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Computer based learning systems and the development of computer self-efficacy: Are all sources of efficacy created equal?

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ABSTRACT

The use of computer-based learning (CBL) systems by information systems educators is rapidly growing. While improvements in student computer skills test results have been attributed to the use of such systems, little is known about the theoretical mechanisms that may be contributing to such improvements, or whether all students benefit equally from all CBL system training features. In this study, we explore self-efficacy theory as a framework for understanding how CBL systems influence student computer performance. More specifically, we examine the effectiveness of CBL systems in raising efficacy beliefs via two sources of efficacy information - enactive mastery and vicarious experience. Preliminary results revealed that students with lower initial specific computer self-efficacy (SCSE) beliefs benefited more from vicarious learning features that demonstrated concepts, whereas those with higher initial SCSE beliefs benefited more from enactive mastery features in which they could experiment on their own. Moreover, post training SCSE judgments were significantly related to computer skills testing scores. Based on our findings, educators can more precisely match CBL features with student demographics such as initial SCSE perceptions, and in turn, improve downstream student computer skills testing performance.

Keywords

Computer-based learning, computer self-efficacy, computer performance

INTRODUCTION

Computer based learning (CBL) systems, such as McGraw-Hill's SIMNET¹ and Prentice Hall's TAIT², are now being utilized extensively by universities across the country. Such systems provide information technology educators with the ability to deliver interactive computer based instruction for a variety of application software packages, including the Microsoft Office suite. CBL systems assist instructors through the provision of a self-guided learning environment in which students can learn a given software application at their own pace, using their own learning style (Kegely 2006). Many beneficial results associated with the use of CBL systems have been reported (Kegely 2006, Limkilde and Irvine 2006), including improvements in computer skills testing results, and increased student satisfaction.

While such reports are encouraging, relatively little is known about the theoretical mechanisms that explain the manner in which CBL systems facilitate these performance improvements, thus limiting our ability to leverage such systems in the most effective manner. One theoretical framework that may be useful for helping us better understand such mechanisms, is Bandura's (1986; 1997) self-efficacy theory, given the conceptual overlap between CBL system features and the sources of self-efficacy information as suggested by self-efficacy theory. For example, features that allow students to master topics or

¹ SIMNET is a registered trademark of McGraw-Hill

² TAIT is a registered trademark of Prentice-Hall

skills are consistent with enactive mastery information, whereas features that demonstrate topics and skills are consistent with vicarious experience information.

In the current study, we investigate the relative effectiveness of specific CBL features in delivering self-efficacy building information, and in turn, the influence of the resultant self-efficacy on downstream student computer skills performance. As a product of our investigation, we contribute to the information technology education literature in several ways. First, we empirically examine the effectiveness of CBL systems training on student computer skills testing performance. Second, we propose and test self-efficacy theory as a framework for explaining why CBL systems may positively influence student computer skills testing results. Third, we relate CBL system features with two prominent sources of self-efficacy information, as suggested by theory. Finally, we examine the role of initial computer self-efficacy beliefs on the use and/or effectiveness of CBL system features.

This paper is structured as follows. First, we provide a theory development section in which we discuss the relevant literature supporting our hypotheses. Next, a methodology section is presented, including a discussion of our analyses and results. Finally, we provide a review of our findings, discuss the study's limitations, and explore potential future research in this area.

Theory Development

Self-Efficacy Theory

Self-efficacy is defined as “a belief in one’s capability to organize and execute the courses of action required to produce given attainments” Bandura (1997, p 3). People’s beliefs in their efficacy have been known to influence the actions they pursue, the effort they put forth, their persistence against repeated failure, and control of their cognitive functioning, such as control over self-debilitating thoughts (Bandura 1997). Because of the influence on these and other factors, self-efficacy has been shown to influence individual performance in a multitude of areas including education (Collins 1982), sports (Bandura 1997), organizational management (Betz and Fitzgerald 1981), and information systems (Compeau and Higgins 1995).

