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Antecedents of Computer-based Testing (CBT) Anxiety and Performance

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Abstract

As the use of computer-based testing (CBT) in educational institutions and organizations continues to expand, managers and administrators search for ways to leverage the benefits of the technology, while minimizing its negative impacts. Prior studies have demonstrated a link between general test anxiety and test performance, yet little is known about how CBT anxiety is impacted by individual technology use characteristics and test design. In this study, we examine the test performance of undergraduate students (n = 73, n = 86) using different test designs. Our analysis reveals that the navigational design of a computer-based test has a significant impact on perceived behavioral control (PBC), which in turn – along with CBT playfulness -- affects CBT anxiety. Our results can help users of CBT technology develop a richer understanding of the process and avoid confounding factors that can negatively impact test-taker performance.

Keywords: Anxiety, Computer-based testing (CBT), Perceived Behavioral Control, Playfulness, Performance

1. INTRODUCTION

Computer-based testing (CBT) is not only a necessary tool for educators, but it is also one of the most widely accepted assessment methods across a variety of organizations. CBT is cost-effective, convenient, and easily tailored to a variety of testing scenarios. It is one of the major functionalities of any learning management system, including countless e-learning and massive open online course (MOOC) platforms. Advances in information and communication technologies (ICTs) promote worldwide acceptance of CBT by educators, testing facilities, corporate trainers, and colleges and universities.

From educators' perspective, CBT increases learning performance (Khoshsima and Toroujeni, 2017) and provides instant results (Wise, 2019). To increase CBT benefits, Walker and Handley (2016) propose a framework for learner engagement activities: orientation to assessment methods, CBT guidance for learners, and navigational designs. The framework includes (1) providing "the rationale and the suitability of the assessment methods to the discipline being assessed" (p. 2), (2) giving "authentic" practice opportunities (i.e., test-taking strategies and 'digital' skills) and exposure to CBT exam environments (i.e., hardware, software, and navigation), and (3) incorporating better

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navigation designs, time management, and question sequencing (Walker and Handley, 2016). While some educators are aware of the learner engagement activities, they generally presume that students are experienced test-takers or have some familiarity with CBT.

However, CBT can be rigid, inflexible, and insensitive to learners' needs. For some students, CBT can lead to dissatisfaction and apprehension (Kim, 2015). The assumption that students are proficient CBT test-takers allows educators to attribute poor test performance to a lack of effort, absenteeism, or disinterest in learning. However, this is not always the case. We need to understand that CBT, regardless of how well-designed or easy-to-use it may be, is not comparable to a simple paper-based test. Like computing platforms, CBT interfaces vary across different learning management systems, such as Sakai, Moodle, Desire2Learn, Open edX, Google Classroom, and many others. Different operations and navigation designs may lead to unanticipated usage scenarios, especially when test-takers have no experience with a particular CBT platform.

While its navigation is cumbersome, CBT also depends on reliable and fast internet connections. Typically, exam duration does not account for network delay and other technological challenges. Remote test-takers are always in constant fear of losing network/internet connection and power outages. Furthermore, the navigational process of revising, correcting, and error checking is not as straightforward as it is for paper-based tests. Therefore, CBT tends to increase the level of anxiety and apprehension felt by exam-takers when compared to a paper-based tests.

Because test anxiety affects academic performance (Chapell et al., 2005; Hembree, 1988; Seipp, 1991), CBT anxiety may also lead to poor test performance. Of course, having pre-navigational experience is advantageous to test-takers, and any familiarity with CBT navigation can reduce anxiety levels. To cope with CBT-related anxiety, the last activity of the framework mentioned earlier (Walker and Handley, 2016) recommends focusing on CBT navigation and interface designs. Perhaps allowing test-takers some navigation controls over the CBT environment may reduce the level of anxiety and increase test performance. When students were allowed more control over the test structure, their test scores increased (Rocklin and O'Donnell,1987). We equate an ability to assert control over CBT navigation as a part of perceived behavioral control (Ajzen, 1989), which can influence behavioral intention together with the changes in attitude and social norms.

