A Longitudinal Investigation of the Effects of Computer Anxiety on Performance in a Computing-Intensive Environment

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ABSTRACT

Computers are pervasive in business and education, and it would be easy to assume that all individuals embrace technology. However, evidence shows that roughly 30 to 40 percent of individuals experience some level of computer anxiety. Many academic programs involve computing-intensive courses, but the actual effects of this exposure on computer anxiety are unknown. This study contributes to the literature as follows. First, direct evidence of a relationship between longitudinal changes in individuals' computer anxiety and performance are reported. Second, the effects of changes in computer anxiety are shown to be dependent on individuals' initial level of anxiety. Third, some evidence is provided that changes in computer anxiety from exposure to a computing-intensive environment are not uniform across individuals. Lastly, the subjects in this study appear to be more representative of contemporary students and workers than those used in prior studies. Implications for research and practice are presented.

Keywords: Computer Anxiety, Computer Anxiety Reduction.

1. INTRODUCTION

The ubiquitous nature of computing in business, government, and education may create a false expectation that all people readily embrace computing technology use. Over the past three decades, the introduction of computers has alternately produced fear and excitement in the workforce (Miles, 1998; Nagata, 2005). Learning to use new technology and adapting business processes to computer systems can create negative reactions (Bouzionelos, 1996; Howard and Smith, 1986; Widhalm, 2004).

Past research suggests that individuals experiencing negative reactions to computing will tend to avoid similar interactions in the future and/or will under-utilize computers (Gos, 1996; Igbaria and Parasuraman, 1989; Rosen, Sears, and Weil, 1987, 1993; Weil and Rosen, 1997; Weil, Rosen, and Wugalter, 1990). For college students, avoiding degree programs that require computer use will dramatically limit the occupational paths of future business leaders (Havelka, Beasley and Broome, 2004). In a dynamic, global economy that continues to rely upon the use and integration of computing technology in everyday life and ongoing commerce, such human avoidance and under-utilization trends portend great difficulties ahead. Although the debate continues within academia regarding what constitutes basic computer literacy, most higher education curricula expect a basic level of computer and software literacy. Some universities include entry level, skills-based courses; others require student self-study and/or tutorials; still others require this as entrance or admission to the academic program (see Keeler and Anson, 1995; McDonald, 2004; Mykytyn, 2007; Panell, 2005). The purpose of a university's computer literacy requirement is to provide students with the computing skills and knowledge necessary to succeed in upper-level courses and professional careers. However, research suggests that learners with negative psychological reactions to computing technology will not perform as well as others with more positive reactions (Maurer, 1994; Weil, Rosen, and Sears, 1987). In the best case scenario, the negative psychological reactions may only interfere with the mastery of the topical material in a particular course. In the worst case scenario, these reactions may hinder an individual's choice of occupation or performance in actual work assignments (Havelka, Beasley and Broome, 2004). In either case, individuals react to computer experiences and then make choices about future computer use based on these experienced reaions. Therefore, it is important that educators gain a better understanding of how an individual's changing reactions influence the person's performance. This understanding is particularly relevant for individual success in computing-intensive courses.

The purpose of this study is to investigate the effects of extended exposure to a computing-intensive environment on computer anxiety and performance. Specifically, this study investigates changes in individuals' level of computer anxiety, the association of those changes with performance, and whether those effects are uniform across individuals. Prior research has not directly addressed the question of whether, in the absence of an intervention, exposure to a computing-intensive learning environment impacts individuals' levels of computer anxiety in a manner related to performance (c.f. Keeler and Anson, 1995). If computer exposure alone impacts anxiety, then the use of costly (in terms of either monetary expense or time investment) interventions may be unnecessary. In addition, much of the computer anxiety literature, including the only study to measure changes in anxiety (Keeler and Anson, 1995), involved the use of subjects who had limited previous exposure to computing technology. A decade later, it is common for contemporary students to report extensive exposure to computing technology, both in formal educational settings and in home use.

