THE INFLUENCE OF PROCTORED TESTING IN DISTANCE LEARNING MATHEMATICS COURSES

by

Kelly Anderson, MS

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Kelly Anderson

APPROVED BY

____
Jana Willis, PhD, Chair

____
Michelle Peters, EdD, Committee Member

____
Michelle Giles, PhD, Committee Member

____
Roberta Raymond, EdD, Committee Member

RECEIVED BY THE COLLEGE OF EDUCATION:

____
Lillian Benavente-McEnery, EdD, Interim Associate Dean

____
Joan Y. Pedro, PhD, Interim Dean

ABSTRACT

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Kelly Anderson
University of Houston-Clear Lake, 2019

Dissertation Chair: Jana Willis, PhD

Distance learning has found a permanent place in higher education, with more colleges and universities embracing online courses as a valid method of course delivery. While there are obvious benefits for students, distance learning presents significant challenges for institutions. One such challenge is the perception academic integrity is too easily compromised on unsupervised online examinations. Proctoring is the ideal way to monitor students' conduct on examinations; however, researchers have devoted little time to examining proctored test environments. The purpose of this mixed methods study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. The study compared survey and examination results from 263 students in distance learning College Algebra and Business Calculus courses in a community college in Texas. Quantitative analysis revealed students performed significantly better and experienced significantly less test anxiety in an unproctored test environment; however, there were no significant differences in test anxiety reported at the beginning of the semester and related to a proctored test environment. Qualitative analysis of course discussion boards revealed factors of students' test anxiety related to time, physical environment, and test format. While unproctored testing should be used when possible to lessen test anxiety and improve test performance, these findings indicate it is acceptable for institutions to enforce proctored testing on high stakes examinations to ensure academic integrity.

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CHAPTER I:

INTRODUCTION

Generally regarded as resistant to change, higher education has experienced a rapid increase in distance learning enrollment over the past 15 years (Fask, Englander, & Wang, 2014). In 2002, a total of 1,602,970 students in higher education enrolled in online courses. By 2011, the number rose to 6,714,792 (Allen & Seaman, 2013). Currently, approximately one-third of all students in higher education are enrolled in at least one online course (Seaman, Allen, & Seaman, 2018). Due to this unprecedented growth, colleges have faced challenges to the integrity of online assessment. The present study examined the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses.

Research Problem

Distance learning has found a permanent place in higher education, with more colleges and universities embracing online courses as a valid method of course delivery (Allen & Seaman, 2013). Supporters of distance learning note several advantages over classroom-based learning. Such advantages include immediate feedback on assignments, accommodation of various learning styles, standardization of course design, and reduction of higher education costs (Moore & Kearsley, 2012; Nguyen, 2015).

Students enroll in online courses primarily for the flexibility and convenience of online coursework (Jaggars, 2014). Nontraditional students, in particular, benefit from the ability to complete coursework online because it allows them to continue their education while juggling multiple obligations outside of the classroom (Gargano &

Throop, 2017; Pontes, Hasit, Pontes, Lewis, & Siefring, 2010). As a result, public institutions and community colleges have become leaders in distance learning course offerings (Allen & Seaman, 2015).

Despite benefits to a variety of learners, the educational merit of distance learning continues to be questioned, most concerningly by higher education faculty (Allen & Seaman, 2016; Paullet, Chawdhry, Douglas, & Pinchot, 2016). One of the first major challenges to the quality of distance learning, relative to traditional classroom learning, was the equivalency of learning outcomes in the two formats (Cavanaugh & Jacquemin, 2015). Is learning a concept in the classroom equivalent to learning it online? Research has largely answered this question, and, with few exceptions, studies support students in online courses have similar learning outcomes to students in traditional courses (Means, Toyama, Murphy, & Bakia, 2013; Nguyen, 2015).

The second major challenge to the legitimacy of distance learning concerns the integrity of online assessment. Academic dishonesty is not a new phenomenon, and it continues to be a concern in higher education (Bowers, 1964; Gallant, Van Den Einde, Ouellette, & Lee, 2013; Gilmore, Maher, & Feldon, 2016; Harris, Harrison, Mcnally, & Ford, 2019). However, there is a persistent belief online courses facilitate higher levels of academic dishonesty than traditional courses (Moten, Fitterer, Brazier, Leonard, & Brown, 2013). This concern likely persists due to the inability of the instructor to monitor students' behavior and the ability of the Internet to provide online resources to tech-savvy students (Cole, Swartz, & Shelley, 2014; Şendağ, Duran, & Fraser, 2012).

Among science, technology, engineering, and mathematics (STEM) students, occurrences of academic dishonesty are significantly greater than other disciplines (Şendağ et al., 2012). Cross-disciplinary studies related to cheating provide estimates of involvement as high as 80.0%, with science and engineering majors more likely to cheat than students in other disciplines (Gilmore et al., 2016). Therefore, it is critical to address assessment in online STEM courses because STEM students often become STEM professionals who work in fields where unethical behavior can have human consequences (Gallant et al., 2013).

Recommendations have been made for the use of cheating deterrents, including honor codes, randomized question order, detection of common errors, question pools, and lock-down browsers (Moten et al., 2013; Paullet et al., 2016). However, according to Moore, Head, and Griffin (2017), the ideal method for assuring academic integrity in online courses is the same method used in traditional courses: proctored examinations. Whether accomplished remotely or in-person, proctoring is unique as a deterrent because it authenticates and monitors the student (Milone, Cortese, Balestrieri, & Pittenger, 2017). In distance learning, however, proctoring is somewhat complicated; it is expensive, inconvenient, and counter to the spirit of distance learning (Sullivan, 2016). Therefore, it may be worthwhile to determine if proctored testing influences student outcomes.

Research (Beck, 2014; Brallier & Palm, 2015; Fask et al., 2014; Stack, 2015) reveals a profound lack of clarity regarding the influence of proctored testing on students' test performance and test anxiety. Regarding test performance, some researchers find students perform similarly in proctored and unproctored test environments (Beck, 2014; Stack, 2015), while others find students score significantly lower in proctored test environments (Alessio, Malay, Maurer, Bailer, & Rubin, 2017; Brallier & Palm, 2015; Fask et al., 2014). In the field of mathematics, two relatively current studies (Flesch & Ostler, 2010; Yates & Beaudrie, 2009) offer contradictory results. Flesch and Ostler observed students' test performance improved in unproctored test environments, while Yates and Beaudrie observed students achieved similar course grades between proctored and unproctored test environments. Regarding test anxiety, there is extremely limited research devoted to differences between proctored and unproctored test environments.

In summary, students have embraced distance learning as a valid academic option, but there is a persistent concern, notably among faculty, that cheating is rampant in online courses (Alessio et al., 2017). Proctored testing appears to be the solution (Moore, Head, & Griffin, 2017). If there are no differences in test performance and test anxiety between proctored and unproctored test environments, then perhaps there is no need to enforce potentially expensive and time-consuming proctoring measures (Sullivan, 2016). However, if differences exist, this study may contribute to an examination of current practices and discipline-wide standards for assessment in distance learning mathematics courses.

Significance of the Study

There is reason to believe the upward trend in distance learning enrollment will continue (Allen & Seaman, 2015). Given assessment is "one of the most fundamental differences between online and traditional face-to-face lecture courses" (Brallier & Palm, 2015, p. 222), artificially inflated test performance might threaten an institution's credibility and, ultimately, accreditation. However, subjecting students to unnecessary proctored examinations may decrease test performance, increase test anxiety, and change the overall experience of distance learning. Therefore, determining appropriate types of assessment in online courses is a critical component for establishing integrity and ensuring longevity of distance learning options for students.

Research Purpose and Questions

The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. The following questions guided the study:

1. Does test environment influence test performance?
2. Does test environment influence test anxiety?
3. Is there a relationship between test anxiety and test performance?
4. What do students perceive as factors contributing to test anxiety in proctored and unproctored test environments?

Definitions of Key Terms

Academic Dishonesty or *Cheating*: King, Guyette, and Piotrowski (2009) define cheating as a "transgression against academic integrity which entails taking an unfair advantage that results in a misrepresentation of a student's ability and grasp of knowledge" (p. 4).

Distance Learning or *Online Course*: A course having at least 80% of the course content delivered online (Allen & Seaman, 2016). Online courses typically have no face-to-face meetings (Allen & Seaman, 2016).

Face-to-Face or *Traditional Course*: A course with 0% - 29% of the course content delivered online (Allen & Seaman, 2016). Face-to-face courses may use web-based technology to facilitate instruction and a learning management system to post course information such as the syllabus and assignments (Allen & Seaman, 2016).

Proctored Test Environment: A test environment in which student identification is verified and student conduct is monitored. Monitoring can be accomplished in-person at the institution, off-site through a testing center, or remotely via a webcam (Milone et al., 2017).

Test Anxiety: An unpleasant psychological state arising during examinations characterized by "feelings of tension and apprehension, worrisome thoughts, and the activation of the autonomic nervous system" (Spielberger, 1972, p. 10).

Unproctored Test Environment: A test environment in which student identification is not verified or student conduct is not monitored (Milone et al., 2017).

Conclusion

This chapter discussed the prevalence of distance learning in higher education and the lack of clarity surrounding appropriate types of assessment to use in online courses. An overview of the research problem was presented, along with the significance of the study, research purpose and questions, and definitions of terms related to the study. The next chapter presents a review of literature related to the study.

CHAPTER II:

REVIEW OF LITERATURE

This chapter reviews the existing literature related to the study. Major themes revealed from the exploration of literature include growth and effectiveness of distance learning, prevalence of academic dishonesty in distance learning, comparison of test performance in proctored and unproctored test environments, and the relationship between test anxiety and test performance. There is limited research devoted to test performance and test anxiety in distance learning at community colleges; therefore, this review includes literature focused on four-year colleges and universities as well.

Distance Learning

Distance learning is not a new concept in education; its development can be traced back to the 18th century (Kentnor, 2015). As Americans moved westward and away from educational opportunities provided by established institutions, the first courses taught at a distance were facilitated by the Pony Express. In the twentieth century, the method of delivery paralleled changes in communication technologies, from radio and television to personal computers and the Internet (Hoskins, 2013; Kentnor, 2015). Distance learning in its current form of web-based instruction has created academic opportunities for a growing number of students separated from the instructor by necessity or choice (Allen & Seaman, 2013).

Rapid Growth of Distance Learning

Much of the current literature surrounding the development of distance learning seeks to observe and quantify its growth in higher education. In a series of annual reports beginning in 2002, Allen and Seaman provide a comprehensive overview of the unprecedented growth of distance learning enrollment in higher education institutions. With assistance from the College Board, they sampled all public, degree-granting institutions of higher education in the United States. Combining their survey results from over 2,000 institutions with enrollment data provided by the National Center for Educational Statistics Integrated Postsecondary Education Data System, Allen and Seaman generated reports emphasizing various aspects of distance learning. These reports offer a comprehensive analysis of total enrollment, types of institutions, success rates, and faculty and administration perceptions related to distance learning.

As an increasing number of institutions made distance learning an option for students, Allen and Seaman described the most rapid 10 years of growth in their 2013 report *Changing Course: Ten Years of Tracking Online Education*. In 2002, a total of 1.6 million students in higher education took at least one online course. By 2011, that number exploded to 6.7 million, an increase of approximately 320%. While the annual growth rate of distance enrollment eventually slowed from this pace, Seaman, Allen, and Seaman (2018) demonstrated distance enrollment continues to increase even as overall enrollment in higher education decreases.

The statistics surrounding distance learning also provide insight into its future. In 2002, less than one-half of all higher education institutions reported online courses were critical to their long-term strategy. By 2011, that number rose to nearly 70.0% (Allen & Seaman, 2013). When considering institutions with the most distance learning students, the impact is more significant. At institutions with more than 10,000 students taking online courses, 90.3% of administrators believe distance learning is a permanent part of their institution's identity and, thus, is included in their formal strategic plan (Allen & Seaman, 2016). The literature consistently shows students and academic leaders have embraced distance learning, ensuring online courses will remain as a course delivery option in modern higher education. However, literature has also addressed several challenges to the legitimacy of distance learning.

Effectiveness of Distance Learning

Due to the rapid growth of distance learning, its overall quality has been questioned, most concerningly by higher education faculty (Allen & Seaman, 2016; Bunk, Li, Smidt, Bidetti, & Malize, 2015; Paullet et al., 2016). One of the first challenges to quality, relative to traditional education, was the equivalency of learning outcomes (Cavanaugh & Jacquemin, 2015). This issue has largely been settled in the literature. With few exceptions, studies support students in online courses have similar learning outcomes to students in traditional courses (Cavanaugh & Jacquemin, 2015; Nguyen, 2015).

Notably, a meta-analysis published by the U.S. Department of Education (USDE; Means, Toyama, Murphy, Bakia, & Jones, 2010) identified more than 1,000 studies published between 1996 and 2008 which compared learning outcomes between online and face-to-face formats. Using a thorough screening process, the researchers narrowed the collection of studies to those which were empirical in nature, experimental or quasi-experimental in design, quantitative in measurement of learning outcomes, and detailed enough to calculate effect sizes. The meta-analysis used quantitative methods to extract effect sizes from 45 acceptable studies. Overall findings suggested "students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction" (p. xiv). Due to its stringent criteria for inclusion, this meta-analysis set the standard for studies which followed (Lack, 2013).

Though largely respected, the USDE report faced some criticism in the literature for inclusion of studies with small sample sizes and studies with courses irrelevant to most colleges and universities (Lack, 2013). However, other studies eventually addressed those concerns and validated the USDE report. For example, in 2013, Means, Toyama, Murphy, and Bakia corrected various transcription errors found in the USDE report. Identical analysis confirmed the overall result of the USDE report.

To address the concern the USDE meta-analysis used relatively small sample sizes, Cavanaugh and Jacquemin (2015) compared more than 6,000 courses (1,997 online courses and 4,015 face-to-face courses) taken over 10 semesters at a single four-year university. Only courses which were taught in both formats by the same instructor were included in the study. Multiple regression isolated grade differences related to course format and not other variables such as GPA, gender, and age. A minor difference of less than 0.07 GPA points was found between the two course formats. These studies further strengthen the conclusion drawn by the USDE report.

Other meta-analyses support these results as well. Nguyen (2015) organized more than 350 studies comparing the effectiveness of distance learning into categories of positive, negative, mixed, and null findings. She observed about 92.0% of the studies supported distance learning is as effective, if not better, than traditional learning. In another review of literature, Simonson, Schlosser, and Orellana (2011) found, yet again, "it is not different education, it is distance education" (p. 140). The sum of these studies seemingly implies distance learning can be trusted to provide educational opportunities without compromising educational quality.

Academic Dishonesty in Distance Learning

Though rarely stated, the underlying motivation for conducting examinations in proctored test environments is concerns related to academic dishonesty. Academic dishonesty is not a new problem; researchers began studying the phenomenon as early as the 1920s (Hartshorne, May, Maller, & Shuttleworth, 1928). Overall, studies suggest cheating is a fairly common practice among college students.

William Bowers (1964) conducted the first large-scale study of cheating in higher education. Bowers developed a questionnaire which asked students to indicate whether they engaged in each of 12 specific behaviors considered to be academically dishonest. Bower's questionnaire was completed by 5,000 students across 99 U.S. colleges and universities, ranging from small private schools to large state universities. The major finding indicated 75.0% of students engaged in some form of academic dishonesty, and, specifically, 39.0% of students admitted to cheating on examinations.

In a replication of Bower's work, McCabe and Trevino (1997) repeated the study using nine of the original institutions. Bower's (1964) 12-item questionnaire was collected from 1,793 students (3.0% freshmen, 20.0% sophomores, 33.0% juniors, 44.0% seniors). A modest increase in cheating behaviors (75.0% to 82.0%) was reported by students. However, there was a significant increase in cheating on examinations (39.0%

to 64.0%). These studies indicate the enduring problem of academic dishonesty on college campuses.