While anxiety affects test performance, playful personality traits may decrease it. Cigdem et al. (2016) find that perceived playfulness is the strongest predictor of web-based assessment when compared to perceived usefulness. According to Martocchio and Webster (1992), playfulness relates to individuals who are "more inventive, and imaginative in their microcomputer interactions, which would have an impact on learning" (p. 557). Computer playfulness, therefore, could play an important role in overcoming CBA-related anxiety. Test-takers who interact with CBTs innovatively and playfully and believe that they can influence their test outcome may be well-suited for CBT usage. According to Serenko and Turel (2007), computer playfulness is two-faceted: computer-related problem solving and playful behaviors (i.e., spontaneous, flexible, and creative). As CBT becomes a de facto choice for e-learning and online assessment, more research is needed to examine these factors' influence on CBT anxiety and exam performance. Specifically, we ask whether perceived behavioral control (PBC) and computer playfulness affect CBT anxiety and performance outcomes. By examining how PBC and computer playfulness impact exam stress levels, educators may gain insight into what steps can be taken to reduce CBT anxiety.

2. RESEARCH MODEL

The premise of this study is based on Ajzen's (1989) Perceived behavioral control (PBC), a construct from the Theory of Planned Behavior (TPB). According to the theory, three factors determine one's behavioral intention to engage in a specific activity: attitude towards the task, societal norms related to the task, and perceived behavioral control (PBC). PBC is defined as "the person's belief as to how easy or *difficult performance* of the behavior is likely to be" (Ajzen and Madden, 1986, p. 457). The *difficulty performance* is governed by the "resources" and "opportunities" a person has available to perform the behavior in question (Ajzen and Madden, 1986). Figure 1 shows our research model.

A computer-based test's (CBTs) technological attributes may impede or facilitate PBC. CBTs

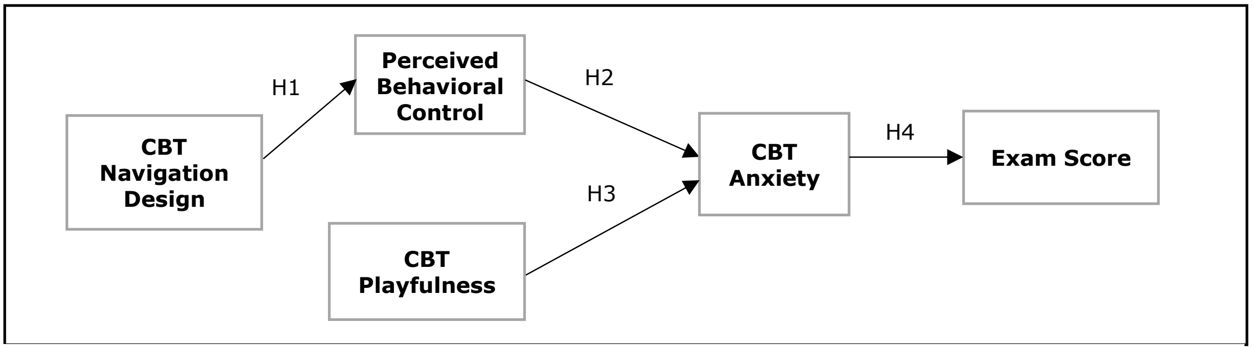

Figure 1 – Research Model

encapsulate many situational and navigational factors, such as webpage design, user interfaces, exam flows, and navigation controls. Adding to its complexity, CBTs operate on various Learning Management Systems (LMS) platforms with security features and third-party software applications. CBTs also "control" test-takers 'resources' and 'opportunities' to interact freely and naturally with the exam questions. As a result, test outcomes may not accurately reflect the skills and content knowledge of the test-takers.

