for the causal role of self-efficacy in metacognitive monitoring comes from research on feedback seeking. Feedback seeking research is generally concerned with the seeking of external feedback, yet many of the findings can be expected to generalize to seeking of self-generated feedback, such as that provided by metacognitive monitoring. Miller and Jablin (1991) found that trainees with low self-efficacy engage in fewer feedback seeking behaviors in an attempt to avoid negative self-evaluations.

Hypothesis 4b. Pre-training self-efficacy will be positively related to learning processes.

Conscientiousness

Conscientiousness has recently emerged as a valuable personality characteristic that has been linked to a wide variety of organizational outcomes. A member of the Big Five taxonomy of personality (Barrick & Mount, 1991; McCrea & Costa, 1987), conscientiousness has been defined as a trait reflecting responsibility, dependability, persistence, self-discipline, hard working, and an achievement orientation. Despite early pessimism regarding the link between personality and organizational outcomes, recent meta-analytic evidence suggests that conscientiousness may be a significant predictor of nearly all performance criteria for nearly all occupational groups (Barrick & Mount, 1991). Drawing on over 30 years of research, resulting in over 130 criterion-related validity studies including conscientiousness, Barrick and Mount found that conscientiousness was positively correlated with the criteria composite.

Conscientiousness has been found to be influential in learning contexts. For example, Barrick and Mount (1991) found that conscientiousness was positively correlated with training performance. Colquitte and Simmering (1998) found that conscientiousness was related to motivation to learn during a 6-week undergraduate management course. These findings are not surprising, given the nature of conscientiousness and the demands of training. In order to succeed in training, it is important for trainees to be willing to put forth the effort needed to acquire the material at hand. Under simple training tasks, a small amount of effort may be sufficient to ensure success. However, when the training content is relatively complex, a sizeable expenditure of effort is necessary on the part of the learner in order to succeed. The persistence that is assumed to accompany high conscientiousness also should lead one to maintain a high level of effort throughout training, even when confronted with difficulties. Additionally, because conscientiousness is thought to subsume the more specific dimension of need for achievement, those high on conscientiousness are likely to set challenging goals and remain committed to those goals (Barrick et al., 1993). Further highlighting the motivational impact of conscientiousness, Mount & Barrick (1995) found it to be more strongly related to criteria that reflect "will do" factors rather than "can do" or ability factors. Based on the body of research on conscientiousness, it is expected that conscientiousness will positively influence learning processes.

Hypothesis 4c. *Conscientiousness will be positively related to learning processes.*

Training Design

Metacognitive Monitoring Training

Interventions aimed at teaching learners effective metacognitive monitoring skills have often been found to a have positive influence on both the extent to which learners engage in metacognitive activity and on a variety of learning outcomes (e.g. Rosenshine et al., 1996). Particularly promising are interventions that are based on self-questioning strategies. Self-questioning allows learners to gain insight as to their current level of knowledge and understanding. This knowledge can then be compared to the goal state to detect any discrepancies, and one can adjust their approach to reduce any discrepancy detected.

Generic question stems, such as those developed by King and colleagues, have been demonstrated to be effective for enhancing metacognitive strategy use, as well as lecture and reading comprehension (King, 1989; King, 1992; King & Rosenshine, 1993). Generic question stems encourage the learner to ask questions that probe their understanding of a variety of aspects of the training content, such as main ideas, strengths and weaknesses, relations between concepts, etc. In addition to the support for their effectiveness, generic question stems have the advantage of being relatively easy to learn and use, and do not appear to require strong cognitive skills.

The process of self-questioning ties in many aspects of monitoring addressed by cognitive researchers reviewed above. Therefore, consultation of this research may help to develop more effective metacognitive monitoring interventions by embedding principles derived from this research. A major finding of research on nearly every component of metacognitive monitoring is that learners tend to be overconfident in their estimates of their knowledge (e.g. Bornstien & Zickafoose, 1999; Koriat & Goldsmith, 1996). Due to their proposed influence on control, this overconfidence is likely to lead trainees to make inaccurate or ineffective decisions concerning control of their learning. From a self-regulatory perspective, if one believes they have attained the desired level of learning for a given training component, their attention may be shifted elsewhere. If this decision is based on inaccurate information, learning and/or performance are likely to suffer. By overestimating their knowledge or comprehension, learners are providing themselves with false feedback, which may be detrimental to training effectiveness.

The metamemory research has identified several sources of and potential remedies to the overconfidence that pervades metacognitive monitoring. Bornstein & Zickafoose (1999) found that simply informing subjects of the tendency to overestimate their learning was sufficient to improve the accuracy of their confidence ratings. Research on judgments of learning (JOLs) has shown that JOL accuracy increases after explicit attempts at retrieval (King, Zechmeister, & Shaughnessy, 1980). This finding supports the benefits of explicit self-testing for gauging one's level of comprehension, rather than relying on more implicit judgments concerning how well one knows the information.

One of the more robust findings in the metamemory literature is the delayed-JOL effect. The accuracy of judgments of learning increase dramatically when the judgments are delayed for a short period of time following item study. As the delay increases, JOLs approach perfect accuracy (Nelson, 1996). Similar results are obtained when item study and JOLs are separated by a brief short-term memory distraction (Kelemen & Weaver, 1997). This clearly implicates STM contamination as a large source of inaccuracy in metacognitive monitoring. Interventions that make trainees aware of and provide strategies for circumventing this problem may greatly enhance the accuracy of monitoring, resulting in ultimate gains in learning.

Hypothesis 5. *Metacognitive training will be positively related to learning processes.*

Metacognitive Prompting

Another approach for increasing metacognitive monitoring during learning is to explicitly prompt its use. Rather than attempting to impart knowledge of metacognitive monitoring skills, these interventions simply instruct trainees at various points during training to assess their current level of learning. It has been indicated that individuals often fail to utilize existing self-regulatory skills (e.g. Brief & Hollenbeck, 1985; Garner, 1990; Ridley et al., 1992). Prompting the learner to engage in self-regulatory activity has been shown to increase the utilization of existing skills (e.g. Owings et al., 1980). Because metacognitive prompting provides explicit structure and guidance for the use of metacognitive monitoring, this represents a "strong" situation, as compared to no prompting of monitoring (Bem & Allen, 1974; Weiss & Adler, 1984). That is, explicit prompting imposes considerable demands or pressure on trainees to conform by enacting the behaviors requested by the prompts, overcoming the tendency to not use metacognitive skills. Thus, by cuing the use of metacognitive monitoring, metacognitive prompting should yield many of the same benefits as metacognitive training with respect to utilization of metacognitive monitoring and ultimate effects on learning outcomes.

Hypothesis 6. *Prompting metacognitive monitoring will be positively related to learning processes.*

Metacognitive Training X Motivation Interaction

Due to the high degree of learner control over the ultimate use of metacognitive skills conveyed in monitoring training, there is likely to be great variability in the extent to which these skills are ultimately utilized during training. In many respects, a high degree of learner control represents a relatively "weak" situation, when compared to more formalized, instructor-led training. Relative to strong situations, weak situations provide fewer demands or pressures to conform to given standards (Mischel, 1977). Metacognitive training, in the absence of further prompting of its use, provides initial instruction, but acquisition and implementation of these skills during subsequent training remains the responsibility of the learners. Therefore, individual differences in motivation are likely to play a key role in the use of trained skills and the ultimate success of the monitoring training. It is expected that the motivational variables of self-efficacy, goal orientations, and conscientiousness will moderate the efficacy of metacognitive training.

Hypothesis 7. *The relationship between metacognitive training and learning processes will be moderated by trainee characteristics (see Figure 2).*

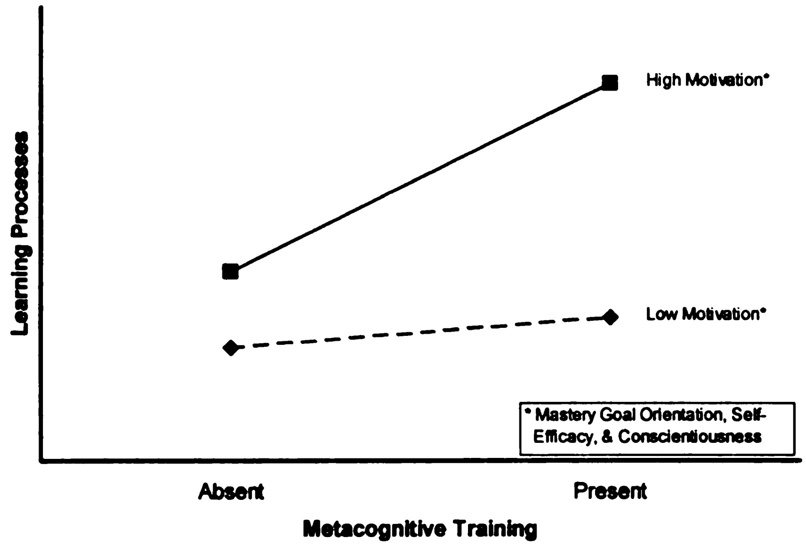


Figure 2. Predicted Interaction of Metacognitive Training and Motivation Variables on Learning Processes

METHOD

This study utilized a 2 X 2 fully crossed factorial design. The first factor consisted of metacognitive training vs. no metacognitive training. The second factor consisted of metacognitive prompting vs. no metacognitive prompting. Thus, one group received only the metacognitive training, one group received only the metacognitive prompting, one group received both training and prompting, and one group served as the control by receiving neither intervention.

Participants

Participants were undergraduate students at Michigan State University enrolled in psychology courses who received course credit in return for participation in the experiment. A power analysis indicated the need for approximately 144 participants. Although few effect sizes are available for many of the relationships to be tested in this study, the few that exist indicated the need for sufficient power to detect medium effect sizes.

For example, Ford et al. (1998) found a .22 correlation between mastery orientation and metacognitive activity, while Wolters (1998) found a moderate relationship between learning orientation and metacognition (r = .45). Pintrich and DeGroot (1990) reported a strong correlation between self-efficacy and measures of strategy use (r = .63) and self-regulated learning (r = .73). King (1992) found a moderate effect (r = .34) for self-questioning training on strategic learning processes, while Payne and Manning (1992) found a large effect (r = .67) with a similar comprehension monitoring intervention. Ford et al. reported correlations of .29, .36, and .38 for the relationship between metacognitive activity and declarative knowledge, training performance, and self-efficacy, respectively. Ford et al. found moderate relationships between declarative knowledge, training performance, and self-efficacy on transfer performance ($r = .44$, .29, and .39, respectively), while Bell (1999) found correlations of .28, .34, and .40 for knowledge, performance, and self-efficacy on generalization performance.

Cohen (1992) suggests a sample size of 68 to detect a moderate correlation with power of .80 and alpha of .05. A sample size of 107 is needed for a multiple regression with 8 predictors and a medium effect size. Cohen states that a sample size of 36 per group is necessary to detect a medium effect with a four-group factorial design. Thus, the estimated total sample size necessary to obtain adequate power (.80) to detect the hypothesized effects is 144 participants.

One hundred seventy-two individuals participated in this experiment. However, two participants were excluded from analyses because they failed to complete the experiment. Therefore, the sample used in this study included 170 participants, with cell sizes ranging from 41 to 44 individuals.

Procedure

Participants completed the experiment in a university computer laboratory. Participants were provided an internet address and completed the experiment on a computer equipped with the Netscape Communicator 4.6 software suite, which included the Navigator web browser and Composer web-page design software. Upon entering the internet address, participants read instructions for completing the experiment. These instructions included a brief description of the content and nature of the training program. Trainees were told that they would learn how to design their own internet web page. They were told that they would have the opportunity to practice what they had learned at the conclusion of training. They were also told that at the conclusion of the training they would take a quiz on the training material, as well as submit the internet address for a web page that they would create.

Next, participants read the informed consent information and indicated their agreement to participate by entering their personal identification number (PID) and continuing with the training program. Anyone who did not wish to participate was free to discontinue the training program at this point, or at any point during the training. The consent form explained the nature and procedures of the experiment, the risks and benefits of the experiment, and their right to withdraw participation at any time without penalty (Appendix A). Contact information was provided for the researcher, the Psychology Department, and UCRIHS.

Participants then completed several short measures of their individual characteristics. Specifically, they answered questionnaires to establish their prior experience with the internet and creating web pages, self-efficacy, mastery and performance goal orientations, conscientiousness, metacognitive skills, and demographic information such as race, gender, and ACT/SAT test scores, which as used as a proxy for cognitive ability (Appendix B).

The web page training program itself was presented to participants in seven major topics, each of which was subdivided into smaller, more specific topics, each on a separate web page (Appendix C). Participants were informed that their goal was to learn the content of the training program to the best of their abilities such that they can successfully complete a series of exercises to be administered after training. They were told that they were free to decide what information to study, in what sequence, and for how long. Participants were not required by the task to access each page in the training program and were allowed to return to previously studied pages as often as they chose.

Upon termination of the training program, the participants completed a series of questionnaires (Appendix D). Specifically, they completed self-report measures of metacognitive activity during training, and post-training self-efficacy. They also completed a multiple-choice quiz over the content of the web-page training. Additionally, they completed a skill-based exercise, wherein they completed a number of items requiring them to execute specific tasks using the web design software. Participants were then provided instructions for a final web page that they were to create. They were asked to submit the internet address for this web page. They then read a debriefing statement detailing the nature of the experiment.

Manipulations

Metacognitive Training

The metacognitive training incorporated principles derived from cognitive and educational research on metacognition intended to impart skills that would assist trainees in more accurately monitoring their knowledge (Appendix E). Metacognitive training (MCT) was presented at the beginning of the study--upon completion of the pre-training questionnaires but prior to beginning the web page training proper. This training began with a brief introduction to the concept of metacognition. Trainees were informed of the importance of monitoring their own knowledge. They were also informed of the tendency for learners to overestimate their level of knowledge and understanding, and the negative impact this overestimation can have on learning.

Participants were then provided with two specific strategies for improving the accuracy of their monitoring, based on self-questioning (i.e. asking oneself questions while progressing through the training). The first strategy was the use of fill-in-the-blank question stems, such as "how are ___ and ___ related?" Research by King and colleagues (King, 1989; King, 1992; King & Rosenshine, 1993) found that the use of these question stems increased metacognitive activity and learning outcomes for a diverse range of learners. The second strategy consisted of briefly delaying self-questioning, rather than asking oneself questions about a topic immediately after study. This strategy was based on a large body of research demonstrating that delayed judgments-of-learning (JOLs) are considerably more accurate than are immediate JOLs (e.g. Nelson & Dunlosky, 1991), as the delay require that the answers to the self-questioning be retrieved from long-term, rather than short-term memory. Finally, trainees were instructed to use the information gained from these strategies to identify areas where they needed to spend additional time studying. Participants in the MCT condition were also given a performance aid (Appendix F) that summarized the metacognitive training, which they could refer to at any point during the web page training. This performance aid was provided in an effort to reduce the cognitive ability requirements needed to learn the skills conveyed in the metacognitive training, thus putting the focus on the use rather than the acquisition of metacognitive skills.

Metacognitive Prompting

In the second intervention, metacognitive prompting (Appendix G), trainees were prompted at various points during the course of the web-page training to assess their current level of understanding of the material they had covered up to that point. Because these prompts were intended to encourage the use of existing metacognitive skills, rather than instruct trainees on the use of new skills, the prompts were kept general, rather than specific. The prompts consisted of a window that periodically appeared on the screen asking trainees to take a few moments to reflect on the material they just studied and to attempt to determine how well they had learned it. Trainees were required to respond to two open-ended questions, one asking what information they had learned in previous lessons and another asking what information they need to learn better. Further, they were encouraged to spend additional time studying any material that they felt they did not fully understand. This window appeared in roughly 10-minute intervals, such that the screen appeared upon clicking the first link to another page after the 10-minute interval had passed. During pre-testing, participants indicated that presenting the prompt every 10 minutes was often enough to encourage frequent reflection on the training material, but not so often as to be distracting or disruptive. After trainees have viewed the prompt and had responded to the two questions listed above, they were returned to the page they initially selected.

Measures

Participants completed several survey measures at the beginning and at the end of the training program. The specific measures can be found in Appendices B and C.

Control Variables

Demographics and Cognitive Ability

Demographic information was collected, including age, gender, race, and college GPA. Participants were asked to provide their ACT or SAT test scores as an indicator of *cognitive ability.*

Prior Experience

Prior experience with computers, the internet, and web programs were assessed with 8 items. Participants responded on a five-point Likert scale ranging from "all the time" (1) to "never" (5). These eight items were subjected to a common factor analysis with varimax rotation. Examination of the resulting eigenvalues suggests a one-factor solution. Coefficient alpha for this scale was .79.

Pre-training Metacognitive Skills

Pre-training metacognitive skills were measured with a 20-item scale adapted from Ford et al. (1998) and Pintrich and DeGroot (1990). The internal consistency reliability of the original Ford et al. 12-item scale was .81. The original scale was developed to assess the degree to which individuals typically engage in self-monitoring of learning, choice of practice scenarios in order to address deficits in learning or performance, and self-evaluation of one's progress in learning contexts. The original items were also targeted specifically at metacognition in the context of the radar-tracking simulation used in that study. Thus, the scale was reworded to assess general tendencies to engage in these activities while learning. Additionally, four items from the self-regulation sub-scale of Pintrich and DeGroot's (1990) Motivated Strategies for Learning

Questionnaire (MSLQ) were added. Individuals respond on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

This scale was developed to assess pre-existing levels of the two primary metacognitive constructs of interest in this study -- monitoring and control. The specific items in this scale are presented in Appendix B, along with headings reflecting the intended dimensionality (these headings were not presented to participants). Based on the conceptual development of the scale, a two-factor solution was expected. To empirically examine the factor structure of the scale, a common factor analysis with varimax rotation was performed on the 20 items. Figure 3 displays the scree plot for this analysis. Despite the expectation of multidimensionality, the scree plot indicates that a single factor solution best fits the data. Coefficient alpha for this single factor scale was .86.