Self-efficacy beliefs are also known to vary along the dimensions of generality, strength, and magnitude. Generality reflects the level of abstraction, or specificity, to which an efficacy belief pertains. Thus, general self-efficacy, a measure of a person’s belief in his or her ability across multiple tasks and achievement domains (Chen, Gully, Whiteman and Kilcullen 2000), represents an efficacy belief that spans a broad range of capabilities. Conversely, an efficacy belief focused on a specific situation or task would be considered to be low in generality (Hardin, Fuller and Valacich 2006) because it targets a particular capability. Variations in efficacy strength reflect a person’s conviction about completing a given task (Marakas, Yi and Johnson 1998), while magnitude reflects the varying level of difficulty inherent in the task to be performed (Bandura 1997, Bandura 2005) In the current study, we are interested in predicting results associated with the assessment of skills using the MS Excel software application. Thus, the self-efficacy belief must be operationalized as specific in terms of generality (Johnson and Marakas 2000, Marakas, et al. 1998), as it focuses on capabilities pertaining to a particular application. Therefore, we conceptualize self-efficacy judgments related to Excel as a form of specific computer self efficacy (SCSE), which is defined as “an individual's perception of efficacy in performing specific computer-related tasks within the domain of general computing” (Marakas, et al. 1998).

While the influence of self-efficacy on behavior and performance is well documented, much less is known about the specific mechanisms that lead to the development of efficacy beliefs in computing contexts (Marakas, et al. 1998). The factors of enactive mastery, vicarious experience, verbal persuasion, and physiological or affective states are generally considered as antecedents to the development of efficacy beliefs (as depicted in Figure 1). Enactive mastery is proposed to be the strongest of the sources of efficacy information (Bandura 1997, Pajares 2004) and is gained through the prior performance of a given task, including activities like hands on training. Vicarious learning is delivered through behavioral modeling training in which training information is provided through the observation of an individual demonstrating a specific task or skill. Verbal persuasion information is delivered through verbal cues, and is often associated with the provision of performance feedback. Finally, physiological states provide information through cues such as muscle pain (during physical activities), while affective states information is provide by cognitive states such as computer anxiety. These sources of information are then combined during an cognitive integration process and used for the development of self-efficacy perceptions (Bandura 1997).

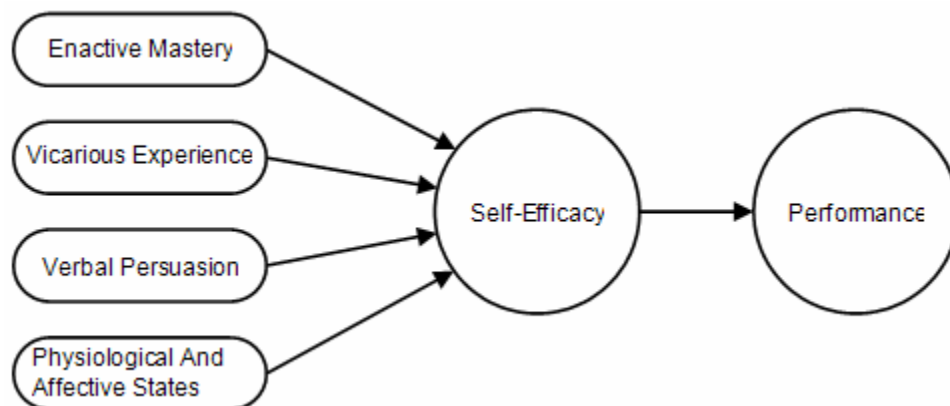


Figure 1. Self-Efficacy Theory—adapted from (Staples, Hulland and Higgins 1999)

Human and Computer Sources

To date, self-efficacy theory has been developed and studied in terms of human-based sources of efficacy information. However, there is reason to believe that training delivered by computerized sources, such as CBL systems, will influence self-efficacy beliefs in a manner similar to training led by human facilitators. The theoretical concept of anthropomorphism—or the attribution of human characteristics to inanimate objects—may help to provide a theoretical explanation for this phenomenon. Previous research has revealed that human characteristics are often attributed to technology by users (Kiesler and Sproull 1997, Reeves and Nass 2002). Additionally, decision making research indicates that decision makers tend to trust information delivered by technology and humans to a similar extent (Jain and Bisantz 2000). Compared to training delivered by human facilitations, we should therefore expect CBL delivered training to affect students in a similar fashion.

