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A Multi-Level Analysis of the Effect of Prompting Self-Regulation
in Technology-Delivered Instruction

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Abstract

We used a within-subjects design and multilevel modeling in two studies to examine the effect of prompting self-regulation, an intervention designed to improve learning from technology-delivered instruction. In Study 1, performance improved over time for trainees who were prompted to self-regulate, relative to control group members, on measures of basic and strategic performance. Trainees' cognitive ability and self-efficacy moderated the effect of the prompts. Prompts were more likely to result in learning gains over time for trainees with higher ability or higher self-efficacy. Study 2 demonstrated that the results generalize to adults participating in online, work-related training. Trainees who were prompted to self-regulate gradually improved their declarative and procedural knowledge over time, relative to the control condition. Overall, the two studies demonstrate that prompting self-regulation had a gradual, positive effect on learning and the strength of the effect increased as trainees progressed through training. These results are consistent with theory suggesting self-regulation is a cyclical process that has a gradual effect on learning and highlight the importance of using a within-subjects design in self-regulation research.

Keywords:

Self-regulation

Multi-level modeling

Cognitive ability

Self-efficacy

Technology-delivered instruction

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People's ability to self-regulate may be their most essential asset (Porath & Bateman, 2006) and is crucial for learning from technology-delivered instruction (Bell & Kozlowski, 2002a). Self-regulation is a process that enables individuals to guide their goal-directed activities over time and across changing circumstances, including the modulation of thought, affect, and behavior (Karoly, 1993). Technology-delivered instruction tends to provide trainees with more control over their training experience than traditional classroom instruction (Sitzmann, Kraiger, Stewart, & Wisher, 2006), and failure to self-regulate may be one reason trainees frequently make poor instructional use of the control they are given (Bell & Kozlowski, 2002a; DeRouin, Fritzsche, & Salas, 2005; Kraiger & Jerden, 2007). Often trainees do not accurately assess their current knowledge levels, do not devote enough effort to training, and make poor decisions about learning resulting in deficiencies in performance (Brown, 2001; Ely & Sitzmann, 2007; Kanfer & Ackerman, 1989). Thus, research is needed to identify strategies to assist trainees in effective self-regulation during technology-delivered instruction.

One strategy involves the use of prompts or questions designed to induce self-regulatory activities, such as self-monitoring of learning behaviors and self-evaluation of learning progress (Corliss, 2005; Keith & Frese, 2005; Toney, 2000). Self-regulation prompts ask trainees questions about whether they are setting goals, whether their study strategies are effective, and whether they are making progress toward their goals in an attempt to encourage self-regulation during training. Although there is theoretical evidence to suggest that this intervention should be an effective means of enhancing learning and performance (Kanfer & Ackerman, 1989; Winne, 1996), several studies have failed to empirically demonstrate a positive effect for prompting self-

regulation on trainee achievement (Corliss, 2005; Keith & Frese, 2005; Toney, 2000). Other studies have reported inconsistent findings for prompting self-regulation across multidimensional indicators of learning (Kauffman, 2004; Kohler, 2002). One potential limitation of prior research is the use of a between-subjects design, rather than modeling changes in learning over time. A between-subjects design assumes there is an immediate improvement in learning at the point when trainees begin to receive the self-regulatory prompts and treats the effect of the prompts as stable over time. However, self-regulation is a continuous process that unfolds over time as individuals set goals for increasing knowledge, evaluate and select strategies that balance progress toward their goals against unwanted costs, maintain emotional control, and monitor to assess whether progress is being made toward their goals (Butler & Winne, 1995; Kanfer & Ackerman, 1989). Accordingly, a better understanding of the utility of prompting self-regulation may be achieved by adopting a within-subjects perspective that models the effects of the prompts on learning and performance over time.

In the current paper, we present two studies aimed at examining an intervention designed to stimulate self-regulation during technology-delivered instruction. These studies address several important gaps in the literature. First, we utilize a within-subjects design and multilevel modeling to examine whether the effects of prompting self-regulation on learning and performance vary over time. Given the unfolding and iterative nature of self-regulation, we predict that the effects of the prompts will increase throughout training. Second, we examine whether prompting self-regulation is equally effective for enhancing multiple indicators of learning, namely basic (i.e., declarative and procedural knowledge) and also strategic (i.e., contextual) performance. Finally, we hypothesize and test several aptitude-treatment interactions to examine whether individual differences may moderate the effectiveness of prompting self-

regulation. In the following section, we present an overview of self-regulation theory. We then consider the potential effects of prompting self-regulation on learning during technology-delivered instruction.

Self-Regulation Theory

Self-regulation is an essential mechanism for changing the proportion of cognitive resources engaged and the proportion devoted to on-task rather than off-task activities during training (Kanfer & Ackerman, 1989). In order to self-regulate, trainees must engage in emotional control and metacognition (Kanfer, 1996; Kanfer & Ackerman, 1996), both of which have direct effects on learning (Keith & Frese, 2005). Emotional control limits the intrusion of performance anxiety and other negative emotions (e.g., worry) during task engagement while metacognition involves controlling one's cognitions, planning, monitoring, and evaluating one's progress during task completion.

In the first phase of self-regulation, trainees clarify the task, generate goals, and develop plans for reaching their goals (Winne, 1996). They examine the breadth of information they believe is relevant to the current task, assess their motivation and aptitude for the task, and identify obstacles that may prevent them from completing the task. This creates a multidimensional profile of the situation and person factors that could be used to approach the task. Once committed to a task, trainees motivate and guide themselves by setting goals that are higher than their current performance levels (Bandura & Locke, 2003). Setting a difficult goal enhances performance via directing attention toward goal-related activities, increasing task effort and persistence, and leading to the discovery and use of task-relevant knowledge and strategies (Locke & Latham, 2002). Trainees then choose strategies that maximize progress toward their goals and minimize unwanted costs (Bulter & Winne, 1995).

The second phase of self-regulation involves applying the chosen tactics and strategies to reach one's goals (Winne, 1996). Trainees receive self-generated and external feedback as they attempt to reach their goals, and the most effective learners develop idiosyncratic routines for continuously generating internal feedback during training (Butler & Winne, 1995). Feedback permits trainees to judge whether their progress matches the standards they set for successful learning. Trainees then metacognitively monitor feedback to judge their progress on the task (Winne, 1996). The three primary purposes of monitoring are to gauge the extent to which information has been comprehended, to recognize whether information that has been comprehended will be retained, and to apply remedial strategies for addressing gaps in learning (Winne, 1995).

Affect arises when trainees detect changes in the rate of progress toward their goals (Carver & Scheier, 1990). At this point, trainees must engage in emotional control in order to continue to make progress toward their goals (Illies & Judge, 2005). The reassessment of the situation results in trainees judging the probability that they can reach their goals if they invest further effort and/or modify their goals (Carver & Scheier, 1990). Progress slower than anticipated spurs negative affect while progress faster than anticipated spurs positive affect. If trainees do not feel they have the ability to fill in gaps in their understanding of the training material, they will physically or mentally disengage from the training environment or adjust their goals downward. However, if self-efficacy is above a threshold, trainees adapt their plans and continue working toward their goals. Thus, self-regulation is a series of volitional episodes that, in aggregate, are characterized by a recursive flow of goals and strategies that ultimately determine performance (Butler & Winne, 1995).

Although self-regulation has been conceptualized as a dynamic process, prior research has generally treated the effects of self-regulation as static or stable over time. However, a few studies have tested components of self-regulation theory using a within-subjects design, providing preliminary evidence that self-regulatory processes vary over time. For example, Ilies and Judge (2005) conducted experiments where undergraduates completed eight trials and successively set a performance goal and performed a task (e.g., brainstorming) for each trial. The findings from two studies indicate students revised their goals downward following negative feedback and upward following positive feedback, consistent with both goal-setting and social-cognitive theories (Bandura & Locke, 2003). In a related study, Thomas and Mathieu (1994) examined changes in self-set goal levels in an undergraduate psychology class and found students were overly optimistic when setting goals prior to their first exam but their goals became more realistic as they reached the end of the course. Finally, Donovan and Williams (2003) examined how college athletes modified their goals during the track and field season. They found individuals set their season goals at a level that was higher than their previous best performance but set proximal competition goals at a level slightly lower than their previous best performance.

Despite this emerging stream of research on self-regulation over time, our understanding of self-regulation at the within-person level remains limited. First, previous work in this area has used relatively simple tasks that rely on previously learned information (e.g., brainstorming) or tasks almost purely physical in nature (e.g., athletics). Thus, it is important to extend this stream of research to more complex, skill acquisition tasks that require ongoing learning and strategy development (Ilies & Judge, 2005). Second, it is important to identify strategies that can be used to enhance learning over time. Prior research in this area has primarily focused on how

individuals use goals over time in the self-regulation of performance. Building on this work, the self-regulation prompts examined in the current study encourage trainees to set goals and evaluate goal-performance discrepancies, but also stimulate other self-monitoring and self-evaluation activities that may gradually facilitate learning outcomes as trainees progress through a course. Finally, researchers have suggested that models of self-regulation over time should be extended to include dispositions as predictors of variation in performance at the within-person level (Ilies & Judge, 2005; Yeo & Neal, 2004). Thus, in the current study we examine two individual differences (i.e., cognitive ability and self-efficacy) as potential moderators of the effects of the self-regulation prompts on learning over time. In the following section, we review previous research on prompting self-regulation and present the hypotheses examined in the current research.