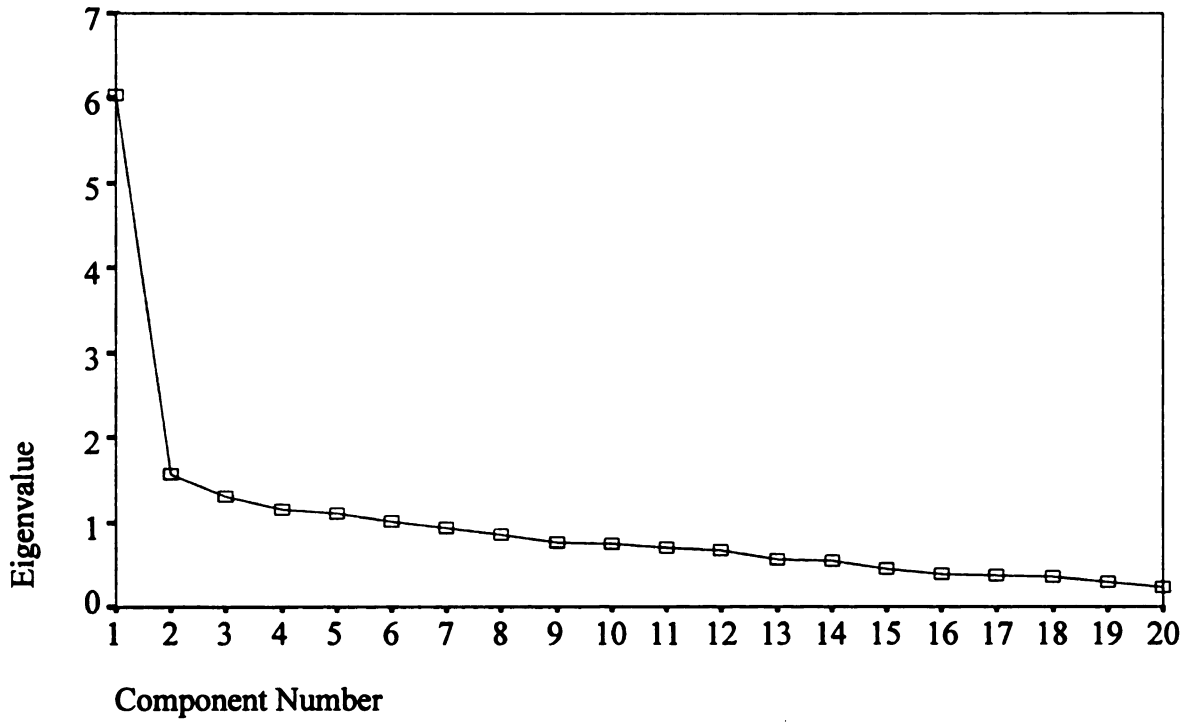


Figure 3. Scree Plot of Metacognitive Skill Measure

Motivation Variables

Mastery Goal Orientation

Goal orientations were measured with a 16-item scale by Button, et al. (1996), which assess trait goal orientations. These scales treat mastery and performance orientation as two distinct constructs. A sample item is "The opportunity to learn new things is important to me." Individuals will respond on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5). Previous research has consistently found a two-factor solution, with reliability for both scales in the range of .75 - .80 (e.g. Button, Mathieu, & Zajac, 1996; Ford et al., 1998). A common factor analysis with varimax rotation performed on all 18 goal orientation items provided support for a two-factor solution, with all items loading on the appropriate scale. Coefficient alpha was .80 and .79 for the mastery orientation scale and performance orientation scale, respectively.

Pre-training Self-efficacy

Pre-training self-efficacy was assessed with a nine-item scale adapted from the self-efficacy sub-scale of Pintrich and DeGroot's (1990) Motivated Strategies for Learning Questionnaire (MSLQ). The internal consistency reliability for the original scale was .89. The original scale items were worded to assess self-efficacy in a classroom setting (ex. " I know that I will be able to learn the material for this class"). For use in this study, the items were re-worded to assess self-efficacy for the training course (ex. "I know that I will be able to learn the material for this training course"). Individuals will respond on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5). A common factor analysis revealed a one-factor solution. Coefficient alpha for this scale was .92.

Conscientiousness

Conscientiousness was measured using the 12-item scale of the NEO FFI personality inventory (Costa & McCrae, 1992). These items were designed to assess characteristics of conscientiousness, including responsibility, dependability, work ethic, achievement orientedness, and perseverance. Previous research has found high internal consistency and reliability for this scale (e.g. .90: Martocchio & Judge, 1997). Individuals responded on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5). Coefficient alpha for all 12 items in this scale was .74. However, examination of individual item-total correlations revealed that item 7 ("I seldom notice the moods or feelings that different environments produce") correlated very weakly ($r = -.06$) with the remaining items in the scale. Thus, the decision was made to remove this item from the scale, resulting in a coefficient alpha of .78.

Learning Processes

Metacognitive Activities During Training

The extent to which trainees engaged in metacognitive activities during training was assessed with a 20-item scale adapted from Ford et al. (1998) and Pintrich and DeGroot (1990). The internal consistency reliability of the original Ford et al. (1998) 12-item scale was .81. The original scale items were targeted specifically at metacognition in the context of the radar-tracking simulation used in that study. Thus, the scale was reworded to assess the degree to which trainees engaged in these activities during the web-page training. Five items from the self-regulation sub-scale of Pintrich and DeGroot's (1990) Motivated Strategies for Learning Questionnaire (MSLQ) were added and similarly rephrased to reference the web-page training program. An additional four items were added specifically for this study to assess strategic allocation of study time. Individuals responded on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

This scale was developed to assess metacognitive monitoring and control as they occurred *during training*. The specific items in this scale are presented in Appendix D, along with headings reflecting the intended dimensionality (these headings were not presented to participants). Based on the conceptual development of the scale, a two-factor solution was expected. To empirically examine the factor structure of the scale, a common factor analysis with varimax rotation was performed on the 20 items. Figure 4 displays the scree plot for this analysis. Despite the expectation of multidimensionality, the scree plot indicates that a single factor solution best fits the data. Coefficient alpha for this single factor scale was .87.

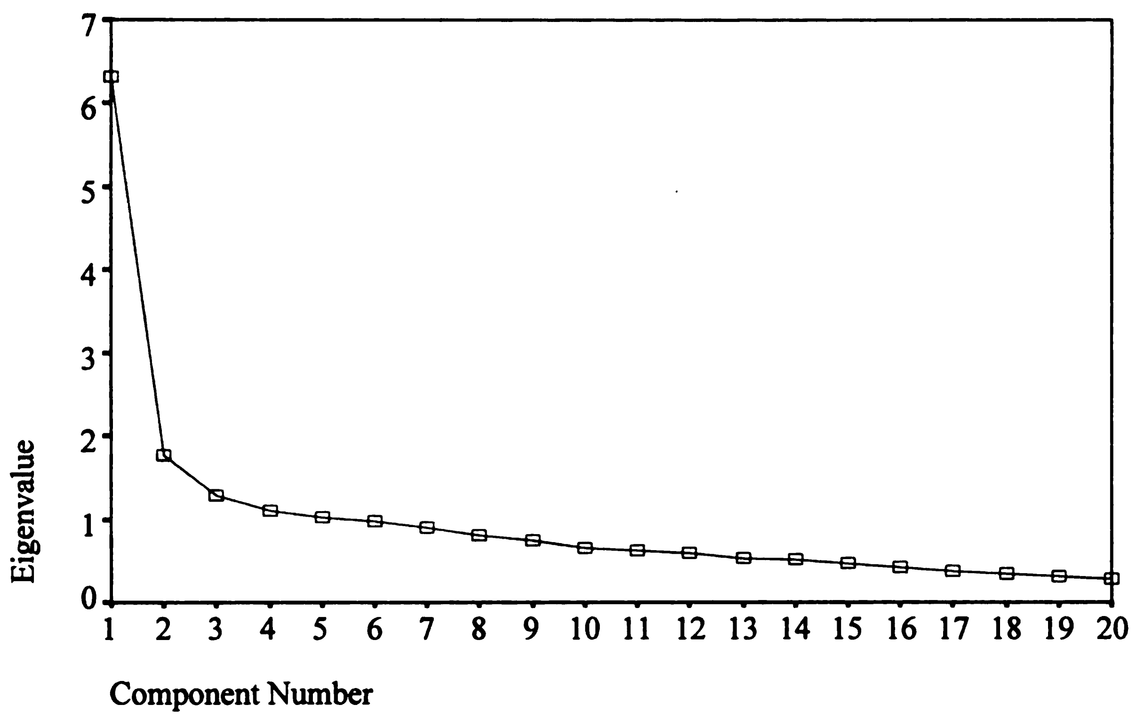


Figure 4. Scree Plot of Metacognitive Activity Measure

Study Time

Study time was represented by the amount of time trainees spend on the training program. A database recorded the amount of time elapsing between the start and completion of the web training program for each participant. This did not include time spent on any of the pre- or post-training measures. Participants spent and average of 43.76 minutes on the training program, with a standard deviation of 17.26 minutes.

Learning Outcomes

Post-training Self-efficacy

Post-training self-efficacy was assessed with a five-item scale adapted from Hollenbeck and Brief (1987). The internal consistency reliability for the original scale was .82. The original scale items were developed to assess self-efficacy on an anagram creation task (ex. "It is just not possible for me to solve anagrams tasks at the level I would like"). For use in this study, the items were re-worded to assess self-efficacy for the training course (ex. "It is just not possible for me to create web pages at the level I would like"). Individuals responded on a 5-point scale ranging from "strongly disagree" (1) to "strongly agree" (5). A common factor analysis revealed a one-factor solution. Coefficient alpha for this scale was .71.

Skill-based Performance

Upon completing the post-training self-efficacy and declarative knowledge measures, participants were presented with a web page containing a 17-item test. For each item, trainees were given specific objectives to complete. Participants were asked to edit the web page by attempting to execute the objectives described in each of the 17 items listed on the page. Some items contained multiple objectives; however, each objective was independent, such that failure to complete one objective did not impair one's ability to complete the remaining objectives, nor did successfully completing one objective assist one in completing another. Participants were asked to spend no more than 10 minutes on this measure. Revised web pages were saved as a unique file for each participant.

Objectives were scored dichotomously, such that a score of one was given for each objective that was successfully completed. Scores were summed across all items, yielding a single measure of skill performance. The resulting range of scores is between 0 and 24. Due to technical problems, the skill-based learning measure for 16 participants could not be scored and these participants were given missing values for this measure. The remaining participants successfully completed an average of 18.29 objectives, with a standard deviation of 5.34. Coefficient alpha for this measure was .91.

Declarative Knowledge

Declarative knowledge was assessed with a 37-item multiple-choice quiz with eight items testing knowledge of each lesson. Responses were scored dichotomously, such that one point was gained for each correct answer. The learning scores were summed across all lessons to yield a single measure of declarative knowledge. Thus, scores on the quiz can range from 0 to 37. Participants averaged 26.44 correct responses, with a standard deviation of 4.15. Coefficient alpha for this measure was .69.

Application Performance

Application performance was assessed at the conclusion of the study. At the conclusion of the training program, participants were required to develop their own web page to demonstrate their knowledge of web page creation. Participants were informed that the goal of this web page was to demonstrate what they had learned in the training program and, thus, they were encouraged to incorporate as much as they could of what they had learned in the training program. Participants were instructed to take no longer than 45 minutes creating this final web page. Web pages were scored based on the number of elements from the training program that were included in the page (see Appendix D). Scores on this measure could range from 0 to 38. Due to technical problems, the web pages for 16 participants could not be scored and these participants were given missing values for this measure. The remaining participants successfully incorporated an average of 16.09 elements, with a standard deviation of 4.61. Coefficient alpha for this measure was .67.

Data Analysis Plan

The model presented in Figure 1 was tested with a series of hierarchical regression analyses (Cohen & Cohen, 1983). The first set of analyses examined the impact of learning outcomes on transfer performance. The second set focused on the influence of the learning processes on learning outcomes. The third set examined the influence metacognitive activity on the remaining learning processes. The fourth set focused on the influence of the motivational variables on learning processes. The fifth set focused on the influence of the metacognitive interventions on learning processes. The final set of analyses examined the interaction between metacognitive training and motivational characteristics on learning processes. Metacognitive training and metacognitive prompting were represented by two dummy coded variables (1 for the presence of the manipulation and 0 for its absence).

RESULTS

Manipulation Checks

Upon completing training, all participants, regardless of experimental condition, were asked a series of questions designed to assess whether they had attended to and attempted to implement the interventions, if they were present. The first question simply asked participants to indicate whether they had or had not been exposed to the intervention in question. Following this question, participants responded to 5 questions concerning their motivation to implement the intervention.

Eighty-five of the 87 participants receiving *metacognitive training* correctly indicated that they had received this training. One participant indicated that they had not received the training, while another indicated that they were not sure whether they had received the training or not. Among the 85 participants receiving *metacognitive prompts*, 78 correctly reported that they had received the prompts, 6 indicated that they had not received the prompts, and 1 was not sure. Given the salience of the interventions, failure to notice and correctly identify when one had received the intervention is likely due to extreme inattentiveness on the part of these participants. Thus, the decision was made to exclude these participants from all analyses.

With respect to implementation of the metacognitive training, participants receiving the training indicated that they made some efforts to utilize the skills and strategies they were taught. Table 1 presents the means for the individual items in the metacognitive training manipulation check, as well as for the measure as a whole. Examination of the table indicates that, although trainees indicated that they attempted to

Table 1. Manipulation Checks

Metacognitive Training

Question	Mean	SD
I tried to apply the learning strategies as I went through the web page training.	3.70	0.82
I made an effort to use the strategies I was taught to help me learn to make web pages.	3.63	0.74
I didn't attempt to use the skills I was taught when going through the training program.	3.51	1.19
During training, I tried to use the fill-in-the-blank questions that were provided to me at the beginning of the study.	2.87	0.96
I felt that using the strategies I was taught would help me learn to create web pages.	3.51	0.67
All Items	3.26	0.49

Metacognitive Prompting

Question	Mean	SD
When I received these instructions, I tried to think carefully about what I had learned.	3.92	0.74
When I received these instructions, I responded quickly and got back to the training.	3.64	0.87
I tried to follow these instructions carefully.	3.87	0.50
I made an effort to use these instructions to help me learn to make web pages.	3.77	0.69
I felt that receiving these instructions would help me learn to create web pages.	3.70	0.88
All Items	3.78	0.44

utilize the metacognitive training as a whole, there was relatively low use of the provided question-stems.

Table 1 also presents the means and standard deviations for the individual items in the metacognitive prompting manipulation check, as well as for the measure as a whole. Examination of the table indicates that trainees attempted to follow and make use of the prompts as instructed.

Correlations

Table 2 presents the descriptive statistics and correlations for the variables in this study. Significant correlations at $p < .05$ are presented in bold, while reliability estimates are presented in parentheses on the diagonal. The correlation matrix provides basic information regarding the relationships among the individual difference, learning process, and outcome variables.

With regard to control variables, cognitive ability had a moderate relationship with mastery goal orientation ($r = .17$) and declarative knowledge ($r = .38$), but no other relationships with cognitive ability were significant. As would be expected, prior experience was positively related pre- and post-training self-efficacy ($r = .37$ for each), skill-based performance ($r = .22$), and application performance ($r = .20$), and was negatively related to study time ($r = -.20$). Somewhat surprisingly, prior experience was also positively related to metacognitive activity during training ($r = .18$).

The motivational constructs of pre-training self-efficacy, mastery goal orientation, and conscientiousness were largely unrelated. Although mastery goal orientation was positively related to both pre-training self-efficacy ($r = .26$) and conscientiousness ($r = .24$), no other relationships among these variables were significant. The learning process

Table 2. Descriptive Statistics

Variable	N	Mean	SD	1	2	3	4	5	6	7
1 Metacognitive Prompting	161	.48	.50	(n/a)						
2 Metacognitive Training	161	.52	.50	.01	(n/a)					
3 Age	161	19.89	1.34	.07	<u>-.17</u>	(n/a)				
4 Gender	161	1.57	.50	.14	-.05	.04	(n/a)			
5 GPA	159	2.80	.52	-.05	.04	.01	.03	(n/a)		
6 Cognitive Ability	152	.69	.78	.07	-.04	-.11	-.09	<u>.30</u>	(n/a)	
7 Prior Experience	161	2.62	.62	.06	.01	-.05	-.08	-.05	-.07	(.79)
8 Metacognitive Skills	161	3.71	.36	.04	-.02	.01	.07	.10	.01	<u>.16</u>
9 Mastery Orientation	161	3.90	.41	.03	.06	.02	.09	<u>.18</u>	<u>.17</u>	.10
10 Performance Orientation	161	3.89	.49	.08	-.05	-.14	.15	.06	-.10	.10
11 Pre-training Self-efficacy	161	3.72	.53	.06	-.04	.02	<u>-.20</u>	-.04	.04	<u>.37</u>
12 Conscientiousness	161	3.56	.47	-.04	.13	.08	.07	<u>.28</u>	-.09	-.02
13 Metacognitive Activity	160	3.72	.36	.04	.14	.00	.13	.10	.03	<u>.18</u>
14 Study Time (minutes)	160	44.30	16.80	<u>.21</u>	.01	.03	<u>.17</u>	.12	.04	<u>-.20</u>
15 Post-training Self-efficacy	160	2.86	.56	.09	.12	.07	-.11	.01	.10	<u>.37</u>
16 Skill-based Performance	143	18.80	4.41	.03	-.02	-.04	-.01	.13	.15	<u>.22</u>
17 Declarative Knowledge	160	26.67	3.98	.15	.00	-.08	.04	.14	<u>.38</u>	.12
18 Application Performance	147	16.09	4.69	-.08	-.01	-.08	.01	-.07	.12	<u>.20</u>

Note: Underlined correlations are significant at $p < .05$

Table 2 (cont.)

8	9	10	11	12	13	14	15	16	17	18
(.86)										
.54	(.80)									
.14	.04	(.79)								
.22	**.26**	-.01	(.92)							
.37	**.24**	.07	.00	(.74)						
.45	**.33**	.10	**.19**	.12	(.87)					
.03	.06	-.06	**-.23**	-.01	.08	(n/a)				
.10	**.16**	-.05	**.54**	.08	**.31**	**-.26**	(.71)			
-.01	-.04	-.05	**.24**	-.02	-.02	-.02	**.35**	(.91)		
.05	.10	**-.16**	.12	**-.16**	.10	**.25**	**.19**	**.56**	(.69)	
.03	.07	.07	**.22**	-.14	.03	-.08	**.19**	**.39**	**.35**	(.69)

variables of metacognitive activity and study time did not exhibit a significant zero-order relationship ($r = .08$), although this relationship is examined more formally in the test of hypothesis 3 reported below.

On the whole, the motivation and process variables were moderately correlated. Two of the three motivational variables exhibited moderate correlations with metacognitive activity, indicating that those who approached the training with a learning focus ($r = .33$) and had confidence in their ability to learn the material ($r = .19$) more thoughtfully engaged in the training program. Only pre-training self-efficacy was directly related to study time ($r = -.23$), such that those who had greater efficacy spent less time studying.

The learning outcomes of post-training self-efficacy, skill-based performance, declarative knowledge, and application performance exhibited moderate to large relationships with each other. Such relationships are not unexpected, as the outcome constructs represent distinct but interrelated aspects of task mastery. However, the magnitude of the relationship between declarative knowledge and skill-based performance ($r = .56$) is a cause for potential concern, raising some questions as to the distinctiveness of the underlying constructs tapped by these two measures.

Formal hypothesis testing is reported below, moving backwards through the model. To make the hypothesis tests easier to follow and interpret, a summary of hypotheses and the analyses used to test each is presented in Table 3.

