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Improving IS Competency: The Role of Self-Explanation and Self-Evaluation

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ABSTRACT

Achieving proficient, effective utilization of information systems (IS) continues to be a challenge. Therefore, effective training techniques can be an area of consideration for improving IS competency. To understand issues underlying competency in IS use, the Cognitive Load Theory is utilized. One potential challenge that resonates with the learning process itself is germane cognitive load. This research proposes to address such issues by exploring potential improvements in germane cognitive load through interventions of self-regulated learning strategies. Drawing upon Social Cognitive Theory and self-regulated learning literature, this research proposes an experiment to evaluate the effectiveness of using self-constructed explanations and self-evaluations to improve IS competency. Learning outcomes will be measured through assessment of declarative knowledge, procedural knowledge, and self-efficacy. Practical implications and contributions of this research include providing an understanding of the effectiveness of incorporating self-regulated learning strategies (i.e., self-constructed explanations and evaluations) in an IS competency context.

Keywords

IS competency, self-explanation, self-evaluation, IS usage, Cognitive Load Theory, Social Cognitive Theory

INTRODUCTION

Achieving information systems (IS) competency has always been a challenge among many users. Although some users are able to carry out routine functions or complete structured tasks, the full utilization of IS in an efficient and effective manner is sparse. Although individuals may receive IS training on the proper utilization of an IS to carry out pre-specified functions, the ability to develop elaborate comprehensions of IS potential such that novel ideas are generated for IS utilization or application are limited.

Hence, new methods of training individuals to elaborate on their understandings of IS functions and to be fully aware of their level of understanding may be needed. Although previous research has demonstrated that techniques such as retention enhancement and symbolic mental rehearsal can improve software application skills (Davis and Yi, 2004; Yi and Davis, 2003), many of these skills are rehearsals and re-enactments of specific functions or routines, and are in the same context. Hence, self-regulated learning techniques such as these can improve one's learning and memory, but may not enhance their overall ability to apply these skills in unique ways or novel contexts. Therefore, additional research is needed to further improve upon IS users' ability to effectively apply IS.

In other words, research is needed that focuses on enhancing an IS user's skill set or competencies to move closer to becoming a highly competent IS user, defined as "one who is able to utilize IS to its fullest potential and obtain the greatest performance from IS use." (Eschenbrenner and Nah, 2007). Some IS users are able to develop more extensive understandings through effective learning mechanisms. In research conducted by Gravill and Compeau (2008), they discovered through interviews with knowledge workers who received software-skill training that perceived successful learning techniques included those related to establishing goals and monitoring their learning progress, or conducting self-evaluations. They also indicated that they thought about their level of understanding and how their strategies needed to be modified through self-explanations and self-evaluations.

Therefore, additional research that focuses on improving IS competencies through self-evaluations and self-explanations during training is important to improving utilization of IS. Training employees on any new technology implementation is considered a necessity by many. However, issues may still arise when an IS user has a problem to solve in a new domain or a complex decision to make regarding how best to utilize an IS if they are taught to only perform routine functions.

Considering less effective learning can ultimately result in less than effective usage of newly implemented technology, additional mechanisms that facilitate the learning process to achieve higher levels of competency is beneficial to practice as well as research. As noted by Payne, Bettman, and Johnson (1993), one approach to improving decision making is through training the decision maker, including providing knowledge of appropriate strategies to use. Therefore, this research study proposes to assess training interventions in which self-evaluations and self-explanations are incorporated into software skill training and the overall impact on learning outcomes is assessed. The research question to be addressed is: "Do self-regulated learning strategies (i.e., self-constructed explanations and self-evaluations) improve learning outcomes in an IS context?"