Sources of efficacy delivered by CBL tools

Efficacy theory proposes enactive mastery information as the strongest source of efficacy building information (Bandura 1997, Pajares 2004). However, it is reasonable to expect that in some cases a requisite level of efficacy may be necessary before an enactive mastery based task will be undertaken and/or benefited from (Gist, Shwoerer and Rosen 1989). In the current context for example, enactive mastery based “let me try” and “practice exam” features require students to complete exercises on their own without the CBL system’s guidance. Such trial and error activities may require students to have a sufficient level of SCSE before feeling confident enough to use the feature and therefore we should expect to find that those with higher initial SCSE will report high use of the “let me try” feature while those with lower initial SCSE will report low use. In addition, we should also expect that those with higher initial SCSE will take advantage of the one time opportunity to use the “practice exam” feature while those with lower initial efficacy will not. Thus we propose:

Hypothesis 1: Students with higher initial SCSE will report high use of the “let me try” feature while students with lower initial SCSE will report low use

Hypothesis 2: Students with higher initial SCSE will report using the practice exam feature while those with lower initial SCSE will not

CBL systems provide features that enable users to experience enactive mastery and vicarious learning, and because of this, should build on an individual’s initial perceptions of SCSE in a manner consistent with self-efficacy theory. For example, features such as “let me try” and “practice exam” allow students to test their mastery and therefore gain enactive mastery based efficacy building information. For the “let me try” feature, unlimited opportunities to interact with the CBL system are provided, while the practice exam feature permits a one time test of the skills learned as part of the training. Because the “let me try” and “practice exam” CBL system features provide information in a manner similar to enactive mastery information, and enactive mastery has been established to have a strong influence on SCSE, we propose that higher use of such features will have a greater influence on SCSE.

Hypothesis 3: High use of the “let me try” feature will result in a greater increase in SCSE than low use.

Hypothesis 4: Using the “practice exam” feature will result in a greater increase in SCSE than not using the feature.

Contrary to the enactive mastery based “let me try” and “practice exam” features, vicarious based features such as “teach me” and “show me” should not require a requisite level of SCSE before being utilized. This is due in part to the ability of vicarious based features to deliver skill building information without the need for the student to complete an exercise on her/his own. Because of this, we should expect that vicarious experience based features may be particularly suitable for students with lower initial levels of SCSE. Providing further support for this reasoning, some efficacy researchers have suggested that in concurrence with findings reported in the self-esteem literature, individuals with low initial efficacy may prefer vicarious based training as it allows them to focus blame for any failures on external sources rather than on themselves (Gist, et al. 1989). In the case of the current context, for example, students can fault the CBL system rather than faulting themselves for failing to properly complete a given task or exercise. For those with higher levels of initial efficacy on the other hand, the motivation should be to use the enactive mastery based features as discussed above, and thus use the vicarious experience based features less. Therefore we propose:

Hypothesis 5: Students with lower initial SCSE will report high use of the “teach me” feature while students with higher initial SCSE will report low use

Hypothesis 6: Students with lower initial SCSE will report high use of the “show me” feature while students with higher initial SCSE will report low

Vicarious experience is delivered by the SIMNET system through the “teach me” and “show me” features. Using the “teach me” feature, students experience modeling training through the observation of CBL system features which demonstrate computer skills using callouts and textual information. Likewise, the “show me” feature demonstrates computer concepts and skills using a combination of animation and narration that allow students to observe the system. Specifically, students are provided with training that is similar to what they would encounter in traditional human facilitated modeling based training sessions. As was the case with the “let me try” feature, both the “teach me” and “show me” features are available for unlimited use by the students and therefore the more these features are utilized, the more vicarious experience information is gained. Based on the ability of these features to deliver vicarious experience information, and the literature establishing a relationship between vicarious experience and SCSE we propose that higher use of these features will have a greater influence on SCSE. Thus:

Hypothesis 7: High use of the “teach me” feature will result in a greater increase in SCSE than low use.

