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

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Keywords
self-regulation, learner control, technology-delivered instruction

Comments

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This paper has not undergone formal review or approval of the faculty of the ILR School. It is intended to make results of Center research available to others interested in preliminary form to encourage discussion and suggestions.

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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. The results of two studies indicate trainees who were prompted to self-regulate gradually improved their knowledge and performance over time, relative to the control condition. In addition, Study 2 demonstrated that trainees' cognitive ability and self-efficacy moderated the effect of the prompts. Prompting self-regulation resulted in stronger learning gains over time for trainees with higher ability or higher self-efficacy. 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. The 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

Learner control

Technology-delivered instruction

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

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 learning 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; Kanfer & Ackerman, 1989; Sitzmann, Ely, Brown, & Bauer, 2008). 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, using effective study strategies, and making progress towards 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 multiple 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 treats the effect of the prompts as stable over time and may fail to detect an effect when averaging across performance early and later in training. However, self-regulation is a continuous process that unfolds over time as trainees set goals for increasing knowledge, evaluate and select strategies that balance progress towards their goals against unwanted costs, maintain emotion control, and monitor progress towards 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-person 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 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 strategic (i.e., tacit knowledge) performance. Third, we test the effect of the self-regulation prompts in both field and laboratory settings. This two study approach is invaluable in that it demonstrates both the internal and external validity of the intervention. Study 1 examines the effect of the prompts in an online course for working adults, where trainees were dispersed across the United States and completed the course on their own time and in a location of their choice. Study 2 examines the effect of the prompts in a laboratory setting in order to maintain tight control over the experimental manipulation and ensure changes in performance over time can be attributed to the self-regulation prompts. Further, in Study 2 we

hypothesize and test two 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 effect 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 emotion control and metacognition (Kanfer, 1996; Kanfer & Ackerman, 1996), both of which have direct effects on learning (Keith & Frese, 2005). Emotion 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 for increasing their knowledge levels (Bandura & Locke, 2003). Setting a difficult goal enhances learning via directing attention towards 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 towards their goals and minimize unwanted costs (Butler & 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 towards their goals (Carver & Scheier, 1990). At this point, trainees must engage in emotion control in order to continue to make progress towards their goals (Ilies & 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 towards their goals (Vancouver, More, & Yoder, 2008). 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 successively set a performance goal and performed a task (e.g., brainstorming) for eight trials. 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 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 whether trainees' cognitive ability and self-efficacy moderate the effect 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). Therefore, it is critical to identify interventions that can help trainees self-regulate and make better 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 the 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 towards 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 asking trainees to examine whether their behaviors are 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 prompted self-regulation in an attempt to enhance 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 treats the effect of the prompts on learning as stable over 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 that 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 are more likely to be detected 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. The first hypothesis is:

> *H1: Self-regulation prompts will have a gradual, positive effect on learning over time. Relative to the control condition, learning will improve over time when trainees are prompted to self-regulate.*

The timing of the administration of the prompts may be an important consideration when designing and implementing the self-regulation intervention. Kanfer and Ackerman (1989) argued that the engagement of self-regulatory processes (e.g., self-monitoring and self-evaluation) demands attentional resources, and learning may be compromised if working memory capacity is exceeded (Sweller, Van Merrienboer, & Paas, 1998). The pool of available

cognitive resources can be influenced by numerous factors, including the information processing demands of a task (Kanfer & Ackerman, 1989) and the training environment (Yakimovicz & Murphy, 1995).

The information processing demands of a task are greatest early in skill acquisition, before knowledge is compiled (Kanfer & Ackerman, 1989). Thus, 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.

Additionally, other researchers suggest navigating an unfamiliar technology-based training environment and making decisions in learner-controlled courses can be cognitively demanding and may pull attentional resources away from learning the course content (DeRouin et al., 2005; Yakimovicz & Murphy, 1995). Sitzmann et al. (2006) found, relative to classroom instruction, trainees learned more in online courses that were longer in duration. 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 increase the cognitive demands of the situation (DeRouin et al., 2005). Early in training, these decisions may hinder trainees' ability to concentrate on learning the course material, reducing learning. This suggests the cognitive demands of the training environment along with the training content may need to be considered when deciding when to implement the self-regulation prompts. Thus, Study 1 examines whether the prompts should be implemented at the beginning or mid-training in an online, self-paced tutorial, and Study 2 examines whether the prompts should be implemented before or after the knowledge compilation stage during complex skill acquisition.

However, several researchers have questioned the extent to which engaging in self-regulation requires attentional resources. DeShon, Brown, and Greenis (1996), for example, used a dual-task methodology to measure the attentional resource requirements of goal-oriented self-regulation. They concluded that self-regulation does not require significant attentional resources and may be an automatized process. Further, Winters and Latham (1996) argued that Kanfer and Ackerman's (1989) findings were due to trainees' goals 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 studies: immediate self-regulation, delayed self-regulation, and control. In the immediate condition, trainees are prompted to self-regulate throughout the entire course. Trainees in the delayed condition are only prompted to self-regulate in the latter half of the course, when the attentional demands of the training environment (Study 1) and training task (Study 2) 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 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 course are high (i.e., 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?