LITERATURE REVIEW AND THEORETICAL BACKGROUND

Organizations typically rely on training to enhance individual skills with using a technology (Compeau and Higgins, 1995a; Sharma and Yetton, 2007). Technology training has been addressed from various perspectives in previous MIS research. For example, microcomputer playfulness (i.e., cognitive spontaneity in microcomputer interactions) introduced into training sessions has a positive impact on learning, mood, involvement, and satisfaction (Webster and Martocchio, 1992). Sharma and Yetton (2007) studied the effects of training on IS implementation success as a function of technical complexity and task interdependence, and found a positive relationship among them. Compeau (2002) identified 53 behaviors of effective trainers which were categorized as knowledge, communication skills, course design, training techniques, sympathy, and class management. However, MIS research is sparse in addressing training interventions of self-regulated learning strategies to improve learning outcomes.

Azevedo (2005a) indicates that previous research has demonstrated that individuals, regardless of age, experience difficulties in learning rich domains. According to his research in the use of hypermedia, students that experience more success in complex topics such as science tend to use more metacognitive strategies (Azevedo, 2005b). Among some key self-regulating strategies included one's judgment of their own learning and their feelings of knowing, as well as self-questioning and monitoring one's progression towards their goals.

The focus of this research is to examine the effect of self-regulated learning strategies, which include self-constructed explanations and self-evaluations, on learning outcomes from software-skill instruction. Hence, Cognitive Load Theory is discussed to specify the dimension of the potential issue that is being studied (germane cognitive load), and Social Cognitive Theory and self-regulated learning literature are discussed next to address the mechanisms employed (self-regulation strategies) to enhance germane cognitive load.

Cognitive Load Theory and Previous Research

Cognitive Load Theory (CLT) has become a well-recognized theory in learning and instruction research (Bruning, 2004; van Merrienboer and Ayres, 2005). CLT asserts that an individual's working memory is very limited in capacity in terms of processing novel information (van Merrienboer and Sweller, 2005). However, one's long-term memory has an unlimited capacity. When information is processed in working memory, the knowledge is stored as schemata in one's long-term memory. After schemata are created, working memory can recall the schemata as one element, which greatly reduces the burden on its already limited capacity. Human expertise is then derived from the ability to construct increasingly complex schemata and, in some circumstances, through the automation of these schemata. Therefore, schemas organize and store knowledge which significantly reduces the burden placed on working memory.

However, working memory needs to process information before it can be placed in schemata to be used effectively at a later date, and concerns arise over working memory's ability to process novel information (van Merrienboer and Ayres, 2005). CLT addresses this issue by posing that there are various types of cognitive load that can influence working memory's processing capabilities. Three types of cognitive load include intrinsic cognitive load, extraneous cognitive load, and germane cognitive load (van Merrienboer and Ayres, 2005). Intrinsic cognitive load evolves from the interaction between an individual's existing level of expertise in a particular subject and the nature of the subject material itself. Extraneous cognitive load is determined by the instructional intervention itself, i.e., learning task itself. Germane cognitive load is associated with the learning process itself, including construction of schemata and the cognitive resources that are invested. Therefore, increasing germane cognitive load can enhance the learning process. However, these three types of loads are additive and, when the combination exceeds an individual's working memory capacity, learning becomes problematic. Hence, the management of these three loads is important so that a proper balance is achieved, and the implications of CLT are to decrease extraneous and increase germane cognitive load. The specific focus of this proposed research study is to enhance germane cognitive load.

Various methods of improving germane cognitive load have been suggested by researchers. These include creating variability in problem situations to promote the learner's thoughtful engagement and motivation, which improves the

construction of schema and transfer of learning (van Merrienboer and Ayres, 2005). Other suggestions include increasing learner interactions with the learning materials or to self-explain. In addition, van Merrienboer and Sweller (2005) suggest that future research may assess the use of prompts to self-explain or implementing pre-training of elaboration strategies. Zimmerman (2001) cites various theoretical perspectives on self-regulated learning which include key processes such as self-evaluation and self-judgment. This research proposes to enhance germane cognitive load through self-explanations and self-evaluations. To understand the impact of self-explaining and self-evaluating on germane cognitive load and, hence, learning, Social Cognitive Theory is addressed next.