When shifting the focus to online courses, self-reporting surveys provide no conclusive evidence regarding the prevalence of academic dishonesty in distance learning. Watson and Sottile (2010) surveyed 635 students (522 undergraduate, 102 graduate) from the same university to determine whether students cheat more in online or face-to-face courses. Students completed a 44-item *Academic Dishonesty Assessment* related to their cheating behaviors. Students also provided their perceptions of cheating in online and face-to-face courses.

Statistical analysis showed similar admissions of cheating behaviors in face-to-face (32.1%) and online (32.7%) courses, but students reported they were more than twice as likely to be caught cheating in face-to-face courses. The only individual behavior which had a higher rate of misconduct in online courses over face-to-face courses was obtaining answers from someone during an examination (18.1% to 23.3%). However, students' revealed they were almost four times as likely to cheat in online courses (10.2% to 42.2%) and believed their classmates were more than five times more likely to cheat in online courses (11.5% to 61.0%). This study demonstrates students' perceptions of academic dishonesty might not align with their actions.

Similarly, King et al. (2009) surveyed 121 undergraduate accounting students using an 11-item *Cheating Questionnaire* to investigate attitudes of business students about specific cheating behaviors in distance learning. Secondarily, they investigated the prevalence of cheating from the students' perspective. In all, 73.6% of the students felt it was easier to cheat in an online course. The only items on the survey labeled as “clearly inappropriate” by students (more than 90.0% agreement) were behaviors which involved another student’s assistance on an examination. Thus, students agree academic misconduct on examinations is unacceptable.

More recently, Cole, Swartz, and Shelley (2014) examined business students’ perceptions related to the impact of technology on academic dishonesty. Undergraduate and graduate students (n = 553) from the same university were surveyed using a combination of closed and open questions developed by the researchers. Quantitative analysis of survey responses revealed more than one-third of students believed integrity is different in online courses. Specifically, most students (67.0%) believed using notes or the textbook during an examination without the instructor’s permission was acceptable in online courses. Qualitative methods revealed students felt “ease of access to resources” and the “inability of the instructor to monitor online behavior” contributed to their belief cheating is easier in online courses (Cole et al., 2014). These results imply students are more likely to cheat in online courses, so concerns about academic integrity in this format should be carefully evaluated.

Other studies, however, somewhat alleviate concerns of academic misconduct in online courses. Bailey and Bailey (2011) conducted a study to determine if there was a difference between reactions of students in online and traditional courses when they became aware of a classmate cheating on an examination. Graduate and undergraduate students (333 students in online courses, 107 students in traditional courses) were asked to rate their level of agreement with five scenarios in which a student was using prohibited notes on an examination. Overall, students in online courses were significantly more likely than students in traditional courses to report an explicit act of cheating by notifying the instructor personally or anonymously. It appears distance learning students may have a heightened awareness of academic dishonesty.

Additionally, Sullivan (2016) conducted a study to determine the impact of technological deterrents on students' academic dishonesty in online courses. Graduate students (n = 178), in eight sections of a distance learning international business course, took two types of quizzes over the course of the semester. One quiz tested mastery of course content, and one quiz tested application of course content to hypothetical situations. All quizzes consisted of objective, multiple-choice questions constructed from large question banks so that each student received a unique quiz. Students could take each quiz up to five times and received narrative feedback about correct answers each time. Students completed a survey about their quiz-taking experiences at the end of the course.

Overall, the results suggested a large majority (83.0%) of students found it easier and more advantageous not to cheat because each quiz was unique and retakes were allowed. On average, students used four of their five quiz attempts, which implies they were likely not engaging in academic dishonesty (Sullivan, 2016). Thus, if sufficient deterrents are in place such as large question banks, randomized assignments, and multiple attempts, there is reason to believe technology can create an environment where cheating is impractical and learning is effective.

Further confusing the relationship between academic integrity and course delivery method, Miller and Young-Jones (2012) conducted a study to compare acts of academic misconduct between online and face-to-face courses. They surveyed 639 graduate and undergraduate students from two southern universities. Some students took courses in a face-to-face format (n = 246), some students took courses in an online format (n = 104), and some students took courses in both formats (n = 289). Students were asked to categorize 18 cheating behaviors in which they engaged or witnessed as "never," "once," "more than once," or "frequently." They were also asked if they thought it was easier to cheat in online courses (1 = Strongly Agree, 5 = Strongly Disagree).

Overall, 57.2% of students agreed it was easier to cheat in online courses, but the results also revealed a level of complexity. Students who took courses in both formats tended to cheat at a higher rate in their online courses (M = 4.15) than face-to-face courses (M = 3.15). However, students who took exclusively online courses tended to cheat less (M = 2.52) overall than students who took exclusively face-to-face courses (M = 4.66). Not surprisingly, these studies establish students' admission of misconduct does not offer clear insight into the prevalence of academic dishonesty in distance learning.

Test Performance in Distance Learning

Although results from self-reporting surveys do not provide clarity regarding academic dishonesty in distance learning, researchers have also used empirical studies to examine academic dishonesty in online courses. Most researchers draw their conclusions in these studies by comparing students' examination grades between proctored and unproctored test environments. Thus, this literature also provides an examination of test performance in various test environments. Due to the wide range of populations, non-systematic testing strategies, and contradictory results, it is worthwhile to consider the studies individually.

Studies Indicating Differences in Test Performance

Studies which find differences in test performance between proctored and unproctored test environments come from a variety of disciplines. Fask, Englander, and Wang (2014) conducted a study of university business students to examine differences in students' test performance between proctored and unproctored test environments. Two sections of a traditional, face-to-face elementary statistics course were identical (i.e., same lectures, same homework assignments, same midterm examination) except for the environment in which the final examination was taken. One section (n = 22) took the final examination online in an unproctored test environment, while the other section (n = 22) took the final examination in the classroom in a proctored test environment.

Fask et al. (2014) largely considered this to be an experimental study. The two sections had no statistically significant differences between them, and the sections were randomly assigned by a coin flip to the test environment in which they took the final examination. Both sections took the same in-class midterm examination, and students had no indication of the test environment in which they would take their final examination until the last week of the semester. Using regression analysis, the researchers found students in the unproctored test environment scored significantly higher on the final examination.

Continuing the work of Hollister and Berenson (2009), Fask et al. also addressed the notion taking an examination online is a disadvantage due to obstacles such as Internet connection problems, distractions, and the absence of an instructor. To separate the impact of cheating from the impact of test environment, students took a practice examination three days before the final examination in their respective test environments. Students believed their efforts on the ungraded practice examination would be extremely beneficial on the "real" final examination, thus eliminating students' motivation to cheat on the practice examination. Surprisingly, a comparison of grades revealed the unproctored test environment created a significant disadvantage for students, which somewhat offset any advantage gained by cheating. This finding suggests differences in test performance may be partially masked by overall outcomes in distance learning.

In 2015, Fask, Englander, and Wang performed a similar study with elementary statistics students but employed a slightly different design. This time, one section of students (n = 52) took a proctored portion of the final examination in class and an unproctored portion of the final examination online. Questions on both portions of the examination came from the same test bank, and answers were numerical in nature. Students could use their textbooks and had a two-hour time limit to complete each portion. Findings were consistent with their 2014 study; the unproctored test environment facilitated higher test performance for students.

In other disciplines, studies have produced similar results. Brallier and Palm (2015) examined the relationship of test environment (proctored versus unproctored) and course format (face-to-face versus online) to test performance. Course examination grades were compiled from a total of 246 undergraduate students in identical introductory sociology courses taught by the same professor over four semesters in both distance (*n* = 87) and face-to-face (*n* = 159) formats. The courses were consistent in all areas except the environment in which examinations were taken. During two semesters, all students took proctored examinations in the classroom (*n* = 116), and during the other two semesters, all students took unproctored examinations online (*n* = 130).

In all, students took unit examinations consisting of 50 multiple-choice questions and a cumulative final examination consisting of 60 multiple-choice questions. Examinations in both test environments consisted of identical questions and had a time-limit of 50 minutes. Proctored examinations were in paper-and-pencil form and proctored by the instructor. Unproctored examinations were available for 24 hours, and questions were presented in random order.

For purposes of the study, a student's overall test performance was calculated as a percentage of total points earned on the four examinations. A comparison of scores in the two environments revealed students who took online examinations in an unproctored test environment scored modestly higher (6 points on average) than students who took classroom examinations in a proctored test environment. Brallier and Palm successfully compared students in traditional and online courses using identical multiple-choice examinations. However, it is unclear if academic dishonesty impacted test performance since the study lasted over the course of four years. Students more inclined to cheat may have gravitated to the format where they could do so with relative ease and safety.

More recently, Alessio, Malay, Maurer, Bailer, and Rubin (2017) performed a study of 147 undergraduate students to compare online quiz results taken in proctored and unproctored test environments. The study consisted of nine sections of a medical terminology course taught by nine different instructors. All quizzes covered similar material using multiple-choice questions from a publisher-provided question pool, but instructors employed non-uniform time limits, question difficulty, and proctoring methods. About half of the students took their online quizzes unproctored, while the other half were required to use online proctoring software.

Controlling for non-uniformity, the researchers determined students spent significantly less time and scored significantly lower (17 points on average) on quizzes in a proctored test environment. Overall, 63.0% of students who took unproctored quizzes earned an A in the course, whereas only 17.0% of students who took proctored quizzes earned an A in the course. Again, these assessments relied on multiple-choice questions over objective information with no consistency of technological deterrents, so perhaps these studies suggest test performance may be inflated when assessments are not properly designed for online courses.

Studies Indicating No Differences in Test Performance

While the inflation of test performance in unproctored test environments is alarming in some cases, the literature also contains several examples where there are no such differences in test performance between test environments. Beck (2014) conducted a study to determine if distance learning students were more likely to engage in academic dishonesty than students in traditional courses. The midterm and final examination grades were collected from three sections of an undergraduate criminology course taught by the same instructor: an online section with unproctored examinations (*n* = 19, M_{GPA} = 2.80), a face-to-face section with examinations proctored by the instructor (*n* = 60, M_{GPA} = 2.68), and a hybrid section with examinations proctored by the university testing center (*n* = 21, M_{GPA} = 2.68). All examinations consisted of 50 identical, multiple-choice questions and a time limit of 70 minutes. For examinations taken online, questions were presented one at a time in random order.

Comparison of grades in the two test environments suggested no significant differences between both the midterm and final examinations. Following the work of Harmon and Lambrinos (2008), Beck used a model designed to predict examination grades based on student-specific variables (i.e., GPA, major, credit hours) collected from university records. Unlike the results of Harmon and Lambrinos, regression analysis revealed the model predicted test performance with the same accuracy in both the proctored and unproctored test environments. Therefore, it is more likely examination scores reflected students' mastery of the material and less likely scores were influenced by academic dishonesty.

An additional study in criminology supports Beck's findings. Stack (2015) investigated whether a lock-down browser was enough to deter cheating in an online, unproctored test environment. Final examination grades were collected from 10 sections of an online undergraduate criminological theory course taught by the same instructor over a six-year period. Five sections (*n* = 141) took proctored examinations, and five sections (*n* = 170) took unproctored examinations in a lock-down browser which limited

Internet-based functions such as web-browsing, e-mail, and instant messaging. All examinations consisted of identical multiple-choice questions presented in random order.

Controlling for the potential of test performance trending throughout the study, regression analysis revealed no significant differences between final examination grades achieved in a proctored test environment and an unproctored test environment utilizing a lock-down browser. These results suggest multiple-choice examinations in some disciplines may be considered secure if sufficient technological deterrents are in place, including time limits, randomized question order, and lock-down browsers. Thus, the formality of proctoring may be unnecessary for certain disciplines and types of examinations.

Studies in Mathematics

Given one of the purposes of the present study was to develop a clearer understanding of test performance in distance learning mathematics courses, the two relatively current studies involving mathematics courses (statistics excluded) are examined in detail in the order in which they appeared in the literature. Unfortunately, these studies are similar in design but yield conflicting results. This adds further confusion to establishing the influence of proctored testing in distance learning mathematics courses.

In 2009, Yates and Beaudrie used a variety of distance learning lower-level mathematics courses (Basic Mathematics, Prealgebra, Beginning Algebra, Intermediate Algebra, Liberal Arts Mathematics) to study the influence of proctored testing on students' overall course grades. Their study involved a large sample of 850 students who took distance learning courses at a single community college over a six-year period. Some students (n = 406) took proctored examinations, and some students (n = 414) took unproctored examinations. Each course consisted of the same content and materials, but little information was provided about the course structures or the instructors' grading schemata.

Statistical analysis revealed no significant differences between final course grades collectively or in any of the individual courses. Given this study included a large sample size including several distance learning mathematics courses, it is hopeful appropriate assessment in online mathematics courses could be established with the result. However, this study contains serious flaws in methodology, including the method of grade comparison between the two test environments. It is worth noting the study of Yates and Beaudrie drew pointed criticism in the literature.

Specifically, Englander, Fask, and Wang (2011) devoted an entire article commenting on the work of Yates and Beaudrie (2009). Though they offered some praise for "addressing the critical issue of the integrity of online exams" (p. 114), several aspects of the study received heavy criticism. Englander et al. made the case the study of Yates and Beaudrie likely suffered from selection bias since students of lesser ability may have gravitated to course sections with unproctored examinations. If this occurred, the students' lack of mathematical ability would offset the positive effect of cheating (Englander, Fask, & Wang, 2011).

Given the study used overall *course grades* as a measurement of integrity on *examinations*, the main result was also questioned. Yates and Beaudrie did not include the percentage of students' courses grades determined by their examination grades. Further, data were collected over six years, which may have impacted the results due to the rapid technological advances which occurred in distance learning between 2001 and 2006. Ultimately, Englander et al. caution "acceptance of the null hypothesis of a lack of cheating appears unwise and unwarranted under these circumstances" (p. 119).

In a similar study, Flesch and Ostler (2010) found contradictory results to Yates and Beaudrie (2009). Flesch and Ostler studied four sections of an online Intermediate Algebra course taken during a single semester at a community college to determine the effect of proctored testing on test performance. Two sections (n = 30) took two of five unit examinations as written examinations at a centralized testing center, and the other two sections (n = 32) took all five unit examinations online in an unproctored test environment. Online examinations contained algorithmically-generated questions and a sufficient time limit. Students in all sections completed a written final examination proctored at a centralized testing center at the end of the semester.

Statistical analysis showed no significant differences in test performance when both groups took examinations in an unproctored test environment. However, examination scores were significantly different when taken in different test environments. Students taking examinations in an unproctored test environment scored approximately 16.0% higher than students taking examinations in a proctored test environment. This study provides clear evidence of the test environment influencing test performance in a distance learning mathematics course, which contradicts the results of Yates and Beaudrie's 2009 study. Therefore, even when the focus is narrowed to the same discipline in the same type of institution, the influence of proctored testing on test performance is unclear.

Test Anxiety in Distance Learning

Anxiety is a complex psychological construct which was recognized as part of the human experience as early as ancient Egypt and can be traced conceptually to Pascal in the 17th century (May, 1977). In biological terms, Darwin (1859) considered fear to be universally experienced by all animals as an evolutionary response to dangerous or threatening situations. Darwin observed certain physiological manifestations of anxiety such as heart palpitations, increased perspiration, dryness of the mouth, and other symptoms triggered by the autonomic nervous system. Freud (1959), however, focused on anxiety as an unpleasant emotional state experienced by the subject as tension, apprehension, and nervousness. Through observations, he differentiated two aspects of anxiety as objective anxiety, the emotional response proportional to the danger, and neurotic anxiety, an internal danger emanating from repressed sexual impulses.

Origins of Test Anxiety Research

In 1914, Folin, Denis, and Smillie conducted the first empirical investigation of anxiety specifically related to a testing situation. The researchers found approximately one out of five medical students showed evidence of glycosuria, sugar in the urine, after a stressful examination but did not show any evidence of glycosuria before the examination. These findings were confirmed by Cannon in 1915, which led to the suggestion academic examinations provide an ideal situation for investigating the effects of stress on individuals.