The paper is organized as follows: A discussion of the theoretical foundations and hypotheses are presented. Methods of the survey data collection and results analysis are then provided. The remaining sections address conclusions and implications for academics and managers.

2. THEORETICAL BACKGROUND

This study contributes to the understanding of the impact of computer anxiety in computing-intensive educational or training situations, especially those situations that extend over a significant period of time and mandate use of computing technology. A computer-intensive situation is characterized by a significant amount (greater than 50%) of exercises and assignments requiring the use of computer software and hardware (e.g., analyzing data using spreadsheets or developing a small program to capture, access, and utilize data) and evaluation of computer concept knowledge. Educational or training situations that require computing technology use can be perceived differently by learners than those situations where computing technology use is voluntary (see Venkatesh et al., 2003). Thus, it is important to understand how learner performance in such environments is affected by longitudinal use of computing technology.

Information systems adoption and diffusion research indicates that individual factors (such as psychological states, perceptions, and beliefs) can influence an individual's decision to use, manner of using, and outcomes from using information technology (Agarwal and Karahanna, 2000; Thatcher and Perrewé, 2002; Venkatesh, et al., 2003). Computer anxiety is an important individual factor to examine in a computing-intensive situation, especially in extended use situations such as a computing literacy course.

2.1 Computer Anxiety

Information systems research defines computer anxiety as "the tendency of individuals to be uneasy, apprehensive, or fearful about current or future use of computers" (Igbaria and Parasuraman, 1989, p. 375). This construct has been investigated in the context of correlations with other individual factors (Maurer, 1994) and has also been identified as a reciprocal determinant of computer self-efficacy (Marakas, Yi, and Johnson, 1998). Computer anxiety was also found to have a mediating influence on the situation-specific trait of personal innovativeness in information technology (Thatcher and Perrewé, 2002). Of greatest interest to this study is the research about computer anxiety's linkage to performance and the effects of changes in computer anxiety over time upon an individual's performance.

2.1.1 Computer anxiety and performance: The evidence for computer anxiety's influence upon individual performance outcomes is inconclusive, as some studies indicate a negative relationship (Keeler and Anson, 1995; Vician and Davis, 2003) while others suggest no relationship (Desai and Richards, 1998; Kernan and Howard, 1990; Webster, Heian, and Michelman, 1990). What are possible explanations for these mixed results? The majority of these studies were completed with subjects who were first introduced to computer use through college coursework, or possibly upper-level high school exposure. The research conducted in that time period preceded the proliferation of computing technology in everyday life (e.g., Internet and World Wide Web, self-service gas pumps, grocery store checkout scanners). Those studies did not control for potentially confounding differences across individuals such as intelligence, effort, or gender. Early research on adoption of information technology shows that the individual factor of computer anxiety has been associated with the decision to avoid or minimize the use of computers (Igbaria and Parasuraman, 1989; Igbaria, Schiffman, and Wieckowski, 1994; Weil, Rosen and Wugalter, 1990). Avoiding or minimizing the use of computing technology could lead to lower performance outcomes in both work and academic environments.

In a work environment, computer avoidance behavior may be manifested in low computer use and could be reflected in diminished worker productivity measures. In a computing-intensive course, computer avoidance behavior may result in lower effort expended on exercises and assignments. One would expect computer anxious learners to either: (a) attempt to avoid completing exercises or assignments, or (b) spend less time completing exercises or assignments. Such behaviors by individuals experiencing computer anxiety would normally result in less positive performance outcomes, such as lower grades, in comparison to individuals with lower levels of computer anxiety. Some recent information systems research argues for a negative relationship between computer anxiety and performance (Chou, 2001).