Hypothesis 8: High use of the “show me” feature will result in a greater increase in SCSE than low use.

SCSE has been shown to be predictive of application specific computer performance (Compeau and Higgins 1995), including the Microsoft Excel application (Johnson and Marakas 2000). While SCSE has been shown to positively influence performance, it has also been argued that efficacy measured most closely to the performance of a given task is often the most predictive (Bandura 1997). Such an effect is due to the malleable nature of efficacy, especially in those situations where individuals have little or no experience with the task to be completed (Gist, et al. 1989). Therefore, we propose that SCSE measured prior to the CBL system training although predictive of Excel skill assessment scores initially, will no longer be predictive once post-training SCSE is entered into the regression equation. Such a relationship is important in supporting our theoretical explanation of why CBL systems positively influence computer skills testing results. Specifically, our theoretical explanation requires that any changes in efficacy beliefs due to the CBL system training should be more predictive of computer performance than pre-training efficacy. Therefore we propose the following hypotheses:

Hypothesis 9: Both pre and post training SCSE will be positively related to computer skills testing scores.

Hypothesis 10: Any direct effect of pre training SCSE on computer skills testing scores will be mediated by post training SCSE.

Methodology

Sample

One-hundred sixty-two students enrolled in an introduction to information systems course at a large Northwestern university participated in the study. Students were engaged with the CBL system as their sole means of learning the software skills assessed as part of the course. Surveys were administered both pre and post CBL training.

Measures

As our focus of interest in the current study is Excel performance, SCSE was measured using the previously validated SCSE measure developed by Johnson and Marakas (2000). The response format for the SCSE measure required a two part question typical of efficacy measures (Bandura 2005). In the first part, students were asked whether they felt capable of completing a specific task or skill using a yes/no response format. In the case of a yes response, students were then asked how confident they were that they could complete the task or skill on a 10 point scale ranging from Not at all Confident (10) to Totally Confident (100). Cronbach's alpha for the SCSE measure was .94 for the pre-training survey, and .96 for the post-training survey. The use of the CBL systems tools was measured by asking students how often they used a specific feature, using a 7 point Likert-type scale ranging from Never (1) to Very Often (7). Consistent with previous research (Valacich, Jung and Looney 2006), we divided the responses into dichotomous categories, where 1 to 4 were coded as low use and 5 to 7 were coded as high use. For the practice exam feature, a simple yes or no response was used due to the feature's limited one-time availability during the CBL system training. Finally, performance was measured using the Excel skills test scores.

Analysis

Preliminary analyses are focused on the mean differences in pre and post training SCSE for students reporting low or high use of a specific feature. Results are presented graphically in the appendix to provide for additional clarity. More in-depth analyses are currently underway and will be completed prior to the AMCIS conference.

Paired sample t-tests were used to test for within subject differences in pre and post training SCSE. Independent sample t-tests were used to test for between subject differences in SCSE for students reporting low or high use of a specific CBL feature. Independent t-tests were also used to compare differences in initial levels of SCSE across the high and low use categories. Finally, regression analyses were conducted to test the affect of SCSE on student assessment scores, both with and without pre-test SCSE included in the regression equation.

Results

Results from our preliminary analyses show an overall trend towards support of our hypotheses. However, not all hypotheses were supported as expected.