Social Cognitive Theory and Previous Research

Bandura's Social Cognitive Theory (an extension to Social Learning Theory) provides perspectives on human competency and learning (Bandura, 1977, 1986). According to Social Cognitive Theory (SCT), human behavior is driven by the interaction of behavioral, environmental, and cognitive (and other personal) factors. These factors interact as "triadic reciprocal determinants" which, thereby, influence one's competency and behavior. This interaction is influenced by one's self-efficacy, or judgment of one's own abilities.

Therefore, SCT views learning as occurring through various mechanisms, and the interaction of these mechanisms. Individuals can learn by observing the behaviors of other individuals, or vicarious learning. Also, individuals can employ their own cognitive abilities such as symbolizing or creating mental models, using forethought, self-regulation techniques, and self-reflection or self-appraisal. Also, learning can occur through an individual's self-initiated behavior, or enactive learning, in which informative feedback can be obtained. Previous MIS training research has focused on such aspects as observational learning, symbolizing, and self-efficacy, but research has not focused on enhancing self-regulatory mechanisms through self-evaluations and self-explanations.

Bandura (1991) argues that "human behavior is extensively motivated and regulated by the ongoing exercise of self-influence" (p. 248) from the perspective of SCT. The structure of self-regulation consists of three functions: self-observation, self-judgment, and self-reaction. Self-observation entails monitoring one's performance and observing one's own behavior, which provides the knowledge needed to establish goals and monitor one's progression towards achieving these goals. Then, self-judgment involves one's comparison of their performance against a set of personal standards. Finally, self-reaction encompasses one's evaluation of their performance or behavior, which can provide direction and motivation for future behaviors and affects such things as one's satisfaction.

Previous MIS research has applied various aspects of SCT in training and learning computer applications. For example, Compeau and Higgins (1995a) studied the influence of various training styles on self-efficacy, outcome expectations, and subsequent technology-usage performance. The styles studied included a behavioral modeling style, based on SCT (Bandura, 1977, 1986) in which the learner observes the instructor modeling technology usage, versus traditional, lecture-based style. The behavioral modeling style had a positive, significant influence on all variables (self-efficacy, outcome expectations and performance) for individuals learning Lotus 1-2-3, and a significant effect on outcome expectations for individuals learning WordPerfect.

Various research studies have also focused on behavioral and observational modeling, symbolic mental rehearsal techniques, and retention enhancement exercises (Davis and Yi, 2004; Yi and Davis, 2001, 2003). For example, Yi and Davis (2003) studied observational learning processes as posed by SCT (Bandura 1986) by presenting and testing a theoretical model of observational learning. In their study, they introduced a retention enhancement exercise that required the learner to highlight and summarize the main points of the material presented (i.e., symbolic coding). Also, the learners visualized themselves performing the tasks to be learned while rehearsing their summarizations. However, what has not been researched is the introduction of training interventions that enhance individual's self-regulated learning through self-explanations and self-evaluations. Although retention enhancement and self-explanations may maintain some similarities, as noted by Yi and Davis (2001), "There are differences, however. Self-explanation emphasizes verbal rehearsal and elaboration of material, whereas retention enhancement emphasizes the formation, through repetition, of stored mental images of a behavior, and the creation of associated symbolic codes that assist in their retrieval from memory." (p. 539). Hence, self-constructed explanations can be considered a mechanism for developing elaborated understandings, whereas retention enhancement is a mechanism for memory.

Other MIS research has identified the importance and utilization of self-regulatory mechanisms in learning computer applications. Gravill (2004) and Gravill and Compeau (2008) surveyed knowledge workers who participated in a web-based, self-paced software training session to determine, among other things, the use of various self-regulated learning strategies. They found that self-regulated learning strategies were significantly related to learning outcomes (declarative and procedural

knowledge, and self-efficacy) and some of the higher ranked strategies included (Note: the following quotes were cited directly from Gravill (2004, p. 154) and Gravill and Compeau (2008, p. 291)):