Table 3. Analysis Summary

Hyp	IV(s)	DV(s)	Control Variables	Analyses	Supported?
1a	DK	AP	Exp, CA, PreSE	HR	No (univariate effect)
1b	SP	AP	Exp, CA, PreSE		Yes
1c	PostSE	AP	Exp, CA, PreSE	HR	No (univariate effect)
2a	MCA, ST	DK	Exp, CA		Yes (ST)
2b	MCA, ST	SP	Exp, CA	HR	No
2c	MCA, ST	PostSE	Exp, CA, PreSE	HR	Yes
3	MCA	ST	Exp, CA	HR	Yes
4a	MGO	MCA, ST	Exp, CA	2 HR	Partial (effect on MCA)
4b	PreSE	MCA, ST	Exp, CA	2 HR	Partial (effect on ST)
4c	Cons	MCA, ST	Exp, CA	2 HR	No
5	MCT	MCA, ST	Exp, CA, MCS, MGO, PreSE, Cons	2 HR	Partial (effect on MCA)
6	MCP	MCA, ST	Exp, CA, MCS, MGO, PreSE, Cons	2 HR	Partial (effect on ST)
7	MGO X MCT PreSE X MCT Cons X MCT	MCA, ST	Exp, CA, MCS, MGO, PreSE, Cons, MCT	2 HR	Partial (Motivation X MCT on MCA: carried by PreSE X MCT)

DK = declarative knowledge; AP = Application Performance; SP = Skill-Based Performance; PostSE = Post-Training Self-Efficacy; MCA = Metacognitive Activity; ST = Study Time; MGO = Mastery Goal Orientation; PreSE = Pre-Training Self-Efficacy; Cons = Conscientiousness; MCT = Metacognitive Training; MCP = Metacognitive Prompting; Exp = experience; CA = Cognitive Ability; HR = Hierarchical Regression

Hypothesis Tests

Hypotheses 1a, 1b, & 1c: Learning Outcomes on Application Performance. Hypotheses 1a, 1b, and 1c, concerning the relationship between the learning outcomes of declarative knowledge, training performance, and post-training self-efficacy on application performance were tested with a single hierarchical regression. Although not of conceptual concern in this study, cognitive ability and prior experience were entered in the first step as control variables. This was done due to their likely effects on all training outcomes – it is important to demonstrate that the training outcomes have unique impacts on application performance and, thus, that any relationships observed between the learning outcomes and application performance do not simply reflect each drawing similarly upon prior experience and cognitive ability. Additionally, because it is important to demonstrate that any effects observed for post-training self-efficacy are unique and distinct from those contributed by pre-training self-efficacy, pre-training self-efficacy was also included in the first step of the regression. The variables of conceptual interest in this analysis, declarative knowledge, training performance, and post-training self-efficacy, were entered in the second step of the regression. Table 4 presents the results of the analysis.

Results indicated that cognitive ability and prior experience accounted for significant variance in application performance ($R^2 = .07$, $F = 4.97$, $p < .01$). Beta-weights indicated that prior experience was positively related to application performance ($\beta = .26$, $p < .01$ at step 1). The second step of the regression, containing declarative knowledge, skill-based performance, and post-training self-efficacy, accounted for significant variance in application performance ($\Delta R^2 = .11$, $\Delta F = 5.10$, $p < .01$), supporting the most general hypothesis that learning outcomes will affect application performance. Beta-weights indicated that skill-based training performance was positively related to application performance ($\beta = .26$, $p < .05$ at step 2), supporting hypothesis 1b. Hypothesis 1a proposed that declarative knowledge would be positively related to application performance. Although declarative knowledge exhibited a significant zero-order correlation with application performance ($r = .35$, $p < .01$), this relationship became non-significant once the influence of the other variables in the model were controlled. Post-training self-efficacy also exhibited a significant zero-order correlation with application performance ($r = .19$, $p < .01$), but the relationship became non-significant when the influence of the other variables in the model were controlled. Thus, these results support hypothesis 1b, but did not support hypotheses 1a or 1c. Overall, the variables in the regression accounted for 17 percent of the variance in application performance ($F_{(5,125)} = 5.27$, $p < .01$).

Table 4. Hierarchical Regression Analysis Results for Hypothesis 1

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.10	.02	.10**	.10**
	Prior Experience	.19	.13		
	Pre-training Self-Efficacy	.16	.10		
2	Declarative Knowledge	.12	.12	.19**	.09**
	Skill-based Performance	.25*	.25*		
	Post-Training Self-Efficacy	.02	.02		

n = 125; * p < .05; ** p < .01

Hypotheses 2a, 2b, & 2c: Learning Processes on Learning Outcomes. Hypotheses 2a, 2b, and 2c concerning the relationship between learning processes (metacognitive activity and total study time) and the three learning outcomes of declarative knowledge, training performance, and post-training self-efficacy were tested with a set of three hierarchical regressions. The three regressions differed only with respect to the DV (H2a: declarative knowledge; H2b: training performance; H2c: post-training self-efficacy). In each of the three regressions, the covariates cognitive ability and prior experience were entered in the first step to control for their impact on the dependent variables. The two learning processes were entered in the second step.

Table 5. Hierarchical Regression Analysis Results for Hypothesis 2a

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.40**	.39**	.18**	.18**
	Prior Experience	.17*	.23**		
2	Metacognitive Activity	-.01	.01	.27**	.09**
	Study Time	.31**	.31**		

n = 150; * p < .05; ** p < .01

Hypothesis 2a predicted that learning processes would be positively related to declarative knowledge. Table 5 presents the results of this analysis. Results indicated that cognitive ability and prior experience accounted for significant variance in declarative knowledge ($R^2 = .18$, $F = 15.75$, $p < .01$). Beta-weights revealed that cognitive ability ($\beta = .40$, $p < .01$ at step 1) and prior experience ($\beta = .17$, $p < .05$ at step 1) were positively related to declarative knowledge. The second step of the regression, including metacognitive activity and study time, accounted for significant variance in declarative knowledge ($\Delta R^2 = .09$, $\Delta F = 8.84$, $p < .01$), indicating support for hypothesis 2a. Examination of the beta-weights found that study time was the only significant parameter, demonstrating a positive relationship with declarative knowledge ($\beta = .31$, $p < .01$ at step 2). Thus, hypothesis 2a was partially supported.

Hypothesis 2b predicted that learning processes would be positively related to skill-based performance. Table 6 presents the results of this analysis. Results indicated that cognitive ability and prior experience accounted for significant variance in skill-based performance ($R^2 = .09$, $F = 6.96$, $p < .01$). Beta-weights revealed that cognitive ability ($\beta = .18$, $p < .05$ at step 1) and experience ($\beta = .28$, $p < .01$ at step 1) were positively related to skill-based performance. The second step of the regression, including metacognitive activity, and study time, did not account for significant incremental variance in skill-based performance ($\Delta R^2 = .01$, $\Delta F = 0.69$, $p > .05$). Neither of the variables in the second step demonstrated significant beta-weights or zero-order correlations with skill-based performance. Thus, hypothesis 2b was not supported.

Table 6. Hierarchical Regression Analysis Results for Hypothesis 2b

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.18*	.18*	.09**	.09**
	Prior Experience	.28**	.31**		
2	Metacognitive Activity	-.10	-.10	.10	.01
	Study Time	.05	.05		

n = 135; * p < .05; ** p < .01

Hypothesis 2c predicted that learning processes would be positively related to post-training self-efficacy. Table 7 presents the results of this analysis. Results indicated that cognitive ability and prior experience accounted for significant variance in post-training self-efficacy ($R^2 = .14$, $F = 12.37$, $p < .01$). Beta-weights revealed that experience ($\beta = .35$, $p < .01$ at step 1) was positively related to post-training self-efficacy. The second step of the regression, including metacognitive activity, and study time, accounted for significant incremental variance in post-training self-efficacy ($\Delta R^2 = .08$, $\Delta F = 7.14$, $p < .01$), indicating support for hypothesis 2c. Examination of the type-three beta-weights found that study time ($\beta = -.17$, $p < .05$ at step 2) was negatively related to post-training self-efficacy, whereas metacognitive activity was positively related to post-training self-efficacy ($\beta = .22$, $p < .01$ at step 2). Thus, hypothesis 2c was supported.

Table 7. Hierarchical Regression Analysis Results for Hypothesis 2c

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.08	.08	.30**	.30**
	Prior Experience	.17*	.13		
	Pre-Training Self-Efficacy	.41**	.38**		
2	Metacognitive Activity	.19**	.19**	.35**	.05**
	Study Time	$-.13^{+}$	$-.13^{+}$		

n = 150; * p < .05; ** p < .01; + p = .06

Hypothesis 3: Metacognitive Activity on Total Study Time. Hypothesis 3 concerning the relationship between metacognitive activity and total study time was tested with a hierarchical regression analysis, regressing metacognitive activity onto learning activity. Given that those with greater cognitive ability and those with more prior experience are likely to require less time on the training program than those low on these characteristics, they represent potentially large sources of variance in study time. Thus, differences in ability and prior experience were controlled for by entering these variables in the first step. Table 8 presents the results of this analysis. Results indicated that cognitive ability and prior experience did not account for significant variance in study time ($R^2 = .03$, $F = 2.40$, $p > .05$). However, beta-weights revealed that prior experience ($\beta = -.17$, $p < .05$ at step 1) was negatively positively related to study time. The second step of the regression, including metacognitive activity, accounted for significant incremental variance in study time ($\Delta R^2 = .03$, $\Delta F = 4.19$, $p < .05$). Examination of the beta-weight indicates that metacognitive activity was positively related to study time ($\beta = .16$, $p < .05$ at step 2). Thus, hypothesis 3 was supported.

Table 8. Hierarchical Regression Analysis Results for Hypothesis 3

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.02	.01	.03	.03
	Prior Experience	-.17*	-.20*		
2	Metacognitive Activity	.16*	.16*	.06*	.03*

n = 150; * p < .05; ** p < .01

Hypotheses 4a, 4b, & 4c: Motivational Characteristics on Learning Processes. Hypotheses 4a, 4b, and 4c concerning the effects of the three motivational characteristics of mastery goal orientation, conscientiousness, and pre-training self-efficacy were examined with a set of three hierarchical regression analyses. The three regressions differed only with respect to the DV (metacognitive activity, and total study time). Given that those with greater cognitive ability and those with more prior experience are likely to require less time on the training program than those low on these characteristics, they represent potentially large sources of variance in study time. Additionally, questions have been raised in the literature regarding the relationship between ability in a domain and one's ability to self-access (e.g., Kruger & Dunning, 1999), suggesting that cognitive ability and prior experience may be important variables to control for when examining the relationship of motivational variables to metacognitive activity. Thus, in all three analyses, cognitive ability and prior experience were entered in the first step. The three motivational variables were entered in the second step.

Table 9. Hierarchical Regression Analysis Results for Hypothesis 4

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.05	.00	.03	.03
	Prior Experience	.18*	.13		
2	Mastery Orientation	.30**	.30**	.13	.10**
	Pre-Training Self-Efficacy	.03	.03		
	Conscientiousness	.07	.07		

n = 150; * $p < .05$; ** $p < .01$

Table 9 presents the results for metacognitive activity. The results revealed that cognitive ability and prior experience did not account for significant variance in metacognitive activity ($R^2 = .03$, $F = 2.33$, $p > .05$). The second step of the regression, including mastery goal orientation, conscientiousness, and pre-training self-efficacy resulted in a significant increase in variance explained ($\Delta R^2 = .10$, $\Delta F = 5.23$, $p < .01$). Examination of the beta-weights indicated that only mastery goal orientation accounted for significant unique variance in metacognitive activity ($\beta = .29$, $p < .01$ at step 2), although pre-training self-efficacy ($r = .18$, $p < .05$) exhibited a significant zero-order relationship with metacognitive activity.

Table 10 presents the results for study time. The results revealed that cognitive ability and prior experience did not account for significant variance in study time ($R^2 = .03$, $F = 2.40$, $p > .05$). However, beta-weights indicated that prior experience was negatively related to study time ($\beta = -.17$, $p < .05$ at step 1). The second step of the regression, including mastery goal orientation, conscientiousness, and pre-training self-efficacy did not result in a significant increase in variance explained ($\Delta R^2 = .04$, $\Delta F = 1.90$, $p > .05$). Examination of the beta-weights indicated that mastery goal orientation ($\beta = .16$, $p = .06$ at step 2) and pre-training self-efficacy ($\beta = -.16$, $p = .08$ at step 2) had marginally significant effects on study time. Pre-training self-efficacy also exhibited a significant zero-order correlation with study time ($r = -.23$, $p < .05$), although this effect became non-significant when the other variables in the model were included. Thus, hypotheses 4a was partially supported, whereas hypotheses 4b and 4c were not supported.

Table 10. Hierarchical Regression Analysis Results for Hypothesis 4

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.02	.01	.03	.03
	Prior Experience	-.17*	-.13		
2	Mastery Orientation	$.16^{+}$	$.16^{+}$	$.07^{+}$	.04
	Pre-Training Self-Efficacy	$-.16^{+}$	$-.16^{+}$		
	Conscientiousness	-.01	-.01		

n = 150; * $p < .05$; ** $p < .01$; + $p < .10$

Hypothesis 5: Metacognitive Training on Learning Processes. Hypothesis 5 concerning the effects of metacognitive training on learning processes was tested with a set of two hierarchical regressions with metacognitive training dummy coded 0 (absent) or 1 (present). The two regressions differed only with respect to the DV (metacognitive activity and total study time). Given that the intervention was designed to enhance learning processes beyond trainees' initial levels, cognitive ability, prior experience, pre-training metacognitive skills, and the motivational characteristics conscientiousness, learning goal orientation, and pre-training self-efficacy were controlled for in both analyses by entering them in the first step of the regression. Metacognitive training was entered in the second step.

Table 11. Hierarchical Regression Analysis Results for Hypothesis 5

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.02	.03	.23**	.23**
	Prior Experience	.11	.11		
	Metacognitive Skill	.42**	.44**		
	Mastery Orientation	.09	.08		
	Pre-Training Self-Efficacy	-.01	-.01		
	Conscientiousness	-.04	-.06		
2	Metacognitive Training	.17*	.17*	.26**	.03*

n = 150; * $p < .05$; ** $p < .01$

Table 11 presents the results for metacognitive activity. The results revealed that the first step accounted for significant variance in metacognitive activity ($R^2 = .23$, F = 7.33, $p > .01$). Beta-weights demonstrated that metacognitive skills ($\beta = .42$, $p < .01$ at step 1) was the only significant predictor in this step. The second step of the regression, including metacognitive training, resulted in a significant increase in variance explained ($\Delta R^2 = .03$, $\Delta F = 5.21$, $p < .05$).

Table 12 presents the results for study time. The results revealed that the first step did not account for significant variance in study time ($R^2 = .07$, $F = 1.85$, $p > .05$). The second step of the regression, including metacognitive training, did not result in a significant increase in variance explained ($\Delta R^2 = .00$, $\Delta F = 0.12$, $p > .05$). Thus, hypothesis 5 was partially supported.

Table 12. Hierarchical Regression Analysis Results for Hypothesis 5

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.01	.01	$.07^+$	$.07^+$
	Prior Experience	-.13	-.13		
	Metacognitive Skill	.07	.08		
	Mastery Orientation	.13	.13		
	Pre-Training Self-Efficacy	$-.17^+$	$-.17^+$		
	Conscientiousness	-.03	-.03		
2	Metacognitive Prompting	.03	.03	.07	.00

n = 150; * p < .05; ** p < .01; + p < .10

<u>Hypotheses 6: Metacognitive Prompting on Learning Processes</u>. Hypothesis 6 concerning the effects of metacognitive prompting on learning processes were tested with a set of hierarchical regressions with metacognitive prompting dummy coded 0 (absent) or 1 (present). The two regressions differed only with respect to the DV (metacognitive activity and total study time). Given that the metacognitive prompting was designed to

enhance learning processes beyond trainees' initial levels, cognitive ability, prior experience, pre-training metacognitive skills, and the motivational characteristics conscientiousness, learning goal orientation, and pre-training self-efficacy were controlled for in each analysis by entering them in the first step of the regression. Metacognitive prompting was entered in the second step.

Table 13 presents the results for metacognitive activity. The results revealed that the first step accounted for significant variance in metacognitive activity ($R^2 = .23$, $F = 7.33$, $p > .01$). Beta-weights demonstrated that metacognitive skills ($\beta = .42$, $p < .01$ at step 1) was the only significant predictor in this step. The second step of the regression, including metacognitive prompting, did not result in a significant increase in variance explained ($\Delta R^2 = .00$, $\Delta F = 0.12$, $p > .05$). Further, prompting did not demonstrate a significant zero-order correlation with metacognitive activity.

Table 13. Hierarchical Regression Analysis Results for Hypothesis 6

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.02	.02	.23**	.23**
	Prior Experience	.11	.11		
	Metacognitive Skill	.42**	.42**		
	Mastery Orientation	.09	.09		
	Pre-Training Self-Efficacy	-.01	-.01		
	Conscientiousness	-.04	-.04		
2	Metacognitive Prompting	.03	.03	.23**	.00

n = 150; * p < .05; ** p < .01

Table 14 presents the results for study time. The results revealed that the first step did not account for significant variance in study time ($R^2 = .07$, $F = 1.85$, $p > .05$). The second step of the regression, including metacognitive prompting, resulted in a significant increase in variance explained ($\Delta R^2 = .06$, $\Delta F = 9.71$, $p < .01$). Beta-weights revealed that metacognitive prompting was positively related to study time ($\beta = .24$, $p < .05$ at step 2). Thus, hypothesis 6 received partial support.

Table 14. Hierarchical Regression Analysis Results for Hypothesis 6

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.01	.00	$.07^+$	$.07^+$
	Prior Experience	-.13	-.13		
	Metacognitive Skill	.07	.06		
	Mastery Orientation	.13	.13		
	Pre-Training Self-Efficacy	$-.17^+$	-.18*		
	Conscientiousness	-.03	-.01		
2	Metacognitive Prompting	.24**	.24**	.13**	.06**

n = 150; * p < .05; ** p < .01; + p < .10

<u>Hypothesis 7: Metacognitive Training × Motivational Characteristics on Learning Processes</u>. Hypothesis 7 concerning the interaction between metacognitive training and motivational characteristics on learning processes was tested with a set of hierarchical regressions. The three regressions differed only with respect to the DV (metacognitive activity and total study time). Given that the metacognitive training was designed to enhance learning processes beyond trainees' initial levels, cognitive ability, prior experience, pre-existing metacognitive skills, motivational characteristics (mastery goal

orientation, conscientiousness, and pre-training self-efficacy), and metacognitive training were entered in the first step as control variables. The three interaction terms (mastery goal orientation × metacognitive training, conscientiousness × metacognitive training, and pre-training self-efficacy × metacognitive training) were entered in the second step.

Table 15. Hierarchical Regression Analysis Results for Hypothesis 7

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.03	.02	.26**	.26**
	Prior Experience	.11	.12		
	Metacognitive Skill	.44**	.31**		
	Mastery Orientation	.08	.09		
	Pre-Training Self-Efficacy	-.01	.15*		
	Conscientiousness	-.06	-.07		
	Metacognitive Training	.17*	.14+		
2	Mastery Orientation X Training	.07	.07	.31**	.05*
	Pre-Training Self-Efficacy X Training	-.17*	-.17*		
	Conscientiousness X Training	.06	.06		

n = 150; * p < .05; ** p < .01

Table 15 presents the results for metacognitive activity. The results revealed that the variables entered in step one accounted for significant variance in metacognitive activity ($R^2 = .26$, $F = 7.22$, $p < .01$). Examination of the beta-weights demonstrates that pre-existing metacognitive skills ($\beta = .44$, $p < .01$ at step 1) and metacognitive training ($\beta = .17$, $p < .05$ at step 1) were the only variables entered in step 1 to account for unique variance in metacognitive activity during training. The second step of the regression, which included the three interaction terms, resulted in a significant increase in variance explained ($\Delta R^2 = .05$, $\Delta F = 3.00$, $p < .05$), providing support for the general hypothesis that motivational characteristics moderate the affect of metacognitive training on metacognitive activity. Examination of the individual beta-weights revealed that the interaction between pre-training self-efficacy and training ($\beta = -.17$, $p < .05$ at step 2) accounted for significant unique variance in metacognitive activity. This interaction is displayed in figure 5.