STUDY 1

Study 1 was a field study that used an experimental design to model the effect of prompting self-regulation on learning across 10 Web-based training modules and examined whether the effect of the prompts differed for the immediate and delayed self-regulation conditions. The training was similar to many online courses in that trainees were geographically dispersed and participated on their own time and in a location of their choice. Thus, Study 1 provided baseline evidence for the effect of the prompts for learning basic knowledge and assessed the external validity of the effect among working adults. Study 2 used a tightly controlled laboratory experiment to replicate and extend the findings to strategic performance and examined whether individual differences moderated the effects of the prompts.

Method

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

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 text covering declarative knowledge and videos demonstrating the functions that can be performed in Blackboard. Within each module, the lecture and videos covered interrelated material. For example, in the chat room 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 focused on locating the appropriate feature on the control panel. Thus, as trainees became familiar with the control panel, they should have begun to automate the location of each of the features and the requirements for navigating, reducing the attentional requirements of the training environment.

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. 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 modules in a predetermined order before taking the test. After reviewing the 10 modules, trainees completed a test to assess their knowledge of the material.

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 reflect on questions during training. Ten self-monitoring and 10 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). Self-monitoring questions asked trainees whether they were allocating their attention to learning the training material and assessing the consequences of their behavior, while self-evaluation questions asked trainees to compare their current knowledge and skills with their training goal. As an incentive, all trainees were told that if they correctly answered at least 16 out of 20 test questions, they would receive a Blackboard training certificate and a copy of the certificate would be sent to the human resources department at their school or organization.

Trainees in the immediate self-regulation condition received information on the desired level of performance at the beginning of training and were told, “This is a good time to tell you 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 towards 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 modules, and trainees answered the questions using a 5-point scale ranging from strongly disagree (1) to strongly agree (5).

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 reviewing five training modules in order to give them time to familiarize themselves with the instructional environment. Following modules 5 through 10, trainees were asked the same self-regulation questions as the immediate condition. Finally, in the control condition, trainees were not asked questions to prompt self-regulation and were not told that self-regulation increases performance.

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 towards 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. Responses to the prompts questions were not used in any of the analyses because they would not reveal whether the prompts are effective. 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. Yet, in each case the question achieves the same objective—to prompt trainees to evaluate their current level of understanding. Accordingly, differences in performance trends across training conditions will be used to assess the effect of prompting self-regulation.

Learning Outcome Measure

A post test was used to assess knowledge of the 10 training modules. Declarative knowledge was assessed with 10 multiple-choice questions with four response options per 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. Each of the test questions was worth 1 point, and trainees received a fraction of a point for correctly performing a facet of a multipart 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 until September 2. 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 assessing knowledge of the same module were averaged. The average score across the 10 modules was 14.66 (SD = 2.43) questions correct.

Analytic Strategy

In the current study, we were not interested in changes in learning over time, but rather differences in learning trends over time for the three self-regulation conditions. Thus, before

analyzing the results, we standardized the learning scores for each of the 10 modules. Standardizing the results removed true changes in learning over time, but allowed us to compare differences in performance trends across conditions as trainees progressed through the course. It also resulted in a common scale across learning indicators, permitting us to compare the results across the two studies and across basic and strategic performance in Study 2.

Hierarchical linear modeling (HLM) with full maximum likelihood estimates was used to analyze the within-subjects results using the procedure recommended by Singer and Willett (2003). We ran a series of models to analyze changes in learning across the 10 training modules. 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- and between-person components.

Our second model assessed the effect of self-regulation on learning over time with a discontinuous growth model (Singer & Willett, 2003, pp. 189-208). A discontinuous growth model allows one to specify the functional form of the data based on theory. In the current study, we proposed that prompting self-regulation would result in a gradual increase in performance across the 10 training modules. Thus, for the immediate self-regulation condition, the self-regulation slope fixed effect was coded 0, 1…8, 9 indicating performance should gradually increase over time as trainees are prompted to self-regulate. In the delayed condition, the self-regulation slope fixed effect was coded 0, 0, 0, 0, 0, 1, 2, 3, 4, 5. The zeros for the first five modules indicate that trainees would not receive the performance improvements over time, relative to the other conditions, before they were prompted to self-regulate. However, performance should gradually increase over time in the latter half of the course as trainees are prompted to self-regulate. In the control condition, the self-regulation slope fixed effect was

coded 0 for all 10 modules since these trainees were not prompted to self-regulate. If the fixed effect for the self-regulation slope parameter is retained in the model, it would indicate that prompting self-regulation results in learning progressing at different rates 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 over time. Also, the growth model was coded such that the intercept term represents performance at trial one.

Next, we ran two additional models with self-regulation prompts condition dummy codes entered as level-2 predictors of the intercept (model 1) and self-regulation slope (model 2). This allowed us to assess if the self-regulation slope term differed for the immediate (vs. control) and delayed (vs. control) conditions.

There is disagreement regarding the effectiveness of hypothesis tests for fixed and random effects in HLM, so statisticians generally prefer to use deviance statistics 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, we relied on deviance statistics, rather than statistical significance, when deciding whether to retain a variable in a model and interpret a parameter.

Results

We used HLM to assess if prompting self-regulation had a gradual effect on learning over time. First, we ran the unconditional means model to examine the variability in learning without any predictors in the model (see Table 1). The intraclass correlation coefficient was .06, which indicates 6% of the variance in test scores was between-persons while 94% of the

variance was at the within-person level. In addition, there was significant within- and between-person variability ($\sigma_\epsilon^2 = 0.930$ and $\sigma_0^2 = 0.060$, $p < .05$).