> *During this training program, I thought about whether what I was learning would allow me to accomplish specific work tasks.*
>
> *During this training program, I tried to determine which things I didn't understand well and adjusted my learning strategies accordingly.*
>
> *During this training program, I tried to monitor closely the area where I needed the most improvement.*
>
> *If I got confused during this training program, I made sure I sorted it out as soon as I could before moving on.*
>
> *When I practiced a new skill in this training program, I monitored how well I was learning its requirements.*
>
> *During this training program, I thought carefully about how well I had learned material I had previously studied.*

Based on the survey results, one may construe that these individuals were conducting self-regulated learning activities such as self-explanations and self-evaluations. For example, "I tried to determine the things I didn't understand well and adjusted my learning strategies accordingly." (Gravill, 2004, p. 154). However, research has not specifically explored this aspect and can only speculate. Therefore, conducting an experiment to determine the effects of prompting individuals to self-regulate their learning, through such mechanisms as self-explanations and self-evaluations, and its resulting impact on performance is warranted.

Self-regulated Learning

Social Cognitive Theory supports the assertions presented earlier that improvements in germane cognitive load (as explained by Cognitive Load Theory) can potentially be achieved through applying self-regulated mechanisms such as self-explanations and self-evaluations. Schunk (2001) addresses self-regulated learning from the perspective of Social Cognitive Theory and defines self-regulated learning as "the learning that results from students' self-generated thoughts and behaviors that are systematically oriented toward the attainment of their learning goals" (p. 125). He cites Zimmerman's (1998) three-phase self-regulation model which depicts three phases that occur during self-regulation: forethought, performance control, and self-reflection. Forethought encompasses setting goals and social modeling. Performance control entails social comparisons, attributional feedback, as well as strategy instruction and self-verbalizations. Self-reflection includes self-evaluation and self-monitoring. This research study proposes to focus specifically on self-explanation and self-evaluation.

Self-Explanation

Social Cognitive Theory suggests that one form of learning can occur from observational learning (Bandura, 1986). Through observations, an individual can establish their own set of rules and knowledge that can be used to guide future actions. One example is abstract modeling in which an individual can learn a generalizable set of rules or principles that can later be applied in novel settings. The processes that are encompassed include extracting the relevant attributes, generating a composite rule, and then applying the rule to new situations. Therefore, once presented certain foundational principles, learners can be tested by providing conditions in which these principles can be applied to novel problems that are different enough such that the principles cannot simply be reiterated or imitated. Bandura also suggests that, "modeling combined with rule verbalization is usually more effective than either alone in promoting rule-governed behavior" (1986, pg. 101).

Previous research has demonstrated that self-explanations, operationalized as self-verbalizations, of self-regulatory strategies can support learning. For example, Schunk (1982) and Schunk and Cox (1986) found that children who self-constructed verbalizations of strategies were more highly motivated, performed better at a given task, and had greater levels of self-efficacy. Crippen and Earl (2007) have demonstrated that in the domain of chemistry, college undergraduates utilizing completed examples and self-explanations to solve problems in a Web-based environment improved performance and self-efficacy. Based on the implications of SCT and previous research, the following hypothesis is derived.

H1: Learning outcomes are increased when users are prompted to utilize self-explanation strategies.

Self-Evaluation

In Bandura's discussion of Social Cognitive Theory, he acknowledges that self-regulation plays a key role in influencing the behavior of individuals. In particular, individuals react to or are regulated by their self-evaluations (Bandura, 1986). Self-

evaluations are based on sets of personal standards that have been internally adopted. Individuals will then assess their performance against these pre-determined standards. This process then prompts self-reactions which thereby influences an individual's future behaviors as well as provides motivation for it. Essentially, this self-evaluation process acts as "personal guidance system for action." (Bandura, 1986, p. 354).

Previous research has demonstrated the influence that self-evaluations can have on learning performance (Schunk, 2003). For example, Schunk cites Graham and Harris (1989) research in which students were taught writing strategies along with self-monitoring and self-evaluation techniques and found improvements in performance. Hence, he advocates that factors such as modeling and self-evaluation affect learning and self-efficacy. However, some learners do not spontaneously self-evaluate their learning. Therefore, he suggests that instructors prompt such techniques. Bandura and Cervone (1983) demonstrated that goal-setting can have a significant influence on performance effort through a combination of personal standards and knowledge of performance. They argue that effective self-evaluation requires internalized standards as well as knowledge of one's performance. Therefore, based on the SCT and previous research of the learning effects of self-evaluation techniques, we hypothesize that:

H2: Learning outcomes are increased when users are prompted to utilize self-evaluation strategies.

