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ABSTRACT

A popular issue in the 1980’s and early 1990’s, computer self-efficacy (CSE) remains an important area of research. Educators, industry leaders, and government officials argue that the United States is falling behind other countries in technology innovation. And, most attribute this situation to ineffective education in the areas of math, science, and technology. The current study provides insight into these issues by linking math confidence, computer confidence, and CSE. Four hypotheses were tested using data gathered from undergraduate business students in a southern university. The results were significant, suggesting that both Math Confidence and Computer Confidence have a significant effect on CSE, both directly and indirectly. This study extends prior research on CSE by examining the link between Math Confidence and CSE and posits that technology educators may be well-served to consider some of the same techniques and methodologies applied in mathematics education to improve CSE in college students.

Keywords

Computer Self-Efficacy, Computer Confidence, Math Confidence, Structural Equation Modeling

INTRODUCTION

As information technology plays an increasingly important role in both academia and industry, understanding the factors that affect an individual’s decision to use computers and technology continues to be a critical area of investigation among IS researchers. One important construct in this arena is Computer Self-Efficacy (CSE) (Compeau & Higgins, 1995). Derived from the more general construct of self-efficacy and rooted in Social Cognitive Theory (Bandura, 1977, 1986), CSE is defined as a person’s perception of their ability to use a computer in the accomplishment of a task (Compeau & Higgins, 1995). Research has shown that CSE has a direct influence on the likelihood that an individual will use a computer for the completion of tasks (Compeau, Higgins, & Huff, 1999); thus, it is important to continue to explore those constructs and factors that should enhance an individual’s CSE.

A popular area of research in the 1980’s and 1990’s, studies of CSE tended to focus on negative antecedents related to anxiety and CSE (e.g., Harrison & Rainer, 1992; Marakas, Yi, and Johnson, 1998; Compeau et al., 1999). Yet, today’s educators are calling for a focus on building confidence in math, science, and technology, as opposed to simply reducing anxiety (Furner & Berman, 2004). Compeau, et al. (1999) suggest that technology adoption results from ensuring that users have the skills they need to feel confident in their abilities. Of particular interest to the current study is support for math confidence as a significant influence on both computer confidence and CSE. Thus, in light of the growing math, science, and technology education crisis in the United States and the concerns that this crisis may be affecting our nation’s ability to compete in a high-tech world (Furner & Berman, 2004), this study calls for a revival of CSE research. In turn, such research focused on more of the positive antecedents of CSE may help in identifying pedagogy that will greatly enhance CSE in college graduates.

RESEARCH MODEL & HYPOTHESES
Research has found that, in general, anxiety has a negative effect on self-efficacy formation and development (Bandura, 1977; Sarason, 1984). Further, this link between anxiety and its effect on self-efficacy formation is widely accepted in the literature (Kavanagh & Bower, 1985). More specifically, support exists regarding the negative impacts of both computer anxiety and math anxiety on CSE (e.g. Harrison & Rainer, 1992; Marakas et al., 1998). While prior studies have focused primarily on the negative relationships associated with anxiety, Harrison and Rainer (1992) demonstrated support for a significant positive link between computer confidence and CSE. Further, calls have been made for a focus on building confidence in math and technology (National Council of Teachers of Mathematics, 1989; Furner & Berman, 2004), suggesting that one’s attitude will impact both confidence and self-efficacy. The National Council of Teachers of Mathematics emphasized confidence in one’s mathematical abilities as one of five goals of school mathematics curricula (National Council of Teachers of Mathematics, 1989). Thus, this study extends and enhances the body of literature on CSE through a focus on the positive-emotion factors of computer confidence and math confidence. This study posits that by increasing math and computer confidence, CSE should be improved.