Prompting Self-Regulation

Prior research suggests trainees often fail to make effective use of the learner control inherent in technology-delivered instruction (Reeves, 1993). For example, studies have shown that trainees are frequently poor judges of what or how much they need to study and practice and typically withdraw from instruction too early or well beyond the point of comprehension (Bell & Kozlowski, 2002a; Brown, 2001). Thus, it is critical to identify interventions that can help trainees self-regulate and make better learning decisions during technology-delivered instruction. Accordingly, self-regulation prompts are designed to encourage trainees to recognize whether information has been comprehended, gauge the extent to which information that has been comprehended will be retained, and trigger remedial procedures for filling in gaps in learning.

Two cognitive processes are essential for self-regulation and are prompted in the current study: self-monitoring and self-evaluation (Kanfer & Ackerman, 1989; Kozlowski & Bell, 2006).

Self-monitoring is the allocation of attention to specific aspects of one's behavior as well as consequences of the behavior. It occurs in response to internal or external prompts and generates feedback that can guide further action (Butler & Winne, 1995). Self-monitoring directs trainees' mental resources toward the training program and ensures they are setting goals and developing strategies to reach their goals. In the current study, self-monitoring is prompted by having trainees respond to questions regarding whether their behavior is effective for learning the training material.

Self-evaluation is a comparison of trainees' current performance with their desired goal state (Kanfer & Ackerman, 1989). Strategies must be used to reduce discrepancies between goals and performance. When their behavior is not enabling them to reach their goals, trainees can use self-monitoring to form new goals or to develop strategies to help them reach their current goals. Self-evaluation is prompted in the current study by asking trainees to compare their current performance with their training goals.

Several studies have examined prompting self-regulation as a strategy for enhancing learning outcomes, but these studies have produced inconsistent or equivocal findings (Corliss, 2005; Kauffman, 2004; Keith & Frese, 2005; Kohler, 2002; Toney, 2000). A common feature of these studies is the use of a between-subjects design, which assumes learning improves immediately after implementing the prompts and treats the effect of the prompts on learning as stable across time. Since self-regulatory processes unfold over time, the effect of the intervention may be more gradual than immediate. Indeed, Keith and Frese (2005) proposed the practice phase in their study may have been too short to see the beneficial effects of self-regulatory processes, suggesting the effects of self-regulation may be more evident if modeled over time.

Thus, a within-subjects design should be used to examine the potential for gradual, intraindividual changes in learning as trainees are prompted to self-regulate.

In the current study, we will examine the extent to which prompting self-regulation influences the rate of change in basic and strategic performance as trainees learn a complex, dynamic task. Basic performance refers to the extent to which a trainee has learned the fundamental principles and operations of a task and includes both declarative and procedural knowledge (Ford & Kraiger, 1995; Tennyson & Breuer, 1997). Strategic performance refers to the extent to which a trainee has learned the underlying or deeper complexities of a task. It includes information on which, why, when, and where to apply one's knowledge and skills, and this information has been identified as critical for adaptive performance (Ford & Kraiger, 1995; Gagné & Merrill, 1992; Tennyson & Breuer, 1997). The current studies examine changes in basic and strategic performance across time as trainees are prompted to self-regulate. It is proposed that, relative to the control (no self-regulation prompts) condition, learning will gradually improve when trainees are prompted to self-regulate. The first hypothesis is:

H1: Self-regulation prompts will have a gradual, positive effect on learning across time.

Relative to the control condition, learning will improve over time when trainees are prompted to self-regulate.

The timing of implementing the prompts may be an important consideration when designing and implementing the self-regulation intervention. Although self-regulation is important for learning and performance, Kanfer and Ackerman (1989) have argued that the engagement of self-regulatory processes (e.g., self-monitoring and self-evaluation) also demands attentional resources. The pool of available cognitive resources can be influenced by numerous factors, including the information-processing demands of a task and trainees' general cognitive

ability. When these resources are limited, for example early in skill acquisition before knowledge is compiled, self-regulatory activities may hinder performance by diverting attention away from the task (Kanfer, Ackerman, Murtha, Dugdale, & Nelson, 1994). As a result, Kanfer and colleagues suggest that it may be prudent to induce self-regulation later in training, after trainees have acquired a basic understanding of the task and resource demands are reduced.

Although Kanfer and Ackerman's (1989) resource allocation perspective has been widely adopted, several researchers have offered alternative perspectives. DeShon, Brown, and Greenis (1996), for example, used a dual-task methodology to measure the attentional resource requirements of goal-oriented self-regulation and concluded that self-regulation does not require significant attentional resources and may instead be an automatized process. Further, Winters and Latham (1996) argued that Kanfer and Ackerman's findings may have been due to the content of the goals that trainees were given during skill acquisition focusing on performance rather than learning, thereby diverting attention from the learning process (see also Locke & Latham, 2002). They demonstrated that when given a complex task that requires the development of task strategies, trainees provided learning goals outperformed trainees provided do-your-best or outcome (i.e., performance) goals.

To test these competing perspectives, we included three conditions in the current study: immediate self-regulation, delayed self-regulation, and control. In the immediate condition, trainees are prompted to self-regulate throughout the entire training course. Trainees in the delayed condition are only prompted to self-regulate in the latter half of the course, when attentional demands should be reduced. Based on prior research demonstrating the importance of self-regulation for learning in technology-delivered instruction (Bell & Kozlowski, 2002a; Kozlowski & Bell, 2006), we expect that both the immediate and delayed self-regulation

conditions will lead to gradual improvements in learning and performance over time, relative to the control condition. However, the research reviewed above is inconclusive with respect to the benefits of prompting self-regulation when the attentional demands of the training course are high (e.g., early in training). Thus, we explore the relative effects of the immediate and delayed self-regulation conditions as an open research question.

Q1: Does the timing of implementing the self-regulation prompts moderate the effect of the prompts on learning over time?

Moderating Effects of Individual Differences

Over the past decade, a growing body of research has identified trait- and stated-based individual differences as predictors of trainees' self-regulatory activities (e.g., Chen, Gully, Whiteman, & Kilcullen, 2000; Payne, Youngcourt, & Beaubien, 2007). However, only recently has research begun to explore the moderating role that individual differences may play in determining the effects of self-regulation on learning over time. Yeo and Neal (2004), for example, found both trainees' cognitive ability and performance goal orientation influenced the rate at which the relationship between effort and performance changed over time. The relationship between effort and performance changed faster for individuals higher in cognitive ability and lower in performance orientation. In an effort to build on this emerging stream of research, the current study examines whether trainees' cognitive ability and self-efficacy moderate the effect of prompting self-regulation on learning across time.

Cognitive ability. Cognitive ability refers to an individual's intellectual capacity and has been shown to be a strong predictor of learning (Colquitt, LePine, & Noe, 2000; Ree & Earles, 1991). Research has shown that cognitive ability predicts both the acquisition of job knowledge and performance in work-related training programs (Ree & Earles, 1991; Schmidt & Hunter,

1998). Cognitive ability determines not only how much but also how quickly a person learns (Hunter, 1986). In addition to being able to absorb and retain more information than lower ability trainees, higher ability trainees may also be more capable of managing their own learning and using self-regulation to increase their knowledge and performance. Snow (1986), for example, suggests that higher ability trainees benefit from relatively unstructured environments that provide room for independent learning, whereas lower ability trainees require more tightly structured instruction. Gully, Payne, Koles, and Whiteman (2002) provide evidence that individuals higher in cognitive ability are more capable of diagnosing and learning from errors than individuals lower in cognitive ability. Bell and Kozlowski (2002b) found higher ability trainees benefited more than lower ability trainees from the adaptive response pattern associated with a learning orientation, which includes a greater degree of self-regulatory activity (Payne et al., 2007). Overall, these findings suggest that, when prompted to self-regulate, higher ability trainees may be more capable than lower ability trainees of effectively using self-monitoring and self-evaluation processes to increase their learning and performance over time. Accordingly, we propose the following:

H2: Trainees' cognitive ability will moderate the effect of prompting self-regulation on learning. Prompting self-regulation will be more likely to have a beneficial effect on learning over time for trainees with higher rather than lower levels of cognitive ability.

Self-Efficacy. Self-efficacy is one's belief in his or her capacity to perform (Bandura, 1986). Trainees with higher self-efficacy are more likely than those with lower self-efficacy to develop effective task strategies (Locke & Latham, 2002). Self-efficacy also has a positive effect on the difficulty of self-set goals, task persistence, goal revision, and goal-striving behavior (Bandura, 1997). As noted earlier, self-efficacy is an important affective component of self-

regulation because trainees who hold stronger self-efficacy beliefs are more likely to set high standards for themselves following goal attainment and are more resilient in the face of negative feedback (Bandura, 1997; Bandura & Cervone, 1983). Trainees who do not possess adequate self-efficacy physically or mentally disengage from training or adjust their goals downward in the face of goal-performance discrepancies.