2.1.2 Changes in computer anxiety over time: Most research supports the position that computer anxiety is a state that can be changed, rather than a stable individual trait that will remain constant across different situations or periods of time (Marakas, Johnson, and Palmer, 2000; Rosen, Sears and

Weil, 1993; Thatcher and Perrewé, 2002; Weil, Rosen and Wugalter, 1990). Such news is encouraging in light of the potential negative influence of computer anxiety upon individual performance outlined above. However, prior research provides little evidence regarding the effects of changes in computer anxiety on performance or how changes in computer anxiety might occur.

Few studies have focused on the change in an individual's computer anxiety level, and the results that are available have been mixed. The results of two research studies, situated within introductory computing courses, contradict one another. Kernan and Howard (1990) discovered a significant decrease in computer anxiety over time, while Carlson and Wright (1993) found a significant increase in computer anxiety over time. A third research study (Keeler and Anson, 1995) focused on the relationship between a learning intervention and performance; the researchers did not directly address the relation between changes in individuals' anxiety levels and performance, but they did find an interaction between initial levels of anxiety and the intervention.

Early computer anxiety research indicates that individuals experiencing high initial levels of computer anxiety often have very low amounts of experience with computers (Heinssen, Glass, and Knight 1987; Igbaria and Chakrabarti, 1990; Igbaria and Parasuraman, 1989; Rosen and Maguire, 1990; Todman and Monaghan 1994). These findings have led some experts to suggest that placing individuals into learning environments to increase computer experience is a way to reduce computer anxiety (Leso and Peck, 1992). In contrast, other researchers have argued that merely increasing the amount of computer experience is unlikely to reduce computer anxiety for individuals experiencing such a psychological state (Rosen and Maguire, 1990; Weil, Rosen and Wugalter, 1990) and that some form of clinical treatment is necessary to successfully reduce the computer anxiety (Weil, Rosen and Sears, 1987). Bloom and Hautaluoma (1990) tested the effects of anxiety management training (e.g., relaxation and cognitive coping skills) upon computer anxiety levels and did not find a relationship, although post-hoc analysis suggests that computer anxiety levels may have decreased after computer training experiences. This decrease was unrelated to the presence or absence of anxiety management training.

2.2 Hypotheses

We test three hypotheses unresolved by prior research. Additionally, the individuals in our sample have greater pre-existing levels of exposure to and experience with computer technology than subjects in most prior research and are therefore more likely to be representative of contemporary students.

As discussed previously, there is disagreement in the literature regarding the effects of exposure to a computing-intensive environment upon computer anxiety and little empirical evidence to resolve the disagreement. While this issue was partially addressed in one previous study (Keeler and Anson, 1995), the subjects in that study were primarily non-traditional students (e.g., average age was 26.97 years) and had, relative to today's students, little experience with computing technology. For example, over half the students in the previous study had no experience with personal computers. With more contemporary students the effects on computer anxiety from computer exposure is unclear. Any benefits may have already occurred; so further exposure will have no effect. The first hypothesis we test is:

> H1: An individual's level of computer anxiety will change after exposure to a computer-intensive learning environment.

Past research has documented a relationship between computer anxiety and performance, and has investigated interventions that may change computer anxiety (e.g., Rosen, Sears and Weil, 1993; Weil and Rosen, 1997). However, prior research has not directly addressed whether exposure to computer technology alone results in a change in anxiety which impacts performance. The second hypothesis is:

> H2: Changes in individuals' levels of computer anxiety will be negatively associated with performance.

Prior research on both predictors of performance and interventions to enhance learning in computer-intensive environments indicates that there may be a floor or ceiling effect with respect to the impact of individual differences on performance (Davis, Johnson, and Vician, 2005; Keeler and Anson, 1995). For instance, it seems likely that individuals with low levels of computer anxiety will benefit less from reductions in anxiety than individuals with high levels of anxiety. The third hypothesis that we test is:

> H3: The performance of individuals whose initial level of computer anxiety is relatively high will be affected more by a change in computer anxiety than those individuals whose initial level of anxiety is low.