Thus, based on Social Cognitive Theory (Bandura, 1977, 1986) and prior research, we propose the following hypotheses:

**H1:** Computer confidence will have a direct, positive influence on Computer Self-Efficacy.

**H2:** Math Confidence will have a direct, positive influence on Computer Self-Efficacy.

Correlational research has demonstrated a positive relationship between computer anxiety and math anxiety (Howard & Smith, 1986; Harrison & Rainer, 1992). In addition, at least one study that utilized path analysis suggested that math anxiety may have a direct causal effect on computer anxiety (Dambrot, Watkins-Malek, et al., 1985; Igbaria & Parasuraman, 1989). These findings are supported by Social Cognitive Theory (Bandura, 1977, 1986) and through research that has demonstrated a person’s perception of their mathematics ability influences their choice of math-oriented courses in school, as well as, their choice of math-oriented careers (Lent, Brown, et al., 1984; Hackett, 1985; Cooper & Robinson, 1991). That is, because mathematics underlies most technical subjects, persons with a low perception of their math ability (i.e. low self-efficacy) have been shown to avoid technical courses involving science and technology (e.g. computing), which in turn impacts their choice of careers (Dew, Galassi, et al., 1984).

Therefore, based on prior research, we offer the following hypotheses:

**H3:** Math confidence will have a direct, positive influence on computer confidence.

**H4:** Math confidence will have a positive influence on computer self-efficacy, partially mediated by computer confidence.

The above hypotheses are summarized in Figure 1, positing that both computer confidence and math confidence will have a direct, positive effect on CSE. In addition, the model posits that math confidence will also have an indirect, positive effect on CSE partially mediated by computer confidence.
METHOD

Participants

The current study engaged a convenience sample of 618 undergraduate upperclassmen in the College of Business at a large southeastern university. One survey was removed due to incomplete data, resulting in a final sample of N=617. The participants were enrolled in one of two required business courses. Selection of participants from these courses provided a reasonable cross-section of upper-level business students within the College of Business. Because the current study examines attitudes, opinions, and approaches to learning in the areas of computing and mathematics, the use of student participants was warranted. Demographic information for the participants is provided in Table 1.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 – 22</td>
<td>528</td>
<td>85.7%</td>
</tr>
<tr>
<td>23 – 42</td>
<td>88</td>
<td>14.3%</td>
</tr>
</tbody>
</table>

Figure 1. Hypothesized Model of Influence of Math Confidence and Computer Confidence on CSE
<table>
<thead>
<tr>
<th>Gender</th>
<th>Male</th>
<th>352</th>
<th>57.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>264</td>
<td>42.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>Sophomore</th>
<th>3</th>
<th>.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Junior</td>
<td>189</td>
<td>30.7%</td>
</tr>
<tr>
<td></td>
<td>Senior</td>
<td>424</td>
<td>68.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major</th>
<th>Business</th>
<th>83</th>
<th>13.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accounting</td>
<td>134</td>
<td>21.8%</td>
</tr>
<tr>
<td></td>
<td>Finance</td>
<td>49</td>
<td>8.0%</td>
</tr>
<tr>
<td></td>
<td>MIS</td>
<td>94</td>
<td>15.3%</td>
</tr>
<tr>
<td></td>
<td>Marketing</td>
<td>167</td>
<td>27.1%</td>
</tr>
<tr>
<td></td>
<td>Economics</td>
<td>2</td>
<td>.3%</td>
</tr>
<tr>
<td></td>
<td>Logistics</td>
<td>21</td>
<td>3.4%</td>
</tr>
<tr>
<td></td>
<td>Entrepreneurship</td>
<td>25</td>
<td>4.1%</td>
</tr>
<tr>
<td></td>
<td>All Other</td>
<td>41</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

Table 1. Demographic Characteristics of Study Participants

**Measurement**

The CSE construct was measured using Compeau and Higgins’ (1995) 10-item scale that asks if an individual could complete an undefined task using an undefined software package. If a response is negative, the individual moves on to the next item. If a response is affirmative, the individual is asked to indicate a level of confidence in their response on a 10-point scale with anchors ranging from 1 (*not at all confident*) to 10 (*totally confident*). The approach of the Compeau-Higgins CSE scale is based on the idea of forcing respondents to think about future behavior rather than past capabilities (Compeau and Higgins 1995). Math Confidence was measured using six positive-emotion items from the Fennema-Sherman Mathematics Anxiety Scale (Fennema and Sherman 1976). Finally, Computer Confidence was measured using nine positive-emotion items from the Computer Anxiety Rating Scale (Heinssen, Glass et al. 1987).