Figure 5. Self-Efficacy X Metacognitive Training on Metacognitive Activity

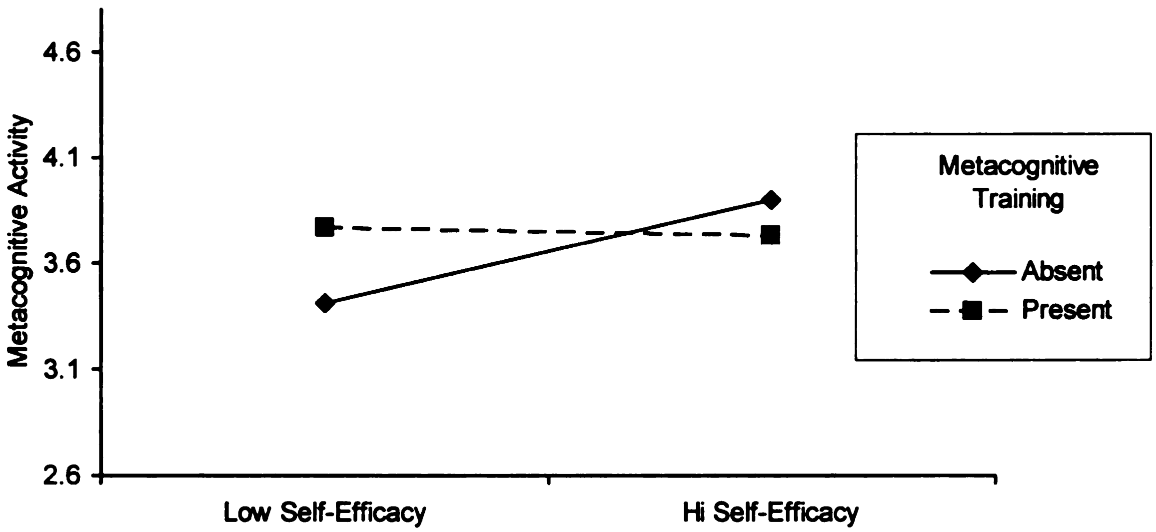


Table 16 presents the results for study time. The results revealed that cognitive ability, prior experience, mastery goal orientation, pre-training self-efficacy, conscientiousness, and metacognitive training did not account for significant variance in study time ($R^2 = .07$ $\Delta F = 1.60$, $p > .05$). The second step of the regression, which included the three interaction terms, did not result in a significant increase in variance explained ($\Delta R^2 = .00$ $\Delta F = .12$, $p > .05$). Thus, partial support was found for hypothesis 7.

Table 16. Hierarchical Regression Analysis Results for Hypothesis 7

Step	Predictors	β at Step	Final β	R^2	ΔR^2
1	Ability	.01	.01	$.07^+$	$.07^+$
	Prior Experience	-.13	-.12		
	Metacognitive Skill	.08	.07		
	Mastery Orientation	.13	.00		
	Metacognitive Prompting	$-.17^+$	-.05		
	Conscientiousness	-.03	-.01		
	Metacognitive Training	.03	.03		
2	Mastery Orientation X Training	.05	.05	.07	.00
	Pre-Training Self-Efficacy X Training	.00	.00		
	Conscientiousness X Training	.00	.00		

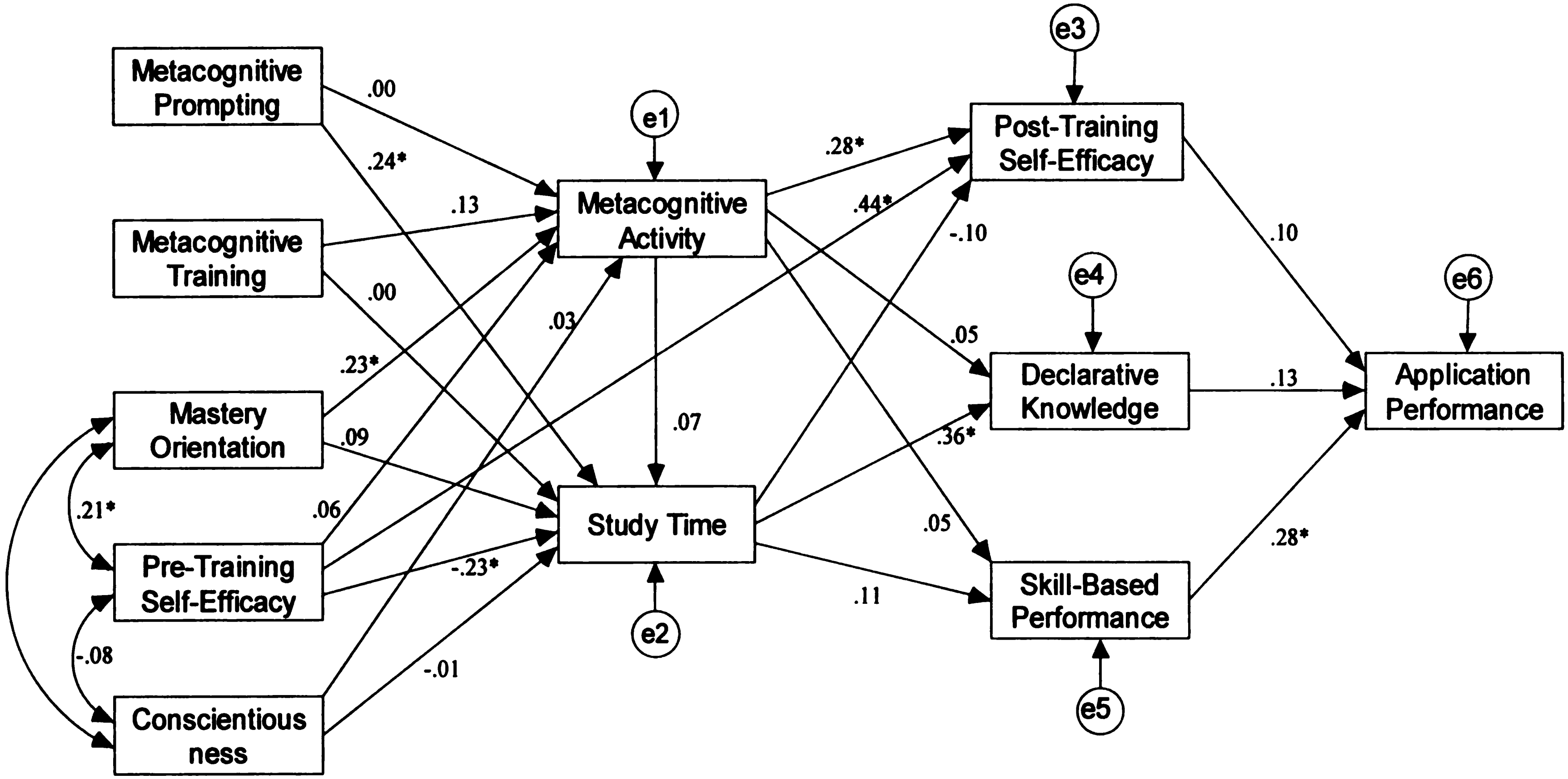
n = 150; * p < .05; ** p < .01; + p < .10

Overall Model Testing

Structural Equations Modeling (SEM) was utilized to test the model in a more comprehensive fashion. The hypothesized model displayed in Figure 1 was tested using AMOS 4. The model was first tested without examining the interactions. Listwise deletion was utilized to address missing data (Schumacker & Lomax, 1996), which reduced the sample size to 126. This structural model, along with the standardized parameter estimates, is displayed in Figure 6.

This model resulted in a χ^2 value of 108.3, df = 31, p > .05. This value is significant, indicating a bad fit of the hypothesized model to the observed data. A goodness of fit index (GFI) of .87 was obtained. The rule of thumb is that this value should exceed .90 at a minimum, but .95 and higher is indication of a good fit. Thus, this again indicates a poor fit for the model. Additionally, a RMSEA value of .14 was found. This value represents the discrepancy between our data and our model, per degree of

Figure 6. SEM analysis of hypothesized model, without interactions



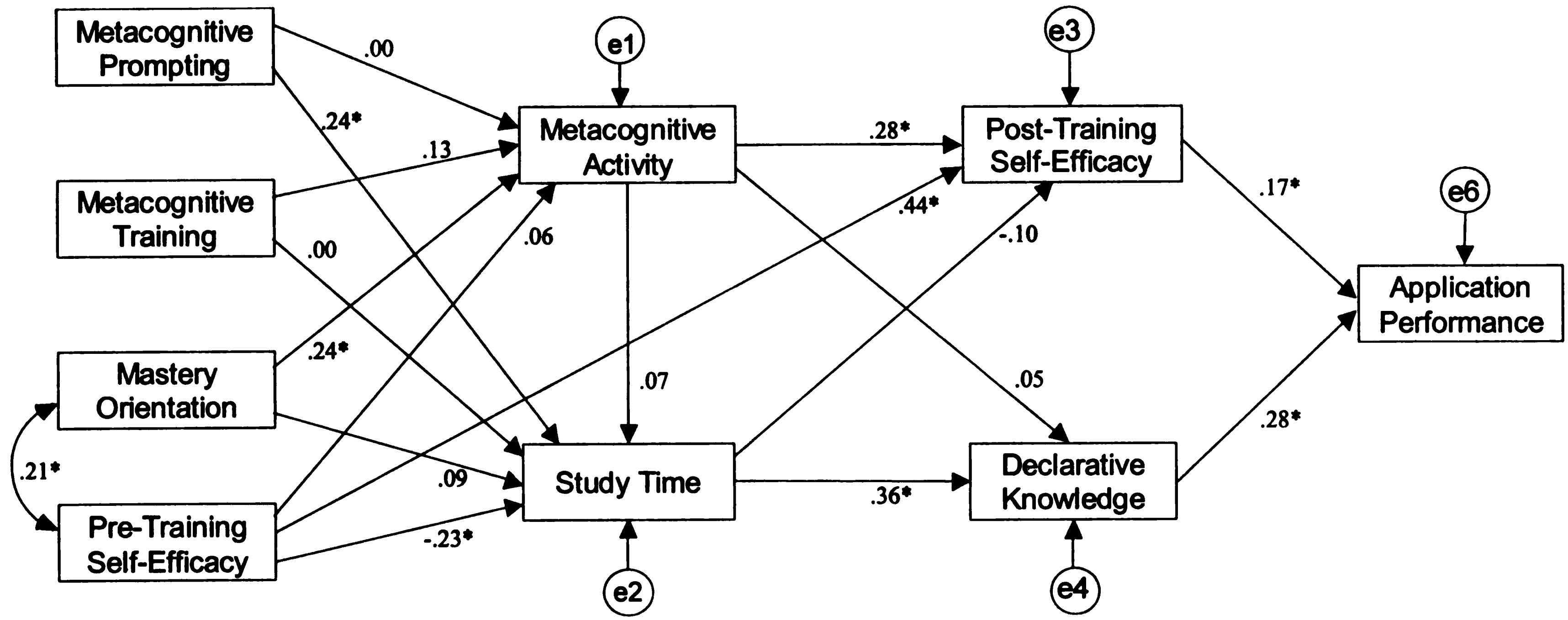
$\chi^2 = 108.3$, DF = 31; GFI = .87; RMSEA = .14

freedom. According to Brown and Cudeck's criteria, which states that .05 or less represents close fit, .05 - .10 represents moderate fit, and .10 or greater is a bad fit, this also indicates a poor fitting model. Overall, this model presents a poor fit to the data.

Consistent with the hypothesis tests described above, examination of the parameter estimates indicated that two variables in particular did not function in the model as expected. Conscientiousness was not related to either study time or metacognitive activity, as specified in the model. Additionally, skill-based performance was not predicted by either metacognitive activity or study time. Additionally, the high correlation between skill-based performance and declarative knowledge is cause for conceptual concern. The unexpected strength of this relationship may be a result of the type of task used in this study. The task was heavily knowledge based and little in the way of skill required to execute that knowledge rather than moving and clicking the mouse. If one knows what to do, little additional knowledge or is skill needed to determine how to do it or to actually perform the action. Thus, the primary factor determining performance on the skill-based performance measure was declarative knowledge, resulting in a great deal of redundancy in the two measures.

Thus, the model was re-tested with conscientiousness and skill-based performance removed (Figure 7). This resulted in drastically improved model fit. This model resulted in a χ^2 value of 23.99, df = 19, p > .05. This value is significant, indicating a lack of model fit. However, a GFI of .96 was obtained, exceeding the .95 rule-of-thumb for a good fit. Additionally, a RMSEA value of .046 was found, again indicating a good fit to the data. Because variables were removed in this model, it is not nested with respect to

Figure 7. Post-hoc model, without interactions



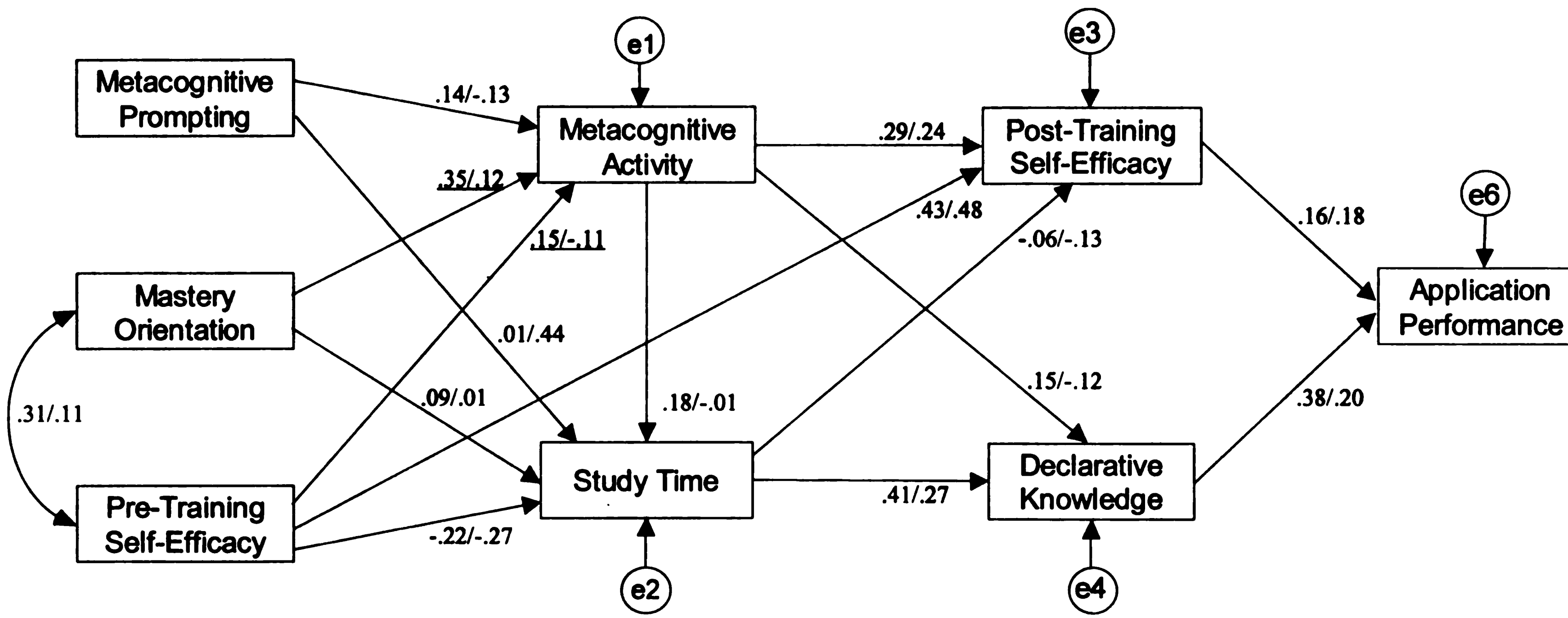
$\chi^2 = 23.99$, DF = 19; GFI = .96; RMSEA = .046

the model described above and, therefore a chi-squared difference test cannot appropriately be calculated (Maruyama, 1997).

The interactions were modeled using multiple-groups analysis, with the two levels of metacognitive training representing different samples. The logic underlying this approach is that, where interactions are present, parameter estimates should differ across the two samples (Schumacker & Lomax, 1996). Two nested models were than examined to determine the equivalence of the hypothesized model across the two levels of metacognitive training. The first model allowed all paths to be freely estimated across both groups. The second model restricted the following four paths to be equivalent across groups: 1) mastery orientation to metacognitive activity, 2) mastery orientation to study time, 3) pre-training self-efficacy to metacognitive activity, and 4) pre-training self-efficacy to study time. Thus, if metacognitive training and motivational variables interacted in their effects on learning processes, restricting these paths to be equal should result in a poorer fit than the model allowing these paths to be freely estimated.

The results from the model comparison ($\chi^2 = 6.48$ with 4 DF, $p = .17$) suggest that imposing the restriction of four equal path coefficients across the two levels of metacognitive training did not result in a significantly worse fitting model. Thus, metacognitive training does not appear to moderate the four paths specified. Examination of the results of the hypothesis tests above, as well as examination of the path coefficients from the present analysis suggest that the relationship between the two motivational variables and study time is not moderated by metacognitive training, whereas the relationship between the motivational variables and metacognitive activity is. Thus, another pair of models was compared which constrained only the path between mastery orientation and metacognitive activity, as well as the path between pre-training self-efficacy and metacognitive activity. Comparison of these two models ($\chi^2 = 5.87$ with 2 DF, $p = .05$) indicate that restricting these two paths two be equal results in a significantly worse fitting model, suggesting that the effect of motivational variables on metacognitive activity is moderated by metacognitive training. This analysis is graphically displayed in Figure 8.

Figure 8. Multiple groups analysis, Metacognitive Training Absent/Present



Model 1 – All Paths Freely Estimated: $\chi^2 = 29.21$, DF = 26; GFI = .95; RMSEA = .032
Model 2 – Underlined Paths Restricted: $\chi^2 = 35.08$, DF = 28; GFI = .94; RMSEA = .045

$\Delta \chi^2 = 5.87$, 2 DF, p = .053

DISCUSSION

The purpose of this study was to examine critical aspects of self-regulation in training contexts. In support of this goal, the concept of metacognition was explored as it relates to the monitoring of one's knowledge and the subsequent influence of this monitoring on actions taken in support of learning. A conceptual model was developed that links trainee characteristics, training design features, learning processes, and training outcomes (Figure 1). Trainees' motivational characteristics were posited to influence two learning processes – metacognitive activity undertaken during training, as well as study time. These learning processes were linked to cognitive, behavioral, and affective training outcomes, represented by declarative knowledge, skill-based performance, and post-training self-efficacy. These training outcomes, in turn, were linked to performance on a task requiring application and integration of the knowledge and skills acquired during training.