Research shows that if test-takers perceive that they have some level of control, they can better tolerate stressful situations (Lazarus and Folkman, 1984; Wise,1994). Studies using this concept in the context of CBT suggest that using self-adapted tests can yield performance scores that are statistically higher and less related to self-reported anxiety when students were allowed more control over the test structure (Rocklin and O'Donnel, 1987). The perception of resource availability also predicts Internet anxiety (Thatcher et al., 2007), suggesting that PBC and anxiety are related. CBT asserts control of the exam environment and thereby increases the levels of anxiety. With CBT, test-takers can assert little control over their CBT environment. Therefore, we hypothesize that a) CBT designs that offer the test-taker less navigational control lead to lower levels of PBC and b) lower levels of PBC can increase the levels of anxiety during CBT exams.

Hypothesis 1: A positive relationship exists between CBT navigational control and perceived behavioral control.

Hypothesis 2: A negative relationship exists between perceived behavioral control and CBT anxiety.

The state of cognitive absorption with technology involves personal innovativeness and playfulness (Agarwal and Karahanna, 2000). Playfulness refers to one's enjoyable and pleasurable experience interacting with computers (Webster, Trevino, and Ryan, 1993). Playfulness has a direct effect on CBT use (Maqableh, Masa'deh, and Mohammed, 2015). Test-takers who are more willing to try out new technology are usually more comfortable with CBT and thus experience lower levels of test anxiety. Since CBT constantly monitors, controls, and enforces test-taking behaviors, we theorize that higher levels of playfulness (situated in the context of CBT) will help reduce the levels of CBT anxiety.

Additionally, playful test-takers may find innovative ways to interact with the CBT. They may explore available CBT functionalities that will help them navigate through different exam questions or sections more efficiently. The term "interactive resourcefulness," which is defined as "user capability to challenge the traditional way of doing things in human-computer interaction" (Serenko and Turel, 2007, p. 663), may be the determining factor to reduce CBT anxiety. Playful test-takers may utilize a hyperlinked index of questions and page forward/backward capabilities, so they are less anxious than others who have lower levels of playfulness. Computer playfulness increases perceived ease of technology use, while anxiety reduces it (Harkbarth et al., 2003). We hypothesize that higher levels of CBT playfulness lead to lower levels of CBT anxiety.

Hypothesis 3: A negative relationship exists between CBT playfulness and CBT Anxiety.

Higher levels of anxiety could dampen one's cognitive ability to do well on the exam. Computer anxiety has been shown to have a negative effect on self-efficacy (Thatcher and Perrewe, 2002). Prior studies have long established a significant

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relationship between test anxiety and performance (Hembree, 1988; Seipp, 1991). Research finds a significant relationship between computer anxiety and performance predictors (Shermis and Lombard, 1998). We therefore hypothesize that higher levels of CBT anxiety reduce test performance.

Hypothesis 4: A negative relationship exists between CBT anxiety and exam score.

3. METHODOLOGY

Questionnaire Design and Data Collection
The questionnaire survey method was used to collect most of the data. To ensure that the questions captured the essence of the constructs being operationalized, items for the questionnaire were drawn from validated instruments in the literature and revised for the context of this study (see Table 1).

Subjects were recruited from four sections of a systems analysis class taught at a mid-sized university in the Midwestern United States to participate in the study. Two of their three CBT exams for the semester were designed with different levels of navigation control for the subjects. The first was a low-control treatment where one (1) question appeared on each page of the exam with subjects only able to navigate one page at a time. The second was a high-control treatment where all exam questions appeared on one page and subjects were able to scroll freely through the entire test. All subjects across all four (4) sections of the class received the same treatment at the same time and were offered extra credit for their participation in the study.

A total of ninety-five (95) students were invited to participate at the beginning of the semester. During the first data collection period (Exam 1), seventy-six (76) subjects completed the online questionnaire while two months later, eighty-five (85) participated during the second exam (Exam 2). After removing duplicates, incomplete questionnaires, and cases of subjects who did not opt-in to data analysis, seventy-three (n = 73; Exam 1), and eighty-five (n = 85; Exam 2) cases were retained for analysis. A total of sixty-nine (69) students completed surveys for both Exam 1 and Exam 2.