However, students' emotional reactions in testing situations were not investigated until Luria in 1932. In his study, 200 medical students were classified as either "stable" or "unstable" in testing situations. "Stable" students were characterized by remaining relatively calm and maintaining well-coordinated speech and motor reactions, while "unstable" students were characterized as becoming excited and having disorganized thoughts and actions. Luria observed 60.0% of students were characterized as "unstable," while only 16.0% of students were characterized as "stable." Given this observation, he concluded academic examinations evoke intense emotional responses and create unmanageable stress for students.

Test Anxiety and Test Performance

Studies have shown elevated levels of test anxiety can significantly weaken students' performance in a variety of testing situations (Cassady & Johnson, 2002; Eum & Rice, 2011; Mandler & Sarason, 1952; Sarason & Mandler, 1952; Seipp, 1991). One of the first studies to examine the relationship between test anxiety and test performance was conducted by Mandler and Sarason in 1952. During their first class meeting, 154 students in an introductory psychology course at Yale University completed the researcher-developed *Anxiety Questionnaire*. The questionnaire consisted of 67 questions divided into four sections: individual intelligence tests, group intelligence tests, course examinations, and general questions. Students indicated their responses along a 15-centimeter continuum.

Using completed questionnaires of non-veteran sophomores and juniors (n = 101), the researchers placed participants scoring the 21 highest scores into a high anxiety (HA) group and the participants scoring the 21 lowest scores into a low anxiety (LA) group. Approximately three months later, the 42 participants completed a series of intelligence tests. Students with high anxiety exhibited a slower and more varied response time on intelligence tests than students with low anxiety (M_{HA} = 76.2, M_{LA} = 58.9).

Following this work, Sarason and Mandler (1952) conducted another study in which their *Anxiety Questionnaire* was administered to 492 students in an introductory psychology course. This time, the lower 30.0% of students were considered low anxiety, and the upper 29.0% of students were considered high anxiety. From archival data, the researchers' statistical analysis revealed students with high anxiety (n = 141) scored significantly lower on the university's Mathematics Aptitude Test (M_{HA} = 579.6, M_{LA} = 602.8) and the Scholastic Aptitude Test (SAT; M_{HA} = 553.5, M_{LA} = 577.9).

In 1991, Seipp performed a meta-analysis of 126 studies published between 1975 and 1988 and found a negative correlation (r = -.21) between test anxiety and test performance. More recent studies confirm this result. In 2002, Cassady and Johnson sought to establish reliability and validity of a new measure of test anxiety and examine the relationship between students' test anxiety and test performance. The *Reactions to Tests Questionnaire* (Sarason, 1984) was used to assess the validity of the researchers' new measure, the *Cognitive Test Anxiety Scale* (CTAS; Cassady & Johnson, 2002).

Cassady and Johnson recruited undergraduates (n = 168) from a large university to participate in the study. Several days before an in-class examination, students completed the two anxiety measures and provided their SAT scores on a demographic survey. Cassady and Johnson examined CTAS scores and divided the students into high (top 33.0%) and low (bottom 33.0%) anxiety groups. Statistical results indicated students with high anxiety were significantly outperformed on the SAT and other in-class examinations by students with low anxiety ($p < .001$). Given Cassady and Johnson used actual classroom examinations, these findings indicate students with high levels of test anxiety have a clear disadvantage in educational settings.

In a more recent study, Eum and Rice (2011) investigated the relationship between cognitive test anxiety and test performance. Participants included 134 undergraduate students (62.0% female) recruited from psychology courses at a large public university. Participants completed self-report questionnaires, including the CTAS (Cassady & Johnson, 2002), as a measure of anxiety and the Rey Auditory Verbal Learning Test (Spreen & Strauss, 1991) as a measure of test performance.

Eum and Rice found a modest, inverse correlation between test anxiety and test performance ($r = -.18$). Specifically, the researchers found students with higher test anxiety suffered in terms of overall GPA and their ability to recall a list of 45 specific words. Thus, it appears high levels of test anxiety negatively impact students' cognitive performance. Overall, these studies suggest test anxiety significantly impacts performance in a variety of evaluative situations.

Test Anxiety and Test Environment

There is limited research with mixed results on the influence of test environment on test anxiety. Schult and McIntosh (2004) investigated students' test anxiety on computer-based examinations. Undergraduates in a traditional psychology course (n = 265) took paper-and-pencil multiple-choice examinations and computer-based examinations. There were no significant differences in test anxiety when both examinations were taken in a proctored test environment. However, students taking paper-and-pencil examinations demonstrated increased anxiety related specifically to computer-based testing. Thus, students with poor computer skills may have increased test anxiety when taking online courses.

Stowell and Bennett (2010) examined whether test anxiety translated from the traditional classroom to the online classroom. Undergraduate students (n = 69) in a Psychology of Learning course were divided into two groups. Students with a last name beginning with A-M (n = 35) took a multiple-choice examination in a proctored test environment, while students with a last name beginning with N-Z (n = 34) took an identical examination online in an unproctored test environment. For the subsequent examination, students took the examination in the opposite test environment.

Findings indicated students who experienced high test anxiety in the classroom had significantly reduced test anxiety online ($t = -5.03$, $p < .001$), while students who experienced low test anxiety in the classroom had significantly increased test anxiety online ($t = 2.08$, $p < .05$). Further, the relationship between test anxiety and test performance was weaker online ($r = -.28$, $p < .001$) than in the classroom ($r = -.57$, $p = .02$). This result suggests students may experience less test anxiety in an unproctored test environment.

Notably, Hayes and Embretson (2013) compared test anxiety of STEM students using a computer-based mathematical examination in proctored and unproctored test environments. Participants consisted of 315 undergraduate science and engineering majors (62% Caucasian, 16% Asian, 13% African American, 9% Indian). Students were randomly assigned to one of the two test environments. They completed a mathematical examination consisting of 30 questions similar to those on the quantitative reasoning portion of the Graduate Record Examination. Test anxiety was measured using the *Revised Test Anxiety* scale (Hodapp & Benson, 1997).

As hypothesized, students experienced significantly greater cognitive distractions ($p < .01$), as well as external distractions related to noise ($p < .01$) and temperature ($p < .01$) in the unproctored test environment. A series of independent *t*-tests concluded cognitive distractions were primarily responsible for the impact of test anxiety in both environments, but the effect was stronger in the unproctored test environment (Hayes & Embretson, 2013). Since the existing literature related to the impact of test environment on test anxiety is severely lacking and inconclusive, further exploration is warranted.

Summary of Findings

Distance learning is a popular (Allen & Seaman, 2013) and effective (Means et al., 2010) method of course delivery. Using strict requirements for inclusion, findings of a USDE report suggest students in online courses perform as well as students in traditional courses (Means et al., 2010). Other research supports distance learning as an effective method of course delivery (Cavanaugh & Jacquemin, 2015; Means et al., 2013; Nguyen, 2015; Simonson, Schlosser, & Orellana, 2011).

Researchers have studied the phenomenon of academic dishonesty dating back to the 1928 study of Hartshorne, May, Maller, and Shuttleworth. Bowers (1964) was the first to conduct a large-scale study of cheating in higher education and found a large majority of students engaged in some form of academic dishonesty. Bower's work was replicated in 1997 by McCabe and Trevino who found a significant increase of cheating on examinations.

In distance learning, surveys do not offer consistent conclusions of students' perceptions of academic dishonesty. Watson and Sottile (2010) found undergraduate and graduate students were significantly more likely to cheat in online courses. King et al. (2009) found a large majority of accounting students also felt it was easier to cheat in online courses. Additionally, Cole et al. (2014) examined business students' perceptions of how technology impacts academic dishonesty. Most students believed using notes during an examination without the instructor's permission was acceptable in online courses.

Contradicting these results, Bailey and Bailey (2011) analyzed university students' reactions to cheating scenarios. Students in online courses were more likely to report misconduct than students in face-to-face courses. Sullivan (2016) conducted a study of graduate students to determine the impact of technological deterrents on cheating in online courses. The results suggested students were actually motivated not to cheat because each quiz was unique and retakes were allowed. Miller and Young-Jones (2012) compared acts of academic misconduct between online and face-to-face courses. Students who took courses in both formats tended to cheat at a higher rate in their online courses, but students who took exclusively online courses tended to cheat less overall than students who took exclusively face-to-face courses.

Empirical studies comparing test performance between proctored and unproctored test environments also do not provide conclusive results. Fask et al. (2014; 2015) conducted two studies of elementary statistics students in face-to-face courses and found unproctored, online examinations created a disadvantage for students which somewhat offset any advantage gained by cheating. Brallier and Palm (2015) found sociology students who took online examinations in an unproctored test environment scored higher than students who took in-class examinations in a proctored test environment. Alessio et al. (2017) found students in an online medical terminology course scored significantly lower when taking quizzes in a proctored test environment.

Other empirical studies found no differences in test performance between proctored and unproctored test environments. Beck (2014) compared examination grades of criminology students in online and face-to-face courses and found no significant differences on both the midterm and final examinations. Again, in criminology, Stack (2015) analyzed whether a lock-down browser was enough to deter cheating in an online, unproctored test environment. There were no significant differences observed between final examination grades achieved in a proctored test environment and final examination grades achieved in an unproctored test environment utilizing a lock-down browser.

In the discipline of mathematics, the two existing studies offer conflicting results. Yates and Beaudrie (2009) analyzed a variety of distance learning, lower-level mathematics courses to determine the impact of proctored testing on students' overall course grades. Findings revealed no significant differences in course grades achieved by taking examinations in proctored and unproctored test environments. On the other hand, Flesch and Ostler (2010) analyzed an online Intermediate Algebra course and found highly significant differences in examination scores when examinations were taken in different test environments.

Anxiety is a complex psychological construct which consists of physiological manifestations (Darwin, 1859) and unpleasant emotions (Freud, 1959). Folin et al. (1914) and Cannon (1915) found medical students showed evidence of sugar in the urine after a stressful examination but not before the examination. Individual differences in students' emotions related to examinations were first investigated by Luria (1932). Results indicated most students are "unstable" during examinations.

Studies have shown high levels of test anxiety can impair students' academic performance (Cassady & Johnson, 2002; Eum & Rice, 2011; Mandler & Sarason, 1952; Sarason & Mandler, 1952). Mandler and Sarason (1952) divided sophomore and juniors into high anxiety and low anxiety groups. Students with high levels of test anxiety exhibited slower response times with larger variability on intelligence tests than students with low levels of test anxiety. The same researchers (Sarason & Mandler, 1952) conducted a similar experiment and found students with high levels of test anxiety achieved lower scores on the university's Mathematics Aptitude Test. Seipp (1991) performed a meta-analysis of 126 studies and found a negative correlation between test anxiety and test performance.

More recent studies confirm these foundational results. Cassady and Johnson (2002) found undergraduates' SAT performance was inversely related to their scores on anxiety measures. Eum and Rice (2011) found a modest, inverse correlation between cognitive test anxiety and various types of evaluative situations. Overall, these results suggest students with high levels of test anxiety perform worse than students with low levels of test anxiety on examinations and other testing situations.

There is limited research on the influence of test environment on test anxiety. It is unclear whether students experience less (Stowell & Bennett, 2010) or more (Schult & McIntosh, 2004) test anxiety in online courses. Notably, Hayes and Embretson (2013) compared STEM students' grades on a computer-based mathematical examination taken in proctored and unproctored test environments. Greater cognitive distractions in the unproctored test environment were found to impact both test anxiety and test performance.

Theoretical Framework

This study was guided by the test anxiety theory of Liebert and Morris (1967). Liebert and Morris identified worry and emotionality as the two major components of test anxiety. Worry is defined as any "cognitive expression of concern about one's own performance" (p. 975) and involves students' perceived lack of competence to counteract the threat of an evaluative situation. Emotionality is defined as "autonomic reactions which tend to occur under examination stress" (p. 975) and involves bodily reactions such as sweating and headaches. Although both components typically coexist in students experiencing test anxiety, they seem to impact students' test performance quite differently. Worry is significantly and negatively related to test performance, but emotionality is not significantly related to test performance (Liebert & Morris, 1967).

The construction and development of the *Test Anxiety Inventory* (TAI) used in this study were guided by Liebert and Morris's test anxiety theory (Spielberger, 1980).

Conclusion

The review of literature in this chapter highlights the confusion surrounding the topic and indicates further research is necessary to improve understanding of the influence of proctored testing in distance learning. The major themes discussed were growth and effectiveness of distance learning, prevalence of academic dishonesty in distance learning, comparison of test performance in proctored and unproctored test environments, and the relationship between test anxiety and test performance. The next chapter details the methodology of the study.

CHAPTER III:

METHODOLOGY

The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. Using mixed methods, the researcher analyzed final examination grades, survey data, and discussion board data related to proctored and unproctored test environments from a purposeful sample of undergraduate students enrolled in distance learning mathematics courses at a large suburban community college in southeast Texas. This chapter presents an overview of the methodology of the study.

Overview of Research Problem

There is a persistent belief online courses facilitate higher levels of academic dishonesty than face-to-face courses due to the inability of the instructor to monitor behavior and the students' ease of access to online resources (Cole et al., 2014; Şendağ et al., 2012). Recommendations have been made for the use of technological deterrents such as question pools and timed assessments, but the only method for assuring academic integrity is proctored examinations (Moore et al., 2017). However, in distance learning, proctoring is expensive, inconvenient, counter to the spirit of distance learning, and may increase test anxiety (Sullivan, 2016). Therefore, it may be necessary to determine the extent to which proctored testing influences student outcomes in distance learning courses.

Operationalization of Theoretical Constructs

This study consisted of three constructs: (a) test environment, (b) test performance, and (c) test anxiety. Test environment is defined as *proctored* when student identification is verified and conduct is monitored and *unproctored* when student identification is not verified or conduct is not monitored (Milone et al., 2017). This construct was measured using self-reports from faculty regarding the test environment in which an examination was administered. *Test anxiety* is defined as an unpleasant state arising during examinations characterized by "feelings of tension and apprehension, worrisome thoughts, and the activation of the autonomic nervous system" (Spielberger, 1972, p. 10). This construct was measured using the *Test Anxiety Inventory* (TAI; Spielberger, 1980). *Test performance* is defined as the grade a student earns on a test or examination (Brallier & Palm, 2015). This construct was measured using numeric final examination grades.

Research Purpose and Questions

The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. The following questions guided the study:

1. Does test environment influence test performance?
2. Does test environment influence test anxiety?
3. Is there a relationship between test anxiety and test performance?
4. What do students perceive as factors contributing to test anxiety in proctored and unproctored test environments?

Research Design

For this study, the researcher used a concurrent mixed methods design (QUAN + qual). Mixed methods was chosen as the mode of inquiry given the strengths of quantitative and qualitative inquiry can provide better insight than either method in isolation (Creswell & Creswell, 2018). The advantage of a concurrent design is it provides triangulation by seeking convergence of results achieved through simultaneous quantitative and qualitative phases (Johnson & Christensen, 2017). In this study, quantitative methods were used to compare test performance and test anxiety in proctored and unproctored test environments, and qualitative methods were used to further understand students' perceptions of factors contributing to test anxiety in proctored and unproctored test environments.

In the quantitative phase, a purposeful sample of students enrolled in distance learning mathematics courses at a large suburban community college located in southeast Texas students completed final examinations in proctored and unproctored test environments. Students also completed the TAI (Spielberger, 1980) at the beginning of the semester and immediately after each of the two final examinations. Quantitative data were analyzed using two-tailed paired *t*-tests and Pearson product-moment correlation coefficients (r).

In the qualitative phase, a purposeful sample of students enrolled in a distance learning mathematics course at a large suburban community college located in southeast Texas responded to prompts posed in a course discussion board regarding proctored and unproctored test environments. A course discussion board was used as an asynchronous focus group (Holtz, Kronberger, & Wagner, 2012) given students posted at different times. This design allowed a study of distance learning students in their natural setting, one of the distinguishing features of qualitative research (Lichtman, 2013). Qualitative data were analyzed using a general inductive coding process (Thomas, 2006) with individual discussion board posts as the unit of analysis (Holtz et al., 2012). Students' expressions of worry or emotionality related to an examination (Liebert & Morris, 1967) were identified as test anxiety.