3. METHOD

We used a longitudinal field study with a survey data collection methodology to test the research hypotheses. The subjects were recruited from an introductory-level Information Systems (IS) course provided by the Business School at a small, Midwestern university. Participation in the study was voluntary and students did not receive grade or course credit for participating; however, class time was allocated for completing the questionnaires. The course was conducted during a fifteen-week semester. One hundred and eight full-time students agreed to participate in this research study. Of these students, fifteen failed to complete the course, another fifteen were not present at both administrations of the questionnaire, and eight failed to fully or correctly complete questionnaires. This resulted in a final sample of sixty-nine subjects. Sixty-four of the sixty-nine subjects were business majors, fairly evenly distributed among accounting, finance, information systems, management, and marketing. The other five subjects included engineering and computer science majors.

The purpose of the course is to provide learners with a fundamental understanding of information systems foundations (e.g., computer literacy) as well as to provide experiential learning with widely used application software packages and a common business programming language (Microsoft Visual Basic). Pedagogy included: traditional lecture, computer demonstration, and hands-on lab sessions. Individual programming/application software assignments, quizzes, and exams constituted the grading evidence for the course. Students were required to use computer technology in order to complete their assignments.

Over 50% of the assignments and exercises covered programming topics and information systems development activities. Thus, the course was clearly computing-intensive in nature.

Subjects completed consent forms and the first questionnaire instrument during the second week of the term. The second questionnaire instrument was administered during the last week of the semester. At the completion of the course, final grades were collected from the instructors. Student transcripts, obtained from the University Registrar, were used to compute each student's cumulative grade point average (GPA) prior to taking the course.

3.1 Measures

The variables of interest in this study were: student performance in the course (dependent variable), computer anxiety, change in computer anxiety, and demographic characteristics. Student performance was measured by the final course grade (A, A/B, B, B/C, D, or F), expressed as a grade point average equivalent of the letter grade (i.e., A = 4.0, A/B = 3.5, B = 3.0, and so on).

We utilized a questionnaire instrument to measure computer anxiety. The scale was adapted from an existing validated scale (Heinssen, Glass and Knight, 1987) and has demonstrated reasonable reliability and validity in prior studies (see Fuller, Vician and Brown, 2006; Webster, Heian and Michelman, 1990). The Cronbach alpha for the 12-item computer anxiety measure was .94.

4. RESULTS

4.1 Preliminary Analysis

Descriptive statistics for the sample are presented in Table 1. The subjects were primarily freshmen and sophomores with a median age of 19 years (average was 20.8 years). Fully 100% of the subjects had prior experience with either Microsoft Office application software or a programming language, or both, and 61% owned their own computer. Their prior experiences with computers had been mostly positive, although 9% of the sample reported that their experiences had been negative. Gender distribution was 61% male, 39% female. Subjects reported an average of 3.2 years of work experience. In general, the demographic characteristics of the sample are consistent with the profile of contemporary students with regard to age, computer experience, and exposure to technology.

4.2 Analysis

In our initial analysis, we tested for changes in computer anxiety over time. Regression analysis was then used to test for relationships between performance and both (a) individuals' change in anxiety, and (b) the interaction between individuals' change in anxiety and their initial anxiety level.

4.3 Tests for Changes in Computer Anxiety

Table 2 presents the mean absolute and signed changes in computer anxiety for the sample as a whole and for both the High and Low anxiety sub-samples (divided based on comparison to the mean computer anxiety score). First, it should be noted that the mean *absolute* changes are all greater than the mean signed changes. The implication is that for the sample as a whole and for both sub-samples (High and Low anxiety), the change in anxiety was not uniform in direction; some subjects' anxiety scores increased and some decreased.