In order to determine if there were differences in computer-based test anxiety and test performance between the two instructors, we first conducted independent samples tests for equality of variances for the two constructs. The results suggested that the variances for CBT anxiety and exam score were not statistically different (p-values .475 and .960, respectively) across instructors. We then conducted t-tests for mean difference across instructors and the results indicated that there was no statistically significant difference in values for CBT anxiety and exam score (p-values .620 and .287, respectively).

The measurement model for each exam was assessed using SPSS 26. The structural model was tested using two multiple regressions (OLS) for each exam and a paired sample t-test, both in SPSS 26. The following section describes the results of testing the measurement and structural models.

4. DATA ANALYSIS AND RESULTS

Indicator reliability
Indicator loadings for both questionnaires were checked to make sure that all of the items had at least 50% of their variance explained by the construct they were representing (e.g., loadings of .70 or higher). Principal components analysis with maximum likelihood extraction and oblimin rotation is appropriate when using existing scales for research (Worthington and Whittaker, 2006), thus we used that approach to assess item loadings.

For the Exam 1 data, five out of the sixteen items exhibited loadings below .70 on their associated component: CBT PLAYFULNESS -- play1, .536; play5, .604; play6, .648, PERCEIVED BEHAVIORAL CONTROL – pbc1, .103; pbc2, .552 and COMPUTER-BASED TEST ANXIETY – anx2, .580 . PBC1 cross-loaded highly on a different component and was removed from the analysis. However, all cross-loadings for the remaining five items were at or below .230, thus they were retained for further consideration.

For the Exam 2 data, three items loaded below .70: (PERCEIVED BEHAVIORAL CONTROL – pbc1, .046; pbc2, .485; COMPUTER-BASED ANXIETY -– anx1, .647). PBC1 exhibited high cross-loading and was removed from the analysis. However, neither pbc2 nor anx1 demonstrated high cross-loadings (<= .140) and both were retained for analysis.

The loadings of the remaining factors for Exam 1 and Exam 2 are listed in Table 2. The resulting path estimation models are shown in Figures 2 and 3.

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Exam		CBT anx	CBT Play	PBC
Exam1				
	anx1	.730		
	anx2	.580		
	anx3	.784		
	anx4	.804		
	play1		.535	
	play2		.859	
	play3		.728	
	play4		.871	
	play5		.604	
	play6		.648	
	play7		.704	
	pbc2			.552
	pbc3			.912
	pbc4			.765
Exam2				
	anx1	.647		
	anx2	.912		
	anx3	.781		
	anx4	.687		
	play1		.714	
	play2		.875	
	play3		.770	
	play4		.871	
	play5		.791	
	play6		.760	
	play7		.855	
	pbc2			.485
	pbc3			.948
	pbc4			.871

Table 2 – Factor Analysis

Internal consistency reliability
Cronbach's alpha provides a measure of the correlations between the items for a construct and is often used as a measure of internal consistency. The composite reliabilities for CBT anxiety, perceived behavioral control, and CBT playfulness are .826, .806, and .878 for Exam 1 and .863, .933, and .814 for Exam 2, respectively, suggesting high levels of internal consistency (Nunally and Bernstein, 1994). A threshold of .60 is recommended (Bagozzi and Yi, 1988) without exceeding a value of .95 (Hair, et., al, 2013).

Convergent validity
Convergent validity is a measure of how much of the variance captured by a construct is due to measurement error. An average variance extracted (AVE) threshold of .50 can be used as evidence of convergent validity (Bagozzi and Yi, 1988). The AVEs for CBT anxiety, perceived behavioral control, and CBT playfulness are .533, .574, and .652 for Exam 1 and .587, .631, and .652 for Exam 2. Therefore, all three constructs show high convergent validity for both exams.

Discriminant validity
Discriminant validity tests whether constructs that are supposed to be unrelated have no relationship with each other. The conservative Fornell-Larker approach to establishing discriminant validity compares the square root of the AVE for a construct to its correlations to the other latent variables in the model. If the sqrt of the AVE is higher than all the correlations, discriminant validity is demonstrated. For both Exam 1 and Exam 2 the square roots of the AVEs for all constructs exceeded the correlations between latent variables. For parsimony, only the results for Exam 2 are displayed in Table 3.