**Model Analysis**

The internal consistency reliabilities for each construct, as measured by Cronbach’s alpha, were well above the minimum level of acceptability of .70 (Hair, Anderson et al. 1992). The covariance matrix and reliabilities are given in Table 2.
Table 2. Covariance Matrix of the Latent Constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CSE</td>
<td>0.91*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Comp Conf</td>
<td>0.107</td>
<td>0.87*</td>
<td></td>
</tr>
<tr>
<td>3. Math Conf</td>
<td>0.092</td>
<td>0.109</td>
<td>0.92*</td>
</tr>
</tbody>
</table>

*Cronbach alpha reliabilities

A number of steps were taken to assess and improve the fit of the measurement model. First, a review of the components in the model revealed that all of the path estimates were positive and significant for the model. The fact that all of the estimates were positive adds support for the hypothesized model and its underlying theory. The significance of the estimates suggests that all of the paths were statistically relevant. Thus, there was no indication that any of the variables should be deleted from the model due to a direct conflict with theory or statistical insignificance. Second, a review of all path coefficients between the latent variables and their respective indicators showed values ranging from 0.499 to 0.871. Therefore, the path coefficients for all of the indicators suggested that they were all providing substantive value in the model relative to the other indicators and that none should be deleted from the model for either empirical or theoretical reasons. Third, the model was tested for dimensionality. The results of this test indicated a significant difference between the chi-square for the original model versus the chi-square for each unidimensional model, thus suggesting that the model does indeed measure three distinct constructs. Finally, as described in the next section, a review of the fit indices offered inconclusive, mixed results with regard to model fit. As such, the suggested modification indices were assessed for theoretical justification.

Although the original model appeared to be theoretically sound, some empirical modifications were necessary to improve the fit of the model. Thus, steps were taken to identify an improved alternative model that would better satisfy the empirical goals of the study, while maintaining the theoretical integrity of the model. Thus, using the modification indices provided by AMOS and the theoretical background of the constructs, we included four covariances between specific item-level error terms to improve the fit of the model.

First, we included a covariance between the error terms for items mconf_04 (I almost never have gotten nervous during a math test) and mconf_05 (I usually have been at ease during math tests). Theoretically, both of these items address the presence or absence of anxiety during a math test; therefore, we would expect these to have similar causes not necessarily represented in the model. Second, we included a covariance between the error terms for items ccse5_03 (I could complete the assignment using the software package if I had only the software manuals for reference) and ccse5_08 (I could complete the assignment using the software package if I had just the built-in help facility for assistance). Theoretically, both of these items address the use of only the reference information provided with the software. In today’s computing environment, many software packages provide both the help facility and the documentation electronically. Thus, we believe responses to these items may have similar causes not represented in the model. Third, we included a covariance between the error terms for items cconf_01 (The challenge of learning about computers is exciting) and cconf_03 (I look forward to using a computer on my job). Theoretically, both of these indicators address a student’s anticipation of using a computer and learning more about computers. Therefore, we may expect the external causes of these items to be similar. Fourth, we included a covariance between the error terms for items cconf_01 (The challenge of learning about computers is exciting) and cconf_05 (If given the opportunity, I would like to learn about and use computers). Theoretically, both of these items address a student’s excitement about learning to use computers. Thus, we would expect that external causes of the students’ responses to these items may be similar.

A comparison of the fit of the original model versus the fit of the final model is presented in Table 3. As shown in the table, the GFI, CFI, NFI, and RMSEA indices for the final model indicated satisfactory fit. In addition, chi-square divided by the degrees of freedom was reasonably close to three, additionally suggesting a satisfactory fit. While the problematic AGFI index was still below 0.9, it was also improved by the modifications and found to be comparable to the value of the GFI index. Thus, the final measurement model was retained.
Table 3. Comparison of Goodness of Fit Indices for Original and Final Models

<table>
<thead>
<tr>
<th></th>
<th>Original Model</th>
<th>Final Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodness of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fit Indexes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.069</td>
<td>(0.065, 0.074)</td>
<td></td>
</tr>
<tr>
<td>90% CI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.058</td>
<td>(0.053, 0.062)</td>
<td></td>
</tr>
</tbody>
</table>

For clarity, the structural model is depicted in Figure 2. Due to the presence of latent factors, we were unable to assess only the structural portion of the full model. However, the structural model was examined for identification. Because no feedback loops were present, all causal effects were unidirectional, and all disturbance terms were uncorrelated, the structural model was determined to be recursive and identified.