In the current research, the self-regulatory prompts were designed to enhance trainees' self-evaluation activity and, as a result, influence trainees' performance via task strategies, task persistence, and goal striving behavior. However, whether trainees engage in activities to address perceived goal-performance discrepancies may depend on their self-efficacy. Trainees with higher self-efficacy should be more likely to believe they are capable of successfully reaching their training goals and to use the self-regulation prompts to adjust their training behavior. However, prompting self-evaluation activity among trainees with weaker self-efficacy beliefs may actually hurt learning and performance because the increased salience of goal-performance discrepancies may force these trainees to withdraw mentally or physically from the task to protect their competence image (Jones, 1989). Accordingly, we propose the following:

H3: Trainees' self-efficacy will moderate the effect of prompting self-regulation on learning. Prompting self-regulation will be more likely to have a beneficial effect on learning over time for trainees with higher rather than lower self-efficacy.

STUDY 1

Study 1 uses an experimental design and multilevel modeling to assess the effect of prompting self-regulation on learning across nine training trials. In addition, it examines whether trainees' cognitive ability and self-efficacy moderate the effect of the prompts on learning over time. Study 2 will extend the findings by examining the generalizability of the effect of the

prompts to an adult work-related training course, thereby shedding light on whether the results apply outside of a laboratory setting and have external validity.

Method

Participants

Participants were 171 undergraduate students from a large Northeastern university who received either course credit or \$30 for participating in a three-hour study. The demographic makeup of the trainees was 55% female and 95.9% were 18 to 21 years old.

Training Simulation

The task used in this research was TANDEM (Weaver, Bowers, Salas, & Cannon-Bowers, 1995), a PC-based radar-tracking simulation. TANDEM is a dynamic and complex task, which requires trainees to learn several basic and strategic skills. Basic skills involve “hooking” contacts on the radar screen, collecting information, and making three subdecisions to classify the contact’s characteristics. Trainees needed to use this information to make an overall decision about the contact (take action/clear). Strategic skills involve preventing contacts from crossing two perimeters located on the radar screen. Trainees needed to learn how to identify the perimeters, monitor contacts approaching the perimeters, and determine their priority. Because the configuration of contacts is dynamic both within and across training trials, effective perimeter defense requires trainees to adapt their strategic skills to changes in the task environment.

Experimental Design and Procedure

Training was conducted in a single, three-hour session. Trainees learned to operate the radar simulation described above during nine, 10.5-minute training trials. Each trial consisted of a cycle of study, practice, and feedback. Participants had three minutes to study an online manual

that contained information on all important aspects of the task. They then had five minutes of hands-on practice. The nine trials all possessed the same general profile (e.g., same difficulty level, rules, number of contacts), but the configuration of contacts (e.g., location of pop-up contacts) was unique for each trial. After each practice trial, participants had 2.5 minutes to review veridical feedback on aspects of the task relevant to both basic and strategic performance.

Before beginning the course, trainees were randomly assigned to one of three self-regulation conditions (i.e., immediate, delayed, and control). Two components of self-regulation, self-monitoring and self-evaluation, were prompted by having trainees respond to questions during training. Self-monitoring questions asked trainees whether they were allocating their attention to learning the training material and the consequences of their behavior, while self-evaluation questions asked trainees to compare their current knowledge and skills with the desired goal state. Nine self-monitoring and nine self-evaluation questions were modified based on previous research (Kauffman, 2004; Kohler, 2002; Toney, 2000; see Appendix for questions used to prompt self-monitoring and self-evaluation).

Trainees in the immediate self-regulation condition were prompted to self-regulate following the feedback session in all nine trials. Following the first feedback session, trainees read a screen indicating, “This is a good time to tell you that research has shown that asking yourself questions about whether you are concentrating on learning the training material will increase your performance on the test following training. The training program will periodically ask you questions about where you are directing your mental resources and whether you are making progress toward learning the training material. Honestly respond to these questions and use your responses to decide how to allocate your review time.” One self-monitoring and one self-evaluation question were presented on the computer screen at the end of each of the training

trials, and trainees answered each of the questions on a worksheet using a 5-point scale ranging from “strongly disagree” (1) to “strongly agree” (5).

Trainees were asked to respond to the self-regulation prompts to ensure they were paying attention to the questions, contemplating whether they were concentrating on learning the training material, and considering whether they were making progress toward their training goals. Thus, the purpose of having trainees answer the prompts questions was to have them assess their current knowledge levels and make necessary modifications to their behavior, not to gather data on whether the prompts were working and responses were not used in any of the analyses. Responses to the prompts questions do not reveal whether the prompts are working. For example, one of the prompts questions is “Do I understand all of the key points of the training material?” A response of “strongly agree” is desirable if the trainee is knowledgeable about the material and a response of “strongly disagree” is desirable if the trainee realizes the need to concentrate more on learning the material. Accordingly, differences in performance trends across training conditions will be used to assess the effect of prompting self-regulation.

In the delayed self-regulation condition, trainees received the same message as the immediate condition indicating self-regulation increases learning. However, they received this information after completing four training trials. Following the feedback sessions in trials four through nine, trainees were asked the same self-regulation questions as the immediate condition was asked in modules one through six. The prompts were withheld during the first four trials for the delayed condition because previous research using TANDEM has shown that this is when trainees acquire basic declarative knowledge and, therefore, the greatest resource demands are placed on trainees’ attention (Kozlowski & Bell, 2002a). In the control condition, trainees were

not asked questions to prompt self-regulation and were not told that self-regulation increases performance.

Measures

Cognitive ability and demographic information was collected at the beginning of the experimental session. Self-efficacy was measured early in training, following the third trial, to give trainees time to familiarize themselves with TANDEM. Basic and strategic performance were assessed using objective data collected by the simulation during each of the nine practice trials.

Cognitive ability. Cognitive ability was measured by having trainees report their highest score on the SAT or ACT. Research has shown that the SAT and ACT have large general cognitive ability components (Frey & Detterman, 2004), and the publishers of these tests report high internal consistency reliabilities for their measures (e.g., KR-20 = .96 for the ACT composite score; American College Testing Program, 1989). In addition, previous research has shown that self-reported SAT/ACT scores correlate highly with actual scores. Gully et al. (2002), for example, found that self-reported SAT scores correlated .95 with actual scores. The majority of participants (86%) provided SAT scores. Thus, ACT scores were converted to SAT scores using a concordance chart provided by the College Board (Dorans, 1999).

Self-efficacy. Self-efficacy was assessed with an 8-item self-report measure developed for use with TANDEM (Ford, Smith, Weissbein, Gully, & Salas, 1998; Kozlowski et al., 2001). A sample item is “I am certain I can manage the requirements of this task.” Trainees responded to the questions on a five-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5). Internal consistency was .93.

Skill-based performance. Objective data collected by the simulation during each practice period was used to assess trainees' basic and strategic performance across the nine training trials. The performance measures used in this study have been established in previous research using the TANDEM simulation and have been shown to capture distinct dimensions of basic and strategic performance (Bell & Kozlowski, 2002a).

Basic performance involves trainees' ability to collect information about the contacts and use this information to make appropriate engagement decisions. Thus, basic performance requires trainees to draw on their declarative knowledge (i.e., knowledge of facts) and procedural knowledge (i.e., knowledge of rules). Trainees' basic performance was calculated based on the number of correct and incorrect contact engagements during each training trial; 100 points were added to trainees' scores for each correct contact engagement and 100 points were deducted for each incorrect contact engagement. Performance on this aspect of the task is driven by knowledge of basic task components (e.g., decision-making values and procedures).

Strategic performance focuses on trainees' ability to understand the deeper elements of the simulation and to develop two critical strategic skills: situational assessment and contact prioritization. Two elements of the task are relevant to the situational assessment: using the zoom function to alter the radius of the radar screen and locating and utilizing marker contacts to identify the location of an unmarked outer perimeter. Contact prioritization requires participants to gather information to determine which contacts constitute the greatest threats to the defensive perimeters and use this information to determine the order in which contacts should be prosecuted. To capture both situational assessment and contact prioritization, strategic performance was composed of the number of times participants zoomed out, the number of markers hooked in an effort to identify the location of the unmarked outer perimeter, and the

number of high priority contacts processed during each practice trial. Each of these indicators was standardized and summed using unit weights to create a strategic performance composite.¹

Analytic Strategy

In the current study, we are not interested in changes in learning across time, but rather differences in learning trends across time for the three self-regulation conditions. Thus, before analyzing the results, we standardized both basic and strategic performance for each of the nine trials. Standardizing the results removes true changes in learning over time, but allows us to compare differences in performance trends across conditions as trainees progress through the course and results in a common scale across learning indicators, permitting us to compare the results across the two studies and across basic and strategic performance.²

Next, a one-way ANOVA was used to test for differences in basic and strategic performance across the three self-regulation conditions. This allowed a comparison of the current results with prior, between-subjects research on prompting self-regulation.

Hierarchical linear modeling (HLM) with ordinary least squares estimates was used to analyze the within-subjects results (Bryk & Raudenbush, 1992). We ran a series of models to analyze changes in learning across the nine training trials. First, we ran the unconditional means (null) model to examine the variance in learning before accounting for any predictors. This model allowed for the calculation of an intraclass correlation coefficient, which partitions the variance in learning into within-person and between-person components. Bliese and Ployhart (2002) suggest the second model should add time as a predictor. However, in our analysis adding

¹ To confirm that the basic and strategic performance indicators captured distinct dimensions of performance, we conducted a principal components factor analysis using varimax rotation on the indicators at trials 3, 6, and 9. In each case, a two factor solution emerged supporting the creation of separate basic and strategic performance composites. These results are available from the first author upon request.