Given the conceptual and empirical support for the role of metacognition during learning, two interventions, metacognitive training and metacognitive prompting, were developed to support and enhance metacognitive activity during training. Metacognitive training consisted of brief instruction prior to the start of the training program proper, wherein trainees were informed of the concept of metacognition, the important role metacognitive monitoring plays during learning, common mistakes trainees typically make when monitoring their learning, and strategies to be used during training to improve monitoring. Metacognitive prompting consisted of periodically instructing trainees to access their learning and comprehension of the studied material. These two interventions were expected to influence both metacognitive activity during training, as well as the total time individuals spent on the training program. In addition, metacognitive training was expected to interact with the motivational characteristics in its influences on learning processes.

Motivation to Learning Processes

The motivational characteristics of mastery goal orientation, pre-training self-efficacy, and conscientiousness were expected to relate to both metacognitive activity and study time. Results indicated that, when entered simultaneously into the regression equation, these three variables explained incremental variance in metacognitive activity beyond that accounted for by ability or prior experience. However, only mastery orientation accounted for unique variance in metacognitive activity.

It was assumed that mastery orientation would exert a positive influence on metacognitive activity primarily through motivational means. That is, those with a high mastery orientation would be more motivated to acquire and master the training material, which would lead to a willingness to exert the additional time and effort needed to engage in metacognitive activity during training. However, post-hoc analyses revealed that mastery orientation failed to account for variance in metacognitive activity after the effects of pre-training metacognitive skills had been partialled, opening the possibility of alternative mechanisms underlying this link. Those with a high mastery orientation appear to possess superior metacognitive skills across situations ($r = .54$). These skills may develop over time as a means of supporting their learning goals. Therefore, in the present study, these individuals may have more skillfully and naturally engaged in metacognitive activity, regardless of their interest or motivation to learn in this particular situation. Another possibility is that the mastery orientation - pre-training metacognitive skill link reflects a stable tendency for those with a high mastery orientation to *utilize* their metacognitive skills, although they may not differ with respect to *possession* of the skills per se. This general tendency to utilize existing skills may have carried over to the training program in this study, resulting in the observed link between mastery orientation and metacognitive activity during training.

Despite its significant positive relationship with pre-training metacognitive skills ($r = .37$), conscientiousness did not exhibit a significant relationship with metacognitive activity. This suggests that metacognitive activity was not dependent upon dutifulness or achievement striving, the most prominent features of those high in conscientiousness. This finding is consistent with those of mastery orientation described above. Thus, it appears that motivational characteristics, at least as operationalized in the current study, do not play as strong a role in directly influencing metacognitive activity as had been expected. This could be due to specific characteristics of the training program used in this study, as will be discussed in limitations below.

Motivational variables also did not exhibit as strong an influence on study time as was expected. None of the three motivational characteristics accounted for significant variance in study time, whether entered individually or simultaneously into the regression equation. However, although not significant by typical standards, both mastery orientation and pre-training self-efficacy had marginally significant relationships with study time. Mastery orientation was positively associated with study time. Individuals with high mastery orientations tend to be more concerned with and interested in learning and, therefore, were expected to invest greater time and effort into studying the training program. The relationship with pre-training self-efficacy was more difficult to speculate on. While those who are low on self-efficacy could be expected to withdraw from the task and, therefore, exhibit a positive relationship with study time, those with higher self-efficacy may also believe, accurately or not, that they have mastered the training material more quickly than those with lower efficacy and, therefore self-efficacy would exhibit a negative relationship with study time. Results suggested that the latter may have been the case in this study, as pre-training self-efficacy was marginally and negatively related to study time.

Metacognitive Interventions

Of primary concern in this study were the two interventions designed to enhance metacognitive activity during training. Consistent with expectations, those receiving metacognitive training reported greater metacognitive activity during training. Although metacognitive training did not have a significant zero-order correlation with metacognitive activity, this effect became significant after the effects of pre-training metacognitive skills were partialled. The suppressor effect as typically observed arises when high intercorrelations are observed among predictors, but a low or non-significant relationship is found between at least one predictor and the criterion (Nunnally & Bernstein, 1994; Tzelgov & Henik, 1991). In such instances, the *suppressing* predictor removes or accounts for (i.e. suppresses) "criterion-irrelevant" variance in the *suppressed* predictor, increasing the predictive power of the remaining variance.

In the present situation, there is virtually no relationship between the two predictors ($r = -.02$, ns). Yet, this correlation is large enough to boost the marginally significant effect of metacognitive training on metacognitive activity ($r = .1399$, $p = .0776$) into statistical significance. Examination of the regression equation demonstrates that this is necessarily so, given the mechanics of the equation. Considering that metacognitive training was a manipulated variable, with metacognitive skills being assessed prior to this manipulation, any relationship between these variables, significant or not, can only be attributed to sampling error. If one sets the correlation between metacognitive training and metacognitive skills to its "true" value of 0, the relationship between metacognitive training and metacognitive activity mirrors the marginally-significant value obtained via the zero-order correlation.

Although metacognitive training and pre-training self-efficacy each had only weak and/or non-significant direct effects on metacognitive activity, an interaction was found among the two, as predicted. This interaction is graphically displayed in Figure 5. Among those who did not receive the metacognitive training, pre-training self-efficacy was positively related to metacognitive activity. Those with low self-efficacy have little faith in their ability to acquire the skills being taught in the training program. As a result, these individuals are less likely to invest the effort required to fully engage in the training, including actively monitoring and controlling their learning processes. Additionally, the positive correlation between pre-training self-efficacy and pre-training metacognitive skills indicates that these individuals are less likely to engage in such activities in many learning situations.

In contrast, pre-training self-efficacy did *not* influence metacognitive activity for those who received metacognitive training. Examination of Figure X suggests that the training had a beneficial effect for trainees with lower self-efficacy. Without training, those with low self-efficacy demonstrated lowered levels of metacognitive activity when compared to trainees with higher self-efficacy. With the metacognitive training, those trainees with low self-efficacy exhibited levels of metacognitive activity on par with those with higher self-efficacy, whereas the metacognitive activity of trainees with high self-efficacy was relatively unaffected by the intervention.

Counter to expectations, metacognitive training had no direct effect on study time, nor did it interact with motivational characteristics to effect study time. This finding is somewhat surprising, particularly given the significant interactive effect of metacognitive training and self-efficacy on metacognitive activity. Hypothesis 3 predicted that metacognitive activity would be positively related to study time. The basis for this expectation was twofold. First, it was assumed that the processes of more actively monitoring one's learning would require time and attentional resources, adding to the total time trainees spent on the training program. Additionally, the metacognitive training encouraged learners to identify training information that they had not yet learned sufficiently and to spend additional time studying this information. To the extent that trainees did so, this would be expected to increase the total time spent on the training program.

Results provided support for this hypothesis, in that metacognitive activity was positively related to study time. However, metacognitive activity accounted for only 3% of the variance in study time, suggesting that this link was much weaker than expected. Given the weakness of the link between metacognitive activity and study time, it is not surprising that metacognitive training, which was intended to primarily influence metacognitive activity, did not have an effect on study time. Several potential explanations can be forwarded for this finding. First, the metacognitive activity measure may reflect differences in both the *quality* and *quantity* of metacognitive activity.

Individuals may engage in metacognitive activities that differ greatly in *quality*, but do not differ in *quantity* or time required for their use. That is, some individuals may less frequently monitor their learning and subsequently adjust their learning strategies, but these few instances may be of sufficient quality to yield equal or superior learning as compared to other individuals who may more frequently utilize less effective monitoring and control strategies. Following this logic, metacognitive training may have affected the quality of metacognitive activities, without increasing the quantity of such activities or the time required for their use. Although metacognitive monitoring and study time allocation has been studied under simple word-list learning tasks, the current study is one of the few known studies to examine this relationship under complex learning tasks, leaving much to be learned about the interplay between these two constructs under such tasks.

Consistent with expectations, metacognitive prompting resulted in greater study time. The prompts, by design, required trainees to periodically reflect on the material they had studied, identify what they had learned so far, as well as what they needed to learn better. Because study time was operationalized as the time elapsing between the initiation and termination of the training program proper, which included time spent on the prompts, it could be argued that the positive relationship between metacognitive prompting and study time is artificial – individuals receiving the prompts spent additional time studying because the task required them to. In contrast, one could argue that the time spent on the prompts is time spent actively thinking about the training material and, therefore, legitimately belongs in the consideration of time spent on training.

Additional analyses may help sort out the issue. When time spent on the prompt screen is removed from the total time spent on training, leaving only time spent on the training content itself, metacognitive prompting no longer has a significant effect on study time ($r = -.05$, $p = .49$). Thus, individuals receiving metacognitive prompts did not spend additional time on the training material itself, as was expected. One could argue that, although the metacognitive prompts did not lead to an increase in the time spent with the training material itself on the screen, the quality of the time spent examining this material improved as a result of the prompts. For example, although two trainees may have spent 45 minutes studying the training material, the one who received the prompts would spend this time more strategically, focusing their time on the aspects they needed to learn most. If this were the case, the relationship between study time and learning outcomes would likely be moderated by prompting, as 45 minutes of high-quality study time would be expected to be more strongly and positively related to learning outcomes than would 45 minutes of low-quality study time. However, no such interaction was observed for any of the learning outcomes. Although null results such as this are difficult to interpret, it at least suggests that neither the quality of study time, nor the quantity, differed as a function of the metacognitive prompting.

Perhaps a more critical question is whether the time spent on the prompts themselves was predictive of learning outcomes. Stated differently, did the amount of time spent on the prompts help trainees to better learn the material? Post-hoc analyses revealed that, for those trainees receiving prompts, time spent on the prompts was marginally correlated with declarative knowledge ($r = .21$, $p = .06$). When criterion-irrelevant variance in the time spent on the prompts due to prior experience and cognitive ability were partialled, time on prompts exhibited a significant positive relationship with declarative knowledge. Thus, although metacognitive prompting did not lead trainees to spend more time on the training material per se, and was not significantly related to metacognitive activity ($r = .16$, $p = .16$), it does appear to have been time spent thinking about the material, as indicated by the positive relationship with declarative knowledge.

Counter to expectations, metacognitive prompting failed to affect metacognitive activity. One potential explanation for this failure could be that not all trainees receiving the prompts made an attempt to fully utilize the prompts. As indicated above, individuals receiving prompts spent significantly more time on the training program, a difference that is directly attributable to the time they spent with the prompts on the screen. However, trainees may have differed in how much they attempted to truly utilize the prompts to evaluate their learning, versus simply complying with experiment requirements. Post-hoc analyses revealed that self-reported motivation to utilize the prompts was positively related to metacognitive activity ($r = .46$, $p < .01$). This effect remains even after partialling the effects of prior experience, ability, and pre-training metacognitive skills. Thus, it appears that the prompts may have influenced metacognitive activity for those who genuinely attempted to utilize them. However, additional post-hoc analyses failed to find a significant interaction between prompting and any of the model variables in predicting metacognitive activity. Thus, if differences in trainee motivation to utilize the prompts are truly responsible for the lack of a significant prompting effect, no variables contained in the current model can account for these differences in motivation.

Another possibility is that characteristics of the prompts were not conducive to encouraging metacognitive activity. First, the prompts were intentionally designed to encourage the use of any existing metacognitive skills, rather than directing participants in the use of specific techniques. More directive prompts may have provided participants with more guidance on exactly how to monitor and evaluate their learning. Such directive prompts could be particularly beneficial for participants lacking skills initially. One possible specific prompt could be requiring the use of the question-stems provided to participants receiving metacognitive training in the current study. Specific content-relevant questions, similar to the declarative knowledge questions asked at the conclusion of training in this study, could also be asked periodically during training. Trainees could be encouraged to use these questions to determine where to direct their attention and study time.

Learning Outcomes

This study found that learning processes were related to some of the learning outcomes. As expected, metacognitive activity was positively related to post-training self-efficacy. This effect remained even after accounting for the effects of pre-training self-efficacy. Thus, consistent with the propositions of Winne (1995) and Bandura (1997), positive feelings of efficacy appear to result from monitoring one's comprehension. It was assumed that this effect would result, in part, from the hypothesized effects of metacognitive activity on knowledge. Those who more actively monitored and controlled their learning were expected to improve their learning, which would result in higher self-efficacy. However, in the present study, no relationship was found between metacognitive activity and cognitive or behavior indices of learning. Thus, higher efficacy appears to result from simply engaging in active monitoring and control of learning leads one to have greater self-efficacy, independent of increases in actual learning. Bandura (1997) has stated the process of successfully guiding one's own learning and performance provides positive self-generated feedback concerning one's competence and capabilities. In support of this claim, Schunk and Cox (1986) found that students who verbalized their cognitive strategies while they performed demonstrated greater increases in self-efficacy than students who did not exercise such self-guidance. However, given that both metacognitive activity and post-training self-efficacy were self-report measures assessed at the same point in time, same source method bias may be contributing to some of the observed relationship.

It may also be that individuals engaging in greater metacognitive activity did, in fact, learn more, but the dependent measures failed to identify this learning. For example, engaging in monitoring and controlling of one's learning may lead to more complete and integrated knowledge structures, which was not assessed in the current study. Given the existing conceptual and empirical support for the relationship between metacognition and learning (e.g., Brown, Bransford, Ferrara, & Campione, 1983; Ford et al., 1998; Meloth, 1990; Nelson & Narens, 1994; Volet, 1991), one must consider that the outcome measures used herein may have failed to capture the learning gains resulting from increased metacognitive activity.

Although post-training self-efficacy was conceptualized as an outcome of learning processes, the dynamic nature of learning makes the true directionality of this relationship difficult to establish. The methodology employed in the current study does not allow for clear determination of the order of causality. The negative relationship observed between study time and post-training self-efficacy also raises questions concerning the true causal order of post-training self-efficacy as measured and learning processes. While it seems reasonable to conclude that possessing low self-efficacy could lead one to spend more time studying the training material, the reverse does not. That is, it is difficult to conceptually justify that spending more time studying would lead one to have *less* confidence in their ability to create web pages. Thus, the negative relationship leads to the conclusion that the aspects of self-efficacy tapped by the post-training measure may more appropriately belong causally prior to study time, rather than after, as specified in the model. It is most likely the case that self-efficacy and study time are dynamically and cyclically related. Self-efficacy beliefs may influence study time, such that those with lower self-efficacy spend greater time studying, as they believe this is necessary to learn the material. However, as these individuals spend more time on the material their efficacy beliefs would be expected to increase. Although the inclusion of both pre- and post-training self-efficacy was intended to capture some of the dynamic nature of self-efficacy within the learning process, the construct validity of the post-training self-efficacy measure may be questioned, as it may be measuring trainees' perceptions of efficacy as they progressed through training, rather than solely measuring self-efficacy after training has been completed. Pre-training self-efficacy was only marginally and negatively related to study time, while post-training self-efficacy was strongly negatively related to study time ($r = -.54$).

More intuitive results emerged concerning the effect of study time on declarative knowledge. As was expected, individuals who studied longer demonstrated greater declarative knowledge than those who studied less. This effect remains whether one considers total study time including time spent on the metacognitive prompts, when applicable, or only just the time spent on the training content itself. This result comes as no surprise. Study time was, in fact, expected to play a key role in the model. One of the key goals of the metacognitive interventions was to prevent individuals from disengaging from the training prior to mastery – that is, to spend more time studying the material. Although, as discussed above, the effect of prompting on study time may be difficult to explain simply as increases in metacognitive activity, the positive relationship observed between metacognitive activity and study time lends some support to the notion that those who engage in greater metacognitive skills are less prone to discontinue study time prematurely. The additional study time, in turn, results in improved learning, as reflected by declarative knowledge.

Results also indicated support for the general hypothesis that the learning outcomes of declarative knowledge, skill-based performance, and post-training self-efficacy would be positively related to application performance. The three outcomes entered simultaneously explained significant variance in application performance beyond that attributed to prior experience, ability, or pre-training self-efficacy. However, only skill-based performance accounted for unique variance in application performance, despite the significant zero-order correlations observed between declarative knowledge and application performance and post-training self-efficacy and application performance.

The failure of declarative knowledge and post-training self-efficacy to account for unique variance in application performance is not surprising, given the pattern of correlations between the three learning outcomes. Skill-based performance and declarative knowledge were correlated .56 calling into question the distinctiveness of the constructs assessed by these measures. However, this explanation does not account for the inconsistent pattern of relationships of these two variables with other variables in the model. For example, declarative knowledge was positively correlated with study time ($r = .25$, $p < .05$), whereas skill-based performance was not. It is more likely the case that, although post-training self-efficacy, skill-based performance, and declarative knowledge are all accessing somewhat unique constructs, the conceptual relationships among them leads to each accounting for similar aspects of application performance.

It may also be that the relationship between declarative knowledge and application performance, as well as that between post-training self-efficacy and application, are in fact mediated by skill-based performance. Post-hoc analyses indicate some support for this notion. Without the presence of skill-based performance, declarative knowledge has a significant direct effect on application performance, although post-training self-efficacy does not. Both variables have significant direct effects on skill-based performance. As indicated above, skill-based performance has a significant effect on application performance. Finally, the direct effect of declarative knowledge becomes non-significant once skill-based performance has been partialled. A variation of this explanation is that skill-based performance may be tapping one aspect of the more general performance domain assessed by the measure of application performance. Post-training self-efficacy and declarative knowledge may be successfully predicting this aspect of performance, but not other aspects of application performance that go beyond skill-based performance. These issues should be sorted out in future research.

Limitations

Several limitations may account for some of the unexpected results in the current study. One limitation concerns the measurement of several variables in the model.

Metacognitive activity was conceptualized as a multi-dimensional construct consisting of both monitoring and control components. However, factor analyses did not support this dimensional structure. Although eigenvalues suggested as many as 6 factors, the scree plot indicated that the first factor was prominent, with the possibility of one or two additional factors. However, the pattern of factor loadings did not support the proposed conceptualization. Post-hoc attempts to define the resulting factors on the basis of item content led to ambiguous and largely uninterpretable constructs with a great deal of conceptual overlap, very high intercorrelations, and relatively low reliabilities. Thus, although metacognitive monitoring and control are conceptually distinct, the two may be so closely tied that the two cannot be readily separated in practice, particularly with self-report measures.

An additional measurement issue concerns the construct validity of self-efficacy. In an effort to capture some element of the dynamic nature of self-efficacy in the learning process, self-efficacy was assessed both before and at the conclusion of training. Although the two measures were highly correlated ($r = .54$), a factor analysis of both pre- and post-training self-efficacy items revealed a two-factor solution, with all items loading on the appropriate scale. Thus, the two measures do appear to be measuring distinct aspects of self-efficacy. However, the negative relationship between study time and post-training self-efficacy raises concerns as to what post-training self-efficacy is truly tapping. In responding to the post-training self-efficacy measure, participants may have reflected on their efficacy throughout the training program, rather than solely assessing their efficacy at that moment. If this were the case, this could explain the negative relationship that remained even when taking pre-training efficacy levels into account.