Variable	Total Sample	Subjects with Initial Computer Anxiety Levels Below the Mean	Subjects with Initial Computer Anxiety Levels Above the Mean
Final Course Grade	3.6 (.62)	3.7 (.54)	3.5 (.76)
GPA	3.21 (.53)	3.14 (.56)	3.33 (.44)
Computer Anxiety	2.19 (1.09)	1.72 (.87)	3.00 (.96)
Change in Anxiety	-.02 (1.5)	-.48 (1.5)	.80 (1.11)
Age (in years)	20.8 (5.49)	19.8 (5.2)	21.9 (5.8)
Gender	61% male 39% female	73% male 27% female	40% male 60% female
Prior Exposure to Microsoft Office Applications or a Programming Language	100%	100%	100%
View Prior Experience with Computers as Positive	91%	94%	88%
Own a Computer	61%	72%	44%
N	69	42	27

Table 1. Descriptive Statistics
Mean (Standard Deviation) or Percentage

Change	Total Sample	Subjects with Initial Computer Anxiety Levels Below the Mean	Subjects with Initial Computer Anxiety Levels Above the Mean
Absolute Change	1.14 (1.17)	1.16 (1.10)	1.08 (1.30)*
Signed Change	-.02 (.013)	-.48 (.32)	.80 (-.72)
N	69	42	27

* significant at .10, one-tail

Table 2. Tests for Changes in Computer Anxiety Mean Change (t-statistic)

For Hypothesis 1 we performed t-tests to evaluate whether the means are significantly different from zero. The absolute change is used to test whether there was a change in subjects' anxiety levels from the beginning of the course to the end while ignoring the direction of the change. The results of the t-tests for the absolute change are not significant for either the sample as a whole or the Low anxiety sub-sample. The absolute change for the High anxiety sub-sample is significantly different from 0 at $p \leq .10$. (Although the mean absolute change for the Low anxiety sub-sample is greater than for the High anxiety sub-sample, the larger variance in the Low anxiety sub-sample results in a lack of significance.) This is consistent with Keeler and Anson (1995) who found the change in anxiety most evident for those who started with high levels of anxiety. Tests for differences from zero and the *signed* change scores for both the sample as a whole and the two sub-samples are not significant. Our results indicate that High anxiety individuals experienced a change in their levels of anxiety, but those changes were not uniform in direction. These results provide some support for Hypothesis 1, as exposure to a computer-intensive learning environment did affect individuals' levels of computer anxiety.

4.4 Tests For Relation Between Changes in Anxiety and Performance

To test Hypotheses 2 and 3, we estimated the following regression model:

Student Performance = GPA + Gender + HighAnxiety + ChangeInAnxiety + HighAnxietyXChangeInAnxiety

where Student Performance is each student's final grade in the class (i.e., A = 4.0, A/B = 3.5, B = 3.0, and so on) and GPA is the subject's cumulative grade point average prior to taking this course. Gender is coded 1 if the subject is a female and 0 otherwise. Consistent with prior research (Keeler and Anson, 1995; Torkzadeh, Chang, and Demirhan, 2006), HighAnxiety equals 1 if the individual's average score for the Computer Anxiety questions (measured on a one to seven scale) from the first administration of the questionnaire instrument is above the mean and 0 otherwise. ChangeInAnxiety is the change in the subject's average response to the Computer Anxiety questions from the first to the second administration of the questionnaire. HighAnxietyXChangeInAnxiety equals the product of the values for HighAnxiety and ChangeInAnxiety. GPA was included to control for differences across students affecting academic performance (e.g., knowledge, abilities and study habits), Gender is intended to control for possible gender effects (Keeler and Anson, 1995), and HighAnxiety controls for the subject's initial level of computer anxiety. ChangeInAnxiety and HighAnxietyXChangeInAnxiety are the two main independent variables and are used to test Hypotheses 2 and 3, with a negative value expected for each coefficient. ChangeInAnxiety is included to test for a relation between changes in individuals' anxiety levels and performance. HighAnxietyXChangeInAnxiety tests whether the effect of a change in anxiety on performance is dependent on individuals' initial level of anxiety.