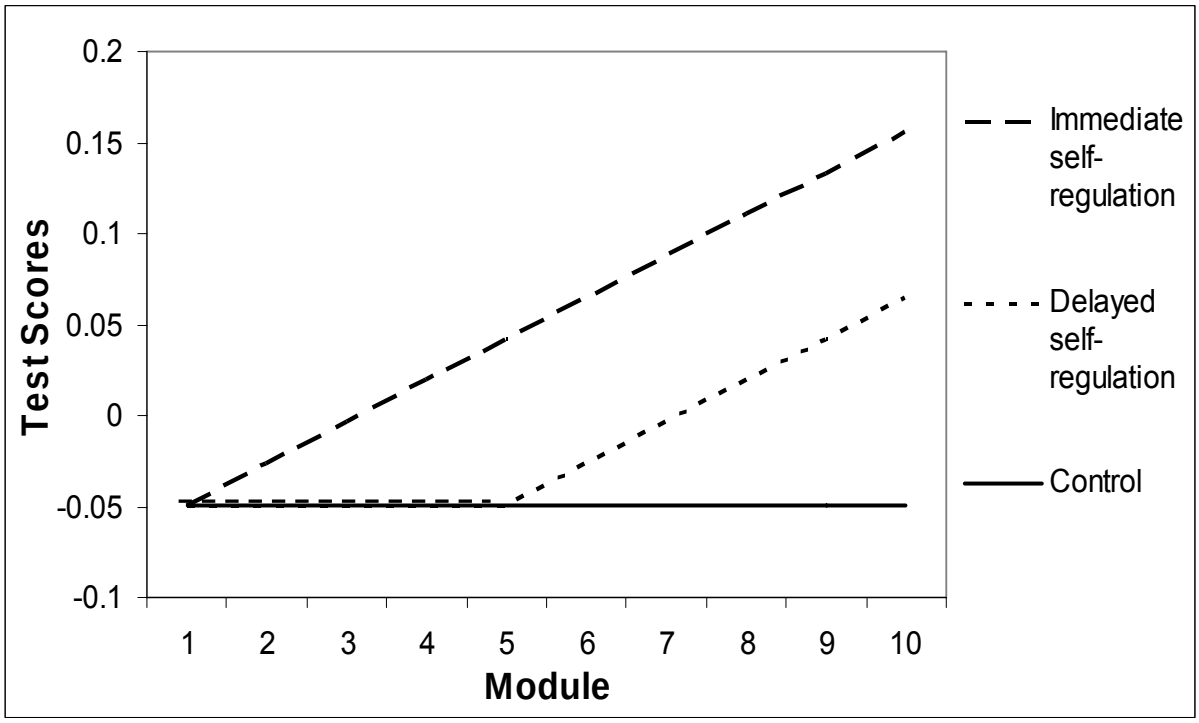
Table 1
HLM Results Predicting Test Scores in Study 1

	Parameter	Unconditional Means	Self-Regulation Prompts
Fixed Effects			
Initial status	γ_{00}	-0.001 (0.041)	-0.049 (0.055)
Self-regulation slope	γ_{10}		0.023† (0.014)
Random Effects			
Within-person	σ_ϵ^2	0.930* (0.046)	0.902* (0.046)
Initial status	σ_0^2	0.060* (0.023)	0.107* (0.039)
Self-regulation slope	σ_1^2		0.005* (0.003)
Deviance Statistic		2583.90	2574.80
df		3	6

Note. The top number is the fixed or random effect coefficient. The number in parentheses is the standard error.
* $p < .05$
† $p < .10$

The second model examines the effect of prompting self-regulation on the rate of change in test scores across modules. Adding the self-regulation slope fixed effect significantly improved model fit relative to the unconditional means model ($\chi^2_{dif}(3) = 9.10$, $p < .05$; see Figure 1). The self-regulation slope parameter was 0.023 indicating performance increased by 0.023 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 0.205 and 0.114 standard deviations, respectively, better than the control. However, trainees differed significantly in the effect of the self-regulation prompts on test scores ($\sigma_1^2 = 0.005$, $p < .05$), indicating there are moderators of the effect of prompting self-regulation. Overall, these results support the first hypothesis and indicate that additional research is needed to examine moderators of the effect of prompting self-regulation on learning over time.

Figure 1
Graph of the effect of self-regulation prompts on learning across the 10 training modules for Study 1



Next, we compared the effect 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 at the beginning or mid-training in a self-paced, online course. We added self-regulation condition dummy codes as level-2 predictors of the self-regulation slope fixed effect to assess if the slope differs across the immediate and delayed conditions, relative to the control. Adding the dummy codes did not significantly improve model fit relative to the level-1 model ($\chi^2_{dif}(2) = 1.66$, 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 over time in both the early and later stages of training.