Population and Sample

For the quantitative phase of the study, the population consisted of all students enrolled in distance learning mathematics courses in a large suburban community college located in southeast Texas. At the time of the study, the community college was composed of three campuses and had a student population of approximately 30,000 students. Regarding distance learning, approximately 10,000 students enrolled in at least one online course each semester (Texas Higher Education Coordinating Board, 2018), which was consistent with the national average (Seaman et al., 2018). Table 3.1 provides student characteristics in Fall 2018 as provided by the community college.

Table 3.1

Student Characteristics

Characteristic	Frequency (*n*)	Percentage (%)
Female	18,786	58.5
Male	13,351	41.5
Hispanic or Latino	19,136	59.5
White or Caucasian	6,986	21.7
Black or African American	3,166	9.9
Asian	1,821	5.7
21 & Under	19,736	61.4
22 & Over	12,401	38.6

For the quantitative phase of the study, the researcher chose a purposeful sample of undergraduate students enrolled in distance learning College Algebra and Business Calculus courses taught by the researcher during the Summer 2018, Fall 2018, Spring 2019, and Summer 2019 semesters. Both courses are included in the core curriculum mandated by Texas law and automatically transfer to all Texas public colleges and universities. College Algebra was chosen as a course to investigate given it is the mathematics course taken by many undergraduate students. Business Calculus was chosen as a course to investigate due to concerns related to differences in test performance between test environments noted in the literature (Cole et al., 2014; Fask et al., 2014; Fask, Englander, & Wang, 2015; King, Guyette, & Piotrowski, 2009).

Participant Selection

For the qualitative phase of the study, the researcher chose a purposeful sample of 25 students enrolled in a distance learning mathematics course in a large suburban community college located in southeast Texas. The criteria for selection was students enrolled in a single section of distance learning College Algebra taught by the researcher during the Fall 2018 semester. Participants completed six discussion board posts as regular, course assignments in Blackboard throughout the semester. Topics addressed in the discussion board included challenges, preferences, and perceptions of test anxiety in proctored and unproctored test environments.

Instrumentation

Test Anxiety Inventory

The TAI is a 20-item self-reporting psychometric scale developed by Spielberger (1980) to measure individual differences in test anxiety as a situation-specific personality trait. The instrument was developed over five years at the University of South Florida to evaluate the effectiveness of various cognitive-behavioral therapies in the treatment of test anxiety in college students (Spielberger, 1980). The two major goals in developing the TAI were: (a) to construct a brief, objective, self-report scale which was highly correlated with other widely used measures of test anxiety and (b) to employ factor analysis to identify subscales measuring worry and emotionality as major components of test anxiety.

To complete the TAI, respondents use a four-point Likert-type scale (1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Almost Always) to report how frequently they experience specific symptoms of anxiety before, during, and after examinations. For example, in responding to item two, "While taking examinations, I have an uneasy, upset feeling," students select the response which best describes their experience during examinations. The TAI provides three scores: Total, Worry, and Emotionality. The Worry subscale consists of items 3, 4, 5, 6, 7, 14, 17, and 20. The Emotionality subscale consists of items 2, 8, 9, 10, 11, 15, 16, and 18. All 20 items are used to determine the TAI Total score. Given each response is weighted from one to four, the minimum TAI Total score is 20, and the maximum Total score is 80. A higher Total score indicates the student experiences higher levels of test anxiety.

Regarding validity, Spielberger (1980) correlated the TAI with six other anxiety measures, including Sarason's (1978) *Test Anxiety Scale* (TAS) and Liebert and Morris's (1967) *Worry and Emotionality Questionnaire* (WEQ). The correlations of the TAI Total scale with the TAS, .82 for males and .83 for females, are comparable to the reliability coefficients for each scale. Thus, the 20-item TAI and the 37-item TAS are comparable measures of test anxiety (Spielberger, 1980). The relatively high correlations of the TAI subscales with the WEQ subscales provide further evidence of validity (Spielberger, 1980). Table 3.2 provides means, standard deviations, and alpha reliability coefficients for the TAI Total scale (Spielberger, 1980).

Table 3.2

Reliabilities of TAI Total Scale

	Undergraduates		Freshmen		Community College	
Stat	Male	Female	Male	Female	Male	Female
n	654	795	533	596	136	184
M	38.48	42.79	39.28	42.30	38.75	43.25
SD	12.43	13.70	10.99	11.83	11.76	13.12
α	.94	.95	.92	.93	.93	.96

Final Examinations

College Algebra. The final examination in the distance learning College Algebra course was a web-based, cumulative assessment composed of 20 multiple-choice questions (see Appendix D). Ten of the questions were determined by professors in the mathematics department, experts in the discipline, to measure achievement of state-mandated Student Learning Outcomes. The other 10 questions were determined by the instructor to address additional concepts covered during the semester. Each question asked students to solve a specific problem and choose the correct answer from four options determined by the instructor. Table 3.3 provides an itemization of examination questions by concept.

Table 3.3

College Algebra Final Examination

Concept	Question Numbers
Properties of Functions	1, 2, 3
Functions and Equations	4, 14, 15, 19
Graphing Techniques	5, 6, 13, 18
Roots of Polynomial Functions	7, 8, 11
Matrices and Systems of Equations	9, 12, 16, 20
Inequalities	10, 17

Business Calculus. The final examination in the distance learning Business Calculus course was a web-based, cumulative assessment composed of 20 multiple-choice questions (see Appendix E). Ten of the questions were determined by professors in the mathematics department, experts in the discipline, to measure achievement of state-mandated Student Learning Outcomes. The other 10 questions were determined by the instructor to address additional concepts covered during the semester. Each question asked students to solve a specific problem and choose the correct answer from five options determined by the instructor. Table 3.4 provides an itemization of examination questions by concept.

Table 3.4

Business Calculus Final Examination

Concept	Question Numbers
Functions, Graphs, and Limits	2, 5, 8, 10
Differentiation	3, 7, 12, 14
Applications of the Derivative	4, 13, 15, 17
Exponential and Logarithmic Functions	6, 9, 18, 19
Integration and Its Applications	1, 11, 16, 20

Data Collection Procedures

Quantitative

Prior to data collection, the researcher gained approval from University of Houston – Clear Lake's (UHCL's) Committee for Protection of Human Subjects (CPHS) and the Institutional Review Board (IRB) of the community college where the study was conducted. At the beginning of the semester, before access to any course content, students completed the TAI as an assignment in Blackboard. Students completing the TAI were provided a cover letter which included the purpose of the study, expected duration, risks, and benefits of participation. During the semester, students completed five regular examinations as web-based assessments in an unproctored test environment.

During the last week of the semester, the final examination was administered in two test environments: proctored and unproctored. First, students took the final examination in a proctored test environment on Monday or Tuesday at times determined by the instructor. The instructor of the course proctored students in a computer lab on campus. For purposes of the study, student identification was verified by a state-issued driver's license or a student identification card issued by the institution. Students had two hours to complete the examination in Blackboard using a scientific calculator, pencil, and scratch paper. All scratch paper was returned to the instructor at the completion of the examination. Immediately after submission of the proctored final examination, students completed the TAI as an assignment in Blackboard before leaving the computer lab.

Following the proctored final examination, students took the final examination in an unproctored test environment on Wednesday or Thursday of the last week of the semester. The unproctored final examination was taken by students on any computer with Internet access. Students could begin the examination at any time on Wednesday or Thursday but had to complete the examination within two hours. The final examination was identical to the final examination taken in the proctored test environment except for the order of the questions and answers. Question order and multiple-choice answers were automatically randomized by Blackboard so that each student received a unique examination. Students could use a scientific calculator, pencil, and scratch paper. Students were instructed not to use any other resources (e.g., notes, textbook, graphing calculator, individuals) for assistance on the examination and to dispose of any scratch paper after the examination. Immediately after submission of the unproctored final examination, students completed the TAI as an assignment in Blackboard.

Final examinations and surveys were automatically stored in Blackboard at the beginning of the semester and as students took the proctored and unproctored final examinations. The researcher transferred the grades and survey data from Blackboard to a Microsoft Excel spreadsheet on the researcher's computer and flash drive. The password-protected computer and flash drive were kept in the researcher's locked office at all times. Final examination grades and survey data will be kept for three years and then deleted per the institution's policy.

Qualitative

In addition to final examination grades and survey data, students participated in a course discussion board regarding advantages and disadvantages of proctored and unproctored test environments. Before posting in the discussion board, students read a letter of consent (see Appendix B) which stated the purpose of the study, procedures, expected duration, risks of participation, benefits, confidentiality, right to withdraw participation, and researcher contact information. Students provided consent electronically through an e-mail sent to the instructor.

During the semester, participants responded to six discussion board prompts in Blackboard related to examinations taken in proctored and unproctored test environments (see Appendix F). The prompts addressed challenges, preferences, and anxiety experienced in proctored and unproctored test environments. The five prompts related to unproctored test environments were posed one at a time in separate forums created by the instructor after each of the five regular examinations. The single prompt related to proctored test environments was posed after the proctored final examination. Participants were encouraged to thoughtfully answer each question and respond to at least two classmates' posts. Forums were available for one week and only visible to students enrolled in the course for the duration of the semester.

During the semester, discussion board posts were automatically stored in Blackboard. After the semester, the researcher accessed and copied discussion board posts to a Microsoft Word document on the researcher's password-protected computer and flash drive. Identifying information was removed, and participants were assigned a numeric pseudonym. Documents will be kept in the researcher's locked office for three years and then deleted per the institution's policy.

Data Analysis

Quantitative

Final examination grades and survey data were transferred from Microsoft Excel to IBM SPSS to be analyzed. To answer Research Question One, a two-tailed paired *t*-test was used to determine if test environment influences test performance. The independent variable, test environment, was categorical (proctored and unproctored), and the dependent variable, test performance, was continuous. Cohen's *d* and coefficient of determination (r^2) were used to calculate effect sizes.

To answer Research Question Two, two-tailed paired *t*-tests were used to determine if test environment influences test anxiety. Given the TAI was completed at three points during the semester (beginning of semester, after proctored examination, after unproctored examination), three paired *t*-tests were used to determine if there were statistically significant mean differences in test anxiety between test environments. In each case, the independent variable, test environment, was categorical (proctored and unproctored), and the dependent variable, test anxiety, was continuous. Cohen's d and coefficient of determination (r^2) were used to calculate effect sizes.

Research Question Three was answered using Pearson product-moment correlation coefficients (r) to determine if there was a statistically significant relationship between test anxiety and test performance. Both variables, test anxiety and test performance, were continuous in measurement. The coefficient of determination (r^2) was used to calculate effect sizes. A significance value of 0.05 was used for this study.

Qualitative

In addition to quantitative analysis, participants' discussion board data were analyzed to provide understanding of students' perceptions of test anxiety in proctored and unproctored test environments. To answer Research Question Four, a general inductive approach (Thomas, 2006) was used. The researcher carefully read participants' discussion board responses several times to identify ideas which emerged from the data. These ideas were used to establish a list of codes. The Word document containing participants' discussion board responses was transferred into NVivo and fully coded using the list of established codes. The researcher condensed the codes into themes by searching for patterns and redundancy among the codes. The emergent themes were used to describe students' perceptions regarding factors contributing to test anxiety in proctored and unproctored test environments.

Validity

Validity was established by triangulation, member checking, and peer review during data collection and data analysis. Triangulation was achieved by collecting student discussion board responses from multiple sections of a distance learning College Algebra course. This allowed for an examination of consistency in results using different data sources but the same method of data collection. Students were also encouraged to review their discussion board posts before the end of the semester, and the researcher's preliminary findings were e-mailed to them at the end of the study. This member-checking process ensured the accuracy of the information and its interpretation. Finally, peer review was provided by experts in qualitative and educational research during the study to support and challenge the researcher.

Privacy and Ethical Considerations

Prior to data collection, the researcher gained approval from UHCL's CPHS and the IRB of the community college used in the study. Students participating in the survey were provided a cover letter which included the purpose of the survey, expected duration, risks, and benefits of participation. Students participating in the discussion board were provided a letter of informed consent stating the purpose of the study, procedures, expected duration, risks of participation, benefits, confidentiality, financial compensation, right to withdraw participation, and researcher contact information.

The researcher transferred final examination grades and survey data from Blackboard to a spreadsheet on the researcher's computer and flash drive. The researcher transferred discussion board posts to a Word document on the researcher's computer and flash drive. All identifying information was removed, and numeric pseudonyms were assigned. The password-protected computer and flash drive were kept in the researcher's locked office at all times. All data will be kept for three years and then deleted per the institution's policy.

Research Design Limitations

This research design consisted of several limitations. First, given the study consisted of two courses taught by a single professor using multiple-choice examinations, generalizability of the findings may be limited. Also, there may have been a repeated testing effect present because students took two final examinations composed of the same content in a relatively short period of time. Even though students did not know their results until after they submitted both final examinations, repeated testing may have impacted students' test performance and test anxiety in the unproctored test environment. Finally, the researcher functioned as the sole instructor in the study. There is always concern when an instructor asks students to self-report about assessment in an educational setting. To maximize objectivity, students were not assigned a grade for their participation, final examinations were automatically graded in Blackboard, and survey and discussion board data were not accessed until final grades were reported to the institution.

Conclusion

The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. The study involved analyzing final examination grades, survey data, and discussion board data related to proctored and unproctored test environments. This chapter described the methodology of the study. In Chapter IV, analysis of final examination grades, survey data, and discussion board data will be discussed in detail.

CHAPTER IV:

RESULTS

The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. This chapter presents the findings of the quantitative and qualitative analyses of the data. An overview of the participants' demographics is presented, followed by results of the data analysis for each of the four research questions. The chapter concludes with a summary of findings.

Participant Demographics

For the quantitative phase of the study, the researcher chose a purposeful sample of 263 students enrolled in distance learning College Algebra and Business Calculus courses at a large suburban community college located in southeast Texas. Regarding gender, 162 students (61.6%) indicated they were female, and 101 students (38.4%) indicated they were male. Regarding race, 130 students (49.4%) indicated they were Hispanic or Latino, 101 students (38.4%) indicated they were White or Caucasian, 21 students (8.0%) indicated they were Black or African American, and 10 students (3.8%) indicated they were Asian. Regarding classification, 102 students (38.8%) were freshmen, 101 students (38.4%) were sophomores, and 60 students (22.8%) were unclassified (72 hours or more) at the time of the study. The average age of the participants was 23.5 years. This sample was fairly representative of the student population of the College. Table 4.1 provides an overview of the demographics of the participants of the quantitative phase of the study.

Table 4.1

Demographics of Participants

Characteristic	Frequency (*n*)	Percentage (%)
Female	162	61.6
Male	101	38.4
Hispanic or Latino	130	49.4
White or Caucasian	101	38.4
Black or African American	21	8.0
Asian	10	3.8
Freshman (0 – 29 hours)	102	38.8
Sophomore (30 – 71 hours)	101	38.4
Unclassified (72 hours or more)	60	22.8
21 & Under	138	52.5
22 & Over	125	47.5

These participants self-selected into distance learning College Algebra and Business Calculus courses during the Summer 2018, Fall 2018, Spring 2019, and Summer 2019 semesters. One hundred and fifty-three students (58.2%) enrolled in College Algebra. Of those students, 84 students (31.9%) took College Algebra in a regular semester lasting 16 weeks, and 69 students (26.2%) took College Algebra in a short semester lasting 10 weeks. One hundred and ten students (41.8%) enrolled in Business Calculus. Of those students, 59 students (22.4%) took Business Calculus in a regular semester lasting 16 weeks, and 51 students (19.4%) took Business Calculus in a short semester lasting 10 weeks. Table 4.2 provides an overview of students by course (College Algebra and Business Calculus) and semester lengths (16 weeks and 10 weeks).