Additionally, pre-training self-efficacy was assessed before having any exposure to the training program. Thus, these efficacy beliefs may not have been well calibrated and could have shifted dramatically upon initial exposure to the training program. Had self-efficacy been assessed early in training, but after some initial exposure to the training program, it may have been found that greater study time did in fact lead to higher self-efficacy when compared to these initial, rather than pre-training levels.

The remaining outcome measures represent an additional measurement concern in this study. One problem concerns the difficulty level of the skill-based performance and declarative knowledge measures. The average item difficulty level of the declarative knowledge and skill-based performance measures was .76 each. The high item means indicate that most trainees were getting most items correct, serving to reduce the variance in the measures attributable to differences in true levels of the constructs being assessed. The high overall means for these two measures further highlight this problem. The average score for skill-based performance was 18.29 out of a maximum of 24, whereas the mean overall score for declarative knowledge was 26.67 out of a maximum of 37. Given that most trainees scored well on both of these measures, this suggests that the measures failed to capture the full range of learning, which may have limited their observed relationships with other measures in the model.

In addition to the measurement issues raised above, several design issues warrant mention as well. The first issue concerns the choice of training topics. Web-page creation was chosen as the training topic because it was expected to be a topic of interest for the trainees and, therefore, at least minimal levels of motivation and attentiveness would result. Additionally, it was expected to be a topic on which most trainees would not have much existing knowledge.

Prior experience was found to play a much larger role throughout the model than had been expected. Including prior experience as a covariate in all analyses only partially solves the problem. One must wonder whether experience accounted for even more variance throughout the model than revealed by the measures used herein. To the extent that the measure of prior experience was not sufficient to fully assess this surprisingly influential construct, this leads to variance in measures throughout the model that cannot be accounted for by measures included within the model. This increase in unexplained variance makes it more difficult to find significant effects where they otherwise may have existed.

Even when trainees had no prior experience with web-page creation per se, experience with the internet and computers in general likely still exerted influence throughout. Those with greater familiarity with the internet would seem likely to possess existing schemas for the concepts covered in the training, particularly with respect to the purpose of various elements within web pages, such as hyperlinks, tables, etc. These schemas would be expected to assist greatly in the acquisition of the training material, as they would need only to learn how to implement the features within web pages of their own creation, but would already be familiar with their meaning and purpose. Those without such schemas would in effect have more information to learn, thereby decreasing their probability of learning any given piece of information.

While web page creation was chosen as the training content in part to ensure some minimal degree of participant motivation, it is possible that trainees were, as a whole, *too* motivated in the present study. That is, there may not have been sufficient variance in trainee motivation to allow the motivational characteristics to truly take effect. For example, mastery orientation is has been found to be related to motivation to learn (e.g., Colquitte & Simmering, 1998), in part because individuals high in this orientation value learning in general, which influences their probability of focusing on learning in specific contexts. Most individuals in the present study may have adopted learning goals, regardless of their general tendency to do so. The only significant effect for mastery orientation in this study was the positive relationship with metacognitive activity. That this effect went away after the effects of pre-training metacognitive skills were removed indicates that this effect was likely due to skills built in support of one's general tendency to adopt learning goals, but the motivational impact was typically associated with a mastery orientation may not have been unique to these individuals in this context. It may have been more revealing to examine *state* mastery orientation, the extent to which individuals were focused on learning and developing their skills *in this specific context*.

Participants were not provided feedback concerning how well they were learning the material in the training program. This was done in an effort to strengthen the influence of metacognition and, relatedly, the metacognitive interventions. With no task-generated feedback, it was expected to particularly critical for trainees to accurately evaluate their learning and use this information to guide their learning activities. However, the influence of task-generated feedback on metacognition has not been well examined, allowing only speculation concerning how this may have affected the results. It is possible that individuals who engage in metacognitive activities benefit from the additional information provided by the task. While participants who engage in less metacognitive activities may rely solely on the task-generated feedback to guide their learning activities, individuals who actively monitor and control their learning may use this feedback to supplement their own evaluations of learning.

The lack of feedback may also have motivational impacts although, again, the nature of these impacts are unclear. The lack of feedback may have been frustrating and demotivating for some, potentially leading to withdrawal. Some individuals may have been acquiring the skills taught in the training program, but their own self-generated feedback may have indicated otherwise, lowering motivation. On the other hand, given the tendency of individuals to overestimate what they know, the provision of feedback may have resulted in more negative evaluations than that provided by self-generated feedback alone, which could impact self-efficacy, persistence, effort, etc. Finally, the lack of evaluation may have encouraged more trainees to adopt a learning orientation, thereby reducing the impact of trainees' dispositional mastery orientations. Providing evaluative feedback may have caused some participants to adopt avoidance goals, such as avoiding being judged incompetent by oneself or others. Avoidance goals such as these may have negative impacts on learning and performance.

Another design feature that may have impacted trainees' learning processes was the unavailability of practice opportunities during training. Trainees were required to first spend time learning the material in the training program before attempting to perform the skills being acquired. The reason for this was two-fold. First, pre-testing, which allowed practice during training, indicated that few trainees seemed to be experience much difficultly in acquiring the information in the training program and most trainees were performing quite well on the outcome measures. Thus, it was feared that insufficient variance might result. Additionally, many trainees seemed to be able to largely ignore the training content but learn to create web pages simply by practicing and with and exploring the web-editing program. While this mode of learning is intriguing and important in its own right, it was not the focus of the current study. By not allowing trainees to practice as they learned, it put the onus on learning the information that was contained within the training program and, in so doing, was expected to increase the difficulty of the training program as a whole and, hopefully, result in more variance throughout the model.

Secondly, it was believed that practice would provide feedback to participants concerning how well they were learning the training material regardless of how actively they were monitoring their learning on their own. Thus, practice may have reduced the importance or impact of metacognitive activity and the metacognitive interventions. By not permitting practice until after completion of the training program, it was expected to be critical that individuals actively and accurately monitored how well they were learning material that they were studying.

As is the case with feedback, the role that practice opportunities play with metacognition has not been well explored, leaving the nature of this relationship unclear. Although not the focus of their study, Ford et al. (1998) found a positive correlation between metacognition and the extent to which trainees practiced a critical task strategy which, in turn, was positively related to declarative knowledge and final training performance. Thus, practice may be a critical method by which individuals attempt to address discrepancies detected through metacognitive monitoring.

Implications and Directions for Future Research

While much of the extant research on metacognition has largely ignored the role of motivational characteristics, the results of this study indicate that motivation is an important determinant of metacognitive activity during training programs. Mastery orientation and self-efficacy were both found to impact metacognitive activity. However, the nature of these relationships still remains to be fully understood, particularly on a longitudinal basis. Although mastery orientation was positively related to metacognitive activity, this effect disappeared after its relationship with pre-training metacognitive skills is taken into account. This suggests that at least part of mastery orientation's effect on metacognitive activity in a given situation is due to metacognitive skills that are developed over time. Future research should examine this possibility by examining the relationship between motivational characteristics, such as mastery orientation, and metacognitive activity longitudinally over time.

The interaction observed between pre-training self-efficacy and metacognitive training on metacognitive activity is of both conceptual and practical significance. From a practical perspective, this finding suggests that metacognitive training of the type utilized in this study may serve the greatest benefit to those who typically struggle in learner control environments, helping these individuals to take advantage of the control granted to them. In so doing, such interventions can help a broader range of learners capitalize on the benefits of learner control. From a conceptual perspective, it suggests that the metacognition is somewhat malleable and can be influenced, at least for some individuals. It also suggests that the some of the detrimental effects of low self-efficacy can be averted in certain contexts. Further research should be conducted to determine the precise mechanisms by which the metacognitive training overcame low trainee efficacy and the specific components of the metacognitive training that were responsible for this effect.

In contrast to some of the previous studies using adult learners (e.g., Bean et al., 1986; King, 1989; King, 1992; Murphy et al., 1987), the metacognitive interventions utilized in this study did not exert a direct effect on learning outcomes. As predicted, metacognitive activity was positively related to post-training self-efficacy, but was not related to declarative knowledge, skill-based performance, or application performance, as had been expected. One reason for the differences may be the scope of the interventions, both with regard to time and the number of components of metacognition addressed. Most of the extant studies examining interventions have taken place over relatively extended periods of time, most often spanning weeks or months, whereas the interventions in the current study took place over the course of a few hours. Second, most metacognitive interventions address multiple components of metacognition, such as planning, monitoring, and evaluation, whereas the interventions in this study focused primarily on monitoring. Although the simplified and focused nature of these interventions may have been best suited to the short time period during which they were expected to exert their effect, they may not have the same strength of influence as interventions that utilize multiple components addressed over an extended time period. Future studies should seek to determine the optimal duration and scope of metacognitive interventions to achieve the desired combination of efficiency and utility.

Additional directions for future research have been suggested throughout, but a few seem particularly intriguing. First, the interplay of feedback and practice opportunities with metacognition should be examined. While one could assert that metacognition is particularly important when these features are not present, the case could also be made that metacognition cannot have as beneficial an impact without feedback and/or practice. Given the central role that these two features often play in training programs and questions that have arisen concerning the conditions under which feedback interventions may prove effective (Kleuger & DeNesi, 1996), examination of metacognition within these contexts may yield interesting and important information for theory and practice.

The current study examined metacognition within a learner control training program. Again, this was expected to increase the importance of metacognition, as participants must make decisions regarding where to devote their time and effort. Future research should contrast learner control with program control to determine if trainee characteristics, design features, and learning processes function differently in these two training settings. Under program control, the guidance built into training may compensate for lack of trainee motivation and/or skill. In contrast, under learner control, trainee characteristics and skills may play a much larger role. However, these propositions remain in the realm of speculation. As organizations continue to shift toward learner control training, the need to understand the critical trainee characteristics, design features, and learning that maximize learning and, most importantly, transfer of training back to the job will become critical for organizational success.

APPENDICES

APPENDIX A: INFORMED CONSENT AND DEBRIEFING FORMS

Informed Consent

Explanation of research	The learning behaviors of trainees in a web-based training program will be examined.
Procedures and estimate of time	You will complete a training program that will teach you how to create a web page. You will have opportunities to practice these skills. At the end of the study, you will be asked to create and submit your own web page. The study is expected to take 3 hours.
Participation	Participation in this study is voluntary. You may choose not to participate in some or all parts of the study. You may discontinue the experiment at any time without penalty.
Confidentiality	Your privacy will be protected to the maximum extent allowable by law. Data gathered from you during this study will be strictly confidential. Your responses will remain anonymous in any research reports. At your request, the result will be made available to you.
Risks and costs	There are no risks or costs associated with your participation
Principal investigator Head of the Department of Psychology University Committee on Research Involving Human Subjects	Aaron M. Schmidt, schmi164@msu.edu 432-7069 Dr. Gordon Wood 355-9563 David E. Wright 355-2180

Agreement to Particpate

The procedures and possible risks of the experiment have been explained.
Do you understand and fully consent to participate in the study described above?

☐ Yes If you makred "Yes," please enter you PID number: A********

☐ No If you marked "No," please exit the experiment at this time.
There are a number of books at you local library from which you can learn the same information without participating in a research study.

Debriefing

The study in which you just participated was designed to examine how people learn complex tasks such as web page designing. The investigator is also examining the effects of metacognition (monitoring and regulating your own learning) on learning processes and training performance.

If you have any questions about this study or would like to receive a copy of the results when they are complete, please notify the investigator now, by phone at 432-7069, or by e-mail at schmi164@msu.edu.

Thank you for participating in this study.

APPENDIX B: PRE-TRAINING MEASURES

Prior Experience Scale

All the Time	Frequently	Sometimes	Seldom	Never

1. I spend time making my own page for the web.
2. I surf the web for enjoyment.
3. I use the internet to find information for work or classes.
4. I have taken courses on the internet.
5. Making my own web page is something I've thought about doing.
6. I purchase products or services over the internet.
7. When I surf the web, I follow links to explore.
8. I use the internet to learn new things.

Please estimate the number of hours you have spent designing and creating web pages:

___

Self-Efficacy

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

1. Compared with others in this training program, I expect to do well.
2. I'm certain I can understand the ideas taught in this course.
3. I expect to do very well in this training course.
4. Compared with others in this course, I think I'm a good trainee.
5. I'm sure I can do an excellent job on the tasks assigned in this training course.
6. I think I will perform well in this course.
7. My learning skills are excellent compared with other trainees in this course.
8. Compared with other trainees in this course I think I know a lot about the subject.
9. I know that I will be able to learn the material for this training course.

Mastery/Performance Orientation

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

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 I work on it.
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 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.

Conscientiousness

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

1. I keep my belongings clean and neat.
2. I'm pretty good about pacing myself so as to get things done on time.
3. I am not a very methodical person.
4. I try to perform all the tasks assigned to me conscientiously.
5. I have a clear set of goals and work toward them in an orderly fashion.
6. I waste a lot of time before settling down to work.
7. I seldom notice the moods or feelings that different environments produce.
8. When I make a commitment, I can always be counted on to follow through.
9. Sometimes I'm not as dependable or reliable as I should be.
10. I am a productive person who always gets the job done.
11. I never seem to be able to get organized.
12. I strive for excellence in everything I do.

Metacognitive Skills

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Monitoring

1. I think about how well my tactics for learning are working.
2. I monitor how well I am learning the requirements of the material I am studying.
3. I think carefully about how well I have learned material I have previously studied.
4. I evaluate how well I am learning the skills of I am trying to develop.
5. I think about what skills need the most practice.
6. I try to monitor closely the areas where I need the most improvement.
7. I ask myself questions to make sure I know the material I have been studying.
8. I try to determine which concepts I don't understand well.
9. I think about what things I need to do to learn.

Control

10. I experiment with different procedures for learning.
11. When choosing what information to study, I consider how the information will help me to learn the skills I am trying to develop.
12. I carefully select what to focus on to improve on weaknesses I identify.
13. I use my past performance to revise how I approach learning situations.
14. I stop once in a while and go over what I have read.
15. I spend more time studying topics that I find to be more difficult.
16. I continue to study topics I am trying to learn until I fully understand them.
17. I spend additional time looking over information that I have studied earlier.

Delayed Judgments (control)

18. I wait a brief period of time after studying something before trying to determine how well I have learned it.
19. I distract myself momentarily after studying particular pieces of information before thinking about how well I know it.
20. I ask myself questions about material that I have studied earlier.

Demographic Information

1. What is your gender?
   1 = Female
   2 = Male
2. What is your age?
   1 = less than 18
   2 = 18 - 19
   3 = 20 - 21
   4 = 22 - 23
   5 = greater than 23
3. What is your year in college?
   1 = First-Year
   2 = Sophomore
   3 = Junior
   4 = Senior
   5 = Other
4. What is your race?
   1 = African-American
   2 = Asian
   3 = Hispanic/Latino (Non-white)
   4 = White
   5 = Other
5. What is your overall grade point average (GPA)?
   1 = 0.0 - 1.0
   2 = 1.1 - 2.0
   3 = 2.1 - 3.0
   4 = 3.1 - 4.0
   5 = greater than 4.0
6. Please enter your ACT or SAT total test score. If you took both exams, please enter your score on the ACT exam. ___

APPENDIX C: WEB PAGE TRAINING

First Steps

Getting started

Opening Netscape Composer

For this training program you will need to use Netscape Composer to create your web page from scratch. Right now, open Netscape Composer by clicking on the Communicator menu above, and then clicking on Composer. Now that Composer is open, you are ready to begin creating your web page. After you have opened Composer, save your document as an HTML document. To do this you will pull down the File menu and choose Save as.... Name your file "page1" and save it to the "web" folder. In the box that appears asking for a page title, click OK.

You have just created a web page! Nothing too exciting yet, just a blank white page. In the sections that follow, you will receive instruction on how to add text, links, graphics, and more to give your page a little life."

Choosing the content

One of the first steps in creating a web page is decide what you will put on your web page. A web page can be about anything you choose. A few ideas include special interests, an or area of expertise you have, your family, TV shows, your favorite music, favorite sport or team, your resume, a page advertising or selling some product or products, or anything else you can imagine. Any of these things will add value to your web page.

Second, think about your audience. Who do you want or expect to be visiting your web page? Will it be other people who share your interest? Or will it be mostly family and friends who want to see the latest photos you have taken? If your visitors will be family members who rarely use the Internet, you may want to set up your web page differently than if you are trying to appeal to a high-tech audience.

Once you have decided on the general content of what you want to showcase on your web page, begin thinking about how you want it to appear on the page. Also be thinking about and noting the addresses for other web sites that are related to or will support the content on your web page. This information will be useful when you begin to add links on your web page.

Design rules

If you've spent much time exploring the Web, you've almost certainly encountered some badly designed Web sites. Since almost anyone can create Web pages, it's not surprising that many sites are confusing, overwhelming, ugly, or incredibly slo-o-o-ow. Tantalizing content can be hidden forever from the world when a site is poorly designed.

While it's not easy to create a well-designed site, following a few rules can help. The following set of rules should help you to create pages that are much better organized and easier for you visitors to appreciate:

- **Keep your pages short (200 - 500 words) and focused.** If you have several topics on your web page that are of each of moderate length (200-500 words), you should create a separate web page for each topic, along with an index page that has links to each of the topics. For example, each topic in this training program is on a separate page.

- **Maintain consistency among your pages.** When your web site consists of more than one page, it is important to keep the style (colors, layout, titles, etc.) of all the pages similar. Because one mouse-click can send someone to a new site at any time, a consistent style provides a significant visual cue to let people know they're still at the same site. This has been done with this training program--all the pages maintain a similar look format.

- **Use subheads.** Insert subheads to break up large blocks of text and make each section stand out. Subheads will draw the viewers' attention to the key sections of your page and allow them to find the information they need more quickly.

Background, Text, & Other Page Basics

Web page title

Internet browsers typically have a "title bar" at the very top of the browser window. This title bar will display the title of the web page currently in the browser window. For example, the title displayed in the title bar for this page is "Web Page Training."

It is important to enter a carefully worded title, because the title describes your page in many ways. Web directories such as Yahoo! use the title as a primary reference for what the page is about. So, if you give your page a poorly worded title, it may not come up when folks search on the very topic your page is all about.

An effective title should accurately describe the content of the page in as few words as possible--no more than 6 to 8 words. The most important aspect of the web page content should be included in the title.

How to Create a Title.

Netscape Composer will ask you to enter a title the first time you save your file. By default, it will list the document name as the title, but you can change this to whatever title you choose.

You can easily change the title of a page you have already developed. Here is how:

1. In Composer, choose Format, Page Colors and Properties. [INSERT PICTURE].
2. On the general tab, find the page's current title in the box marked Title [INSERT PICTURE].
3. Click in the Title box and type in your new title.
4. Click OK.

Page colors

By default, the visitor's web browser chooses the colors for the text, links, and background of a page. Generally, the default background will be white, the main text will be black, and the hyperlinks will be in blue.

If you want to control how the page will appear to others, you can specify the colors you want to be applied to your page, rather than letting the visitors web browser apply the default colors. This adds uniqueness and personality to your page. Using custom colors has an immediate and noticeable effect on the appearance of your page. Plus, changing the colors is very easy to do.