Discussion

Study 1 examined the effect of prompting trainees to self-regulate on changes in learning over time as working adults progressed through a 3-hour online training course. Overall, the results indicate prompting self-regulation has a positive, gradual effect on learning over time, relative to trainees who are not prompted to self-regulate. This is consistent with theory which suggests self-regulation is an unfolding, iterative process, and within-subjects designs are more likely to detect the effect. In addition, we found the timing of implementing the self-regulation prompts did not moderate the self-regulation slope term, suggesting trainees benefit from the prompts throughout training. These results suggest that to achieve maximum performance gains it may be most effective to implement the prompts at the beginning of training and to continuously prompt self-regulation throughout self-paced training courses.

STUDY 2

Study 1 provided support for the positive effect of prompting self-regulation on learning over time, but it is important to examine whether the results generalize across learning contexts. In addition, two important research questions remain which Study 2 addresses. First, does the beneficial effect of prompting self-regulation differ for 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 where, when, why, and how 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). In Study 2, we examined whether the positive effect of prompting self-regulation generalizes to strategic as well as basic performance as trainees learn a more complex, dynamic task.

Second, the results of Study 1 indicate there is variability in the effect of prompting self-regulation across trainees. This suggests that additional research is needed to identify potential aptitude-treatment interactions that may provide insight as to the types of trainees that are most likely to benefit from the self-regulation prompts.

Moderating Effects of Individual Differences

Over the past decade, a growing body of research has identified 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 play in determining the effects of self-regulation on learning over time (e.g., Donovan & Williams, 2003; Yeo & Neal, 2004). In an effort to build on this emerging stream of research, the current study examined whether trainees' cognitive ability and self-efficacy moderate the effect of prompting self-regulation on learning over 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 both how much and 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, suggested that higher ability trainees benefit from relatively unstructured environments that provide room for independent learning, whereas lower ability trainees require more tightly structured environments. Gully, Payne, Koles, and Whiteman (2002) provided 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 mastery orientation, which includes a greater degree of self-regulatory activity (Payne et al., 2007). Overall, these findings suggest that higher ability trainees may be more capable than lower ability trainees of effectively using self-monitoring and self-evaluation processes to increase their learning over time when prompted to self-regulate. 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 positive 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 may physically or mentally disengage from training or adjust their goals downward when faced with goal-performance discrepancies.

In the current research, the self-regulation 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. 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 impair learning because the increased salience of goal-performance discrepancies may result in trainees withdrawing 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 positive effect on learning over time for trainees with higher rather than lower self-efficacy.*

Method

Study 2 used an experimental design and multilevel modeling to assess the effect of prompting self-regulation on learning across nine training trials. It extended Study 1 by examining whether the effect of prompting self-regulation generalized to strategic performance and could be replicated in training that focused on complex skill acquisition. In addition, it examined whether trainees' cognitive ability and self-efficacy moderated the effect of the prompts on learning over time.

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 study 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 decisions 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, 3-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 3 minutes to study an online manual that contained information on all important aspects of the task followed by 5 minutes of practice. The nine trials all possessed the same general profile (i.e., same difficulty level, rules, number of contacts), but the configuration of contacts (i.e., 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.

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. When the prompts were implemented, trainees in the immediate and delayed conditions received the same message used in Study 1 regarding the positive effects of self-regulation on performance. One self-monitoring and one self-evaluation question were then presented following the feedback sessions. These questions were presented on the computer screen, and participants answered each of the questions on a worksheet using a 5-point scale ranging from strongly disagree (1) to strongly agree (5). Trainees in the immediate self-regulation condition were prompted to self-regulate following all nine feedback sessions while trainees in the delayed condition were prompted to self-regulate following the feedback sessions

for trials four through nine. 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' cognitive resources (Bell & Kozlowski, 2002a).

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 was 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 and ACT scores correlate highly with actual scores. Gully et al. (2002), for example, found 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 5-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 and procedural knowledge. 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 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]

Data Analysis

The analysis strategy paralleled the analyses in Study 1. First, we standardized both basic and strategic performance for each of the nine trials in order to compare the results across the two studies and across basic and strategic performance. Next, we ran two level-1 HLM models for basic and strategic performance, such that the first model was an unconditional means model and the second model used discontinuous growth modeling to assess if the test score trajectory changed when self-regulation prompts were implemented (Singer & Willett, 2003).

After establishing the level-1 model, we tested whether the intercept and 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. 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. Once again deviance statistics rather than individual significance tests for each of the fixed and random effects were used to decide whether to accept a simpler or more complex model (Singer & Willett, 2003).

[1] To confirm that the basic and strategic performance indicators capture 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.

Results

First, we calculated the between-persons descriptive statistics and correlations for Study 2 measures (see Table 2). 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).

Table 2
Correlations among Study 2 Measures at the Between-Subjects Level

		Mean	*SD*	1	2	3	4	5
1	Immediate (1) vs. delayed self-regulation & control (0)	0.37	0.49					
2	Delayed (1) vs. immediate self-regulation & control (0)	0.30	0.46	-.50*				
3	Cognitive ability	1341.04	112.98	.02	.09			
4	Self-efficacy	3.31	0.78	.05	.14	.18*		
5	Basic performance	0.00	0.73	.09	.11	.20*	.49*	
6	Strategic performance	0.00	0.75	.15*	-.01	.30*	.39*	.38*

* p < .05

Level-1 HLM Analyses

Table 3 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 in test scores was at the between-person level while 53% of the variance was at the within-person level (σ_ϵ^2 = 0.522 and σ_0^2 = 0.465).