Latent Variable Correlations (LVC)					**Discriminant validity demonstrated? (SQRT AVE > LVC)**
	CBT anxiety	**PBC**	**Comp play**		
CBT anxiety	**.766**				Yes
PBC	-.376	**.794**			Yes
CBT play	.346	-.413	**.807**		Yes

Table 3 – Discriminant validity (Fornell-Larker technique)

Coefficient of Determination (R^2)
An important part of structural model assessment is the coefficient of determination (R^2). The threshold values for weak, moderate, and strong coefficients of determination are .25, .5, and .75, respectively (Hair, et al., 2013). In our results, the two predictor constructs (computer playfulness and perceived behavioral control) together explain .145 percent of the variance in CBT anxiety for Exam 1 and .165 for Exam 2. For both Exam 1 and Exam 2, the CBT anxiety predictor generates a negative R^2, indicating that the values in both cases could be equal to zero (0).

Path Estimates
Path estimates indicate the strength and direction of relationships between constructs. The standardized path estimates for the structural model are shown in Table 4. For each exam, two regressions were run. The first to test the impacts of PBC, computer playfulness, and the control variables (age and gender) on CBT anxiety. The second regression tested the relationship between CBT anxiety and exam score, controlling for age and gender.

As can be seen in the table, the regression analysis produced mixed results for the structural model. For Exam 1, CBT playfulness (CP) had a significant, positive relationship to CBT anxiety (0.265, p = .025) while perceived behavioral control (PBC) had a negative relationship that was not significant (-0.187, p = .112). The estimate for the relationship between CBT anxiety and exam score was small and not significant (0.065, p = .595). The control variables age and gender were not significant (p = .407 and .129, respectively) for the first regression nor for the second regression (p = .861 and .673 , respectively).

The Exam 2 results indicated a significant, negative relationship between PBC and CBT anxiety (0.306, p = .007)) while the relationship between CP and anxiety was not significant (0.208, p = .062). Again, no significance was found when testing the relationship between CBT anxiety and exam score (0.003, p = .979). The control variables age and gender were found not to be significant for the first regression (p = .184 and .147, respectively) as well as the second regression (p = .538 and .830, respectively).

Exam	Regression	Path	Std. Path coefficient	t-value	p-value	Hypothesis
Exam 1	First R^2 = .162 (.112)	PBC → CBT anx	-0.187	-1.611	.112	H1B:Partial support
		CP → CBT anx	0.265	2.294	.025	H2:Partial support
	Second R^2 = .006 (-.037)	CBT anx → Exam score	0.065	0.534	.595	H3:No support
Exam 2	First R^2 = .217 (.178)	PBC → CBT anx	-0.306	-2.794	.007	H1B:Full support
		CP → CBT anx	0.208	1.893	.062	H2:No support
	Second R^2 = .005 (-.032)	CBT anx → Exam score	0.003	0.026	.979	H3:No support

Table 4 – Significance Tests Results

Including a test of hypothesis 1A (the impact of CBT navigational control on PBC) in our regression analysis would violate the residual independence assumption. So instead, we identified subjects who participated in both the Exam 1 and Exam 2 surveys, matched their responses (n = 69), and conducted a paired t-test for mean difference. The results indicated that there was a significant increase (p = .000) in test-takers' PBC from Exam 1 (low control) to Exam 2 (high control), thus providing support for hypothesis 1.

5. DISCUSSION

As computer-based testing (CBT) becomes more prevalent in institutions, there have been more scientific examinations of the phenomenon. Yet few studies have attempted to determine what part individual characteristics -- known to affect technology use -- play in CBT outcomes. Our study developed and analyzed a simple, straightforward model incorporating individual technology use variables as predictors of CBT anxiety.