You can assign custom colors to each of the following page elements:

Normal Text: All text in the page that is not a link.
Link Text: All links in the page, except those that are active or followed (described next).
Active Link Text: A link is active for as long as a visitor is clicking it, from the time they press the mouse button until the mouse button is released. This specifies what color the link will be while it is being clicked.
Followed Link Text: These are links that the visitor has previously used through his or her browser. Usually this color is different from the color of the hyperlinks, so that visitors to your web page will know what links they have already clicked on.
Background: This is the area that sits behind the text or images in the page. The background never covers or affects other elements in the page.

Here's how to change the background color:

1. In Composer, choose Format, Page Colors and Properties. [INSERT PICTURE].
2. On the Colors and Background tab, select Use Custom Colors (Save Colors in Page) [INSERT PICTURE].
3. Click the colored box just to the left of the words Background (Background image overrides this color) to open a selection of color options [INSERT PICTURE]
4. Click on the color that you want to use for the background.
5. Click OK.

To change the other colors, such as text colors and link colors, repeat these steps, only clicking on the appropriate box in step 3.

Keywords

Most people who publish a web page want others who have an interest in the page's topic to find and view their page. Web search pages like Yahoo! (www.yahoo.com) and Excite (www.excite.com) allow people to search the web for pages that cover particular topics they are interested in. If you web page is about classic cars, you would like your web page to be found when someone enters search terms related to your site, like "vintage cars," etc.

Just as having the right title will help visitors find your page when they search a topic, you can also use "keywords" to further help interested visitors find your web page. Keywords do not appear anywhere on your web page. You specify them in the same manner as the title of your web page. Adding keywords related to the content of your site increases the chances that those interested in your web page's topic will be able to find your page through searches. You can have just about as many keywords as you can think of, and the more specific names and phrases you include the better your web page will fare in search results.

Here's how to add keywords in Composer:

1. If it is not already, open the page for which you want to add keywords.
2. In Composer, choose Format, Page Colors and Properties. [INSERT PICTURE].
3. On the META Tags tab, click inside the User variables (META tag): box [INSERT PICTURE].
4. Click in the Name box and type the word keywords
5. Click in the Value box and type your keywords. Put a comma (but no spaces) between keywords [INSERT PICTURE].
6. Click OK.

Formatting text

One of the most important elements of any web page is, of course, the text. Although the text generally conveys the content of your page, the ideas and information you want to share with your visitors, it can also contribute to the look or aesthetic appeal of your page. Netscape Composer allows you to modify a number of properties that determine the look of your text.

Here is how to format text:

Font:
1. Select the characters you want to format.
2. Click the arrow on the right side of the Font list box [INSERT PICTURE].
3. Click the name of the font you want to apply.

Size:
1. Select the characters you want to format.
2. Click the arrow on the right side of the Font Size list box [INSERT PICTURE].
3. Click the font size you want to apply.

Color:
1. Select the characters you want to format.
2. Click the arrow on the right side of the Font Color box [INSERT PICTURE].
3. Click the color you want to apply to the text.

Bold:
1. Select the characters you want to format.
2. Click the Bold icon [INSERT PICTURE].
3. To un-bold, repeat steps 1 and 2.

Italicized:
1. Select the characters you want to format.
2. Click the Italic icon [INSERT PICTURE].
3. To un-italicize, repeat steps 1 and 2.

Alignment:
1. Select the characters you want to format.
2. Click the Alignment icon on the far right [INSERT PICTURE].
3. Click the Align Left, Center, or Align Right icon [INSERT PICTURE].

Graphics

Background images

One of the easiest and most common places to use graphics is as the background of your page. Instead of having a plain color for the background of your web page, you can have a texture, or a picture that will cover the entire background area. Some textures include marble, wood,
burlap, and water droplets. Click on the links above to see examples of background images [add examples].

Just be sure that you choose a text color that can be seen over the background texture. A background image that has a lot of contrast (a combination of light and dark colors) will make it more difficult to read the text that is placed over it, so choose your background carefully.

Background images are "tiled" by the browser, meaning that the image is repeated across the entire background. This means that even a very small image will fill the entire background. Click the following image to see it as a background.

To create a background image:

1. Make sure the image you want to use is in the same directory (folder) as your web page.
2. In Composer, choose Format, Page Colors and Properties. [INSERT PICTURE].
3. On the Colors and Background tab, under the heading Background image, select Use Image [INSERT PICTURE].
4. Type in the filename of the image you want to use, or click on the Choose File... button and select the image.
5. Click OK.

Horizontal lines

Another simple type of graphic to insert on your web page is called a "horizontal line". These are the straight lines that appear on web pages that are often used to separate different sections of the page. These can be plain gray lines like the ones in this training program, or can be more decorative to give the page more character, depending on the image you want to convey.

To insert a horizontal line:

1. Click in you page at the spot where you want to insert the line.
2. Click the Insert Horiz. Line icon [INSERT IMAGE], or click Insert on the text menu, then Horizontal Line.

Now that you have a line, you can format the line to customize the look of it. To format a line:

1. Click on the line.
2. From the text menu, click Format, then Horizontal Line.
3. Set the following options as you prefer: [INSERT IMAGE]
   - Dimensions
     - Height: How thick the line is.
     - Width: How far across the page the line will fill, in percents.
   - Alignment
     - Left: Line is positioned on the left side of the page
     - Center: Line is positioned in the center of the page
     - Right: Line is positioned on the right side of the page
   - 3-D Shading: Gives the line a three-dimensional look.

Inserting and Resizing Images

Most webpages include at least some minimal graphics. Graphics include both photos and clip-art drawings. An example is the picture in the upper left corner of this page. [INSERT IMAGE].

To insert a picture:

1. Make sure the image you want to use is in the same directory (folder) as your web page.
2. Click in you page at the spot where you want to insert the image.
3. Click the Insert Image button on the toolbar [INSERT IMAGE] or on the text menu up top, click Insert, then Image... A box will open that looks like this: [INSERT IMAGE].
4. Select the image you want to insert by clicking on "choose file." Select the file and click "OK". The name of the file will now appear in the white text box under the heading Image Location
5. Click OK.

OK, so now you've got a picture on the page, but it may be either bigger or smaller than you want. You can resize the picture to fit the space you want. Keep in mind, however, that image quality may not be as good when the image is resized, so experiment and see what looks best to you.

To change the size or shape of an image:

1. Click on the image to select it (a border will appear around the image).
2. Position your cursor in one of the corners. The arrow-shaped cursor will change to a double-headed arrow when you are in the right spot [insert image]
3. Click and Hold down the left mouse button and drag the corner in towards the center of the picture to reduce the size of the image, or out to increase the size.

You can also resize a picture from the top, bottom or side edges, but if you do, you will lose the original proportions of the image. You will retain the original proportions if you click and drag from the corners.

Aligning text with graphics

By default, the first line of text immediately following the picture will appear to the right of the picture, near its bottom. Any text that goes for more than one line will appear below the image (example: [INSERT IMAGE]). However, you can specify where you want the text to appear relative to the image. You can also have the text appear all around the image.

To change the text alignment and wrapping around the images:

1. Click on the image to select it (a border will appear around the image).
2. Click the Insert Image button on the toolbar [INSERT IMAGE] or, on the text menu up top, click Insert, then Image… [INSERT IMAGE].
3. In the middle of the box that will appear are the options for text alignment, under the heading Text alignment and wrapping around images.
4. Click the appropriate button for the text alignment you want (click images below for an example or each).

    - Top alignment [INSERT IMAGE]
    - Absolute middle alignment [INSERT IMAGE]
    - Middle alignment [INSERT IMAGE]
    - Absolute bottom alignment [INSERT IMAGE]
    - Bottom alignment [INSERT IMAGE]
    - Text wrap left [INSERT IMAGE]
    - Text wrap right [INSERT IMAGE]

5. Click OK.

Linking to Stuff

Understanding links

One of the main features of a web page is the fact that it contains links to other sites on the web. A hyperlink is a link you create between your web page and another web page on the Internet. The other web page can be another one of your own web pages or it can be someone else's web page. This is done by including the address of the other web page in your web page.

For example, the menu on the left contains links to the pages that make up this training program. When you click on a link, it automatically goes to the address listed.

You may want to add links on your web page. These links can point your visitors toward other web pages you have, or to other web pages on the Internet that are related to the content of your web page. For example, if you have information on your web page about your favorite musician, you might have a link to that musician's official web site. Or if your web page details information about the MSU football team, you might want to include a link to the ESPN web page that provides the Big Ten football conference standings, or your team's statistics. In this way, you can help your visitors find more information that you either don't have, or don't have the time or desire to constantly update on your web page.

A link can point to a number of resources in addition to other sites. It can point to email addresses, newsgroups, or files such as Word documents, sound files, videos, etc. Links can also point to particular places within the same web page.

Creating text links

Links have two main parts:

- The actual text (or graphic) that appears on your web page
- The URL of the page, file, to be accessed when the link is clicked.

You can format the text part of the link just as you would any other text, except that the link will be automatically underlined once a URL is associated with it.

To create a link to another web page:

1. Select the text that you want to make into a link.
2. Click the Insert Link icon on the toolbar [INSERT IMAGE] or, on the text menu up top, click Insert, then Link...
3. In the box that will appear, in the white text area labeled "link to a page location or local file," type in the URL of the page you want to link to (ex. http://www.msu.edu).

NOTE: If you want to link to a page that exists IN THE SAME FOLDER as the page on which you are putting the link, you need only type the filename (ex. page1.html). However, if the page you want to link to is NOT in the same folder (ex: another site on the web), you MUST type the entire path, including the http:// portion (ex. http://www.wor.com).

4. Click OK.

You can also create links to an email addresses. When a visitor clicks on one of these links, it will open the users default email program with a message addressed to the address specified in the link (ex. sample link).

To create a link to an email address:

1. Select the text that you want to make into a link.
2. Click the Insert Link icon on the toolbar [INSERT IMAGE] or, on the text menu up top, click Insert, then Link...
3. In the box that will appear, in the white text area labeled "link to a page location or local file," type "mailto:" followed immediately by the email address (ex. mailto:sparty@msu.edu).
4. Click OK.

To remove a link, hold the mouse pointer over the link and click the right mouse button. Select "Remove Link" from the menu.

Creating links in graphics

You may want visitors to be able to link to another web page by clicking on a graphic rather than by clicking on text. (You can learn more about inserting graphics on your web page in another lesson.) For example, if you have a photo of Beaumont Tower on your web page, you can embed a link to the MSU home page in the graphic. That way, when a visitor clicks on the photo they will be linked to the MSU page.

Making an image into a link is simply a matter of attaching the URL to the image. It is done just like creating a text link, except you select an image, instead of text, before creating the link:

1. Select the image that you want to make into a link.
2. Click the Insert Link icon on the toolbar [INSERT IMAGE] or, on the text menu up top, click Insert, then Link...
3. In the box that will appear, in the white text area labeled "link to a page location or local file," type in the URL of the page you want to link to (ex. http://www.msu.edu).

NOTE: If you want to link to a page that exists IN THE SAME FOLDER as the page on which you are putting the link, you need only type the filename (ex. page1.html). However, if the page you want to link to is NOT in the same folder (ex: another site on the web), you MUST type the entire path, including the http:// portion (ex. http://www.wor.com).

4. Click OK.

To remove a link, hold the mouse pointer over the link and click the right mouse button. Select "Remove Link" from the menu.

Creating targets

When you click on a link, the page will load showing you the top of the file in the browser. You can then scroll down to see the rest of the page. But there may be times when you want to create not only a link to a page, but a link to a specific part of a page that is not necessarily the top of the page. If you have a lot of information on your web page, you may want to create links near the top of the page that will make it easier for visitors to get to specific information located further down on your web page.

This is what targets do. They take a visitor to an exact spot on a page, rather than just to the top of the page. Click here for an example [INSERT EXAMPLE]

Creating targets is a two-stage process. *First*, you must create the target in the destination page (the page the link will take the visitor). *Second*, you must create a link to that target. The link can be in the same page as the target, or it can link to a target on a different page.

To create Targets in a page:

1. Open the page you want the link to lead to (it can be the same page as the link itself).
2. Click a spot where you would like a link to lead.
3. Click on the Insert Target icon [INSERT IMAGE], or click on the Insert menu, and then click on Target. The Target Properties box will pop up: [INSERT IMAGE]
4. In the Target Properties box, type in a name for the target.
5. Click OK.

To create a link to a Target:

1. Open the page that you want to put the link in (it can be the same page as the target).
2. Select the text that you want to make into a link.
3. Click the Insert Link icon on the toolbar [INSERT IMAGE] or, on the text menu, click Insert, then Link...
4. **If you are linking to a target on a *DIFFERENT* page**, in the box that will appear, in the white text area labeled "link to a page location or local file," type in the filename of the page you want to link to (ex. page1.html).
   If you are linking to a target on the *SAME* page, then skip this step.
5. In the white box toward the bottom, under the label "Select a named target in current page (optional), click on the name of the target you want to link to [INSERT IMAGE].
6. Click OK.

To remove a link, hold the mouse pointer over the link and click the right mouse button. Select "Remove Link" from the menu.

Tables

Table Basics

Alignment of text and images is a serious problem in web documents. Tabs don't work in web pages like they do in word processing programs like Microsoft Word. You can't use tabs to line up columns, for example. You can't just keep hitting the space bar, either. So, if you want to format any information or pictures in columns, you will need to use a table.

For example, here is one way a table can help you format your web page:

	Favorite players	
Baseball	Basketball	Football
Manny Ramirez	Grant Hill	Terrell Davis

In a normal document, you would use tabs to create the columns, but in an HTML document you must use tables to create the columns.

A table, regardless of the medium in which it appears, is chunks of information arranged in rows and columns. The grid of rows and columns forms the cells in which you can organize text. A cell is the box made from the intersection of a row and column. You can put text or images in a table cell.

A basic table is easy to create in Netscape Communicator:

1. Click the spot on you page where you want to insert a table.
2. Click the Insert Table icon on the toolbar [INSERT IMAGE] or, on the text menu, click Insert, then Table...
3. At the top of the box that will appear, set the number of rows and columns you will need.
4. Click OK
5. Click in any cell and enter text or pictures as you would anywhere else on your page.

Once you have created a table, you can easily add or delete rows and columns. To add more rows, you simply hit the tab key when you are in the last cell (bottom-right cell) in the table and another row will appear. On the text menu, click Insert, Table, then Column.

To remove a row or column, or entire table:

1. Click in the row or column you want to delete.
2. On the text menu, click Edit, Delete Table.
3. Click on Table to delete the entire table, row to delete just the selected row, or column to delete just the selected column.

Table Borders

You can choose to have a border that surrounds the table to give it a "framed" look. For example, here is the same table with [INSERT TABLE] and without borders [INSERT TABLE]. You can also adjust the size of the border around your table. When you have no borders on a table, you will still see a blue double dashed line around the table when working in Composer [INSERT IMAGE]. This is to help you work with you table and will not be seen visible when the page is viewed in a web browser.

To modify table borders:

1. Click anywhere inside the table you want to format.
2. On the text menu, click Format, Table Properties. [INSERT IMAGE]
3. Click on the Table tab at the top of the box.
4. Click in the box labeled "Border line width:" and enter a number for the width of the border.

   NOTE: By default, the border size is set to 1 pixel. Choose a larger number for a bigger border. Type 0 if you do not want a border around your table.
5. Click OK.

Table and Cell Colors

By default, the background for a table and all of its cells will be transparent, meaning that it will take on whatever background you have specified for the page. However, you can assign custom colors to the table as a whole, or to individual cells within the table, that is different from the rest of the page. This can add emphasis to the table and its contents and help it to stand out from the rest of the page.

To change a table's background color:

1. Click anywhere inside the table.
2. On the text menu, click Format, Table Properties. [INSERT IMAGE]
3. Click on the **Table** tab at the top of the box.
4. Under the heading "Table Background", check the box to the left of the label "Use Color:"
5. Click the colored box just to the left of the label "Use Color:" to open a selection of color options [INSERT PICTURE]
4. Click on the color that you want to use for the background.
5. Click OK.

To the background color of a particular cell:

1. Click inside the cell.
2. On the text menu, click Format, Table Properties. [INSERT IMAGE]
3. Click on the **Cell** tab at the top of the box.
4. Under the heading "Cell Background", check the box to the left of the label "Use Color:"
5. Click the colored box just to the left of the label "Use Color:" to open a selection of color options [INSERT PICTURE]
4. Click on the color that you want to use for the background.
5. Click OK.

Table Width and Alignment

By default, the table will be the full width of the page. However, you can make you smaller than the width of the page.

The primary way to set the table width is as a percentage of the page width. For example, you could set the table to be 80% of the page width. Then, whatever size a visitor's browser window, the table will be 80% as wide. When the page is made smaller, the table gets proportionally smaller, and vice versa.

To change a table's width:

1. Click anywhere inside the table.
2. On the text menu, click Format, Table Properties. [INSERT IMAGE]
3. Click on the **Table** tab at the top of the box.
4. Make sure the box to the left of the label "Table width:" is checked (by default, this should already be checked).
5. Click the inside the box to the left of the label " Table width:" and type in the percentage of the window you want the table to fill.
6. Click OK.

If the table width is set to less than 100% of the page width, you will need to decide where you want the table to be positioned (or aligned). Do you want the table to be positioned on the left of the page (left alignment), on the right side of the page (right alignment), or in the center of the page (center alignment)? By default, the table will be aligned on the left side of the page.

To change a table's alignment:

1. Click anywhere inside the table.
2. On the text menu, click Format, Table Properties. [INSERT IMAGE]
3. Click on the **Table** tab at the top of the box.
4. Under the heading "Table Alignment", choose left, right, or center.
5. Click OK.

Putting it on the web

Publishing your page

To load your web page on the Internet, you must save it to your space on the MSU internet server. All MSU students are provided with space on the MSU internet server to which they can post a web page.

If you haven't already converted your page to HTML format, you will need to pull down the File menu and choose Save as HTML. If you have it in HTML format, you only need to choose Save. In either case, save your document to the "web" folder and give it the name "index".

Any graphics you have placed on your web page should automatically save to the "web" folder.

Publishing your page Using FTP programs
FTP stands for File Transfer Protocol. This program allows you to transfer documents from one file to another on a network to which you have access. All MSU students have access to the MSU server through the pilot network.

The FTP program you will be using is a DOS command-based program. You have to know the right commands in order to transfer files.

To upload you web page to the MSU server using FTP:

1. Click on the Windows "Start" button, then click Run...
2. In the Run box, type **ftp** and press enter.
3. At the "ftp>" prompt, type: open
4. After the word "To", type: pilot.msu.edu
5. After "User (pilot.msu.edu: (none)):" type your pilot e-mail login.
6. When it prompts you for your password, type that in.
7. At the next "ftp>" prompt, enter the following: **cd web** and press enter.
8. At the next "ftp>" promt type: put a:\index.html (or whatever the path name is for where your web page file is saved; i.e. c:/mydocuments/index.html) and press enter.
9. Now your web page is online.