Next, we examined whether there was a change in the slope of basic performance 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 ($\chi^2_{dif}(3)$ = 54.91, p < .05). The basic performance results support Hypothesis 1, and the effect was similar to Study 1 (see Figure 1). The self-regulation slope fixed effect was 0.029 indicating performance increased by 0.029 standard deviations, relative to the control, for each trial 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 training but their performance improved over time when they were prompted to self-regulate. By the ninth trial, the immediate and delayed conditions were outperforming the control by 0.234 and 0.146 standard deviations, respectively.

Table 3
Level-1 HLM Results Predicting Basic and Strategic Performance in Study 2

		Basic Performance		Strategic Performance	
	Parameter	**Unconditional Means**	**Self-Regulation Prompts**	**Unconditional Means**	**Self-Regulation Prompts**
Fixed Effects					
Initial status	γ_{00}	0.031 (0.060)	-0.016 (0.062)	0.009 (0.062)	-0.040 (0.065)
Self-regulation slope	γ_{10}		0.029† (0.015)		0.032† (0.017)
Random Effects					
Within-person	σ_ϵ^2	0.522* (0.022)	0.464* (0.020)	0.500* (0.021)	0.418* (0.018)
Initial status	σ_0^2	0.465* (0.061)	0.467* (0.067)	0.504* (0.065)	0.522* (0.072)
Self-regulation slope	σ_1^2		0.014* (0.003)		0.020* (0.004)
Deviance Statistic		3215.18	3160.27	3174.55	3076.58
df		3	6	3	6

Note. The top number is the fixed or random effect coefficient. The number in parentheses is the standard error.
* $p < .05$
† $p < .10$

The level-1 HLM results for strategic performance are presented in Table 3. ICC was .50, indicating 50% of the variance in test scores was at the between-person level while 50% of the variance was at the within-person level. Once again, there was significant within- and between-person variability ($\sigma_\epsilon^2 = 0.500$ and $\sigma_0^2 = 0.504$).

The second model examined 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 (χ^2_{dif} (3) = 97.97, $p < .05$), and the effect was similar to the Study 1 results presented in Figure 1. The self-regulation slope fixed effect was 0.032 indicating performance increased by 0.032 standard deviations,

relative to the control, for each trial when self-regulation was prompted. The immediate and delayed conditions were outperforming the control by 0.253 and 0.158 standard deviations, respectively, by the end of training. Thus, both the basic and strategic performance results support Hypothesis 1 and suggest prompting self-regulation has a gradual, positive effect on learning over 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 at the beginning of training (immediate condition) or midway through training (delayed 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 ($\chi^2_{dif}(2) = 4.14$, 4.47, respectively, $p > .05$). Thus, these results provide additional support that prompting self-regulation has a positive effect on learning over 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. This resulted in extremely small cognitive ability coefficients that required four or more decimal

places for interpretation, even when ability had a meaningful effect. Thus, ability was standardized to aid interpretation.[2]

Adding cognitive ability and self-efficacy as moderators of the self-regulation slope significantly improved the prediction of basic and strategic performance ($\chi^2_{dif}(4) = 42.45$, 34.09, respectively, $p < .05$; see Table 4). The ability fixed effects were 0.026 for basic and 0.006 for strategic performance while the self-efficacy fixed effects were 0.010 for basic and 0.060 for strategic performance.

Table 4
Level-2 HLM Results Predicting Basic and Strategic Performance in Study 2

Fixed Effect	Parameter	Basic Performance	Strategic Performance
Intercept	γ_{00}	-0.018 (0.057)	-0.042 (0.062)
Ability	γ_{01}	0.049 (0.055)	0.164* (0.060)
Self-efficacy	γ_{02}	0.397* (0.075)	0.185* (0.082)
Self-regulation slope	γ_{10}	0.022 (0.015)	0.022 (0.016)
Ability	γ_{11}	0.026† (0.014)	0.006 (0.015)
Self-efficacy	γ_{12}	0.010 (0.020)	0.060* (0.021)
Deviance Statistic		3117.82	3042.49
df		10	10

Note. The top number is the fixed effect coefficient. The number in parentheses is the standard error.
* $p < .05$
† $p < .10$

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 had a stronger 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 over time when trainees were prompted to self-regulate, relative to higher ability trainees in the control condition. For lower ability trainees, prompting self-

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

regulation did not have as strong of an effect over time, but was beneficial for strategic performance.