Hypotheses 1 and 2

The respective mean differences are illustrated in Tables 1 and 2 and graphically represented in Figures 2 and 3. While intriguing, hypotheses 1 and 2 were not supported in the strictest sense. However, upon examining the mean differences it is evident that students reporting higher levels of initial efficacy also reported high use of the "let me try" and "practice exam" features. Although not significant, these results provide circumstantial support for prior research proposing that a sufficient level of efficacy may be necessary before enactive mastery type activities are utilized (Gist et al. 1989).

Hypotheses 3 and 4

The respective mean differences are illustrated in Tables 1 and 2 and graphically represented in Figures 2 and 3. Hypotheses 3 and 4 were again not supported in the strictest sense. The increase in SCSE for students reporting high use of the "let me try" feature is not significantly different than the increase for those reporting low use ($p = .411$). However, by visually examining the means it is evident that those reporting high use of the "let me try feature" did see a greater increase in post-training SCSE. For the practice exam feature, as was the case for the "let me try" feature, the difference in pre and post training SCSE for those reporting high and low use was once again non-significant. However, the between subject difference for those using the practice exam feature is significant at the $p < .05$ level, illustrating that students who report using the practice exam feature experienced a significant increase in post-training SCSE, while those report not using the feature did not.

	Low Use	High Use	Significance
SCSE T1	583.33	618.60	p = .425
SCSE T2	594.38	654.47	
Difference	11.05	35.87	p = .411

Table 1: “Let me try” feature results

	No	Yes	Significance
SCSE T1	585.23	616.69	p = .484
SCSE T2	587.27	655.08	
Difference	2.05	38.39	p = .260
Significance	p = .94	p = .037*	