The last step is to upload an graphics you have on your page. You do this in the same way.

At the "ftp>" prompt type: put c:\graphicname.gif (or the path name for your graphic)

Just be sure to substitute the actual name of your graphic, and to know whether it is a .gif or a .jpg file.

Testing and troubleshooting

Once you have loaded your web page onto the Internet, you should check it to make sure all of the text and graphics look the way you want, and that all of the links work.

If one of the links doesn't work, hold the mouse pointer over the link until the address appears. Try to figure out why the link isn't working. Is the address correct? Did you remember the "http://" prefix?

If your graphics don't work, or your page didn't load at all, try to figure out why. Make sure you typed in the correct file names when you loaded them. Try loading them again.

After making corrections, you will need to press the "Refresh" key on your toolbar to see the changes take effect when you check your page again on the Internet.

Keep checking and troubleshooting until your web page looks just right. This may take a few tries.

Browser compatibility

An important thing to keep in mind when creating web pages is that the same page may look very different in different browsers, and certain features that work great in one browser may not work at all in another.

The two most commonly used web browsers are Netscape Navigator and Microsoft Internet Explorer. You should test you page out with each of these browsers to make sure that it displays as you intended.

Another point to consider is that different versions of the same browser may have markedly different capabilities. You must be aware that some of the features of your page may not work the same, if at all, on an older browser. For example, Netscape Navigator 4.7 has more feature than does Netscape Navigator 3.2. Many internet users still surf with older browsers, so it is advisable to test your page with older browsers, as well.

APPENDIX D: POST-TRAINING MEASURES

Self-Efficacy

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

1. I have mastered web-page creation.
2. I do not create web pages as well as I would like.
3. I am certain that I can create web pages well.
4. It is just not possible for me to create web pages at the level I would like.
5. I think my performance in creating web pages could be improved substantially.

Metacognition
For each of the items below, rate the extent to which you were thinking about these issues during the training.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Monitoring
1. I thought about how well my tactics for learning were working.
2. I monitored how well I was learning the requirements of the training program.
3. I thought carefully about how well I had learned material I had previously studied.
4. I evaluated how well I was learning the skills of web page design.
5. I thought about what skills needed the most practice.
6. I tried to monitor closely the areas where I needed the most improvement.
7. I asked myself questions to make sure I knew the material I had been studying.
8. I tried to determine which concepts I didn't understand well.
9. I thought about what things I needed to do to learn.

Control
10. I experimented with different procedures for learning.
11. When choosing what information to study, I considered how the information would help me to learn the skills of web page design.
12. I carefully selected what to focus on to improve on weaknesses I identified.
13. I used my past performance to revise how I approached this training program.
14. I stopped once in a while and went over what I had read.
15. I spent more time studying topics that I found to be more difficult.
16. I continued to study each topic until I fully understood it.
17. I spent additional time looking over information that I had studied earlier.

Delayed Judgments (control)
18. I waited a brief period of time after studying something before trying to determine how well I had learned it.
19. I distracted myself momentarily after studying particular parts of the training before thinking about how well I knew it.
20. Later on in training, I asked myself questions about material that I had studied earlier in training.

Web Page Exercises
(Skill-Based Performance)

Instructions: Start Netscape Composer and perform each of the following tasks:

1. Save this page as *student ID*.html (ex. if student id is A12345678, save as 12345678.html).
2. Make the title of this page "Creating Web Pages"
3. Change the background color of this page to a shade of blue.
4. Change the color of the normal text to White.
5. Change the color of the following link to Yellow: Link 1
6. Insert the following Keywords into this page: Michigan State University
7. Format all the text on this line so that it is a) bold, b) italicized, and c) size 16.
8. Center this line:
9. Insert a horizontal line directly below this text:
10. Edit the horizontal line below by a) making the line thicker, b) set the width to 50% of the window, and c) position it on the right side of the window.

---

11. Decrease the size of the image below: [Insert Image]
12. Below this line, create a text link to www.msu.edu
13. Create a link in the image below, so that it will link to the email address *sparty@msu.edu* [INSERT IMAGE]
14. Remove the following link, without deleting the text itself: Delete this link
15. Directly below this line, create a link to question #4 on this page.
16. Directly below this line, create a table with 3 rows and 4 columns.
17. On the table below, a) create a table border, b) change the table's background to gray, c) add another column, and d) set the table width to 80% of the window.

	Favorite players	
Baseball	Basketball	Football
Manny Ramirez	Grant Hill	Terrell Davis

Declarative Knowledge

1. Which is not a good reason to place a link on your web page?

   a. To point to extra information on another web page
   b. To point to another web page related to content on your web page
   c. To connect to another one of your own web pages
   d. You can't think of anything else to put on your web page

2. How does a hyperlink work?

   a. It uses the address of another web page
   b. It uses the title of another web page
   c. It uses meta tags from another web page
   d. It uses magic

3. How do you place a link on your web page?

   a. Edit, Paste as Hyperlink
   b. Insert, Link...
   c. Right mouse button, Edit Hyperlink...
   d. Right mouse button, Select Hyperlink

4. Where do you type the link address in the dialog box?

   a. Link to a page location or local file"
   b. Path:
   c. Base:
   d. Named location in file:

5. How do you know a link is in place on your web page?

   a. You can't tell
   b. It is underlined
   c. It is a different color
   d. It is underlined and a different color

6. How do you remove a link from your web page?

   a. Edit, Hyperlink...
   b. Insert, Hyperlink...
   c. Right mouse click, Hyperlink, Remove Link
   d. Right mouse click, Hyperlink, Select Hyperlink

7. How do you edit a link on your web page?

   a. Edit, Hyperlink...
   b. Insert, Link...
   c. Right mouse click, Hyperlink, Edit Hyperlink...
   d. Right mouse click, Hyperlink, Select Hyperlink

8. What name should you save your first web page document under?

   a. user
   b. index
   c. any name you want
   d. Your pilot login name

9. In what folder should you save your web pages?

   a. web
   b. www
   c. snapshots
   d. any folder

10. How many web pages can you have on the MSU server system?

   a. only one, and it must be named "index.html"
   b. several web pages; the one named "index.html" is your home page
   c. only two; "index.html" and one other web page
   d. only one, but it can have any name you want

11. How are graphics files uploaded to the Internet?

   a. by saving each one separately
   b. by saving them as a group of files
   c. automatically when the html file is saved
   d. only by using FTP

12. How do you open a new browser window to locate your web page?

   a. New, Browser window...
   b. Tools, New window...
   c. Edit, New, Window
   d. File, New, Window

13. What do you need to know to find your web page on the Internet?

  a. The page title
  b. The document name
  c. The address
  d. Your pilot password

14. Which of the following is the correct prefix for an MSU student's web page address?

  a. http://www.msu.edu/user/
  b. http://www.msu.edu/
  c. http://www.msu.edu/pilot/
  d. ftp://www.msu.edu/user/

15. Which statement about changing the background colors of a web page is true?

  a. You can change the colors, but there are only a couple from which to choose
  b. You can change the colors, and it is easy to do
  c. You can change the colors, but it is difficult to do
  d. You can't change the colors

16. Which menu is used in order to change the background colors on a web page?

  a. Edit
  b. Insert
  c. Format
  d. Tools

17. Which sets the colors for all of the non-linking text that you write?

  a. Body text
  b. Normal text
  c. Hyperlinks
  d. Followed hyperlinks

18. How do you set the colors for text on a web page?

  a. Format, Font..., Effects
  b. Format, Style...
  c. Format, Color
  d. Format, Text colors...

19. Why are tables useful on a web page?

a. Because all text on web pages must be in tables
b. Because you can't use the tab key to create columns
c. No particular reason; they're just fun to make
d. Tables are not useful; you can't put tables on a web page

20. How do you place a table on a web page?

a. Table, Insert table...
b. Insert, Table, Table...
c. Insert, Object...
d. You can't

21. Which of the following can be placed in a table?

a. Text
b. Graphics
c. Both text and graphics
d. Neither text nor graphics

22. When should you begin planning the content for your web page?

a. Before you do anything else
b. Before you post it to the Internet
c. After you post it to the Internet and see how it looks
d. You don't need to plan your content as long as you have links and graphics

23. Which of the following is not something to think about when planning your web page?

a. Your audience
b. How you want your page to look
c. How someone else's page looks
d. What links you might want on your page

24. Where does the title for your web page appear?

a. At the top of the web page
b. At the top of the Internet browser
c. At the bottom of the Internet browser
d. You can't see it

25. Why should you have a title for your web page?

    a. There is no reason to have a title
    b. A title is required for web pages
    c. A title makes your web page look nicer
    d. Search engines can find your web page more easily

26. What is it important for your web page title to contain?

    a. Your name
    b. The Internet address for your web page
    c. The most important aspect of the page's content
    d. It doesn't really matter what is in the title

27. How do you create a title for your web page?

    a. Format, Page Colors and Properties, General
    b. Edit, Preferences, Title
    c. Insert, Autotext
    d. Insert, Title...

28. What happens if you don't create a title for your web page?

    a. No title appears in the title bar of the browser
    b. Your web page won't load to the Internet
    c. Your Internet address is used as a title
    d. Your document name is used as a title

29. What can't you do with a horizontal line?

    a. Move it
    b. Hide it
    c. Delete it
    d. Align it

30. Which of the following is not a graphic that can be inserted on a web page?

    a. Photo
    b. Horizontal Line
    c. Chart
    d. Table

31. Which menu is used in order to place a graphic on a web page?

    a. Edit
    b. Insert
    c. Format
    d. Tools

32. What can you do with a graphic once you have inserted it on a web page?

    a. Resize it
    b. Change its color
    c. Rotate it
    d. Nothing

33. Which of the following is not an alignment option for horizontal lines and graphics?

    a. Left
    b. Center
    c. Right
    d. None

34. What is the maximum number of words you *should* put on a single web page?

    a. 800
    b. 500
    c. 100
    d. 300

35. Which of the following is a valid URL for a hyperlink?

    a. http://www.msu.edu
    b. www.msu.edu
    c. neither A or B is a valid URL for a hyperlink
    d. Both A or B are valid URLs for a hyperlink

Final Web Page Checklist

- ❑ 500 or fewer words?
- ❑ Subheads?
- ❑ Modified Title (not just filename)?
- ❑ Title less than 8 words?
- ❑ Modified *global* normal text color?
- ❑ Modified *global* link color?
- ❑ Modified *global* active link color?
- ❑ Modified *global* followed link color?
- ❑ Modified background color?
- ❑ Background image?
- ❑ Keywords?
- ❑ Modified font?
- ❑ Modified font size?
- ❑ Modified text color?
- ❑ Bolded text?
- ❑ Italicized text?
- ❑ Modified text alignment?
- ❑ Inserted horizontal line?
- ❑ Modified line dimensions (height or width)?
- ❑ Modified line alignment?
- ❑ Modified line shading?
- ❑ Inserted image?
- ❑ Modified image size?
- ❑ Aligned text with graphics?
- ❑ Created hyper link?
- ❑ Does link function correctly?
- ❑ Created email link?
- ❑ Does link function correctly?
- ❑ Created link in graphic?
- ❑ Created target?
- ❑ Created link to target?
- ❑ Does link function correctly?
- ❑ Created Table?
- ❑ Modified table border?
- ❑ Modified Table background color?
- ❑ Modified Cell background color?
- ❑ Modified Table width?
- ❑ Modified table alignment?

Total Number of items checked: ___

APPENDIX E: METACOGNITIVE TRAINING

Metacognitive Training

"Before we begin the web-page design training, I'd like to take a few minutes to teach you some skills that have been shown to improve learning. I would like you to use these learning skills and strategies to help you learn during the training program. These skills can be used outside of this study as well, such as in your classes.

I'm going to go over three things to teach you these learning skills. First, I'm going to provide a brief introduction, then an example, and finally teach you some specific learning skills and strategies for you to use while learning to make web pages.

OK, first the introduction. "These skills are what is known as **metacognition**--Metacognition is "thinking about your thinking." It includes things such as your beliefs about your intelligence, what types of things you are good or bad at, etc.

"Metacognition also includes your beliefs about how well you know something that you are trying to learn. This aspect of metacognition is known as **monitoring**. Monitoring is very important when learning new material. It will determine, what people choose to study, and how long they choose to study it.

"So we've covered two new terms – metacognition and monitoring. Metacognition is "thinking about your thinking," and monitoring is "beliefs about how well you know something that you are trying to learn."

"Now I'm going to go over an example to help clarify the meaning of these terms.

"Imagine that you are preparing for an exam in your psychology class that covers 3 chapters in your textbook. You first have to decide exactly what you will study. Lets imagine that you think you understand the information from chapters 1 and 2, but that you don't really know chapter 3 very well yet. What would we call the judgment of how well you know the material in each chapter? [This is an example of monitoring]. The benefit of monitoring is that you realize that since you don't yet understand chapter 3 and you would most likely begin by studying that chapter.

This was a relatively simple example, but monitoring involves much more than deciding what you will study *before* you begin studying--it also comes into play *as* you are learning or studying. To be an effective learner, you have to figure out if you understand what you are trying to learn and spend more time on the material you don't know yet.

"Most people don't try to determine how well they know the material they are trying to learn--Instead, they simply continue to work their way straight through the material, and never really learn what they are trying to learn. What I would like you to do is, as you progress through the material presented in this training program, try to determine how well you are actually learning the material you are studying. This is important, so let me say it again: *as you progress through the material presented in this training program, try to determine how well you are actually learning the material you are studying*

"As you do this, keep in mind that people almost always overestimate how well they know something. That is, people usually think that they have learned the material better than they actually have. You have probably experienced this yourself--you studied for a test and were sure that you knew all the material backwards and forwards. However, when it came time to take the test, you found that you weren't able to answer the questions correctly--you didn't actually know the material as well as you thought that you did. If you had realized that you didn't actually know all the material, you would have spent more time studying. *Can anybody give me an example of a time when you thought you knew something you were trying to learn, but found out later that you didn't?* [If not, give personal example]. You can see that if you think you know something, when in fact you don't, you probably won't spend as much time studying as you really need to.

So, I've introduced you to metacognition and monitoring, and we've gone over an example. I've also asked that when we get to the training that you try to determine how well you are actually learning the materials you are studying. The only thing left is to do is to teach you some specific strategies to help you do this.

"What I am going to do is teach you some simple strategies that you can use to more accurately determine how well you know something you are trying to learn. First of all, when most people do try to monitor their learning, they do so by making quick, intuitive "gut" decisions. After studying something, they just "feel" like they know something or not. A better strategy is asking yourself specific questions about the material you just studied. By doing this, you can get a better idea of how well you know it. For example, assume that you are trying to learn all of the state capitols. Can anyone give me an example of a question you could ask yourself to see how well you know the capitols? [If not, give example "what is the capitol of Ohio?"]. If you can't answer your own question, then you need to spend more time studying that particular piece of information. *As you go through this training program, ask yourself specific questions about the information you are studying. If you cannot answer your own questions, spend more time studying that information.*

"To help you create questions to ask yourself, the performance aid that I have passed out provides fill-in-the-blank questions that can be used for anything that you are trying to learn. Can anyone give me an example of a question you could ask yourself about what I have taught you so far, using these fill-in-the-blank questions? [If not, "What is the main idea of <u>this presentation</u>?" The answer would be that people aren't very good at determining how well they know what they are trying to learn, and I am giving you ways to solve this problem]. *As you progress though this training program, create questions based on these fill-in-the-blank questions and see if you can answer them. If you cannot, you should spend additional time studying the material you do not understand.*

So the first strategy I've taught you is to create questions and see if you can answer them. The second thing I want to teach you is when to use these questions.

"Even when asking themselves questions like these, most people still tend to overestimate how well they know the material. They will ask themselves a question about material as soon as they have looked it over, and often are able to correctly answer their question. They then assume that they will be able to answer the question latter on as well. However, this may not be true.

"If you ask yourself a question about something immediately after studying it, you may be able to correctly recall the information. Thus, you may determine that you know the material and stop studying it. However, you may not be able to answer these same questions only moments later when you need to use the information.

"There are a few ways to avoid this. The first way is to wait for a brief period of time after studying something before asking oneself questions about it. Generally, somewhere around 30 seconds to a minute is enough of a delay. Another strategy is to start thinking about something else for a few seconds to distract you attention away from the target material, and then ask yourself questions. Further, even after you feel you know and understand the information, it is helpful to ask yourself questions about information you had studied earlier to be sure that you can still recall it.

So, as you try to learn how to make web pages, try to be aware of how well you are learning and what you are not learning as well as you need to. I have taught you three strategies to help you do this. First, throughout training, ask yourself questions about what you are trying to learn. I have given you some fill-in-the-blank questions that can help you with this. Second, don't try to answer the question immediately after looking at the material. Either wait about 30 seconds or distract yourself by studying something else momentarily, then asking yourself questions about material you had studied earlier.

"One of the most important points that I have tried to make many times already is that it is not enough to simply monitor your knowledge. You must use the information gained by monitoring to determine which information you will spend additional time on, to determine if your learning strategies are working, and so on. For example, if you determine that you don't understand or remember information you have studied earlier, spend some additional time reviewing this information. These strategies have been shown to improve learning. As you progress through the training, use these strategies to help improve your learning. Feel free to refer to the Performance Aid that I have given you at any point during the training."

APPENDIX F

Performance Aid

- Metacognition is "thinking about your thinking"
  - Knowing how well you understand the information you are trying to learn
  - Important for decided what to study and for how long

- **As you move through the training program, try to determine how well you are learning the information.**

- **People over-estimate what they know**--Research consistently finds that people overestimate what they know. Be careful not to overestimate how well you know the information in this training program.

- Ask yourself specific questions about the material you are studying to determine what you know and what you need to learn better (test yourself).

- The following fill-in-the-blank question stems may help you create questions to ask yourself:

  - "What is the main idea of ___?"
  - "How are ___ and ___ alike?"
  - "What are the strengths and weaknesses of ... ?"
  - "How does ___ affect ___?
  - "How does ___ tie in with what I have learned before?"
  - "How is ___ related to ___?"
  - "What is a new example of ___?"
  - "What conclusions can you draw about ___?"
  - "Why is it important that ___?"

- To get a more accurate estimation of how well you know something, ask yourself questions about it at least 30 seconds after you have studied or thought about it. Alternatively, distract yourself by thinking of something else (such as other information from the training) briefly before asking yourself questions.

- **If you determine that you don't understand something as well as you should, spend additional time studying it or modify your learning strategies.**

APPENDIX G

Metacognitive Prompting

<u>Pre-Training Instructions</u>:

"As you go though this training program, you should be attempting to monitoring your knowledge--That is, you should be thinking about how well you are learning the information you need to know in order to create your own web page. If you determine that you don't fully know or understand information that you have already covered, you should go back and spend additional time studying that part of the training."

<u>Prompt Screen</u>:

"Please take a few of minutes to think about how well you are learning the information you need to know in order to create your own web page.

"First, think about what information you know from the last lesson, and enter some brief notes about it here:

"Second, think about what information you need to know from the last lesson, but you may not remember it or know it well enough, and enter some brief notes about it here:

"If you feel that you don't fully know or understand information that you have already covered, you should go back and spend additional time studying that part of the training."

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