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

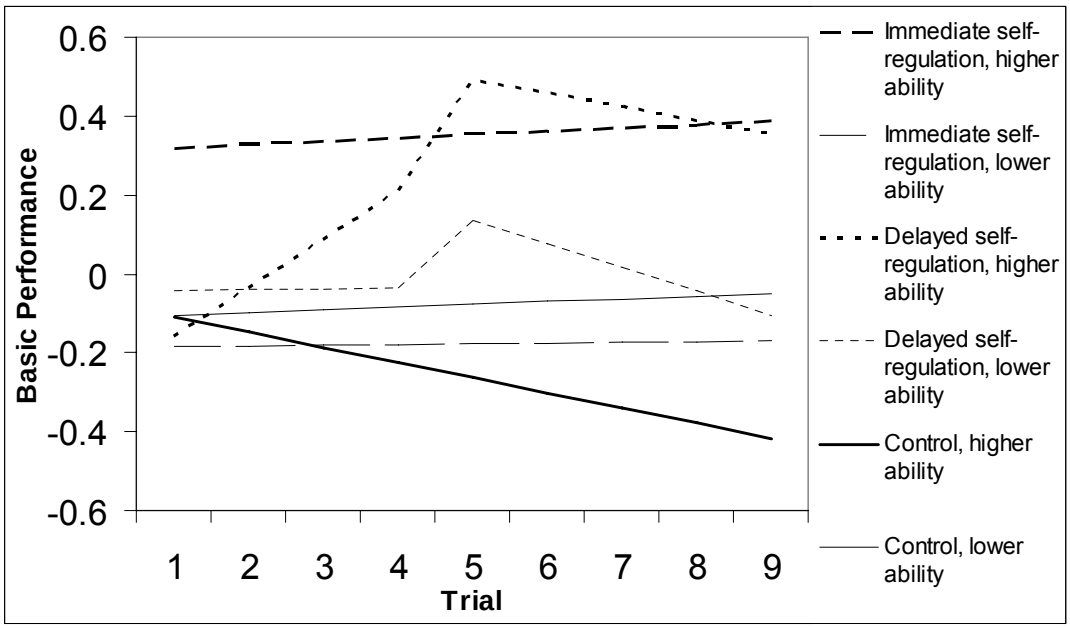
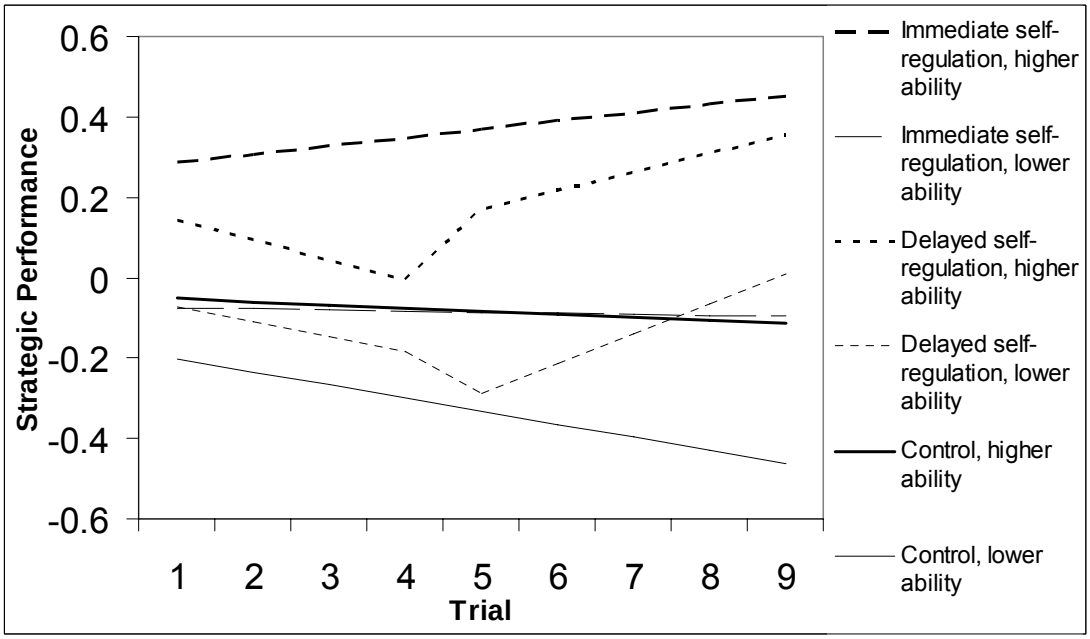


Figure 3
Graph of self-regulation prompts by ability interaction when predicting strategic performance across the nine training trials for Study 2



Graphs of the moderating effects 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 had less of 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 has more of a positive effect on performance over time for trainees with higher self-efficacy levels.

Figure 4
Graph of self-regulation prompts by self-efficacy interaction when predicting basic performance across the nine training trials for Study 2