The results suggest that higher levels of perceived behavioral control (PBC) can lower CBT anxiety. This finding is consistent with prior work demonstrating that the loss of control when engaging in a wide-range of activities has an impact on one's expectation of performance. We found -- unexpectantly -- that higher levels of CBT playfulness lead to higher levels of CBT anxiety. Perhaps students who felt unprepared for the exams did not expect to do well and as a way of coping with their increased stress, decided not to take the exam seriously, contributing to the finding of a positive relationship. More examinations of this effect are needed in order to determine if this result persists.

Surprisingly, our tests found no significance for the relationship between CBT anxiety and test exam score. One possible explanation is that contrary to their beliefs and expectations, students in the study were, on average, better prepared for the exam content in the systems analysis course than other courses. This might cause them to have higher levels of anxiety toward taking computer-based tests, but then achieve higher scores than they anticipated when taking the course exams.

Analysis results also indicate that CBT design factors can have an impact on individual technology use variables. Navigation controls that determine how test-takers are able to "move" through computer-based exams can be adjusted to allow for "high" or "low" levels of freedom of movement. We found that when participants were granted higher control over their ability to move through a CBT, they reported higher levels of PBC.

While our model did not include predictors of CBT playfulness, we did discover in a paired sample test that even though navigation restrictions were relaxed, subjects' perception of CBT playfulness did not change significantly from exam 1 to exam 2. This might suggest that CBT playfulness is a personality trait that remains "sticky" over time and may be more resilient to instructor-controlled manipulations.

Finally, CBT anxiety decreased, though not significantly, from exam 1 to exam 2. Presumably, the high-navigation format for exam 2 contributed to this change. But perhaps this shift was, in part, also due to an increased level of familiarity with the CBT format used for the course (i.e., types of questions, length of exam, etc.). Students knew what to expect of the tests given in the course by exam 2. As a result, they may have felt more confident in their preparation.

The practical implications for educators include: 1) test anxiety may be mitigated by providing quizzes or pre-tests in the test environment. This will allow testers/students to become familiar with the testing tool and allow them to bring their playfulness to bear; and 2) when instructors allow testers to more freely navigate the exam, they experience higher levels of perceived behavioral control and lower levels of anxiety.

6. LIMITATIONS AND AREAS FOR FUTURE RESEARCH

This research study has a few limitations that must be mentioned. First, the data were collected from multiple sections of a single course. Subjects were somewhat similar to one another in terms of major, gender, and point of matriculation. Caution is warranted when generalizing our findings to the population.

Secondly, self-reported measures of CBT anxiety were used in the study. While validated instruments of general test anxiety were modified and used here, other studies should be conducted to cross-validate the CBT anxiety items using objective, biometric measures that are not subject to self-report biases. A well-development, widely-accepted instrument for computer-based test anxiety is needed in order to allow researchers to compare results across different studies.

Thirdly, various CBT functionalities themselves may assert control during assessment (e.g. password authentication, web-traffic monitoring, browser lockdowns, webcams, and other advanced biometric verification intended to enforce academic integrity). Many CBTs have the capability to generate random exam questions, set time limits, allow selective releases of results, and control exam navigation features. These combined features and functionalities are intended to discourage information exchanges and collaboration among test-takers. While we are strongly in favor of ensuring academic integrity, these CBT functionalities may have the potential to create additional exam anxiety and lower test performance. We acknowledge those facets of the testing environment may have impacts on testing outcomes, but, we have not specifically identified them in our current study.

Finally, future studies should explore other factors that contribute to anxiety such as socio-demographic characteristics, user characteristics, and various features of the test itself.

7. CONCLUSION

The use of computer-based testing (CBT) continues to increase, it is vital that organizations develop a better understanding of how the technology impacts learner outcomes. Several studies have contributed to knowledge in this area by examining the phenomenon of CBT from the perspectives of education and psychology. This study builds on that work by demonstrating that the learner's comfort and familiarity with personal technology use contributes to our understanding of CBT outcomes.This research should help the test designer to be more intentional with the test design and how it influences test performance.