Table 4.2

Participants by Course

Course	Frequency (*n*)	Percentage (%)
College Algebra	153	58.2
Regular Semester (16 weeks)	84	31.9
Short Semester (10 weeks)	69	26.2
Business Calculus	110	41.8
Regular Semester (16 weeks)	59	22.4
Short Semester (10 weeks)	51	19.4

For the qualitative phase of the study, the researcher chose a purposeful sample of 25 participants enrolled in a single section of a distance learning College Algebra course taught by the researcher during the Fall 2018 semester at a large suburban community college located in southeast Texas. Regarding gender, 19 of the participants (76.0%) indicated they were female, and six participants (24.0%) indicated they were male. Regarding race, 15 participants (60.0%) indicated they were Hispanic or Latino, nine participants (36.0%) indicated they were White or Caucasian, and one participant (4.0%) indicated he was Asian. Regarding classification, 12 students (48.0%) were freshmen, eight students (32.0%) were sophomores, and five students (20.0%) were unclassified (72 hours or more) at the time of the study. The average age of the participants was 24.5 years. Table 4.3 provides an overview of the demographics for discussion board participants for the qualitative phase of the study.

Table 4.3

Demographics of Discussion Board Participants

Characteristic	Frequency (*n*)	Percentage (%)
Female	19	76.0
Male	6	24.0
Hispanic or Latino	15	60.0
White or Caucasian	9	36.0
Asian	1	4.0
Freshman (0 – 29 hours)	12	48.0
Sophomore (30 – 71 hours)	8	32.0
Unclassified (72 hours or more)	5	20.0
21 & Under	12	48.0
22 & Over	13	52.0

Research Question One

Research Question One, *Does test environment influence test performance?,* was answered using two-tailed paired *t*-tests. For College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(262) = -14.621$, *p* < .001, *d* = 1.00 (large effect size), r^2 = .202. On average, students performed better in an unproctored test environment (*M* = 87.3) than a proctored test environment (*M* = 72.1). Approximately 20.0% of the variance in test performance can be attributed to the test environment. Table 4.4 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.4

Test Performance (All Courses, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	263	72.1	18.0	-14.621	262	< .001*	1.00	.202
Unproctored	263	87.3	11.6					

*Statistically significant (*p* < .05)

For College Algebra and Business Calculus taken in regular semesters (16 weeks), results of the paired *t*-test indicated test environment does influence test performance, *t*(142) = -11.449, *p* < .001, *d* = .99 (large effect size), r^2 = .198. On average, students performed better in an unproctored test environment (*M* = 86.1) than a proctored test environment (*M* = 70.4). Approximately 20.0% of the variance in test performance can be attributed to the test environment. Table 4.5 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks).

Table 4.5

Test Performance (All Courses, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	143	70.4	18.3	-11.449	142	< .001*	.99	.198
Unproctored	143	86.1	12.6					

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in short semesters (10 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(119) = -9.179$, $p < .001$, $d = 1.03$ (large effect size), $r^2 = .210$. On average, students performed better in an unproctored test environment ($M = 88.9$) than a proctored test environment ($M = 74.2$). Approximately 21.0% of the variance in test performance can be attributed to the test environment. Table 4.6 displays numeric results for College Algebra and Business Calculus taken in short semesters (10 weeks).

Table 4.6

Test Performance (All Courses, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	120	74.2	17.4	-9.179	119	< .001*	1.03	.210
Unproctored	120	88.9	10.1					

*Statistically significant ($p < .05$)

For College Algebra taken during regular semesters (16 weeks) and short semesters (10 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(152) = -9.704$, $p < .001$, $d = .93$ (large effect size), $r^2 = .178$.

On average, students performed better in an unproctored test environment (*M* = 89.3) than a proctored test environment (*M* = 75.1). Approximately 18.0% of the variance in test performance can be attributed to the test environment. Table 4.7 displays numeric results for College Algebra taken during regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.7

Test Performance (College Algebra, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	153	75.1	18.7	-9.704	152	< .001*	.93	.178
Unproctored	153	89.3	10.7					

*Statistically significant ($p < .05$)

For College Algebra taken during regular semesters (16 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(83) = -8.102$, $p < .001$, $d = 1.01$ (large effect size), $r^2 = .203$. On average, students performed better in an unproctored test environment (*M* = 88.5) than a proctored test environment (*M* = 72.3). Approximately 20.0% of the variance in test performance can be attributed to the test environment. Table 4.8 displays numeric results for College Algebra taken during regular semesters (16 weeks).

Table 4.8

Test Performance (College Algebra, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	84	72.3	19.7	-8.102	83	< .001*	1.01	.203
Unproctored	84	88.5	11.4					

*Statistically significant ($p < .05$)

For College Algebra taken during short semesters (10 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(68) = -5.537$, $p < .001$, $d = .85$ (large effect size), $r^2 = .152$. On average, students performed better in an unproctored test environment ($M = 90.3$) than a proctored test environment ($M = 78.6$). Approximately 15.0% of the variance in test performance can be attributed to the test environment. Table 4.9 displays numeric results for College Algebra taken during short semesters (10 weeks).

Table 4.9

Test Performance (College Algebra, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	69	78.6	17.0	-5.537	68	< .001*	.85	.152
Unproctored	69	90.3	9.9					

*Statistically significant ($p < .05$)

For Business Calculus taken during regular semesters (16 weeks) and short semesters (10 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(109) = -11.655$, $p < .001$, $d = 1.16$ (large effect size), $r^2 =$

.252. On average, students performed better in an unproctored test environment (*M* = 84.6) than a proctored test environment (*M* = 68.0). Approximately 25.0% of the variance in test performance can be attributed to the test environment. Table 4.10 displays numeric results for Business Calculus taken during regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.10

Test Performance (Business Calculus, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	110	68.0	16.1	-11.655	109	< .001*	1.16	.252
Unproctored	110	84.6	12.2					

*Statistically significant ($p < .05$)

For Business Calculus taken during regular semesters (16 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(58) = -8.749$, $p < .001$, $d = 1.00$ (large effect size), $r^2 = .200$. On average, students performed better in an unproctored test environment (*M* = 82.5) than a proctored test environment (*M* = 67.8). Approximately 20.0% of the variance in test performance can be attributed to the test environment. Table 4.11 displays numeric results for Business Calculus taken during regular semesters (16 weeks).

Table 4.11

Test Performance (Business Calculus, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	59	67.8	15.8	-8.749	58	< .001*	1.00	.200
Unproctored	59	82.5	13.5					

*Statistically significant ($p < .05$)

For Business Calculus taken during short semesters (10 weeks), results of the paired *t*-test indicated test environment does influence test performance, $t(50) = -7.951$, $p < .001$, $d = 1.37$ (large effect size), $r^2 = .319$. On average, students performed better in an unproctored test environment ($M = 87.0$) than a proctored test environment ($M = 68.2$). Approximately 32.0% of the variance in test performance can be attributed to the test environment. Table 4.12 displays numeric results for Business Calculus taken during short semesters (10 weeks).

Table 4.12

Test Performance (Business Calculus, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	51	68.2	16.5	-7.951	50	< .001*	1.37	.319
Unproctored	51	87.0	10.2					

*Statistically significant ($p < .05$)

Research Question Two

Research Question Two, *Does test environment influence test anxiety?*, was answered using two-tailed paired *t*-tests. Students took the *Test Anxiety Inventory* (TAI) at the beginning of the semester, immediately after taking the final examination in a proctored test environment, and immediately after taking the final examination in an unproctored test environment. Therefore, three comparisons of test anxiety were analyzed: (a) beginning of semester and related to a proctored test environment, (b) beginning of semester and related to an unproctored test environment, and (c) related to a proctored test environment and related to an unproctored test environment.

Beginning of Semester and Proctored Test Environment

For College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(262) = .216$, $p = .829$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 49.0$) and related to a proctored test environment ($M = 48.9$). Table 4.13 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.13

Test Anxiety Proctored (All Courses, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	263	49.0	14.8	.216	262	.829
Proctored	263	48.9	15.4			

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in regular semesters (16 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(142) = -.486$, $p = .628$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 48.8$) and related to a proctored test environment ($M = 49.2$). Table 4.14 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks).

Table 4.14

Test Anxiety Proctored (All Courses, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	143	48.8	14.8	-.486	142	.628
Proctored	143	49.2	15.7			

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in short semesters (10 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(119) = .801$, $p = .425$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 49.3$) and related to a proctored test environment ($M = 48.4$). Table 4.15 displays numeric results for College Algebra and Business Calculus taken in short semesters (10 weeks).

Table 4.15

Test Anxiety Proctored (All Courses, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	120	49.3	14.8	.801	119	.425
Proctored	120	48.4	15.0			

*Statistically significant ($p < .05$)

For College Algebra taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(152) = .888$, $p = .376$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 48.8$) and related to a proctored test environment ($M = 48.0$). Table 4.16 displays numeric results for College Algebra taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.16

Test Anxiety Proctored (College Algebra, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	153	48.8	14.5	.888	152	.376
Proctored	153	48.0	15.7			

*Statistically significant ($p < .05$)

For College Algebra taken in regular semesters (16 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(83) = .567$, $p = .572$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 48.7$) and related to a proctored test environment ($M = 48.0$). Table 4.17 displays numeric results for College Algebra taken in regular semesters (16 weeks).

Table 4.17

Test Anxiety Proctored (College Algebra, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	84	48.7	13.9	.567	83	.572
Proctored	84	48.0	15.6			

*Statistically significant ($p < .05$)

For College Algebra taken in short semesters (10 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(68) = .685$, $p = .496$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 48.9$) and related to a proctored test environment ($M = 48.0$). Table 4.18 displays numeric results for College Algebra taken in short semesters (10 weeks).

Table 4.18

Test Anxiety Proctored (College Algebra, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	69	48.9	15.4	.685	68	.496
Proctored	69	48.0	16.0			

*Statistically significant (p < .05)

For Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(109) = -.783$, $p = .435$. On average, students reported similar levels of test anxiety at the beginning of the semester ($M = 49.3$) and related to a proctored test environment ($M = 50.0$). Table 4.19 displays numeric results for Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.19

Test Anxiety Proctored (Business Calculus, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	110	49.3	15.2	-.783	109	.435
Proctored	110	50.0	14.9			

*Statistically significant (p < .05)

For Business Calculus taken in regular semesters (16 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(58) =$

-1.525, *p* = .133. On average, students reported similar levels of test anxiety at the beginning of the semester (*M* = 48.9) and related to a proctored test environment (*M* = 50.9). Table 4.20 displays numeric results for Business Calculus taken in regular semesters (16 weeks).

Table 4.20

Test Anxiety Proctored (Business Calculus, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	59	48.9	16.1	-1.525	58	.133
Proctored	59	50.9	15.9			

*Statistically significant ($p < .05$)

For Business Calculus taken in short semesters (10 weeks), findings of the paired *t*-test indicated no statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to a proctored test environment, $t(50) = .420$, $p = .676$. On average, students reported similar levels of test anxiety at the beginning of the semester (*M* = 49.7) and related to a proctored test environment (*M* = 49.1). Table 4.21 displays numeric results for Business Calculus taken in short semesters (10 weeks).

Table 4.21

Test Anxiety Proctored (Business Calculus, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value
Beginning of Semester	51	49.7	14.1	.420	50	.676
Proctored	51	49.1	13.7			

*Statistically significant ($p < .05$)

Beginning of Semester and Unproctored Test Environment

For College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(262) = 12.984$, $p < .001$, $d = .76$ (large effect size), $r^2 = .127$. On average, students reported less test anxiety related to an unproctored test environment ($M = 38.2$) than at the beginning of semester ($M = 49.0$). Approximately 13.0% of the variance in test anxiety can be attributed to the test environment. Table 4.22 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.22

Test Anxiety Unproctored (All Courses, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	263	49.0	14.8	12.984	262	< .001*	.76	.127
Unproctored	263	38.2	13.5					

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in regular semesters (16 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(142) = 11.353$, $p < .001$, $d = .94$ (large effect size), $r^2 = .184$. On average, students reported less test anxiety related to an unproctored test environment ($M = 36.0$) than at the beginning of semester ($M = 48.8$). Approximately 18.0% of the variance in test anxiety can be attributed to the test environment. Table 4.23 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks).

Table 4.23

Test Anxiety Unproctored (All Courses, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	143	48.8	14.8	11.353	142	< .001*	.94	.182
Unproctored	143	36.0	12.2					

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(119) = 7.004$, $p < .001$, $d = .57$ (large effect size), $r^2 = .076$. On average, students reported less test anxiety related to an unproctored test environment ($M = 40.9$) than at the beginning of semester ($M = 49.3$). Approximately 8.0% of the variance in test anxiety can be attributed to the test environment. Table 4.24 displays numeric results for College Algebra and Business Calculus taken in short semesters (10 weeks).

Table 4.24

Test Anxiety Unproctored (All Courses, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	120	49.3	14.8	7.004	119	< .001*	.57	.076
Unproctored	120	40.9	14.4					

*Statistically significant ($p < .05$)

For College Algebra taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(152) = 11.086$, $p < .001$, $d = .78$ (large effect size), $r^2 = .132$. On average, students reported less test anxiety related to an unproctored test environment ($M = 37.9$) than at the beginning of semester ($M = 48.8$). Approximately 13.0% of the variance in test anxiety can be attributed to the test environment. Table 4.25 displays numeric results for College Algebra taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.25

Test Anxiety Unproctored (College Algebra, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	153	48.8	14.5	11.086	152	< .001*	.78	.132
Unproctored	153	37.9	13.4					

*Statistically significant ($p < .05$)

For College Algebra taken in regular semesters (16 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(83) = 8.646$, $p < .001$, $d = .84$ (large effect size), $r^2 = .150$. On average, students reported less test anxiety related to an unproctored test environment ($M = 37.6$) than at the beginning of semester ($M = 48.7$). Approximately 15.0% of the variance in test anxiety can be attributed to the test environment. Table 4.26 displays numeric results for College Algebra taken in regular semesters (16 weeks).

Table 4.26

Test Anxiety Unproctored (College Algebra, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	84	48.7	13.9	8.646	83	< .001*	.84	.150
Unproctored	84	37.6	12.6					

*Statistically significant ($p < .05$)

For College Algebra taken in short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(68) = 6.960$, $p < .001$, $d = .71$ (large effect size), $r^2 = .112$. On average, students reported less test anxiety related to an unproctored test environment ($M = 38.4$) than at the beginning of semester ($M = 48.9$). Approximately 11.0% of the variance in test anxiety can be attributed to the test environment. Table 4.27 displays numeric results for College Algebra taken in short semesters (10 weeks).

Table 4.27

Test Anxiety Unproctored (College Algebra, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	69	48.9	15.4	6.960	68	< .001*	.71	.112
Unproctored	69	38.4	14.4					

*Statistically significant ($p < .05$)

For Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(109) = 7.351$, $p < .001$, $d = .74$ (large effect size), $r^2 = .120$. On average, students reported less test anxiety related to an unproctored test environment ($M = 38.6$) than at the beginning of semester ($M = 49.3$). Approximately 12.0% of the variance in test anxiety can be attributed to the test environment. Table 4.28 displays numeric results for Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.28

Test Anxiety Unproctored (Business Calculus, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	110	49.3	15.2	7.351	109	< .001*	.74	.120
Unproctored	110	38.6	13.6					

*Statistically significant ($p < .05$)

For Business Calculus taken in regular semesters (16 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(58) = 7.583$, $p < .001$, $d = 1.08$ (large effect size), $r^2 = .227$. On average, students reported less test anxiety related to an unproctored test environment ($M = 33.7$) than at the beginning of semester ($M = 48.9$). Approximately 23.0% of the variance in test anxiety can be attributed to the test environment. Table 4.29 displays numeric results for Business Calculus taken in regular semesters (16 weeks).