![Figure 2. Structural Model](image)

The final hybrid model is presented in Figure 3. Subsequent analysis of the full hybrid model, which incorporates the theoretically supported modifications, revealed essentially no differences in the path estimates when compared to the final measurement model. Goodness of fit indices for the final hybrid model were the same as those for the final measurement model, thus indicating an acceptable fit. Goodness of fit indices for the final hybrid model are shown in Table 4.
RESULTS

The standardized path estimates for the paths between Math Confidence and CSE (0.163), Math Confidence and Computer Confidence (0.174), and Computer Confidence and CSE (0.467) were positive and significant, offering support for hypotheses 1, 2, and 3. These results support prior research that suggests Math Confidence will have a direct and positive effect on Computer Confidence and on CSE. In addition, because theory and research have suggested that there are a number of antecedent and subsequent variables that can affect CSE formation (e.g. Marakas, Yi et al. 1998), it is not unreasonable to expect a relatively small path coefficient between a single antecedent variable, such as Math Confidence, and CSE.

A review of the squared multiple correlations for the final hybrid model indicated that the model explains 27.2% of the variability in CSE and 3% of the variability in Computer Confidence. The relatively small amount of variability
in Computer Confidence explained by the model suggests that while Math Confidence does have a direct and significant impact on Computer Confidence, its impact is comparatively small.

Frazier, Tix, and Brown (2004) define a mediator as “a variable that explains the relation between a predictor and an outcome” (p. 116). Therefore, in the current study, we have suggested that the impact of Math Confidence on CSE may be partially explained by Computer Confidence. To establish support for this mediation effect, we compared the goodness of fit, model components, and model parameters for a model containing mediation and a model containing only direct effects. In both models, all regression weights were found to be significant, suggesting that there is a relationship between Math Confidence and Computer Confidence and Computer Confidence and CSE. Additionally, the relationship between Computer Confidence and CSE was comparable, but slightly larger, than the relationship between Math Confidence and Computer Confidence, suggesting the power of the mediation effect is containing only direct effects. In both models, all regression weights were found to be significant, suggesting that there is a relationship between Math Confidence and Computer Confidence and Computer Confidence and CSE. Additionally, the relationship between Computer Confidence and CSE was comparable, but slightly larger, than the relationship between Math Confidence and Computer Confidence, suggesting the power of the mediation effect is satisfactory (Frazier, Tix et al. 2004). Therefore, hypothesis 4 was supported, suggesting that Computer Confidence does partially mediate the effect of Math Confidence on CSE.

**DISCUSSION**

For academicians and practitioners alike, this study emphasizes the importance of a continued focus on improving CSE as a part of our educational process. From the research perspective, the findings of this study provide additional evidence regarding the influence of mathematics on CSE. Most prior studies have utilized correlational analysis with regression to identify and assess these relationships (e.g. Harrison and Rainer 1992); but no other studies were identified that used SEM to investigate the directionality and influence of mathematics on CSE. Our findings provide supporting evidence for the idea that Math Confidence positively influences CSE directly and indirectly, being partially mediated by Computer Confidence. In addition, the finding that Math Confidence has a direct impact on Computer Confidence adds support for previous findings that suggest Math Anxiety may have a causal effect on Computer Anxiety (Igbaria and Parasuraman 1989).

An important implication for business practice is the recognition that enhancing CSE among potential employees before they enter the workforce may result in savings of both time and money. Because educational institutions offer a primary source of computer education opportunities for persons not yet in the job market, a parallel implication is that higher levels of CSE should be developed among students prior to entering the job market. The use of a student population in this study makes the results especially relevant to the area of university education, which in turn, has a subsequent and direct impact on business practice. A better understanding of the posited relationships among students offers the opportunity for improved interpretation and remediation of student-centered learning barriers in both the domains of mathematics-statistics and computing-technology (Bessant 1997). The immediate result of such improved interpretation and remediation could serve to produce students who are better able to confidently focus on actually learning mathematics-statistics and on using computers to accomplish tasks, rather than having anxiety repeatedly undermine their focus and short-circuit their ability to learn and function (Marakas, Yi et al. 1998). To that end, the link between math confidence and both computer confidence and CSE suggests that some of the same pedagogy and techniques used to build math confidence may be applicable in a university setting for building computer confidence and CSE. For example, perhaps the ideas of math remediation, placement testing, and other similar techniques can be adapted for technology education to ensure that students reach an optimal level of CSE before entering the workforce.