Table 2: Practice exam feature results

*p < .05

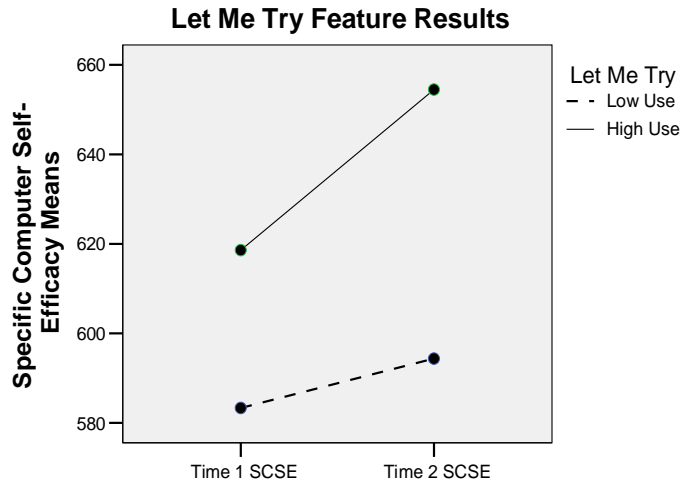


Figure 2: Graphical results of the “let me try” feature usage

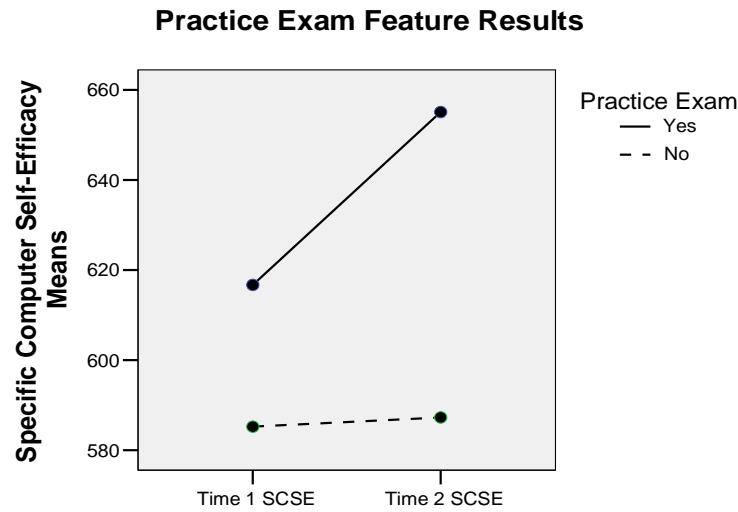


Figure 3: Graphical results of the practice exam feature usage

Hypothesis 5 and 6

The respective mean differences are illustrated in Tables 3 and 4 and graphically represented in Figures 4 and 5. Hypotheses 5 and 6 were supported. Students with lower initial SCSE reported high use of the vicarious based tools. Such a finding may indicate that vicarious experience based CBL features may be more attractive for students with lower levels of initial SCSE and is consistent with previous findings reported in the efficacy literature.

Hypothesis 7 and 8

The respective mean differences are illustrated in Tables 3 and 4 and graphically represented in Figures 4 and 5. Hypotheses 6 and 7 were also supported. High use of the “teach me” and “show me” features resulted in significantly greater increases in SCSE beliefs than for low use. In addition, students reporting high use of the “show me” feature realized a significant increase in their post-training SCSE perceptions.

	Low Use	High Use	Significance
SCSE T1	633.60	552.75	p = .037
SCSE T2	650.00	607.65	
Difference	16.40	54.90	p = .01*
Significance	P = .28	p = .11	

Table 3: “Teach me” feature results

*p < .05

	Low Use	High Use	Significance
SCSE T1	640.79	554.10	$p = .026$
SCSE T2	639.31	632.30	
Difference	-1.49	78.20	$p = .019^*$
Significance	$P = .92$	$p = .01^*$	

Table 4: "Show me" feature results

* $p < .05$



Figure 4: Graphical results of the "teach me" feature usage

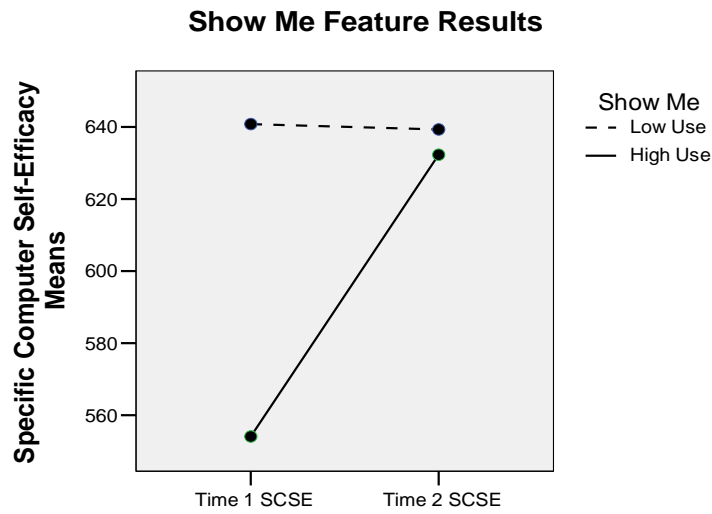


Figure 5: Graphical results of the "show me" feature usage

Hypothesis 9 and 10

Table 5 shows the regression results associated with the tests of hypotheses 9 and 10. Both hypotheses were supported. As predicted by efficacy theory, both pre and post training SCSE were related to student computer assessment scores. Further, and again consistent with efficacy theory, any affect of pre-training SCSE was no longer present once post CBL training SCSE was entered into the regression equation. This finding demonstrates that the SCSE measured most proximally to the behavior in question was more predictive and provides support for the theoretical premise of our study.

	Beta	Significance
SCSE T1	0.247	p = .002*
SCSE T2	0.429	p = .000**
SCSE T1 w/ CSE T2 included	-0.057	p = .549
SCSE T2 w/ CSE T1 included	0.466	p = .000**

Table 5: Regression results

* p < .05

** p < .001

Discussion

This research makes several contributions to the IT in education literature. First, we empirically examined the effectiveness of CBL systems training on student computer skills testing performance. Second, we proposed and tested self-efficacy theory as a framework for explaining why CBL systems may positively influence student computer skills testing results. Third, we related CBL system features with two prominent sources of self-efficacy information, as suggested by theory. Finally, we examined the role of initial computer self-efficacy beliefs on the use and/or effectiveness of CBL system features.