Regression results are shown in Table 3. Except for the intercept, all tests are one-tailed based on our expectations as discussed above. Regression diagnostics indicate that the validity of our results are not threatened by multicollinearity among the variables or due to outliers. As expected, cumulative GPA was positively correlated with final grade. Individuals who received high (low) grades in prior courses tended to receive higher (lower) grades in this course. The coefficient on Gender was significant and negative; on average, females in the course received lower final grades than did males. Also as expected, the coefficient on HighAnxiety is negative and significant. Individuals who started the course with a high level of computer anxiety received a lower final grade than other students. The coefficient on ChangeInAnxiety is not significant. However, the coefficient for the interaction between the starting level of anxiety and the change in anxiety (HighAnxietyXChangeInAnxiety) is negative and significant. This result indicates that there is a relationship between the change in computer anxiety and performance, but that the effect is dependent on an individual's original level of anxiety. More specifically, this result indicates that for those individuals who start out with a high level of anxiety, a reduction (increase) in anxiety is associated with a higher (lower) final course grade.

Figure 1 visually represents a plot of the estimated regression line for each group (high and low initial anxiety) when the change in computer anxiety is regressed on final course grade, illustrating the interaction. The difference in the slopes of the two lines shows that the effect of a change in anxiety is dependent on an individual's initial level of anxiety. Although the line for individuals who began with low levels of anxiety seems to indicate an increase in final course grade as anxiety increases, the coefficient on the change in anxiety was not significant for this group. The coefficient on the change in anxiety *was* significant for the high anxiety group ($p \leq .10$).

4.5 Additional Tests

Regression diagnostics indicate that the validity of our results is not threatened by multicollinearity among the variables or due to outliers. Tests for differences across sections were not significant at conventional levels. Similarly, tests for interactions between gender and computer anxiety (both the original level of anxiety and the change) were not significant.

Variable	Expected Sign	Coefficient (t-statistic)
Intercept		2.28 (6.17) ****
GPA	+	.55 (4.91) ***
Gender	-	-.17 (-1.95) **
HighAnxiety	-	-.10 (-1.95) **
ChangeInAnxiety	-	.09 (1.1)
HighAnxietyXChangeInAnxiety	-	-.055 (-1.73) **
R-Squared = .32, F-value = 7.2, (p < .0001)		
N = 69		

Table 3. Regression Results
**** Significant at .01, two-tailed
*** Significant at .01, one-tailed
** Significant at .05, one-tailed

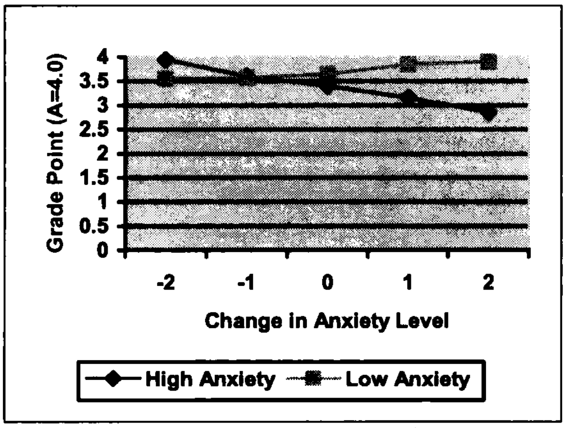

Figure 1. Plot of Estimated Regression Line When Final Course Grade is Regressed on Change in Anxiety

5. DISCUSSION

The purpose of this study was to investigate the effects of extended exposure to a computing-intensive environment on computer anxiety and performance. Our results provide some evidence that such exposure does influence individuals' levels of computer anxiety, at least for those who begin with high levels of computer anxiety. Further, the changes in anxiety levels are not uniform in direction; they may either increase or decrease. A similar relationship exists between changes in computer anxiety and performance. For individuals who begin with high levels of anxiety, changes in anxiety are negatively correlated with changes in performance. Individuals whose anxiety decreases experience improved performance while individuals whose anxiety increases experience impaired performance.