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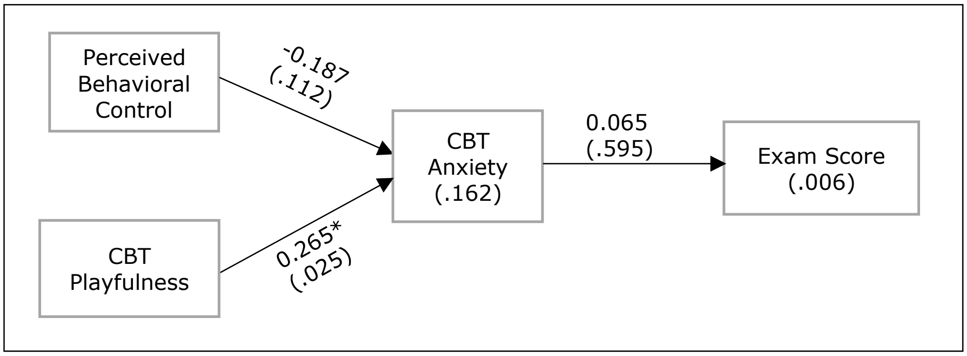
Appendix

Construct	Definition	Original Items	Items
Perceived Behavioral Control	An individual's perception of their ability to perform a given behavior.	Ajzen (19889)	1. I am able to choose how difficult my computer-based tests are. 2. Deciding how to navigate my computer-based tests is up to me. 3. It was easy for me to go back and review my answers to previous questions on computer-based tests. 4. Computer-based tests allow me to navigate my exams.
CBT playfulness	An individual's tendency to interact spontaneously, inventively, and imaginatively with a CBT exam.	Webster and Martocchio (1992)	For each adjective listed below, please circle the number that best matches a description of yourself when you take a computer-based test (CBT). 1. Spontaneous 2. Imaginative 3. Flexible 4. Creative 5. Playful 6. Original 7. Inventive
CBT anxiety	The feelings of apprehension or anxiety while an individual takes a CBT exam.	Compeau et al., (1999)	1. I feel apprehensive about taking computer-based tests. 2. It scares me to think that I could cause the computer-based test to select an incorrect answer by hitting the wrong key. 3. I hesitate to take a computer-based test for fear of making mistakes I cannot correct. 4. Computer-based tests are somewhat intimidating to me.
CBT navigation design	Test-takers' ability to navigate a CBT.	N/A	Low/High Navigation
Test performance	Test-takers' percentage score on exam.	N/A	Percentage score on exam

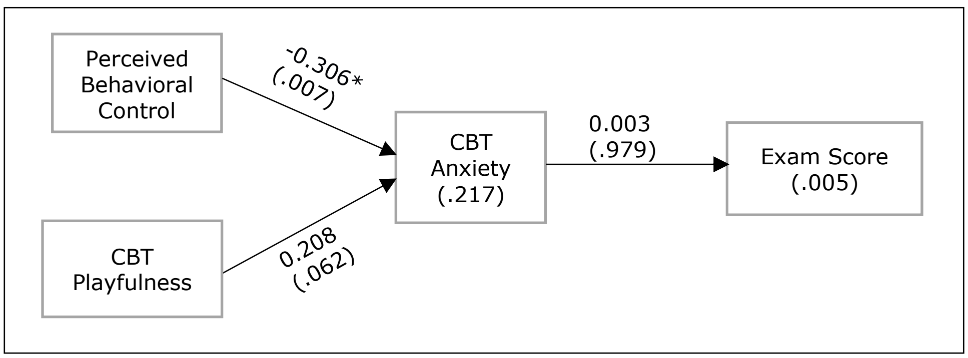
Table 1 – Study Items

Appendix (cont'd)



Standardized path estimates (p-value; r^2)
* = Significant: α = .05

Figure 2 – Regression Path Model Estimation (Exam 1)



Standardized path estimates (p-value; r^2)
* = Significant: α = .05

Figure 3 – Regression Path Model Estimation (Exam 2)