² We ran the same models with unstandardized data and the results mirrored the results found using standardized data. The fixed effects were in the same direction and the same parameters were statistically significant.

time as a predictor would assume that learning progresses in the same direction and at the same rate across the three conditions, which is contrary to the study hypothesis, and standardizing the results removes true changes in learning across the nine trials. Thus, our second model assessed the effect of self-regulation on learning over time with a discontinuous growth model (Singer & Willett, 2003, pp. 191-208). This allowed us to model performance trends across the nine trials for the three self-regulation conditions and examine whether prompting self-regulation resulted in a change in the slope of the basic and strategic performance trajectories. A change in slope would indicate that prompting self-regulation results in learning progressing at a different rate across conditions and before and after self-regulation is prompted in the delayed condition. The direction of the fixed-effect indicates whether prompting self-regulation has a positive or negative effect on learning across time. The growth model was coded such that the intercept term represents performance in module one for all three conditions.

Next, we ran an additional model with self-regulation prompts conditions dummy coded and entered as a Level 2 predictor of the self-regulation slope. This allowed us to assess if the self-regulation slope term differed for the immediate (vs. control) and delayed (vs. control) conditions.

Finally, we added grand mean centered cognitive ability and self-efficacy as Level 2 predictors to examine whether they moderated the intercept and self-regulation slope according to the procedure specified by Bliese and Ployhart (2002). These models allow us to examine whether there are individual differences that explain variance in the effect of the self-regulation prompts on performance over time.

There is disagreement regarding the effectiveness of hypothesis tests for fixed- and random-effects in HLM so statisticians generally prefer to use the deviance statistic to decide

whether to accept a simpler or more complex model (Singer & Willett, 2003). The deviance statistics can be compared for two models estimated with full maximum likelihood based on identical data in which one model (reduced model) is nested within the other (full model). The difference between the deviance statistics for the reduced and full models is chi-square distributed with degrees of freedom equal to the number of constraints imposed by the reduced model. Thus, in the current study, we will rely on deviance statistics, rather than statistical significance, when deciding whether to retain a variable in a model and interpret a parameter.

Results

First, we calculated the between-subjects descriptive statistics and correlations for Study 1 measures (see Table 1). Basic and strategic performance were significantly correlated with both cognitive ability ($r = .20, .30$, respectively) and self-efficacy ($r = .49, .39$, respectively). Basic and strategic performance were moderately correlated ($r = .38, p < .05$).

Next we ran a one-way ANOVA to examine if the self-regulation prompts had a significant effect on average basic and strategic performance at the between-person level. The ANOVA results for basic performance indicated there was a significant difference in basic performance across the three conditions ($F(2,161) = 3.26, p < .05, \eta^2 = .04$). A comparison of means indicated that both the immediate ($M, SD = .08, .79$) and delayed self-regulation prompts conditions ($M, SD = .12, .65$) scored higher on the assessment of basic performance than the control ($M, SD = -.21, .69; t(113) = 2.07, t(99) = 2.47$, respectively, $p < .05$). However, the immediate and delayed self-regulation conditions did not significantly differ from one another with respect to basic performance ($t(110) = .27, p > .05$). Strategic performance scores were highest for the immediate ($M, SD = .15, .84$), followed by the delayed ($M, SD = -.09, .69$) and control ($M, SD = -.17, .66$) conditions, but one-way ANOVA results indicated there was not a

significant difference in strategic performance across the three self-regulation conditions ($F(2,161) = 2.54, p > .05, \eta^2 = .03$).

These results suggest that prompting self-regulation had an overall positive effect on basic but not strategic performance. While these results provide some support for the utility of prompting self-regulation to improve performance, it is important to examine the effect of the self-regulation manipulation over time and to examine whether the effect of prompting self-regulation varies meaningfully based on individual differences.

Level 1 HLM Analyses

Table 2 presents the Level 1 HLM results examining changes in basic performance across the nine training trials. The unconditional means model examines variability in basic performance without any predictors in the model. The intraclass correlation coefficient was .47, which indicates 47% of the variance was at the between-person level while 53% of the variance in test scores was at the within-person level ($\sigma_e^2 = .522$ & $\sigma_0^2 = .465$).

The second model examines the effect of prompting self-regulation on the rate of change in basic knowledge across trials. If adding the self-regulation slope term improves model fit, it indicates that prompting self-regulation results in learning progressing at a different rate across conditions and before and after self-regulation is prompted in the delayed condition. Adding the self-regulation slope fixed-effect significantly improved model fit relative to the unconditional means model ($\chi_{dif}^2(3) = 54.91, p < .05$). The basic performance results strongly support Hypothesis 1 (see Figure 1). The self-regulation slope fixed-effect was .029 indicating performance increased by .029 standard deviations, relative to the control, for each module when self-regulation was prompted. The immediate and delayed self-regulation conditions were performing at the same level as the control at the beginning of the course but their performance

improved across time when they were prompted to self-regulate. By the ninth trial, the immediate and delayed conditions were outperforming the control by .234 and .146 standard deviations, respectively.

The Level 1 HLM results for strategic performance are presented on Table 2. ICC was .50, indicating 50% of the variance was at the between-person level while 50% of the variance in test scores was at the within-person level. There was also significant within and between-person variability ($\sigma_e^2 = .500$ & $\sigma_0^2 = .504$).

The second model examines the effect of prompting self-regulation on the rate of change in strategic performance across trials. Adding the self-regulation slope fixed-effect significantly improved model fit relative to the unconditional means model ($\chi_{dif}^2(3) = 97.97, p < .05$) and the effect was similar to the basic performance results presented in Figure 1. The self-regulation slope fixed-effect was .032 indicating performance increased by .032 standard deviations, relative to the control, for each module when self-regulation was prompted. The immediate and delayed conditions were outperforming the control by .253 and .158 standard deviations, respectively, by the end of training. Thus, both basic and strategic performance results strongly support Hypothesis 1 and suggest self-regulation prompts have a gradual, positive effect on learning across time, relative to the control.

Timing of Implementing Self-Regulation Prompts

The next model added self-regulation condition dummy codes as Level 2 predictors to assess if the self-regulation slope term differs across the immediate and delayed conditions, relative to the control. This analysis allowed us to test whether the timing of the self-regulation prompts moderates the self-regulation slope term such that changes in test scores across trials differ, relative to the control, depending on whether the self-regulation prompts are implemented

midway through training (delayed condition) or at the beginning of the course (immediate condition). Overall, the results indicate that allowing the self-regulation slope parameter to differ for the immediate and delayed conditions, relative to the control, did not significantly improve model fit for basic or strategic performance in comparison to the Level 1 model ($\chi_{\text{dif}}^2(2) = 4.14, 4.47$, respectively, $p > .05$). Thus, these results provide additional support that prompting self-regulation has a positive effect on learning across time in both the early and later stages of training.

Cognitive Ability and Self-Efficacy Moderator Analyses

Next, we examined the extent to which cognitive ability and self-efficacy moderate changes in basic and strategic performance across the nine trials. To test Hypotheses 2 and 3, cognitive ability and self-efficacy were added as Level 2 predictors of the intercept and self-regulation slope fixed-effects in both the basic and strategic performance models. Cognitive ability was measured on a 1,600-point scale and the Level-2 fixed effects are scale dependent, resulting in extremely small cognitive ability coefficients that require four or more decimal places for interpretation, even when ability has a meaningful effect. Thus, ability was standardized to aid interpretation.³

Adding cognitive ability and self-efficacy as moderators significantly improved the prediction of basic and strategic performance relative to the Level 1 model ($\chi_{\text{dif}}^2(4) = 42.45, 34.09$, respectively, $p < .05$; see Table 3). The ability fixed effects were .026 for basic performance and .006 for strategic performance while the self-efficacy fixed effects were .010 for basic performance and .060 for strategic performance.

³ Standardizing cognitive ability did not influence the conclusions drawn and unstandardized results are available upon request from the first author.

Graphs of the self-regulation prompts by ability interactions when predicting basic and strategic performance are presented in Figures 2 and 3. The results indicate the intervention was more likely to have a positive effect on learning across trials for trainees with higher rather than lower levels of cognitive ability, supporting Hypothesis 2. For higher ability trainees, performance substantially improved across time when trainees were prompted to self-regulate, relative to higher ability trainees in the control. For lower ability trainees, prompting self-regulation did not have as strong of an effect across time for the immediate condition, but was beneficial for the delayed condition for strategic performance.

Graphs of the moderating effect of self-efficacy on basic and strategic performance are presented in Figures 4 and 5. For basic performance, prompting self-regulation had a strong positive effect on performance over time for higher self-efficacy trainees in the immediate but not the delayed condition, relative to higher self-efficacy trainees in the control condition. For strategic performance, prompting self-regulation had a strong positive effect on performance over time for higher self-efficacy trainees in the immediate and delayed conditions, relative to higher self-efficacy trainees in the control. Prompting self-regulation was less likely to have a positive effect on performance over time, relative to the control, for lower self-efficacy trainees who were prompted to self-regulate. Supporting Hypothesis 3, these results suggest that prompting self-regulation is more likely to have a positive effect on performance over time for trainees who possess higher levels of self-efficacy.