5.1 Implications for Research

This study underscores the importance of longitudinal research on factors affecting adoption and use of computing technology, especially individual differences such as computer anxiety that can shape future beliefs and actions with computing technology. Our results indicate that at least for high anxiety individuals computer anxiety levels can change over time and that those changes are associated with performance. However, our findings indicate that both increases and decreases in anxiety and performance levels may occur. Future research might focus on methods of identifying individuals who would benefit from an intervention designed to improve performance.

In this study, we investigated the computer anxiety effect within the context of a computing-intensive situation. What will be the effect of computer anxiety in situations that rely upon computing technology, but are not as intensive in its use? For example, many college courses now utilize course management systems (e.g., WebCT/Blackboard) for the publication of course materials and to enable online evaluation of course topic mastery. Many practical certification environments use computerized delivery of examinations (e.g., CPA exam). Federal, state, and local governments are quickly adding computerized services for their constituents. Additional longitudinal research is needed to determine the resilience of high computer anxiety levels in future, repeated exposures to varying kinds of computing environments.

For researchers, our results indicate that computer anxiety is an important individual difference to continue studying, even with more contemporary subjects. Our findings suggest that computer anxiety is unlikely to disappear completely or on its own through the advancement of computing in society. However, computing technology has advanced over time, and the measures for computer anxiety are primarily rooted in the computing environment of the 1980's. The qualitative computer anxiety investigation performed by Gos (1996) suggests that there may be programming anxiety that is separate from a general computer anxiety. Other IS adoption research has argued for the presence of both general and application-specific elements of individual differences in models of individual use of computing technology (Brown, Fuller, and Vician, 2004; Marakas, Yi and Johnson, 1998). It may be time for revision of the computer anxiety instrument in order to more properly reflect the anxiety construct in today's computing environment. Future research should focus attention on adapting and extending the computer anxiety measure in that manner.

Although not a central goal of our study, our results also suggest that gender may play a role in shaping the occurrence of computer anxiety and its effect upon performance. In our study, females performed less well in a computing-intensive environment than their male counterparts. Our findings, together with research that indicates significant gender differences in technology perceptions (Buche, 2006), and current popular press reports on the decline in female participation in computing, science, technology, engineering, and math careers (DePalma, 2001; Hoffman, 2006) indicate a need for further study. The relationship of gender, computer anxiety, and career choices may be a fruitful area of future research.

5.2 Implications for Practice

Our results suggest two primary implications for the practice of computing education and training. First, merely providing individuals with exposure to computing technology is not enough to reduce computer anxiety for all individuals. We discuss this first implication in terms of the nature of early computing experiences and career choice guidance. The second practical implication is that the definition of computing literacy may need to be re-visited by educators and trainers.

The general expectation is that contemporary students arrive at colleges and universities with substantial computer experience, embracing technology. However, our results indicate that merely providing exposure to computers and technology will not necessarily reduce computer anxiety, and might actually exacerbate the problem. Prior research reports that the early experiences with technology are crucial, and may inoculate individuals to overcome subsequent negative experiences with technology (Todman and Drysdale, 2004). What does that statement reveal about the importance of quality instruction within basic computer literacy courses? Quality instruction in a computer literacy course demands three elements: (a) an instructor sensitive to varying individual needs and computer anxiety levels; (b) early, discreet identification of computer anxious individuals; and (c) easy to implement interventions for computer anxious individuals. Without careful attention and empathy, an instructor might inadvertently compound the problem by increasing the individual's level of computer anxiety. The right person, with an appropriate teaching style, can make a lasting difference in the ability of highly computer-anxious individuals to master computing technology. Therefore, staffing of the computer literacy course takes on greater importance.

If appropriate instruments can be developed, universities might identify at-risk students who are both computer anxious and unlikely to benefit from continued exposure to computing-intensive environments. At-risk individuals scoring in the high anxiety range could be offered the opportunity to participate in an intervention to reduce computer anxiety levels. In this information age, computer skills are comparable to writing and mathematical skills in overall importance to academic success and lifelong learning. Proactive intervention might be necessary to provide individuals with the basic skills to succeed.