Our first contribution provides empirical support for the effectiveness of CBL systems based training on student computer skills testing results. Previously reported improvements in student computer skills testing results have generally been based on a comparison of different students across different semesters. While valuable, these reports do not establish the effectiveness of CBL systems for improving computer skills testing results for a single class of students during the course of a semester. Using self-efficacy theory as a framework however, we were able to establish just that. Specifically, students using the CBL system experienced an increase in their SCSE beliefs over the course of the training. In turn, students higher post training SCSE beliefs were then established to be more predictive of computer skills testing results than were pre-training SCSE beliefs.

Our second contribution addresses the question; what theoretical mechanisms may be responsible for the influence of CBL systems on computer skills assessment? Based on our results as explained above, it appears that the influence of CBL system features on student SCSE perceptions, and in turn the influence of the post-training SCSE perceptions on computer skills testing outcomes, may provide one possible explanation for this influence.

Regarding our third contribution, our results suggest that CBL system features may be capable of delivering the sources of self-efficacy information associated with efficacy theory. Previous research in the area of anthropomorphism helps to explain these findings. Specifically, previous research finding that human characteristics are often attributed to technology, and the treating of technology delivered information as equal to that delivered by human sources, provides support for our finding that the CBL system features of “let me try”, “practice exam”, “teach me”, and “show me” increase efficacy beliefs in a manner similar to human facilitated training.

Our final contribution is unquestionably the most important. Our findings show that all self-efficacy sources are not equally effective for all students. While the inequality of self-efficacy sources in terms of importance has been discussed by Bandura (1997), the previous consensus has been that enactive mastery provides the strongest form of efficacy building information (Bandura 1997, Pajares 2004). Our results seem to conflict with this reasoning. Specifically, our results show that students with lower initial SCSE beliefs use the vicarious based CBL system tools more often than students high in initial SCSE and also benefit more. While not strictly supported in a statistical sense, mean differences also show that those with higher initial

beliefs use the enactive mastery based features more often than those lower in initial SCSE, and also benefit more. Graphical results in the appendix help to illustrate this affect. Such results provide valuable insights into how CBL systems may be used more effectively by information technology educators.

Limitations and future research

Our study has limitations. First, we were able to assess only one application package delivered by the CBL system, prohibiting us from replicating our results across different software packages. Future research should be designed to replicate our results across more than one software package as initial self-efficacy beliefs may not be consistent across specific applications, meaning that a particular student might find certain CBL features more effective depending on the software package being learned. A second limitation is that our study took place during a typical computer skills course, limiting the control that could have been exerted through the use of a laboratory experiment. Initial SCSE was measured prior to the CBL system training, and the training took place over a period of approximately two weeks, thus allowing for other factors to potentially influence students' time 2 SCSE. However, mitigating this possibility is that the training provided during the two week time span targeted only Excel skills, and that the students were not concurrently enrolled in any other IT specific courses. Third, because we did not manipulate usage, independent t-tests were conducted across categories that varied in terms of their sample size. Thus, a lack of power could be influencing our non-significant findings in some cases. However, the mean differences reported are in the correct direction, and our other hypotheses were supported as theorized. Nonetheless, future research should be designed to replicate our findings in an experimental setting.

Conclusion

This study provided an initial investigation into the viability of CBL systems as tools for improving student performance in the area of information technology education. Using self-efficacy theory as a framework we were able to show the influence of CBL system features on students' SCSE beliefs, which in turn influenced downstream computer skills testing scores. However, our results also revealed that CBL system features affect different individuals in different ways. Armed with this knowledge, information systems educators and researchers alike may be better able to address student learning needs through an initial assessment of SCSE, and the matching of SCSE assessment scores to relevant CBL system features.

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