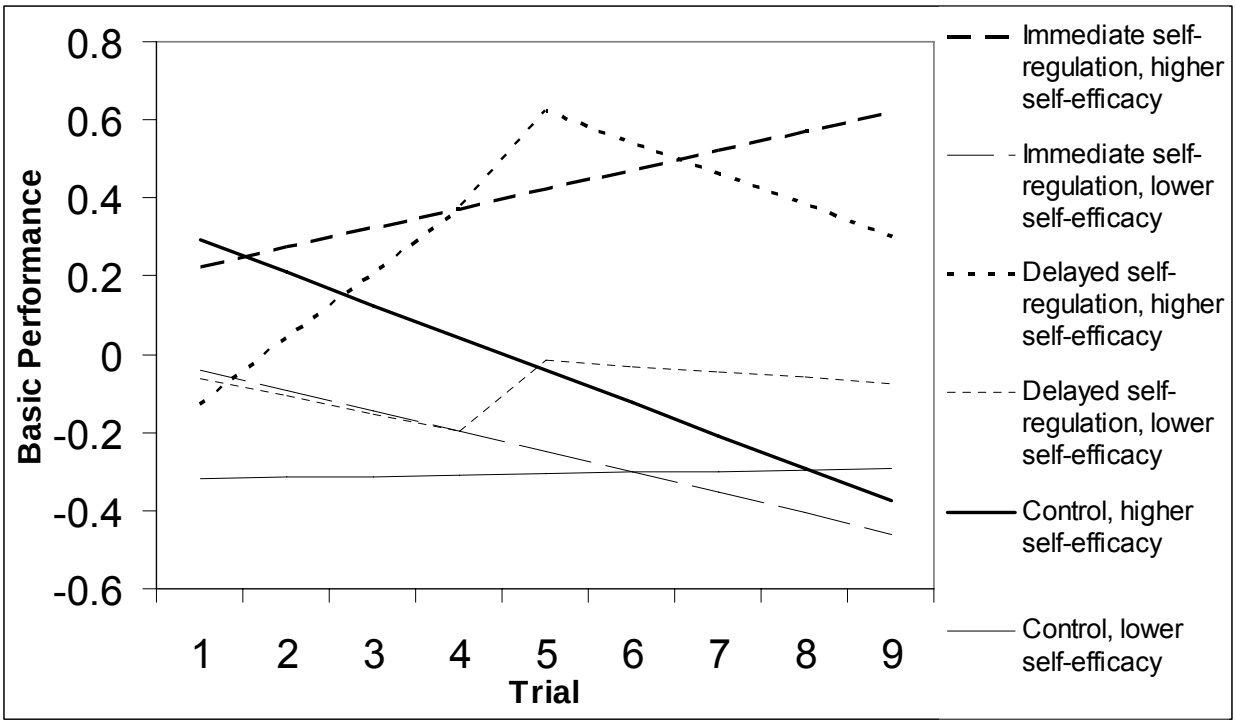
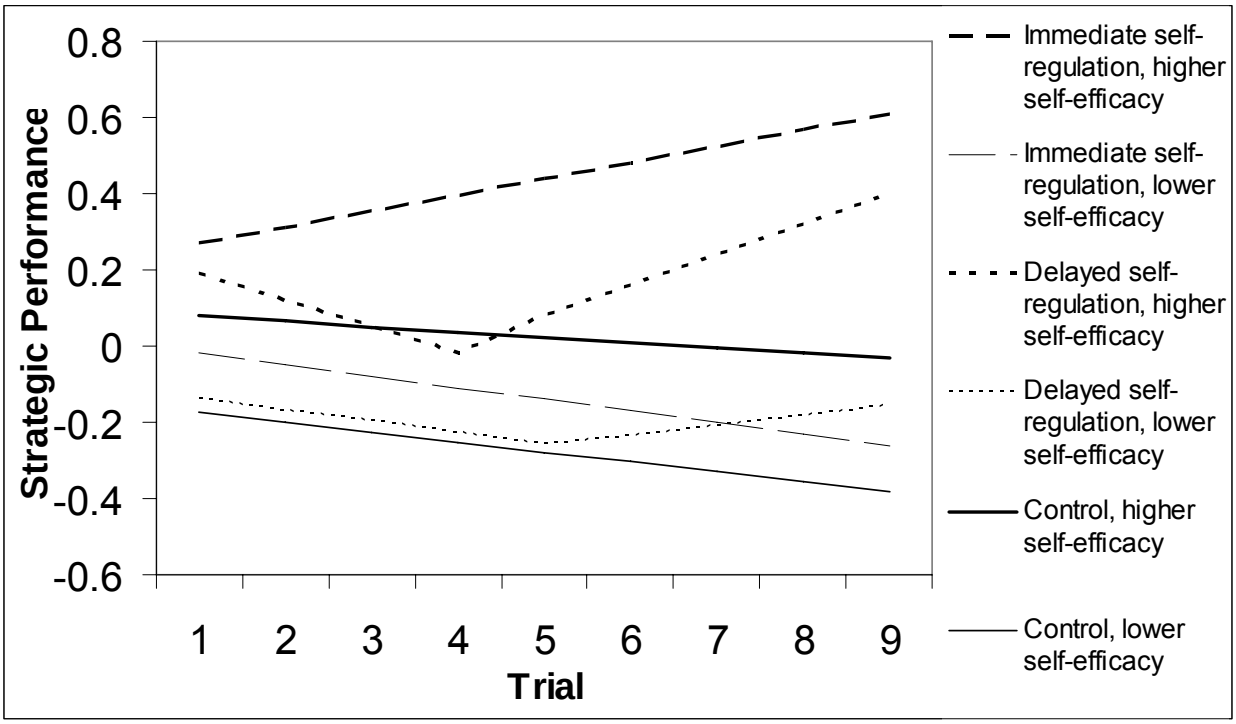


Figure 5
Graph of self-regulation prompts by self-efficacy interaction when predicting strategic performance across the nine training trials for Study 2



Discussion

Study 2 results replicated and extended the findings of Study 1 by demonstrating that prompting self-regulation has a positive effect on both basic and strategic performance and the strength of the effect increases over time. In addition, the effect of prompting self-regulation on performance was moderated by trainees' cognitive ability and self-efficacy. Trainees with higher levels of cognitive ability and stronger self-efficacy beliefs benefited more from the self-regulation prompts.