Weil and her colleagues (Rosen, Sears and Weil, 1987; Weil and Rosen, 1997; Weil, Rosen and Sears, 1987) administered cognitive and behavioral conditioning interventions designed to reduce computer anxiety. Direct, easy to implement techniques should be adapted that can be readily applied by instructors within computer-intensive courses. The preferred method of intervention would seem to be a combination of basic computer tasks created to build on prior successes, gradually increasing in difficulty and complexity, along with personalized attention from an expert computer user. Social cognitive theory (Bandura, 1997) suggests that support from peers during training, and observation of classmates performing computing tasks may instill confidence in individuals with initially high levels of computer anxiety. As much as possible, instructors need to incorporate exercises that allow everyone to experience successful outcomes, while providing readily-available assistance when problems arise.

Academic instructors interact with students at a pivotal juncture in their educational development. Essentially, this is the period when young adults choose their careers and the appropriate academic programs to enter that discipline. Computer anxiety can limit those choices for high anxiety individuals. They might not even be aware of the negative effect that computer anxiety has on their behavior, and are unlikely to actively seek help. Instead, they will probably try to avoid courses that are computer-intensive and select majors/careers that require limited exposure to computers and technology. With effective intervention, reducing computer anxiety can broaden career choices and future opportunities for those people. It is an enormous disservice for universities and companies to ignore the obstacles facing this sub-group.

The second practical implication from our study is that the definition of computer literacy may need to be updated in light of advancing technology capabilities. As computers and technology become ubiquitous in society, fewer programming skills are required of end users. Therefore, computer literacy might not necessarily include programming skills. We suggest that computer literacy is the combination of skills required to interact with computing technology to perform a variety of tasks, including the ability to access help when necessary. It is unlikely that the knowledge, skills and abilities would be a static list, therefore the constant evolution of technology prohibits the formulation of a finite set of skills. To address this issue, curriculum for computer basic skills courses must be flexible and responsive to the skills required for successful integration into the work environment.

5.3 Limitations

As with all research, there are limitations to the interpretation of the findings in this study. Generalizability of our results could be a concern. Our subject sample was drawn from traditionally-aged, contemporary students at a Midwestern university's business school. Applying our results to individuals participating in computing-intensive environments that occur in other academic programs and countries may require additional empirical research. With the inclusion of GPA in our model, we control for systematic differences in intelligence and effort, thus we believe our results will generalize to other North American learners in computing-intensive environments.

As is typical with longitudinal studies, our sample size was reduced due to natural attrition such as absences during survey administration, missing answers to items, and students choosing to self-eliminate from the class. Comparison of questionnaire responses for subjects who were and were not included in the final sample indicate that the two groups were similar. Lastly, technology use was mandatory in this study. Future research might investigate settings in which technology use is voluntary.

6. CONCLUSION

The ability to interact effectively with information technology is necessary for success in both educational and work environments. Prior research has shown that computer anxiety may impair individuals' computing abilities. The results of this study indicate that exposure to a computing-intensive environment impacts individuals' level of computer anxiety, but that effect is not uniform. Exposure to a computing-intensive environment increases some individuals' levels of anxiety and decreases others. Further, changes in computer anxiety are most likely to have a measurable effect on performance for those individuals who begin with a relatively high level of anxiety. For high anxiety individuals, a reduction (increase) in anxiety will have a positive (negative) impact on performance. Future research should focus on effective approaches for identifying computer anxious individuals who are unlikely to experience reductions in their anxiety levels from direct exposure to computing-intensive environments only. Successful interventions should be developed and evaluated with this sub-set of the population in both academic and field settings.

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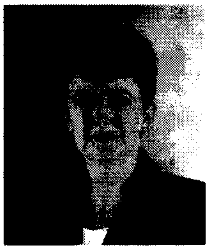

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