Both Self-Explanation and Self-Evaluation

In summary, based on Cognitive Load Theory, germane load (one's cognitive processes) influences working memory's ability to process information, or one's ability to learn. Social Cognitive Theory suggests that learning occurs through various mechanisms, including individual cognitive factors such as self-regulated learning. Hence, improving germane load through such techniques as self-regulated learning (specifically, self-explanation and self-evaluation techniques) can improve learning outcomes. Considering the improvements in learning outcomes that can be derived from each technique as described above, we expect improvement in learning outcomes to be further improved when both techniques are utilized. Therefore, the following hypothesis is proposed:

H3: Learning outcomes are increased when users are prompted to utilize both self-explanation and self-evaluation strategies than with just one strategy or no strategy.

RESEARCH METHOD

For this research study, a 2 x 2 experimental design is proposed (see Table 1). The subjects are to learn to use specific functions of Microsoft Access and will receive either an intervention for performing self-explanations during training, an intervention for performing self-evaluations during training, an intervention for both self-explanations and self-evaluations during training, or no interventions at all (control group). Each subject will be randomly assigned to one of the four conditions.

Self-Explanation only	Both Self-Explanation and Self-Evaluation
Neither Self-Explanation and Self-Evaluation	Self-Evaluation only

Table 1. Treatment Conditions

In the pre-experiment, subjects will complete a demographic questionnaire that includes assessments of their computer self-efficacy. Based on the experimental assignment, they then receive either training for self-constructed explanations, training for self-evaluations, training for both self-constructed explanations and self-evaluations, or a brief history of the software they are about to learn. Next, they participate in the Microsoft Access training based on the intervention assigned to them. In the post-experiment, subjects complete a quiz (to measure declarative knowledge), a set of exercises (to measure procedural knowledge), and a final questionnaire (measuring such variables as self-efficacy and motivation to learn as well as performing manipulation checks for use of self-evaluation and self-explanation techniques). Quiz questions and exercises will be adopted from a well-known database management textbook that are not used by the students in their classes. Analysis of the effects of the training interventions will be assessed using factorial ANOVA.

Subjects

Students from Introduction to Management Information Systems classes will be recruited who have no experience with advanced Microsoft Access functions (e.g., running queries requiring joining tables). All students will earn extra credit for

participating in the activity. To provide incentives to learn and perform well in the exercises, all students earning a grade of 70% or better on both the quiz and procedural exercises will be entered into a pool to win a $50 cash prize.

Procedures and Measures

The experimental conditions will entail subjects either writing their self-constructed explanations, writing their self-evaluations, conducting both, or performing neither. For the self-explanations intervention, subjects will be asked to consider applying what they have just learned to other problems or contexts (e.g., students may be asked to consider what they have just learned and how they would use this knowledge to solve a unique problem). Hence, the students will be asked to not just memorize or rehearse what they have learned, but to consider its use in a novel situation. Students in the self-evaluation conditions will be asked to evaluate their comprehension of the material and their ability to apply this knowledge to a task to be completed at the end of the training session. Therefore, self-explanation prompts students to consider what they have just learned and how they would use this knowledge to complete a novel task or apply this knowledge to answer a unique problem. Self-evaluation, on the other hand, prompts students to rate themselves on their ability to apply this knowledge on a future task. Hence, self-explanation focuses on elaboration whereas self-evaluation focuses on judging one's knowledge.

Before sessions begin, the subjects will be given instructions on how to perform self-explanation and self-evaluation techniques and given 5 minutes to practice. The quizzes and exercises will entail activities that are based on the skills just learned, but applied in a novel context. For example, subjects will be taught how to run a query involving multiple tables, but the exercise will ask them to provide an answer to a specific question (e.g., the number of customers who purchased a given item on a given date in which the information needed is located in several tables) such that the former knowledge needs to be transferred to the current, novel problem.