Table 4.29

Test Anxiety Unproctored (Business Calculus, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	59	48.9	16.1	7.583	58	< .001*	1.08	.227
Unproctored	59	33.7	11.5					

*Statistically significant ($p < .05$)

For Business Calculus taken in short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety at the beginning of the semester and test anxiety related to an unproctored test environment, $t(50) = 2.904$, $p = .005$, $d = .39$ (medium effect size), $r^2 = .036$. On average, students reported less test anxiety related to an unproctored test environment ($M = 44.3$) than at the beginning of semester ($M = 49.7$). Approximately 4.0% of the variance in test anxiety can be attributed to the test environment. Table 4.30 displays numeric results for Business Calculus taken in short semesters (10 weeks).

Table 4.30

Test Anxiety Unproctored (Business Calculus, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Beginning of Semester	51	49.7	14.1	2.904	50	.005*	.39	.036
Unproctored	51	44.3	13.8					

*Statistically significant ($p < .05$)

Proctored Test Environment and Unproctored Test Environment

For College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(262) = 13.244$, $p < .001$, $d = .74$ (large effect size), $r^2 = .119$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 48.9$) than an unproctored test environment ($M = 38.2$). Approximately 12.0% of the variance in test anxiety can be attributed to the test environment. Table 4.31 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.31

Test Anxiety Proctored and Unproctored (All Courses, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	263	48.9	15.4	13.244	262	< .001*	.74	.119
Unproctored	263	38.2	13.5					

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in regular semesters (16 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(142) = 11.688$, $p < .001$, $d = .94$ (large effect size), $r^2 = .181$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 49.2$) than an unproctored test environment ($M = 36.0$). Approximately 18.0% of the variance in test anxiety can be attributed to the test environment. Table 4.32 displays numeric results for College Algebra and Business Calculus taken in regular semesters (16 weeks).

Table 4.32

Test Anxiety Proctored and Unproctored (All Courses, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	143	49.2	15.7	11.688	142	< .001*	.94	.181
Unproctored	143	36.0	12.2					

*Statistically significant ($p < .05$)

For College Algebra and Business Calculus taken in short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(119) = 7.058$, $p < .001$, $d = .51$ (medium effect size), $r^2 = .062$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 48.4$) than an unproctored test environment ($M = 40.9$). Approximately 6.0% of the variance in test anxiety can be attributed to the test environment. Table 4.33 displays numeric results for College Algebra and Business Calculus taken in short semesters (10 weeks).

Table 4.33

Test Anxiety Proctored and Unproctored (All Courses, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	120	48.4	15.0	7.058	119	< .001*	.51	.062
Unproctored	120	40.9	14.4					

*Statistically significant ($p < .05$)

For College Algebra taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(152) = 10.708$, $p < .001$, $d = .69$ (large effect size), $r^2 = .107$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 48.0$) than an unproctored test environment ($M = 37.9$). Approximately 11.0% of the variance in test anxiety can be attributed to the test environment. Table 4.34 displays numeric results for College Algebra taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.34

Test Anxiety Proctored and Unproctored (College Algebra, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	153	48.0	15.7	10.708	152	< .001*	.69	.107
Unproctored	153	37.9	13.4					

*Statistically significant ($p < .05$)

For College Algebra taken in regular semesters (16 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(83) = 9.080$, $p < .001$, $d = .74$ (large effect size), $r^2 = .120$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 48.0$) than an unproctored test environment ($M = 37.6$). Approximately 12.0% of the variance in test anxiety can be attributed to the test environment. Table 4.35 displays numeric results for College Algebra taken in regular semesters (16 weeks).

Table 4.35

Test Anxiety Proctored and Unproctored (College Algebra, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	84	48.0	15.6	9.080	83	< .001*	.74	.120
Unproctored	84	37.6	12.6					

*Statistically significant ($p < .05$)

For College Algebra taken in short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(68) = 6.188$, $p < .001$, $d = .63$ (large effect size), $r^2 = .091$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 48.0$) than an unproctored test environment ($M = 38.4$). Approximately 9.0% of the variance in test anxiety can be attributed to the test environment. Table 4.36 displays numeric results for College Algebra taken in short semesters (10 weeks).

Table 4.36

Test Anxiety Proctored and Unproctored (College Algebra, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	69	48.0	16.0	6.188	68	< .001*	.63	.091
Unproctored	69	38.4	14.4					

*Statistically significant ($p < .05$)

For Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(109) = 8.109$, $p < .001$, $d = .80$ (large effect size), $r^2 = .138$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 50.0$) than an unproctored test environment ($M = 38.6$). Approximately 14.0% of the variance in test anxiety can be attributed to the test environment. Table 4.37 displays numeric results for Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks).

Table 4.37

Test Anxiety Proctored and Unproctored (Business Calculus, All Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	110	50.0	14.9	8.109	109	< .001*	.80	.138
Unproctored	110	38.6	13.6					

*Statistically significant ($p < .05$)

For Business Calculus taken in regular semesters (16 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(58) = 8.138$, $p < .001$, $d = 1.24$ (large effect size), $r^2 = .277$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 50.9$) than an unproctored test environment ($M = 33.7$). Approximately 28.0% of the variance in test anxiety can be attributed to the test environment. Table 4.38 displays numeric results for Business Calculus taken in regular semesters (16 weeks).

Table 4.38

Test Anxiety Proctored and Unproctored (Business Calculus, Regular Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	59	50.9	15.9	8.138	58	< .001*	1.24	.277
Unproctored	59	33.7	11.5					

*Statistically significant ($p < .05$)

For Business Calculus taken in short semesters (10 weeks), findings of the paired *t*-test indicated a statistically significant mean difference in test anxiety between proctored and unproctored test environments, $t(50) = 3.653$, $p < .001$, $d = .35$ (medium effect size), $r^2 = .029$. On average, students experienced higher levels of test anxiety related to a proctored test environment ($M = 49.1$) than an unproctored test environment ($M = 44.3$). Approximately 3.0% of the variance in test anxiety can be attributed to the test environment. Table 4.39 displays numeric results for Business Calculus taken in short semesters (10 weeks).

Table 4.39

Test Anxiety Proctored and Unproctored (Business Calculus, Short Semesters)

Test Environment	*N*	*M*	*SD*	*t*-value	*df*	*p*-value	*d*	r^2
Proctored	51	49.1	13.7	3.653	50	< .001*	.35	.029
Unproctored	51	44.3	13.8					

*Statistically significant ($p < .05$)

Research Question Three

Research Question Three, *Is there a relationship between test anxiety and test performance?*, was answered using Pearson product-moment correlation coefficients (*r*). For College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), results indicated there was no statistically significant relationship between test anxiety and test performance in an unproctored test environment, $r = -.053$, $p = .392$. A student's test anxiety had no effect on a student's test performance when the examination was taken in an unproctored test environment.

For College Algebra and Business Calculus taken in regular semesters (16 weeks) and short semesters (10 weeks), however, results indicated there was a statistically significant relationship between test anxiety and test performance in a proctored test environment, $r = -.377$, $p < .001$, $r^2 = .142$. As a student's test anxiety decreased, the student's test performance increased. Approximately 14.0% of the variance in test performance can be attributed to test anxiety in a proctored test environment. Table 4.40 displays numeric results by course (College Algebra and Business Calculus) and semester lengths (16 weeks and10 weeks).

Table 4.40

Test Anxiety and Test Performance Relationship

	Unproctored		Proctored		
Course	*r*	*p*-value	*r*	*p*-value	r^2
All Courses	-.053	.392	-.377	< .001*	.142
Regular Semester	-.036	.671	-.376	< .001*	.141
Short Semester	-.132	.151	-.377	< .001*	.142
College Algebra	-.098	.227	-.413	< .001*	.171
Regular Semester	-.089	.423	-.412	< .001*	.170
Short Semester	-.119	.331	-.430	< .001*	.185
Business Calculus	.011	.910	-.304	.001*	.092
Regular Semester	-.058	.661	-.302	.020*	.091
Short Semester	-.079	.582	-.309	.027*	.095

*Statistically significant ($p < .05$)

Research Question Four

Research Question Four, *What do students perceive as factors contributing to test anxiety in proctored and unproctored test environments?*, was answered using a qualitative inductive coding process. The researcher coded participants' posts from a course discussion board regarding online examinations taken in proctored and unproctored test environments. Analysis revealed three themes related to students' perceptions of contributors to test anxiety: (a) time, (b) physical environment, and (c) test format.

Time

Time was chosen as a theme because most participants (*n* = 22) communicated a connection between test anxiety and feeling rushed in both unproctored and proctored test environments. In the unproctored test environment, students identified the time limit of the examination and the visible timer as causes of test anxiety. In the proctored test environment, students believed seeing other students finish their examinations before them contributed to their test anxiety.

Time limit. The examinations taken in the unproctored test environment had a time limit of two hours. Once the student opened the examination, he or she could not stop the clock. In all, nine students felt the time limit made them anxious in the unproctored test environment. In responding to the prompt "What do you dislike about unproctored exams?" a 27-year-old female posted, "Unfortunately, the two-hour time limit was enough to stress me out … I clearly do have test anxiety, and certainly when there is a time limit." A 20-year-old female replied in agreement, "I can relate to you about having test anxiety, especially when it's timed. I just feel more pressured and end up doing worse than … when it isn't timed. It's crazy how our mind messes with us!" These quotes indicate an examination's time limit increases anxiety for some students and may impact their performance.

Timer. The examinations in the unproctored test environment displayed a timer which counted down the time remaining on the examination and provided notifications at one hour, 20 minutes, five minutes, and 30 seconds remaining. Many students (*n* = 15) felt this visible timer contributed to their test anxiety. A freshman compared anxiety between a digital timer on her computer screen and an analog clock in a classroom:

> I think the only thing I dislike about unproctored tests is the time clock at the bottom of the screen. I feel it gives me more anxiety seeing the time tick right next to my test, but I guess in a classroom it is the same thing with the clock sitting at the top of the chalkboard. I think it changes it when it is digital and right in front of me where I can see how much time I spent on one question.

A particularly anxious moment for students seemed to be when the timer began providing more frequent warnings at the end of the examination. A 37-year-old male believed the timer reactivated his anxiety:

> Well, before the exams I mostly feel very comfortable and ready to take the test, but as I start I feel like I can go blank and seem to lose focus very quickly. Once I get my bearings, I figure it out and get comfortable, but once I get reminded of the clock, I tend to get nervous again … I also don't think exams should be timed. The whole point is to know if you know the material or not? Correct? Then why try to rush people and limit them on time?

Another male student strongly supported his classmate's concern about the timer: "I feel you on the clock ticking. That gives me the most anxiety, especially when it hits the 20-minute mark. That just paralyzes me." These quotes indicate a visible timer increases anxiety during an examination.

Seeing other students finish. In the proctored test environment, there was a similar timer and the same time limit, but students did not mention either as contributing to their anxiety in this test environment. Instead, almost every student (*n* = 21) expressed worry due to the time-related concern of seeing other students finish the examination before them. "Seeing that other people are finishing faster than me makes me more nervous than what I already am," said an older female student. Younger students claimed seeing students finish caused them to rush through the examination. A male freshman posted, "I always feel pressure when another student gets up and turns his or her test before I am even half way done. That always gets me to rush through my problems." Another male freshman responded, "I agree with you on when another student gets up to turn a test in that always gets to me and that I feel like I should rush to finish."

Students reflecting on examinations in an unproctored test environment also mentioned this concern. A 22-year-old female emphasized privacy as an attractive component of unproctored examinations:

> I really enjoy taking unproctored exams. They are way less stressful than on-campus exams … I usually rush myself during on-campus exams once I see everyone starting to leave because I don't want to run out of time or be the reason the teacher has to stay behind. So, being at home alone definitely releases that pressure off of me.

A male student posted in agreement, "Hey [student's name], I also feel the same when it comes to feeling comfortable at home versus at school. My biggest problem is seeing someone else turn their assignment in way earlier than me." Ironically, a male student who finished quickly was impacted by similar anxiety: "I felt pressured when I was done because no one else was, so it made me think I had rushed through too soon, and I sat nervously." Though most examinations are timed, anxiety seems to be heightened in the unproctored test environment by the presence of a timer and in the proctored test environment by seeing others finish the examination at a different pace.

Physical Environment

The physical environment refers to the location in which a student takes an examination. Students took the unproctored examination at any location of their choosing on any computer with Internet access. Overall, students in the unproctored test environment felt control over their physical environment relieved their test anxiety. A sophomore posted, "I like taking unproctored tests because I get to do it in the comfort of my home or anywhere that makes me feel at ease. It is less stressful and lets me focus." Students took the proctored examination, however, in a computer classroom on campus and were monitored by the instructor of the course. Students in this test environment identified several components of the physical environment which caused test anxiety, including being watched by others and noise-related distractions.

Being watched. Some students (n = 10) in the proctored test environment felt the simple act of being watched was sufficient to cause test anxiety. A female freshman posted, "The anxiety builds up as someone is watching you." In a later post, she elaborated, "My anxiety flares up to the point where I get sick before taking [the proctored examination]. I disliked how I felt like I was being watched and judged while I took it." A male freshman admitted this anxiety might be somewhat unfounded: "I felt the pressure as well because I felt everyone was watching me even though they weren't."

Most students (*n* = 7) spoke of being watched in general, but a few (*n* = 3) students felt anxiety was caused specifically by the presence of the professor. A 21-year-old freshman posted, “It's also nerve-racking to see [that] the professor can tell you're confused making you even more nervous.” A 24-year-old unclassified student indicated the absence of a professor as the main reason she enjoyed unproctored examinations: “I LOVE unproctored exams. I like how there is no pressure from the professor watching you and making me nervous.” Another student responded in agreement, “What I like about unproctored exams is there isn't a professor watching … When there is a professor present I feel like they are looking at me the whole exam time and that I am not doing good enough.” These quotes indicate some students experience heightened anxiety when the instructor of the course serves as the proctor of the examination.

Noise. In addition to visual stimuli, some students (*n* = 7) felt audible noises contributed to their anxiety in the proctored test environment. Students labeled these distractions as “noises beside me,” “tapping feet or making noise with paper,” and “some kind of noise due to their nerves.” One sophomore communicated the seriousness of this issue for her:

> The only thing I disliked about the proctored exam was that I kept getting distracted with the small noises around me. I have misophonia, so specific noises trigger me, and I heard a few of them during the exam. It made me very anxious and irritated, but I pushed though and was able to finish. Besides that, taking the final was good.

However, not all students agreed noise-based distractions were unique to the proctored test environment. A freshman felt familiar noises in the unproctored test environment were actually more of a distraction for him: “Although doing the test at home saves me from in class distractions [,] at home distractions are worse with my phone going off or my family talking to me and also the TV distracting me.” Another student replied in disagreement, “Somehow the noises at home are less distracting because I know what they are.” Noise-based distractions appear to cause varying levels of anxiety for students.

Test Format

The phrase *test format* is used to indicate specific features of the examinations students took in both test environments. In the unproctored test environment, students took web-based examinations on a website hosted by the textbook publisher of the course. Examinations had approximately 15 questions, and students predominantly entered free-response answers into blanks. Overall, students felt this format caused anxiety due to the precision required in entering answers and technical issues with the website. In the proctored test environment, students took a web-based examination in Blackboard, a Learning Management System used by the institution. Examinations had 20 questions, and students selected answers from five options. Overall, students felt the multiple-choice format relieved their anxiety.

Free response. A few students (n = 3) admitted technical issues with the website caused them anxiety. A 48-year-old female posted, “The [unproctored examination] was a little more difficult only due to Connect Math not working properly. That gave me a lot of anxiety." Her post received enthusiastic agreement from a 24-year-old female: "YESSSS!!!! I totally agree! The program is very frustrating, super slow!"

More students (n = 13), however, experienced anxiety related to entering answers. "I don't have any problem with [the unproctored examination] except the program itself," said a sophomore. "When I take the test online, if I make one little mistake like a comma or I accidentally hit a key, then the whole problem is wrong." Two students linked this frustration with anxiety: "I agree, [student's name]. It is especially nerve raking [*sic*] when you're not sure how it wants the fraction or if it even wants the fraction at all." "Yes, I agree 100%! There's so much pressure even when you have the right answer, but connect math counts it wrong because there's an extra space or you forgot a comma." Therefore, it appears the possibility of an infinite number of solutions causes anxiety for students.