STUDY 2

Study 1 provided support for the positive effect of prompting self-regulation on learning across time, but it is important to examine whether the results generalize beyond a laboratory setting. Trainees in Study 2 are working adults who participated in an online course to improve

their work-related knowledge and skills. The course is similar to many online courses in that trainees are dispersed across the United States and completed the course on their own time and in a location of their choice. Thus, Study 2 will assess the external validity of the effect of prompting self-regulation in a “real-world” training environment.

Study 1 demonstrated that prompting self-regulation did not impair performance during the knowledge compilation stage, when training tends to place the greatest demands on cognitive resources. However, other researchers have suggested navigating an unfamiliar technology-based training environment and making decisions in learner-controlled courses can also be cognitively demanding and may pull attentional resources away from learning the course content. Sitzmann et al. (2006) found, relative to classroom instruction, trainees learned more in long than short online training courses. They suggest that along with the course content, learning to navigate the training environment may place cognitive demands on trainees and trainees may need time to familiarize themselves with the training environment before they are able to master the course content. Allowing trainees to make decisions by providing them with a high level of learner control may also place cognitive demands on trainees (DeRouin et al., 2005). Early in training, these decisions may hinder trainees’ ability to concentrate on learning the course material, reducing learning. Thus, the cognitive demands of the training environment along with the training content may need to be considered when deciding whether to implement self-regulation prompts at the beginning of training. Thus, Study 2 will examine the extent to which prompting self-regulation generalizes beyond the laboratory setting and assess whether prompts should be implemented immediately or mid-training in an online, self-paced tutorial.

Method

Study 2 uses an experimental design to model the effect of prompting self-regulation on learning across 10 online training modules. It extends Study 1 by replicating the effect of the prompts in a different setting and to an occupationally-relevant course to test the generalizability of the results beyond a laboratory setting.

Participants

Ninety-three working adults were recruited online and received free training in exchange for research participation. The majority of participants were instructors at a university or community college (85%), and participants were highly educated (24% had a Ph.D. or M.D. and 48% had a master's degree). The average age of participants was 44 years and 66% were female.

Experimental Design and Procedure

The participants completed an online course on how to use the Blackboard Learning System™. Blackboard allows trainers to perform instructional activities online such as disseminating handouts and readings to students, creating tests, maintaining gradebooks, and organizing chat rooms.

The training consisted of 10 modules with lecture covering declarative knowledge as well as embedded videos demonstrating the procedural skills that can be performed in Blackboard. Within each module, the lecture and videos covered interrelated material. For example, in the chat rooms module, the slides explained the purpose of the chat tool and its functions and one of the videos demonstrated how to create a chat room session. Although the modules each covered a different feature of Blackboard, there was some overlap in the steps required for using the various features. For example, the first step in many of the videos covered locating the appropriate feature on the control panel. Thus, as trainees became familiar with the control panel they should begin to automate the location of each of the features and the requirements for

navigating the training course and the attentional requirements of the training environment should be reduced.

Trainees were given a high level of control over the pace of instruction; they could choose the amount of time spent on each training module and complete the course in a single day or spread it out over several weeks.⁴ However, trainees were informed that there would be a test on all of the material at the end of training and they were required to review all of the training modules in a predetermined order before taking the test. After reviewing the 10 training modules, trainees completed a test to assess their knowledge of each of the modules.

Participants were randomly assigned to one of three experimental conditions: immediate, delayed, and control. These conditions were designed to mirror those utilized in Study 1. Trainees in the immediate and delayed conditions received the same message used in Study 1 regarding the positive effects of self-regulation on performance when the self-regulation prompts were implemented. One self-monitoring and one self-evaluation question was then presented following each training module. The questions were presented on the computer screen, and participants answered each of the questions using a 5-point scale ranging from “strongly disagree” (1) to “strongly agree” (5). Consistent with Study 1, trainees responded to the self-regulation prompts to ensure they were paying attention to the questions, but their responses were not used in any of the analyses. Rather, differences in performance trends across training conditions will be used to assess the effect of prompting self-regulation.

Learning Outcome Measure

A posttest was used to assess knowledge of the 10 training modules. Declarative knowledge was assessed with 10 multiple-choice questions with four response options per

⁴ We examined days required to complete the course as a moderator variable and found the effect of the prompts on learning over time did not differ according to completion times.

question and procedural knowledge was assessed by having trainees login to Blackboard and perform 10 of the skills demonstrated in the training videos. Within each of the modules, there was a strong correspondence between the declarative and procedural material covered on the exam. For example, to assess knowledge of the chat room module trainees created their own chat room session and were asked a multiple-choice question regarding the options available for managing users in a chat room. The test questions and an objective scoring system for the procedural exam were developed by the first author. Each of the test questions was worth one point, and trainees received a fraction of a point for correctly performing a facet of a multi-part task. For example, trainees were asked to create a Lightweight Chat session, name the session “Review for Test,” and make the session available from August 1, 2005 until September 2, 2005. Creating the session, naming the session, and making the session available for the correct dates were each worth one-third of a point. Two test questions were used to assess knowledge of each of the training modules and responses to questions were averaged to indicate knowledge of each of the modules. The average score across the 10 modules was 14.66 questions correct ($SD = 2.43$).

Data Analysis

The analysis strategy paralleled the analyses in Study 1. Test items assessing knowledge of a single module were averaged and then standardized to control for differences in item difficulty across training modules. Thus, similar to Study 1, learning results will be interpreted as differences in the rate of change for learning relative to the other conditions. Next, we ran a one-way ANOVA to examine the between-subjects effect of the self-regulation prompts on learning. We then ran two Level 1 HLM models, such that the first model was an unconditional means model and the second model assessed if the test score trajectory changed when self-regulation

prompts were implemented. Once again the deviance statistic rather than individual significance tests for each of the fixed and random effects was used to decide whether to accept a simpler or more complex model (Singer & Willett, 2003). After establishing the Level 1 model, we tested whether the self-regulation slope differed for the immediate and delayed conditions, relative to the control, by adding self-regulation condition dummy codes as Level 2 predictors.

Results

The first analysis assessed whether prompting self-regulation had a significant effect on average test scores at the between-subjects level. Standardized test scores were highest for the immediate ($M, SD = 1.02, 6.06$), followed by the delayed ($M, SD = -.12, 6.12$) and control conditions ($M, SD = -1.39, 6.65$). However, one-way ANOVA results indicated there was not a significant difference in test scores across the three self-regulation conditions ($F(2,90) = 1.25, p > .05, \eta^2 = .03$). Thus, we used HLM to assess if prompting self-regulation had a gradual effect on learning across time.

First, we ran the unconditional means model to examine the variability in learning without any predictors in the model (see Table 4). The intraclass correlation coefficient was .06, which indicates that 6% of the variance was between-persons while 94% of the variance in test scores was at the within-person level. In addition, there was significant within and between-person variability ($\sigma_{\epsilon}^2 = .930$ & $\sigma_0^2 = .060, p < .05$).

Next, we examined whether there was a change in the slope of the test score trajectory when self-regulation was prompted in the immediate and delayed conditions. Adding the self-regulation slope fixed-effect significantly improved model fit relative to the unconditional means model ($\chi_{\text{dif}}^2(3) = 9.10, p < .05$) and the effect was similar to Study 1 (see Figure 1). The self-regulation slope parameter was .023 indicating performance increased by .023 standard

deviations, relative to the control, for each module when self-regulation was prompted. By the end of the course the immediate and delayed conditions were performing .205 and .114 standard deviations, respectively, better than the control. Overall, these results support the first hypothesis and indicate that prompting self-regulation has a positive, gradual effect on learning over time.

Next, we compared the effects of the prompts in the immediate and delayed self-regulation conditions, relative to the control, in an effort to examine whether the self-regulation prompts should be implemented immediately or mid-training in a self-paced, online course. We added self-regulation condition dummy codes as a Level 2 predictor the self-regulation slope fixed-effect to assess if the slope differs across the immediate and delayed conditions, relative to the control. Overall the results indicate that adding the Level 2 predictor did not significantly improve model fit relative to the Level 1 model ($\chi_{\text{dif}}^2(2) = 1.66$, respectively, $p > .05$). This reveals that the timing of implementing the self-regulation prompts did not moderate the self-regulation slope term, suggesting that prompting self-regulation had a positive effect on learning across time in both the early and later stages of training.

Discussion

Study 2 results replicated and extended the findings of Study 1 by demonstrating that the effect of prompting self-regulation generalizes beyond the laboratory to adults participating in an online work-related training course. Prompting self-regulation had a positive effect on learning and the strength of the effect increased over time, demonstrating the external validity of the learning intervention.

GENERAL DISCUSSION

The purpose of the current study was to examine the effect of prompting trainees to self-regulate on learning over time in technology-delivered instruction. Across two courses, trainees

were prompted to developing study strategies and goals and continuously assess whether they were making progress toward their goals. We assessed if the prompts were sufficient for producing learning gains across time and the extent to which two individual differences, cognitive ability and self-efficacy, moderated the effect of the self-regulation prompts on learning.