To ensure consistency in the amount of time between training and conditions, individuals in the control session will be given a brief history of Microsoft Access. Students in each session will be instructed not to discuss any of the materials they learn with other students. They will also be asked to complete a short questionnaire in which measures of computer self-efficacy, motivation to learn, previous computer/software experience, prior database knowledge, familiarity with Microsoft Access, GPA, year in school, and age will be gathered.

Microsoft Access training will be administered through the instructors utilizing a piloted script. Although many functions of Microsoft Access exist, only certain modules will be selected in order that actual training time will not exceed 45 minutes. Also, the functions that will be taught will be those that students are least likely to have encountered in any introductory business computing course. Microsoft Access was chosen for this experiment because most undergraduate business majors should be novices to this software and because of the derived value of knowing how to utilize this software that the subjects may find throughout their college experience and future career paths. The data collected for those with prior knowledge (i.e., knowledge of the functions that will be taught) of Microsoft Access will be excluded.

After the training is completed, subjects will be asked to complete a quiz which will entail answering questions to measure declarative knowledge and then to complete a series of exercises to measure procedural knowledge within a pre-specified amount of time. Upon completion of the exercises, the subjects will be asked to complete another questionnaire to measure self-efficacy for their declarative and procedural knowledge (separately), satisfaction with the training interventions on self-constructed explanations and self-evaluations, satisfaction with the Microsoft Access training, need for cognition, and motivation to learn. They will also be asked about their perceptions of the training interventions for the self-constructed explanations, self-evaluations, and Microsoft Access training, including level of difficulty, level of interest, ability to learn, learning performance, usefulness, ease of use, and intentions to utilize the self-regulated learning strategies and Microsoft Access in the future.

Grading will be completed by two experienced Microsoft Access instructors/users, and inter-rater reliabilities will be assessed. Students achieving 70% or better will have their names subsequently entered into a pool. One individual's name will be drawn and delivered a cash prize of $50.

CONCLUSION

In summary, challenges in utilizing information systems remain for many individuals. Being unable to fully realize the potential of IS can reduce efficiencies and effectiveness, and may result in foregone competitive advantages being realized. Therefore, this research study proposes to improve germane cognitive load, or the learning process itself as described by Cognitive Load Theory, through interventions of self-regulated learning strategies and draws on Social Cognitive Theory and the self-regulated learning literature to do so. Specifically, this research incorporates mechanisms to prompt individuals learning Microsoft Access to self-explain and self-evaluate, and assess the impact on learning outcomes. Learning outcomes

will include assessments of declarative knowledge, procedural knowledge, and self-efficacy for both declarative as well as procedural knowledge.

The results of this study will then provide guidance as to potential pre-training interventions that may be utilized by practitioners. These interventions may assist learners in utilizing self-regulating learning mechanisms that could lead to better learning outcomes and, ultimately, more effective utilization of new software and technologies. Hence, the interventions focus on implementing strategies to assist in achieving the greatest potential from IS use versus just being able to "push buttons."

This study will provide implications for research by applying Social Cognitive Theory, specifically self-regulated learning strategies that consist of self-evaluation and self-explanations, in an IS context. Therefore, the results will build upon previous research in which other mechanisms (e.g., retention enhancement) have been studied and focuses on developing highly competent IS users who have more elaborated understandings. Also, this research study views the issues of learning to utilize an IS in a greater capacity through a unique lens of Cognitive Load Theory, specifically germane cognitive load.

This study will also provide guidance for future research regarding specific aspects of self-regulated learning strategies in an IS context. Future research can test the generalizability of these findings in other contexts, which could be considered a limitation of the current research considering only Microsoft Access was utilized.

Overall, the results may provide interesting insights into the utility of self-regulated learning mechanisms that include self-explanations and self-evaluations in an IS context. Therefore, challenges that may exist today for some to fully utilize an IS may be improved upon through these techniques.

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