Multiple choice. Before even taking the proctored examination, one student anticipated multiple-choice examinations would relieve her anxiety: "I get nervous before [the unproctored examination]. I just get in my head about what the answer could be because these aren't multiple choice exams." Students' lived experiences confirmed this to be true. "I was really nervous about this [f]inal," said a sophomore, "but once I saw it was multiple choice a huge weight was lifted off my shoulders." Another sophomore agreed, "A multiple choice exam was the best way to take this final exam. I felt very anxious all for nothing!" Not forcing students to generate the solution from scratch appears to relieve their test anxiety significantly, especially in a proctored test environment.

Summary of Findings

A purposeful sample of 263 students enrolled in distance learning College Algebra and Business Calculus at a large suburban community college located in southeast Texas completed a series of surveys related to test anxiety and final examinations in proctored and unproctored test environments. The quantitative analysis indicated test environment influences both test performance and test anxiety. Students performed significantly better and experienced significantly less test anxiety in an unproctored test environment. Findings also indicated there were no significant differences in test anxiety measured at the beginning of the semester and related to a proctored test environment. When examining the correlation between test anxiety and test performance, the researcher found a significant relationship in a proctored test environment; as test anxiety decreased, test performance increased. No such relationship was found in an unproctored test environment.

A purposeful sample of 25 students enrolled in a single section of distance learning College Algebra participated in six discussion board forums related to proctored and unproctored test environments. Qualitative analysis revealed students perceived examination features related to time, physical environment, and test format as contributing factors of their test anxiety in proctored and unproctored test environments. In the unproctored test environment, students believed the time limit, visible timer, and free-response answers contributed to their test anxiety. In the proctored test environment, students believed seeing other students finish before them, others watching them as they took the examination, and noise-related distractions contributed to their test anxiety.

Conclusion

This chapter presented participant demographics, quantitative and qualitative analyses for each of the four research questions, and a summary of findings. In the next chapter, findings will be discussed in the context of existing literature related to the study. Implications of this study and recommendations for future research will also be presented.

CHAPTER V:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. This chapter presents a summary of the findings of the study in the context of existing literature related to the study. Implications for distance learning faculty, implications for college administration, and recommendations for future research are also discussed.

Summary

A purposeful sample of 263 undergraduate students enrolled in distance learning College Algebra and Business Calculus courses at a large suburban community college located in southeast Texas completed a series of surveys and final examinations in proctored and unproctored test environments. Twenty-five students also participated in a course discussion board related to their experiences in proctored and unproctored test environments. Quantitative and qualitative analyses were used to answer four research questions related to proctored testing in distance learning mathematics courses.

Research Question One

Research Question One, *Does test environment influence test performance?*, was answered using paired *t*-tests to compare students' final examination grades achieved in proctored and unproctored test environments. Students performed significantly better in the unproctored test environment across all courses (College Algebra and Business Calculus) and semester lengths (16 weeks and 10 weeks) used in the study. These findings are consistent with the majority of previous studies (Alessio et al., 2017; Brallier

& Palm, 2015; Fask et al., 2014; Fask et al., 2015; Flesch & Ostler, 2010), which suggest examination grades are higher in unproctored test environments.

However, these findings contradict other studies (Beck, 2014; Stack, 2015; Yates & Beaudrie, 2009), which found no differences between grades achieved in proctored and unproctored test environments. In Beck's 2014 study, some students were proctored by the instructor, and some students were proctored at a campus testing center. Students may have experienced less test anxiety at the testing center and, thus, inconsistent test performance in the unproctored test environment. Also, Beck controlled for academic dishonesty with her statistical analysis, which may have impacted the results.

Stack (2015) controlled for academic dishonesty by requiring students to use a lock-down browser when taking online examinations. The lock-down browser may have simulated a proctored test environment and decreased students' test performance in the unproctored test environment. Additionally, both studies involved students in criminology, so there may be discipline-specific factors which impact test performance.

Notably, the findings of the present study also conflict with the 2009 study of Yates and Beaudrie involving community college students in distance learning mathematics courses. Yates and Beaudrie found no significant differences when comparing students' course grades achieved by taking examinations in proctored and unproctored test environments. However, the methodology of this study faced criticism in the literature (Englander et al., 2011) for selection bias and using course grade comparisons instead of examination grade comparisons. Therefore, no legitimate conclusions can be drawn about differences in test performance from this study.

Research Question Two

Research Question Two, *Does test environment influence test anxiety?*, was answered using a series of paired *t*-tests to compare students' scores on the *Test Anxiety Inventory* (TAI) taken at the beginning of the semester, after the proctored final examination, and after the unproctored final examination. Students experienced similar levels of test anxiety at the beginning of the semester and related to a proctored test environment. Also, students experienced significantly lower levels of test anxiety related to an unproctored test environment than a proctored test environment. These findings held across all courses (College Algebra and Business Calculus) and semester lengths (16 weeks and 10 weeks) used in the study.

A review of the literature provided only limited context for these results. These results somewhat align with the work of Stowell and Bennett (2010), who found psychology students with high test anxiety in a classroom-based, proctored test environment experienced significantly reduced test anxiety in an online, unproctored test environment. It appears test anxiety in proctored and unproctored test environments is a topic which has yet to be addressed by research. The present study, therefore, may provide a significant contribution to the topic.

Research Question Three

Research Question Three, *Is there a relationship between test anxiety and test performance?*, was answered using Pearson product-moment correlation coefficients (*r*) on students' final examination grades and TAI scores related to proctored and unproctored test environments. In the unproctored test environment, test anxiety had no relationship to test performance across all courses (College Algebra and Business Calculus) and semester lengths (16 weeks and 10 weeks) used in the study. This result is somewhat validated by the work of Stowell and Bennett (2010), who found the relationship between test anxiety and test performance was weaker in an unproctored test environment than a proctored test environment.

In the proctored test environment, however, the present study found test anxiety had a significant and inverse relationship to test performance. As test anxiety decreased, test performance increased across all courses (College Algebra and Business Calculus) and semester lengths (16 weeks and 10 weeks) used in the study. In general, these findings are supported by seminal studies (Cassady & Johnson, 2002; Eum & Rice, 2011; Mandler & Sarason, 1952; Sarason & Mandler, 1952; Seipp, 1991), which found elevated levels of test anxiety significantly weaken students' test performance in a variety of traditional testing situations. There is limited research specifically devoted to the relationship between test anxiety and test performance on computer-based examinations taken in proctored and unproctored test environments.

Research Question Four

Research Question Four, *What do students perceive as factors contributing to test anxiety in proctored and unproctored test environments?*, was answered using a qualitative inductive coding process on student responses gathered from a course discussion board. Students perceived examination features related to time, physical environment, and test format as contributing factors to test anxiety in proctored and unproctored test environments. In the unproctored test environment, students believed the time limit, visible timer, and free-response answers contributed to their test anxiety. In the proctored test environment, students believed seeing other students finish before them, others watching them as they took the examination, and noise-related distractions contributed to their test anxiety.

In the literature, there are limited studies devoted to identifying causes of test anxiety in proctored or unproctored test environments. However, the factors identified by the present study are primarily cognitive in nature. Hayes and Embretson (2013) found cognitive distractions were primarily responsible for the impact of test anxiety in both proctored and unproctored test environments. This study may contribute to identifying specific features of examinations which heighten students' test anxiety.

Implications

As a result of the present study's examination of the influence of proctored testing on test performance and test anxiety in distance learning mathematics courses, there are obvious implications for faculty teaching distance learning courses in mathematics and other disciplines and college administration making decisions about assessment in distance learning courses. Distance learning faculty should utilize unproctored examinations when possible and implement anxiety-reducing features in test design. College administration should be cautious about assumptions of academic dishonesty and confident when enforcing proctored testing in distance learning courses.

Distance Learning Faculty

Distance learning faculty should utilize unproctored test environments in their courses when possible. The present study demonstrates students experience less test anxiety and improved test performance when examinations are taken in unproctored test environments. Specifically, students felt having control over their physical environment significantly reduced their test anxiety. An unproctored test environment also prevents students from being bothered by noises and rushed by seeing other students finish examinations at a pace different from their own.

Additionally, the present study identifies specific factors related to examinations which contribute to students' test anxiety. Thus, faculty can minimize test anxiety by implementing certain features on computer-based examinations taken in proctored and unproctored test environments. To minimize test anxiety, faculty should consider using multiple-choice examinations with a generous time-limit or no time-limit. To eliminate concerns about being watched and seeing other students finish, faculty should schedule proctored examinations in a centralized testing center with different start times, so students cannot make a direct comparison of testing pace between themselves and other students. Additionally, students should be allowed to use noise-canceling headphones or headphones with music to eliminate noise-related distractions.

College Administration

First, college administration should be cautious about assumptions related to academic dishonesty in distance learning courses. There is a persistent concern in higher education online courses facilitate a higher level of academic dishonesty than traditional courses (Moten et al., 2013; Paullet et al., 2016). This belief is validated by many researchers (Alessio et al., 2017; Brallier & Palm, 2015; Fask et al., 2014; Fask et al., 2015; Flesch & Ostler, 2010) who find significantly improved test performance in unproctored test environments. However, these researchers neglected to consider the role of test anxiety in different test environments. The present study reveals grade differences in proctored and unproctored test environments can be somewhat attributed to differences in test anxiety between the two test environments. Students in the present study experienced significantly higher test anxiety in the proctored test environment than the unproctored test environment. Given high levels of test anxiety are known to negatively impact test performance (Seipp, 1991), college administration should be cautious about careless association of academic dishonesty and unproctored test environments.

Also, college administration should enforce some degree of proctored testing in distance learning courses with confidence. The present study suggests students do not experience significantly more test anxiety in a proctored test environment than their test anxiety measured at the beginning of the semester suggests they should. Thus, proctored testing in a distance learning course is no more of a psychological burden to a student than proctored testing in a classroom setting. While unproctored testing should be used when possible to lessen test anxiety and improve test performance, it is acceptable for institutions to enforce proctored testing on high-stakes examinations to ensure academic integrity.

Recommendations for Future Research

The present study involved quantitative analysis of three surveys and final examinations in proctored and unproctored test environments and qualitative analysis of students' discussion board posts related to proctored and unproctored test environments. Recommendations for future research will help enhance understanding and expand knowledge of proctored testing in distance learning courses. Specifically, future research should focus on the role of academic dishonesty, eliminating a potential repeated testing effect, implementing anxiety-reducing features on examinations, and a more nuanced view of test anxiety.

First, it is still unclear if academic dishonesty plays a role in improved test performance in unproctored test environments. This is very difficult to establish due to the inability of the instructor to monitor students' behavior and the students' ease of access to resources in unproctored test environments (Cole et al., 2014). Many studies, which examine academic dishonesty, do so using comparisons of grades in proctored and unproctored test environments. However, the present study shows a significant difference in test anxiety between the two test environments. It is unclear if lower test anxiety and improved test performance are partially caused by increased chances to cheat in an unproctored test environment. Thus, future research should focus on identifying the prevalence of academic dishonesty in unproctored test environments and investigate the interaction between academic dishonesty and test anxiety.

Future research should also focus on eliminating the repeated testing effect, which is a limitation of the present study. In this study, students took a final examination in a proctored test environment followed by a nearly identical final examination in an unproctored test environment a few days later. Thus, it is unclear if repeated testing in a short period of time contributed to improved test performance and lower test anxiety. Future research could potentially utilize midterm examinations taken in an unproctored test environment and final examinations taken in a proctored test environment. Also, parallel examinations with problems from a large question pool or algorithmically-generated problems could be used to minimize this effect.

Additionally, this study identified features of computer-based examinations, which students perceive as contributors to test anxiety. Future research should investigate whether designing an examination with these features in mind has a meaningful impact on students' test anxiety. For example, if an instructor constructed a multiple-choice examination with no time limit taken in a centralized testing center with noise-canceling headphones, would there be a significant impact to student' test anxiety and test performance in the proctored test environment?

Finally, the present study took a very broad view of test anxiety and used relative comparisons of test anxiety at different points in the semester to draw conclusions. Future research could pursue a more nuanced view of test anxiety, including an examination of gender, ethnicity, and the test performance of students who report high test anxiety or low test anxiety. For example, Stowell and Bennett (2010) found students who experienced high test anxiety in the classroom had significantly reduced test anxiety online, while students who experienced low test anxiety in the classroom had significantly increased test anxiety online. Also, future research could focus on worry and emotionality in unproctored test environments, the two components of test anxiety identified by Liebert and Morris (1967). A more in-depth exploration of test anxiety would provide a deeper understanding of its relationship with test performance in distance learning courses.

Conclusion

This chapter presented a summary of the findings of this study in the context of existing literature, implications for distance learning faculty and college administration, and recommendations for future research. The purpose of this study was to examine the influence of proctored testing on students' test performance and test anxiety in distance learning mathematics courses. The results of this study contribute to an examination of current practices and pave the way for further exploration of this important topic.

REFERENCES

Alessio, H. M., Malay, N., Maurer, K., Bailer, A. J., & Rubin, B. (2017). Examining the effect of proctoring on online test scores. *Online Learning*, *21*(1), 146–161. doi:10.24059/olj.v21i1.885

Allen, I. E., & Seaman, J. (2013). *Changing course: Ten years of tracking online education in the United States*. Babson Park, MA: Babson Survey Research Group.

Allen, I. E., & Seaman, J. (2015). *Grade level: Tracking online education in the United States*. Babson Park, MA: Babson Survey Research Group.

Allen, I. E., & Seaman, J. (2016). *Online report card: Tracking online education in the United States*. Babson Park, MA: Babson Survey Research Group.

Bailey, W. C., & Bailey, S. S. (2011). Do online and lecture students view cheating differently? *Review of Business Research, 11*(5), 33–45. Retrieved from http://www.rbr-journal.org

Beck, V. (2014). Testing a model to predict online cheating – much ado about nothing. *Active Learning in Higher Education, 15*, 65–75. doi:10.1177/1469787413514646

Bowers, W. J. (1964). *Student dishonesty and its control in college*. New York, NY: Bureau of Applied Social Research, Columbia University.

Brallier, S., & Palm, L. (2015). Proctored and unproctored test performance. *International Journal of Teaching & Learning in Higher Education*, *27*, 221–226. Retrieved from http://www.isetl.org/ijtlhe

Bunk, J., Li, R., Smidt, E., Bidetti, C., & Malize, B. (2015). Understanding faculty attitudes about distance education: The importance of excitement and fear. *Online Learning, 19*(4), 132–142. Retrieved from https://onlinelearningconsortium.org/read/online-learning-journal

Cannon, W. B. (1915). *Bodily changes in pain, hunger, fear and rage; an account of recent researches into the function of emotional excitement*. New York, NY: Appleton.

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology, 27,* 270–295. doi:10.1006/ceps.2001.1094

Cavanaugh, J. K., & Jacquemin, S. J. (2015). A large sample comparison of grade based student learning outcomes in online vs. face-to-face courses. *Online Learning, 19*(2), 25–32. Retrieved from https://onlinelearningconsortium.org/read/online-learning-journal

Cole, M. T., Swartz, L. B., & Shelley, D. J. (2014). Students' use of technology in learning course material: Is it cheating? *International Journal of Information and Communication Technology Education, 10*(1), 35–48. doi:10.4018/ijicte.2014010104

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Los Angeles, CA: SAGE Publications.

Darwin, C. (1859). *On the origin of species by means of natural selection, or, the preservation of favoured races in the struggle for life*. London, England: J. Murray.