The current results are consistent with theory suggesting self-regulation is a cyclical process that has a gradual effect on learning across time (Butler & Winne, 1995; Carver & Scheier, 1990; Kanfer & Ackerman, 1996). We used a within-subjects design and multilevel modeling in two studies and demonstrated the effect of the self-regulation prompts increased throughout training. In Study 1, the immediate and delayed conditions were outperforming the control by .23 and .15 standard deviations, respectively, for basic performance and .25 and .16 standard deviations, respectively, for strategic performance by the end of the course. Study 2 incorporated the prompts in an online, work-related training course. By the end of the course, the immediate and delayed conditions were outperforming the control by .21 and .11 standard deviations, respectively, on a test of declarative and procedural knowledge. Together, these results suggest prompting self-regulation has a positive effect on performance by the end of training and enhances the extent to which trainees learn both the fundamental principles and deeper complexities of a task.

Although the self-regulation prompts had positive effects in both studies, the size of these effects are considered small by the guidelines advanced by Cohen (1977). However, we propose on several grounds that these effects are both meaningful and practically significant. First, numerous researchers have argued that small effects may be quite important theoretically (e.g., Chow, 1988). In fact, Fern and Monroe (1996) argue that in theory-testing research “small effect

sizes may be more informative than large ones if they were predicted by the theory” (p. 96). Indeed, in the current research we have argued that the effects of prompting self-regulation are likely to be gradual and should be modeled over time. Second, the self-regulation prompts represent a minimal manipulation when compared to other approaches that have been used to influence learners’ self-regulation. For example, Schmidt and Ford (2003) similarly prompted learners’ self-regulation at various points during training, but also provided participants with 10 minutes of instruction on metacognition at the start of training. As Prentice and Miller (1992) note, under minimalist conditions the impressiveness of an effect is not due to its size but rather the subtlety of the instigating stimulus. In addition, an important implication of the minimalist approach is that the self-regulation prompts represent a very low cost intervention. Thus, almost any benefit in terms of learning and performance is likely to outweigh the costs of the intervention and lead to a positive return on investment. Finally, Abelson (1985) notes that when interpreting an effect size it is important to consider the process through which variables operate in the real world. He suggests that the effects of certain types of processes, including educational interventions, cumulate in practice. Thus, while the self-regulation prompts may produce small increases in training performance, these effects may cumulate over time leading to significant gains in work-related outcomes such as efficiency and productivity.

We also support previous research suggesting a within-subjects design is required to understand intraindividual changes in self-regulation and that results may differ at the within and between-subjects levels of analysis (Donovan & Williams, 2003; Ilies & Judge, 2005; Thomas & Mathieu, 1994; Vancouver & Kendall, 2006; Yeo & Neal, 2004). In Study 2 and for strategic knowledge in Study 1, we failed to find a significant between-subjects effect, but demonstrated the strength of the effect increased throughout training. Self-regulation is an unfolding and

iterative process that must be examined over time in order to understand the recursive flow of goals and strategies that ultimately determine performance (Butler & Winne, 1995; Kanfer & Ackerman, 1989; Winne, 1996). This highlights the importance of theory in guiding our understanding of learning processes and emphasizes the criticality of conducting research at the appropriate level of analysis (Kreft & de Leeuw, 1998).

Our comparison of the immediate and delayed self-regulation conditions failed to support the resource allocation perspective and suggests that it is beneficial to prompt self-regulation throughout the entire course. These results are consistent with DeShon et al.'s (1996) argument that self-regulation does not necessarily require a significant amount of attentional resources and may be carried out as an automatized process. They suggest that through training and practice, self-regulatory skills can become well-learned and relatively resource independent. Given that both of our samples were highly educated and academically accomplished, participants in our studies may have possessed well-developed self-regulatory skills that, when prompted, operated without consuming significant attentional resources. This combined with the fact that the self-regulation prompts are relatively simple and unobtrusive may have limited the resource conflicts experienced by participants in the intervention conditions, even during the more demanding stages of learning. Future research is needed to explore the effects of the self-regulation prompts on learning for trainees with different educational backgrounds.

Our results also suggest that it is important to consider aptitude-treatment interactions when examining the effects of prompting self-regulation. Both trait and state individual differences moderated the effect of prompting self-regulation on learning over time. Cognitive ability and self-efficacy moderated the basic and strategic performance results. Prompting self-regulation was more likely to have a positive effect on learning for higher rather than lower

ability trainees and for trainees with higher rather than lower self-efficacy. This supports the argument that highly intelligent trainees and trainees with higher self-efficacy may be better equipped to leverage self-regulation to increase their knowledge and performance. Overall, these aptitude-treatment interaction results suggest that prompting self-regulation is likely to have the greatest effects for trainees who have both the ability and the motivation to use the intervention to guide and enhance their learning.

Future research should explore strategies that can be used to stimulate and support the self-regulatory activities and learning of trainees lower in ability and self-efficacy, as ultimately these may be the trainees that need the greatest assistance. One fruitful avenue may be focusing trainees attention on the affective element of self-regulation, which has traditionally been understudied in previous research (Ilies & Judge, 2005). In particular, emotional control is a critical component of self-regulation and involves limiting the intrusion of performance anxiety and other negative emotions during training (Kanfer, 1996; Kanfer & Ackerman, 1996). Negative emotions may be more likely to interfere with the performance of low self-efficacy trainees (Bandura, 1997; Bandura & Cervone, 1983). Future research should examine whether prompting both cognitive and affective self-regulation increases the likelihood that lower self-efficacy trainees benefit from the prompts.

Recommendations for Practitioners

Our results suggest it is beneficial to incorporate self-regulation prompts throughout the entire course in technology-delivered training. Across two studies, we demonstrated learning improved over time when trainees were prompted to self-regulate, relative to trainees who were not prompted to self-regulate. Prompting self-regulation is a very low cost intervention that results in moderate gains in basic and strategic performance. To incorporate the prompts in

training, organizations need to add a series of reminders to their courses to prompt trainees to monitor their learning behaviors, develop goals and strategies, and assess their learning progress.

The prompts improved both basic and strategic performance over time. This suggests implementing the prompts will enhance trainees' ability to remember the key principles presented in training and their understanding of which, why, when, and where to apply their knowledge and skills (Ford & Kraiger, 1995; Gagné & Merrill, 1992; Tennyson & Breuer, 1997).

Organizations should be aware that highly intelligent trainees and trainees with higher self-efficacy may be more likely to benefit from the prompts. Although the prompts may have little or no effect on learning for lower ability or lower self-efficacy trainees, we also did not find evidence that the prompts are likely to be detrimental to the performance of these trainees. These findings suggest that organizations can use the prompts without much risk of hurting trainees' learning and performance, but certain individuals may not benefit without additional structure and guidance (e.g., emotional control support).

Limitations and Directions for Future Research

While each of the individual studies has several limitations, each one provides unique contributions. The primary limitation of Study 1 is the participants were undergraduates participating a laboratory study, which may limit the extent to which the results generalize to organizational training courses. Study 2 demonstrated prompting self-regulation is beneficial in online training for working adults, but due to the nature of the training material we could not replicate whether the results apply to strategic performance.

Consistent with adult learning theory (Knowles, 1975), the current results suggest adults are capable of managing their own learning. Simply reminding adults to be good learners had a

positive effect on learning over time. However, the current results did not investigate the mediating psychological processes (e.g., effort, self-evaluation, on-task cognition) that may explain differences in performance across the self-regulation conditions. Accordingly, our explanations for differences in performance across conditions, while based on theory, are nonetheless speculative. Future research should measure both affective and cognitive components of self-regulation to assess the process by which the prompts affect learning.

Research is also needed to replicate the current findings and to examine boundary conditions for the effect of the prompts on learning across time. The current research focused on a limited set of individual differences, and future research should explore additional trainee characteristics that may moderate the effects of prompting self-regulation. Donovan and Williams (2003), for example, examined the effect of locus of control on the goal revisions of college athletes. Individuals with large discrepancies between their goals and performance who attributed their performance to stable factors tended to engage in more goal revisions than individuals who attributed performance to unstable factors. This suggests trainees with stable and uncontrollable causal attributions are more likely to modify their goals following poor performance and may be more likely to benefit from the self-regulation prompts. Thus, additional research should examine the extent to which locus of control and other individual differences moderate the effect of prompting self-regulation on performance across time.

Finally, research should examine the extent to which trainees continue to self-regulate in future courses that do not include prompts and the extent to which trainees become desensitized to the prompts over time. It is possible that incorporating the prompts in one training course is sufficient for improving trainees' self-regulation skills and trainees will be able to apply these skills across a wide range of courses. However, there is also research evidence indicating self-

regulation ability varies greatly across tasks and situations (Weaver & Kelemen, 2002). This suggests that the prompts may need to be incorporated in all courses to continuously remind trainees to self-regulate or that the prompts may not be effective in all courses.

Conclusion

Prompting self-regulation is an effective intervention for enhancing learning from technology-delivered instruction. Across two studies we demonstrated implementing the prompts does not result in an immediate improvement in learning, but rather, gradually increases basic and strategic performance as trainees progress through the course. The effect of the prompts was moderated by trainees' cognitive ability and training self-efficacy. Prompts were more likely to result in learning gains over time for trainees with higher levels of ability and self-efficacy. These results highlight the value of multilevel modeling and within-subjects designs for understanding learning processes and provide a baseline for future research examining the effect of prompting self-regulation in technology-delivered instruction.