In related research, Wood and Bandura (1989) demonstrated that individuals who have low self-efficacy within the particular demands of their environment tend to focus their concern on their personal ability to perform (i.e. self-diagnostic) rather than showing concern for what they must do to complete the task (i.e. task-diagnostic). Additionally, Tocci and Engelhard (1991) demonstrated that simply mastering the necessary skills is insufficient to ensure confidence and self-efficacy; it is equally important to help students develop a positive attitude toward the subject, e.g. math, science, technology. Skill and attitude should then combine to build a higher level of confidence (Tocci & Engelhard, 1991). Clearly, students who have not established an adequate level of confidence and self-efficacy with computer use can become employees who are less productive due to their self-diagnostic focus. Therefore, addressing and building student confidence with both mathematics and computers at the university level—or even earlier— should lead to students becoming better prepared employees who are able to focus on the business task-at-hand rather than on their fears, concerns, and/or shortcomings.

Finally, it is important to note that CSE is no longer an issue only for industry, but should also be of concern in our colleges and universities. In the 1990’s when Harrison and Rainer (1992) demonstrated a positive link between
computer confidence and CSE, these authors pointed out the problems that low CSE could have on job performance. In turn, these authors identified the potential issues for businesses, including employee training and selection, and the lasting impact to the employee. While these issues are indeed still relevant, equally important is the student’s ability to thrive and succeed in a university setting. Today’s college setting is quite different from that of the early 1990’s. Technology is an integral part of the educational process, with an ever-increasing use of technology for both the delivery and completion of courses across disciplines. Thus, the findings of this study suggest that math confidence, computer confidence, and CSE should be addressed throughout the educational process, both in the K-12 systems and at the university level, to ensure that students are able to achieve a maximum level of computer confidence and CSE.

Limitations

As with any empirical study, the current study has limitations that should be noted. Bias may be present due to the research design, as the study utilized a single method and a single set of respondents. Attempts were made to reduce this possibility by allocating study variables to different sections of the questionnaire. Additionally, as a separate measure of the dependent variable, participants were asked to provide the grade they received in the university-required introductory computer course. Although a self-reported measure with a narrow range of variability, course grade was found to have a low, but positive correlation with CSE ($r = .20$, $p < .01$). Therefore, while recognizing its inherent limitations, the grade received in the computer course could be considered a rough proxy for computer skill or performance, since prior research has demonstrated a strong, positive relationship between CSE and computer skill or performance (Harrison and Rainer 1992; Marakas, Yi et al. 1998). Consequently, the grade served as a limited, secondary measure of CSE, providing a degree of additional support for the validity of the CSE construct as measured by the cross-sectional survey, thereby reducing common method bias and same source bias.

Due to the cross-sectional nature of the data, the study does not address changes in perception or behavior over time. Also, Math Confidence was not measured prior to Computer Confidence or CSE. Therefore, while the analysis does suggest how Math Confidence may influence Computer Confidence and CSE, the study does not attempt to fully establish causal relationships among the latent variables. Finally, the study considers only the affective dimension of the Math and Computer Confidence constructs, while a measure of cognitive influences is not included in the model. However, despite the limitations, the findings of this study provide meaningful implications for research and practice.

CHARTING THE FUTURE OF CSE RESEARCH

Though examined in some detail in the late 1980’s and early 1990’s, CSE remains an important issue for investigation. As educators, industry leaders, and government officials have noted, the United States is in danger of losing competitive advantage in the realm of technology innovation. And, most attribute this situation to ineffective education in the areas of math, science, and technology. The current study lends support to these concerns, through empirical evidence that links math confidence, computer confidence, and CSE. As such, further investigation of methodologies and techniques that will improve student confidence with both math and computers is of the utmost importance. Also, because studies are lacking that have investigated math confidence and its causal relationship to CSE, this study contributes new data and information that additional studies involving CSE can build upon. Finally, in light of more extensive uses of technology in the educational process at all levels, it can be important to gain a better understanding of how students’ CSE may impact the effectiveness of using technology to enhance education.

REFERENCES