General Discussion

The current results are consistent with theory suggesting self-regulation is a cyclical process that has a gradual effect on learning over time (Butler & Winne, 1995; Carver & Scheier, 1990; Kanfer & Ackerman, 1996). We used a within-subjects design in two studies and

demonstrated the effect of the self-regulation prompts increased throughout training. Study 1 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 0.21 and 0.11 standard deviations, respectively, on a test of declarative and procedural knowledge. In Study 2, the immediate and delayed conditions were outperforming the control by 0.23 and 0.15 standard deviations, respectively, for basic performance and 0.25 and 0.16 standard deviations, respectively, for strategic performance by the end of training. Together, these results suggest prompting self-regulation has a positive effect on performance over time and enhances the extent to which trainees learn both the fundamental principles and deeper complexities of a task.

We also support previous research suggesting a within-subjects design is more appropriate for understanding intra-individual 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). We used ANOVAs, the analysis technique used in previous prompts research (e.g., Corliss, 2005; Toney, 2000), to examine whether the prompts had a significant effect on learning at the between-subjects level of analysis. In Study 1 and for strategic performance in Study 2, we failed to find significant between-persons effects.[3] This is consistent with research which suggests 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). The results

[3] In Study 1, one-way ANOVA results indicated there was not a significant difference in test scores across the three self-regulation conditions ($F(2,90) = 1.25$, $p > .05$, $\eta^2 = .03$). In Study 2, 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 and delayed self-regulation prompts conditions scored higher on the assessment of basic performance than the control ($t(113) = 2.07$, $t(99) = 2.47$, respectively, $p < .05$). One-way ANOVA results also indicated there was not a significant difference in strategic performance across the three self-regulation conditions ($F(2,161) = 2.54$, $p > .05$, $\eta^2 = .03$).

highlight the importance of theory in guiding our understanding of learning processes and emphasize the criticality of conducting research at the appropriate level of analysis (Kreft & de Leeuw, 1998).

Although the self-regulation prompts had positive effects in both studies, the size of these effects are considered small based on Cohen's (1977) guidelines. 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 argue 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) prompted learners to self-regulate during training, but also provided learners 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 low cost intervention. Thus, almost any benefit in terms of learning and performance is likely to outweigh the cost 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, accumulate in practice. Thus, while the self-regulation prompts may produce small increases in learning over time, these effects may translate into significant gains in work-related outcomes such as efficiency and productivity.

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, trainees 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. Cognitive ability and self-efficacy moderated the basic and strategic performance results. Prompting self-regulation was more beneficial 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 enhance their learning.

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 basic and

strategic performance improved over time when trainees were prompted to self-regulate, relative to trainees who were not prompted to self-regulate. This suggests implementing the prompts will enhance trainees' ability to remember the key principles presented in training and their understanding of when, where, why, and how to apply their knowledge and skills (Ford & Kraiger, 1995; Gagné & Merrill, 1992; Tennyson & Breuer, 1997). In addition, prompting self-regulation is a low cost intervention, which is easy to implement. To incorporate the prompts in training, organizations need to add a series of reminders to their courses to encourage trainees to monitor their learning behaviors, develop goals and strategies, and assess their learning progress.

Organizations should be aware that highly intelligent trainees and trainees with higher self-efficacy benefit more from the prompts. Although the prompts should have little or no effect on learning for lower ability or lower self-efficacy trainees, we did not find evidence that the prompts were 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.

Limitations and Directions for Future Research

While each of the individual studies has several limitations, they also provide unique contributions. Study 1 demonstrated prompting self-regulation is beneficial in online training for working adults. However, due to the nature of the training material, we could not examine whether the results apply to strategic performance. Study 2 utilized undergraduates participating in a laboratory study, which may limit the extent to which the results generalize to organizational training courses.

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 studies did not investigate the

mediating psychological processes (e.g., effort, self-assessment, 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 examine boundary conditions for the effect of the prompts on learning over 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 revision 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 over time.

Future research should also 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 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, emotion 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). Thus, future research should examine whether prompting both cognitive and affective self-regulation increases the likelihood that lower self-efficacy trainees benefit from the prompts.

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 course is sufficient for improving trainees' self-regulatory skills and trainees will be able to apply these skills in future 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 the prompts may not be effective in all courses.

Conclusion

Prompting self-regulation is an effective intervention for enhancing learning from technology-delivered instruction. Results from two studies demonstrated that the prompts gradually increased basic and strategic performance as trainees progressed through training. The effect of the prompts was moderated by trainees' cognitive ability and training self-efficacy. Prompts resulted in stronger learning gains over time for trainees with higher ability and higher self-efficacy. These results highlight the value of multilevel modeling 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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Appendix

Questions Used to Prompt Self-Monitoring and Self-Evaluation

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 exam?
5. Am I setting learning goals to ensure that I will be ready to take the post test?
6. Have I developed a strategy 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. Are the study strategies I'm using helping me learn the training material?
9. Am I distracted during training?
10. 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 exam if I studied more?
3. Do I know enough about the training material to answer at least 80% of the questions correct on the post test?
4. Have I forgotten some of the terms introduced in previous training material?
5. Are there areas of training I am going to have a difficult time remembering for the final exam?
6. Do I understand all of the key points of the training material?
7. Have I spent enough time reviewing to remember the information for the final exam?
8. Have I reviewed the training material as much as necessary to perform the skills on the final exam?
9. Do I need to continue to review before taking the final exam?
10. Am I making progress towards answering at least 80% of the questions correct on the post test?