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Table 1

Correlations among Study 1 Measures at the Between-Subjects Level

	Mean	SD	1	2	3	4	5
1 Immediate (1) vs. delayed self-regulation & control (0)	.37	.49					
2 Delayed (1) vs. immediate self-regulation & control (0)	.30	.46	-.50*				
3 Cognitive ability	1341.04	112.98	.02	.09			
4 Self-efficacy	3.31	.78	.05	.14	.18*		
5 Basic performance	.00	.73	.09	.11	.20*	.49*	
6 Strategic performance	.00	.75	.15*	-.01	.30*	.39*	.38*

* $p < .05$

Table 2

Level 1 HLM Results Predicting Basic and Strategic Performance in Study 1

	Parameter	Basic Performance		Strategic Performance	
		Unconditional Means	Self-Regulation Prompts	Unconditional Means	Self-Regulation Prompts
Fixed-Effects					
Initial status	γ_{00}	.031 (.060)	-.016 (.062)	.009 (.062)	-.040 (.065)
Self-regulation slope	γ_{10}		.029 [†] (.015)		.032 [†] (.017)
Random-Effects					
Within-person	σ_e^2	.522* (.022)	.464* (.020)	.500* (.021)	.418* (.018)
Initial status	σ_0^2	.465* (.061)	.467* (.067)	.504* (.065)	.522* (.072)
Self-regulation slope	σ_1^2		.014* (.003)		.020* (.004)
Deviance Statistic		3215.18	3160.27	3174.55	3076.58
df		3	6	3	6

The top number is the fixed or random-effect coefficient. The number in parentheses is the standard error.

* $p < .05$

[†] $p < .10$

Table 3

Level 2 HLM Results Predicting Basic and Strategic Performance in Study 1

Fixed-Effect	Parameter	Basic Performance	Strategic Performance
Intercept	γ_{00}	-.018 (.057)	-.042 (.062)
Ability	γ_{01}	.049 (.055)	.164* (.060)
Self-efficacy	γ_{02}	.397* (.075)	.185* (.082)
Self-regulation slope	γ_{10}	.022 (.015)	.022 (.016)
Ability	γ_{11}	.026 [†] (.014)	.006 (.015)
Self-efficacy	γ_{12}	.010 (.020)	.060* (.021)
Deviance		3117.82	3042.49
df		10	10

The top number is the fixed-effect coefficient. The number in parentheses is the standard error.

* $p < .05$

[†] $p < .10$

Table 4

HLM Results Predicting Test Scores in Study 2

	Parameter	Unconditional Means	Self-Regulation Prompts
Fixed-Effects			
Initial status	γ_{00}	-.001 (.041)	-.049 (.055)
Self-regulation slope	γ_{10}		.023 [†] (.014)
Random-Effects			
Within-person	σ_e^2	.930* (.046)	.902* (.046)
Initial status	σ_0^2	.060* (.023)	.107* (.039)
Self-regulation slope	σ_1^2		.005* (.003)
Deviance Statistic		2583.90	2574.80
df		3	6

The top number is the fixed or random-effect coefficient. The number in parentheses is the standard error.

* $p < .05$

[†] $p < .10$

Figure 1. Graph of the effect of self-regulation prompts on learning across the nine training trials for Study 1.

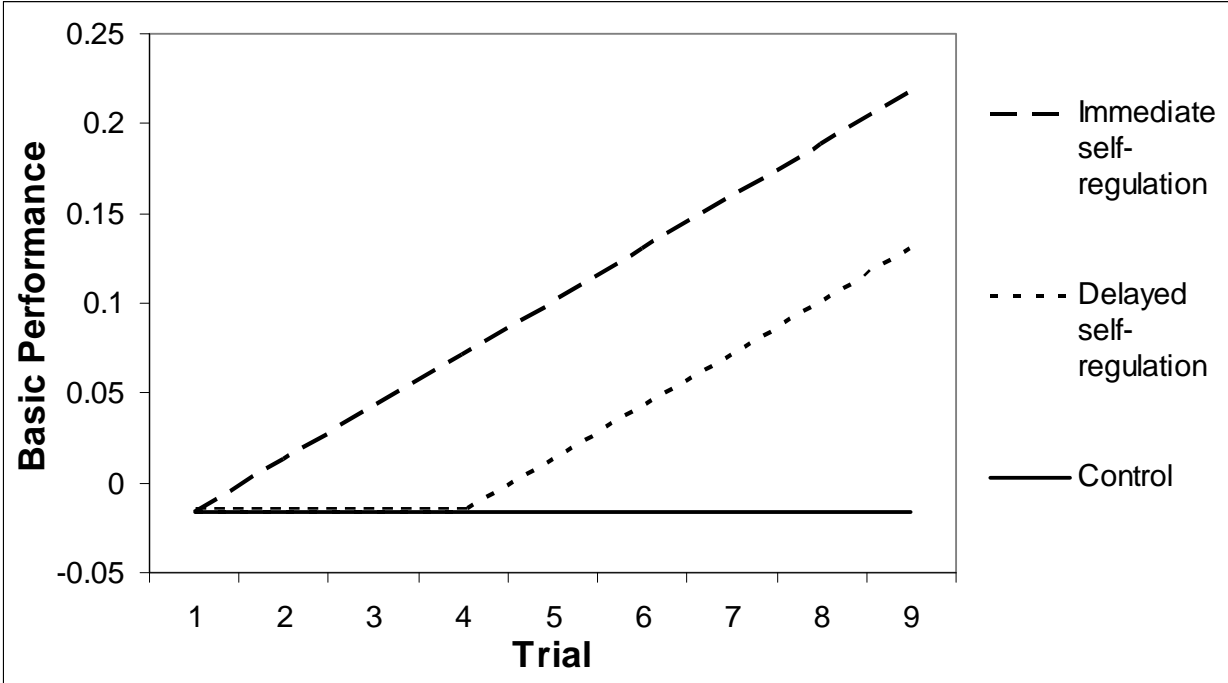


Figure 2. Graph of self-regulation prompts by ability interaction when predicting basic performance across the nine training trials for Study 1.

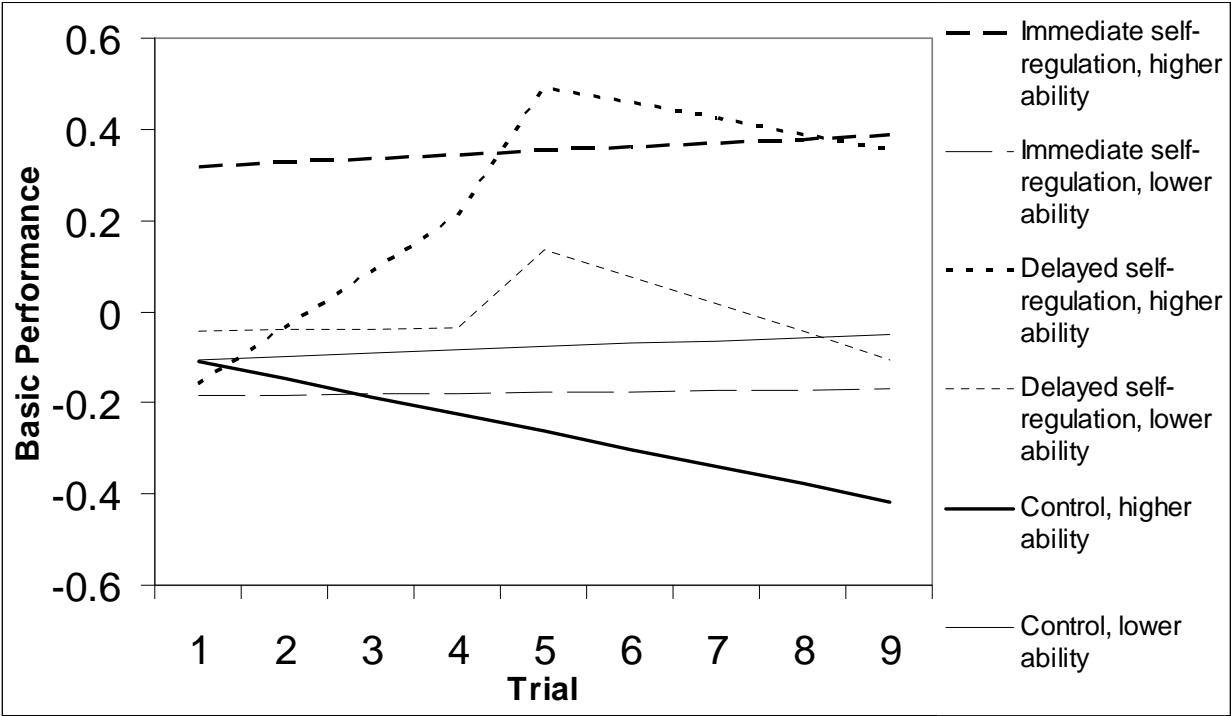


Figure 3. Graph of self-regulation prompts by ability interaction when predicting strategic performance across the nine training trials for Study 1.

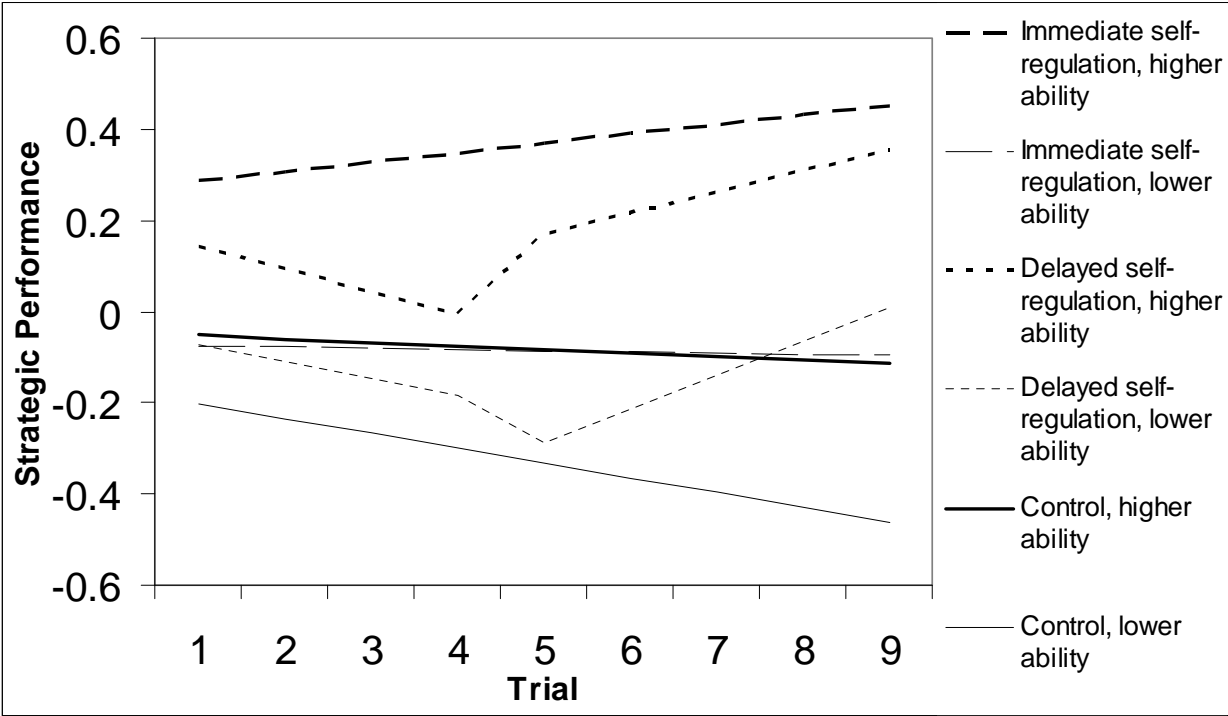


Figure 4. Graph of self-regulation prompts by self-efficacy interaction when predicting basic performance across the nine training trials for Study 1.

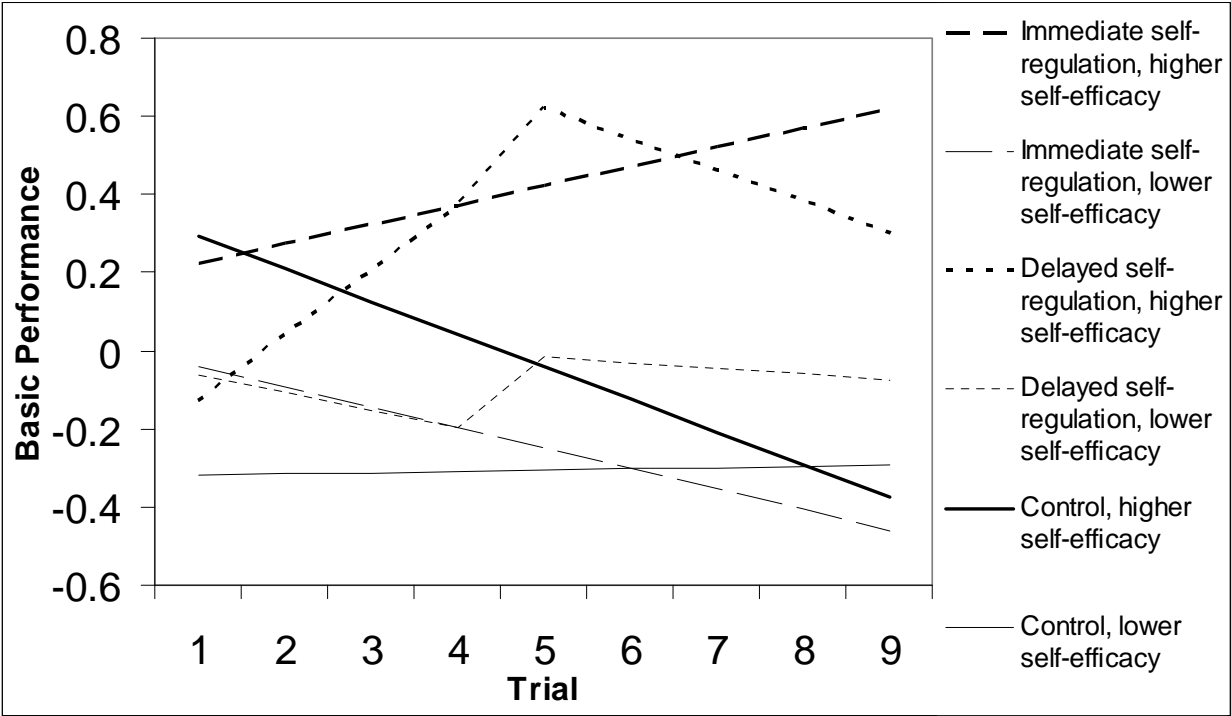
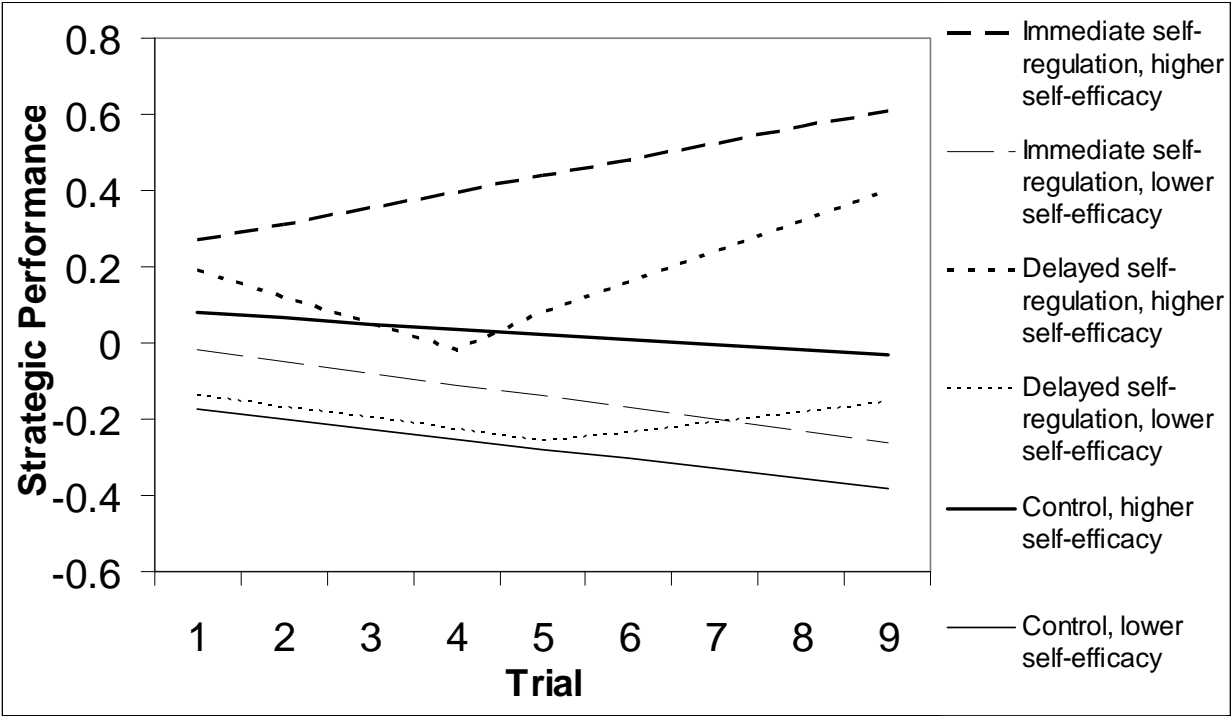


Figure 5. Graph of self-regulation prompts by self-efficacy interaction when predicting strategic performance across the nine training trials for Study 1.



Appendix

Questions Used to Prompt Self-Monitoring and Self-Evaluation in Study 1

Self-Monitoring

1. Am I concentrating on learning the training material?
2. Do I have thoughts unrelated to training that interfere with my ability to focus on training?
3. Are the study tactics I have been using effective for learning the training material?
4. Am I setting learning goals to help me perform better on the final trial?
5. Am I setting learning goals to ensure that I will be ready for the final trial?
6. Have I developed strategies for increasing my knowledge of the training material?
7. Am I setting learning goals to ensure I have a thorough understanding of the training material?
8. Am I distracted during training?
9. Am I focusing my mental effort on the training material?

Self-Evaluation

1. Do I know more about the training material than when training began?
2. Would I do better on the final trial if I studied more?
3. Have I forgotten some of the concepts I covered in earlier sessions?
4. Are there areas of training I am going to have a difficult time remembering for the final trial?
5. Do I understand all of the key points of the training material?
6. Have I spent enough time reviewing to remember the information for the final trial?
7. Have I reviewed the training material as much as necessary to perform well on the final trial?
8. Do I need to continue to review before the final trial?
9. Am I prepared to perform well on the final trial?