Englander, F., Fask, A., & Wang, Z. (2011). Comment on “The impact of online assessment on grades in community college distance education mathematics courses” by Ronald W. Yates and Brian Beaudrie. *American Journal of Distance Education*, *25*, 114–120, doi:10.1080/08923647.2011.565243

Eum, K., & Rice, K. G. (2011). Test anxiety, perfectionism, goal orientation, and academic performance. *Anxiety, Stress & Coping, 24*, 167–178. doi:10.1080/ 10615806.2010.488723

Fask, A., Englander, F., & Wang, Z. (2014). Do online exams facilitate cheating? An experiment designed to separate possible cheating from the effect of the online test taking environment. *Journal of Academic Ethics*, *12*, 101–112. doi:10.1007/s10805-014-9207-1

Fask, A., Englander, F., & Wang, Z. (2015). On the integrity of online testing for introductory statistics courses: A latent variable approach. *Practical Assessment, Research & Evaluation, 20*(10), 1–12. Retrieved from http://pareonline.net

Flesch, M., & Ostler, E. (2010). An analysis of how proctoring exams in online mathematics offerings affects student learning and course integrity. *International Journal for Mathematics Teaching and Learning*, *12,* 1–13. Retrieved from http://www.cimt.org.uk/ijmtl

Folin, O., Denis, W., & Smillie, G. (1914). Some observations on "emotional glycosuria" in man. *Journal of Biological Chemistry, 17,* 519-520.

Freud, S. (1959). Inhibitions, symptoms and anxiety. In J. Strachey (Ed.), *The standard* *edition of the complete psychological works of Sigmund Freud*. London, England: Hogarth.

Gallant, T. B., Van Den Einde, L., Ouellette, S., & Lee, S. (2013). A systemic analysis of cheating in an undergraduate engineering mechanics course. *Science and Engineering Ethics, 20,* 277–298. doi:10.1007/s11948-013-9435-6

Gargano, T., & Throop, J. (2017). Logging on: Using online learning to support the academic nomad. *Journal of International Students, 7*, 918–924. doi:10.5281/zenodo.570041

Gilmore, J., Maher, M., & Feldon, D. (2016). Prevalence, prevention, and pedagogical techniques: Academic integrity and ethical professional practice among STEM students. In T. Bretag (Ed.), *Handbook of academic integrity* (pp. 729–748). Singapore: Springer. doi:10.1007/978-981-287-098-8

Harmon, O. R., & Lambrinos, J. (2008). Are online exams an invitation to cheat? *Journal of Economic Education, 39,* 116–125. doi:10.3200/JECE.39.2.116-125

Harris, L., Harrison, D., Mcnally, D., & Ford, C. (2019). Academic integrity in an online culture: Do McCabe's findings hold true for online, adult learners? *Journal of Academic Ethics*. Advance online publication. doi:10.1007/s10805-019-09335-3

Hartshorne, H., May, M. A., Maller, J. B., & Shuttleworth, F. K. (1928). *Studies in the nature of character*. New York, NY: The Macmillan Company.

Hayes, H., & Embretson, S. E. (2013). The impact of personality and test conditions on mathematical test performance. *Applied Measurement in Education, 26*, 77–88. doi:10.1080/08957347.2013.765432

Hodapp, V., & Benson, J. (1997). The multidimensionality of test anxiety: A test of different models. *Anxiety, Stress & Coping, 10*, 219–244. doi:10.1080/10615809708249302

Hollister, K., & Berenson, M. (2009). Proctored versus unproctored online: Studying the impact of exam environment on student performance. *Decision Sciences Journal of Innovative Education, 7*, 271–294. doi:10.1111/j.1540-4609.2008.00220.x

Holtz, P., Kronberger, N., & Wagner, W. (2012). Analyzing Internet forums: A practical guide. *Journal of Media Psychology, 24*(2), 55–66. doi:10.1027/1864-1105/a000062

Hoskins, B. J. (2013). The changing face of distance education. *The Journal of Continuing Higher Education, 61*, 189–190. doi:10.1080/07377363.2013.839243

Jaggars, S. S. (2014). Choosing between online and face-to-face courses: Community college student voices. *The American Journal of Distance Education, 28,* 27–38. doi:10.1080/08923647.2014.867697

Johnson, R. B., & Christensen, L. (2017). *Educational research: Quantitative, qualitative, and mixed approaches* (6th ed.). Los Angeles, CA: SAGE Publications.

Kentnor, H. E. (2015). Distance education and the evolution of online learning in the United States. *Curriculum and Teaching Dialogue, 17*(2), 21–34. Retrieved from http://www.infoagepub.com/series/Curriculum-and-Teaching-Dialogue

King, C. G., Guyette, R. W., Jr., & Piotrowski, C. (2009). Online exams and cheating:

An empirical analysis of business students' views. *The Journal of Educators Online, 6*(1), 1–11. Retrieved from https://www.thejeo.com

Lack, K. A. (2013). *Current status of research on online learning in postsecondary education*. New York, NY: Ithaka S+R. doi:10.18665/sr.22463

Lichtman, M. (2013). *Qualitative research in education: A user's guide* (3rd ed.). Los Angeles, CA: SAGE Publications.

Liebert, R. M., & Morris, L. W. (1967). Cognitive and emotional components of test anxiety: A distinction and some initial data. *Psychological Reports, 20*, 975–978. doi:10.2466/pr0.1967.20.3.975

Luria, A. R. (1932). *The nature of human conflicts*. (W. H. Gantt, Trans.). New York, NY: Liveright.

Mandler, G., & Sarason, S. B. (1952). A study of anxiety and learning. *The Journal of Abnormal and Social Psychology, 47*, 166–173. doi:10.1037/h0062855

May, R. (1977). *The meaning of anxiety* (2nd ed.). New York, NY: W. W. Norton.

McCabe, D. L., & Trevino, L. K. (1997). Individual and contextual influences on academic dishonesty: A multicampus investigation. *Research in Higher Education, 38*, 379–396. doi:10.1023/A:1024954224675

Means, B., Toyama, Y., Murphy, R., & Bakia, M. (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers College Record, 115*(3), 1–47. Retrieved from http://www.tcrecord.org

Means, B., Toyama, Y., Murphy, R., Bakia, M, & Jones, K. (2010). *Evaluation of* *evidence-based practices in online learning: A meta-analysis and review of online learning studies*. Washington, DC. Retrieved from the U.S. Department of Education website: www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf

Miller, A., & Young-Jones, A. D. (2012). Academic integrity: Online classes compared to face-to-face classes. *Journal of Instructional Psychology, 39*, 138–145. Retrieved from http://www.projectinnovation.biz/journal_of_instructional_psychology

Milone, A. S., Cortese, A. M., Balestrieri, R. L., & Pittenger, A. L. (2017). The impact of proctored online exams on the educational experience. *Currents in Pharmacy Teaching and Learning, 9,* 108–114. doi:10.1016/j.cptl.2016.08.037

Moore, P. H., Head, J. D., & Griffin, R. B. (2017). Impeding students' efforts to cheat in online classes. *Journal of Learning in Higher Education, 13*(1), 9–23.

Moore, M., & Kearsley, G. (2012). *Distance education: A systems view of online learning* (3rd ed.). Belmont, CA: Wadsworth.

Moten, J., Jr., Fitterer, A., Brazier, E., Leonard, J., & Brown, A. (2013). Examining online college cyber cheating methods and prevention measures. *Electronic Journal of e-Learning, 11*, 139–146. Retrieved from http://www.ejel.org

Nguyen, T. (2015). The effectiveness of online learning: Beyond no significant difference and future horizons. *Journal of Online Learning and Teaching, 11,* 309–319. Retrieved from http://jolt.merlot.org

Paullet, K., Chawdhry, A. A., Douglas, D. M., & Pinchot, J. (2016). Assessing faculty perceptions and techniques to combat academic dishonesty in online courses. *Information Systems Education Journal, 14*(4), 45–53. Retrieved from http://isedj.org

Pontes, M. C., Hasit, C., Pontes, N. M., Lewis, P. A., & Siefring, K. T. (2010). Variables related to undergraduate students preference for distance education classes. *Online Journal of Distance Learning Administration, 13*(2), 1–12. Retrieved from https://www.westga.edu/~distance/ojdla/

Sarason, I. G. (1978). The test anxiety scale: Concept and research. In C. D. Spielberger, & I. G. Sarason (Eds.), *Stress and anxiety* (Vol. 5, pp. 193-216). New York, NY: John Wiley & Sons.

Sarason, I. G. (1984). Stress, anxiety, and cognitive interference: Reactions to tests. *Journal of Personality and Social Psychology, 46*, 929–938. doi:10.1037/0022-3514.46.4.929

Sarason, S. B., & Mandler, G. (1952). Some correlates of test anxiety. *The Journal of Abnormal and Social Psychology, 47*, 810–817. doi:10.1037/h0060009

Schult, C. A., & McIntosh, J. L. (2004). Employing computer-administered exams in general psychology: Student anxiety and expectations. *Teaching of Psychology, 31*, 209–211. doi:10.1207/s15328023top3103_7

Seaman, J. E., Allen, I. E., & Seaman, J. (2018). *Grade increase: Tracking distance education in the United States*. Babson Park, MA: Babson Survey Research Group.

Seipp, B. (1991). Anxiety and academic performance: A meta-analysis of findings.

Anxiety Research, 4, 27–41. doi:10.1080/08917779108248762

Şendağ, S., Duran, M., & Fraser, M. R. (2012). Surveying the extent of involvement in online academic dishonesty (e-dishonesty) related practices among university students and the rationale students provide: One university's experience. *Computers in Human Behavior, 28*, 849–860. doi:10.1016/j.chb.2011.12.004

Simonson, M., Schlosser, C., & Orellana, A. (2011). Distance education research: A review of the literature. *Journal of Computing in Higher Education, 23*, 124–142. doi:10.1007/s12528-011-9045-8

Spielberger, C. D. (1972). Conceptual and methodological issues in anxiety research. In C. D. Spielberger (Ed.), *Anxiety: Current trends in theory and research* (Vol. 2, pp. 481-492). New York, NY: Academic Press.

Spielberger, C. D. (1980). *Manual for test anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spreen, O., & Strauss, E. (1991). *A compendium of neuropsychological tests: Administration, norms, and commentary*. New York, NY: Oxford University Press.

Stack, S. (2015). The impact of exam environments on student test scores in online courses. *Journal of Criminal Justice Education, 26*, 273–282. doi:10.1080/10511253.2015.1012173

Stowell, J. R., & Bennett, D. (2010). Effects of online testing on student exam performance and test anxiety. *Journal of Educational Computing Research, 42*, 161–171. doi:10.2190/EC.42.2.b

Sullivan, D. P. (2016). An integrated approach to preempt cheating on asynchronous, objective, online assessments in graduate business classes. *Online Learning, 20*(3), 195–209. Retrieved from https://onlinelearningconsortium.org/read/online-learning-journal

Texas Higher Education Coordinating Board. (2018). *Distance education data by location and instruction mode for public community, state and technical colleges*. Retrieved from http://www.txhighereddata.org.

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation, 27*, 237–246. doi:10.1177/1098214005283748

Watson, G. & Sottile, J. (2010). Cheating in the digital age: Do students cheat more in online courses? *Online Journal of Distance Learning Administration, 13*(1), 1–10. Retrieved from http://www.westga.edu/~distance/ojdla

Yates, R. W., & Beaudrie, B. (2009). The impact of online assessment on grades in community college distance education mathematics courses. *American Journal of Distance Education, 23*, 62–70. doi:10.1080/08923640902850601

APPENDIX A:

SURVEY COVER LETTER

University
of Houston
Clear Lake

June 2018

Dear Student:

Greetings! You are being solicited to complete the *Test Anxiety Inventory* survey. The purpose of this survey is to examine the influence of test anxiety on test performance in proctored and unproctored test environments. The data obtained from this study will allow me to understand how test anxiety affects students when they are taking examinations in proctored and unproctored environments, and it will also provide feedback to the Mathematics Department about examinations in online classes.

Please answer all questions completely. Filling out the survey is entirely voluntary but answering each question will make the survey most useful. This survey will take approximately 10 minutes to complete, and all your responses will be completely anonymous. No obvious undue risks will be endured, and you may stop your participation at any time. In addition, you will not benefit directly from your participation in the study.

Your cooperation is greatly appreciated, and your willingness to participate in this study is implied if you proceed with completing the survey. Your completion of the *Test Anxiety Inventory* survey is not only greatly appreciated but also invaluable to research. If you have any further questions, please feel free to contact Dr. Jana Willis (willis@uhcl.edu) or myself (andersonk4403@uhcl.edu). Thank you!

Sincerely,

Kelly Anderson, M.S.
UHCL Doctoral Student
College of Education
andersonk4403@uhcl.edu

APPENDIX B:

INFORMED CONSENT

Informed Consent to Participate in Research

You are being asked to participate in the research project described below. Your participation in this study is entirely voluntary. You may refuse to participate, or you may decide to stop your participation at any time. Should you refuse to participate in the study or should you withdraw your consent and stop participation in the study, your decision will involve no penalty or loss of benefits to which you may be otherwise entitled. You are being asked to read the information below carefully and ask questions about anything you don't understand before deciding whether to participate.

Title: The Influence of Proctored Testing in Distance Learning Mathematics Courses

Principal/Student Investigator(s): Kelly Anderson, M.S.
Faculty Sponsor: Jana Willis, Ph.D.

PURPOSE OF THE STUDY
The purpose of this research is to investigate the influence of proctored testing on test performance and test anxiety in distance learning mathematics courses.

PROCEDURES
A concurrent mixed methods research design will be implemented. The study will consist of two simultaneous phases: quantitative and qualitative. The quantitative data will be collected through surveys and final examinations. The qualitative data will be collected through a discussion board. Your participation will take place through your course discussion board in Blackboard. There will be no more than six open-ended questions posed to you during the semester.

EXPECTED DURATION
The total anticipated time commitment will be approximately 1 hour.

RISKS OF PARTICIPATION
There are no anticipated risks associated with participation in this project.

BENEFITS TO THE SUBJECT
There is no direct benefit received from your participation in this study, but your participation will help the investigator(s) better understand the influence of proctored testing in distance learning mathematics courses.

CONFIDENTIALITY OF RECORDS

Every effort will be made to maintain the confidentiality of your study records. The data collected from the study will be used for educational and publication purposes; however, you will not be identified by name. For federal audit purposes, the participant's documentation for this research project will be maintained and safeguarded by the Principal Investigator for a minimum of three years after completion of the study. After that time, the participant's documentation may be destroyed.

FINANCIAL COMPENSATION

There is no financial compensation to be offered for participation in the study.

INVESTIGATOR'S RIGHT TO WITHDRAW PARTICIPANT

The investigator has the right to withdraw you from this study at any time.

CONTACT INFORMATION FOR QUESTIONS OR PROBLEMS

If you have additional questions during this study about the research or anything related, you may contact the Student Researcher, Kelly Anderson, at phone number 281-998-6150, ext. 1751 or by email at andersonk4403@uhcl.edu. The Faculty Sponsor, Jana Willis, Ph.D., may be contacted at phone number 281-283-3568 or by email at willis@uhcl.edu.

SIGNATURES:

Your signature below acknowledges your voluntary participation in this research project. Such participation does not release the investigator(s), institution(s), sponsor(s) or granting agency(ies) from their professional and ethical responsibility to you. By signing the form, you are not waiving any of your legal rights.

The purpose of this study, procedures to be followed, and explanation of risks or benefits have been explained to you. You have been allowed to ask questions and your questions have been answered to your satisfaction. You have been told who to contact if you have additional questions. You have read this consent form and voluntarily agree to participate as a subject in this study. You are free to withdraw your consent at any time by contacting the Principal Investigator or Student Researcher/Faculty Sponsor. You will be given a copy of the consent form you have signed.

Subject's printed name: ______________________________

Signature of Subject: ______________________________

Date: ______________________________

Using language that is understandable and appropriate, I have discussed this project and the items listed above with the subject.

Printed name and title ______________________________

Signature of Person Obtaining Consent: ______________________________

Date: ______________________________

THE UNIVERSITY OF HOUSTON-CLEAR LAKE (UHCL) COMMITTEE FOR PROTECTION OF HUMAN SUBJECTS HAS REVIEWED AND APPROVED THIS PROJECT. ANY QUESTIONS REGARDING YOUR RIGHTS AS A RESEARCH SUBJECT MAY BE ADDRESSED TO THE UHCL COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (281-283-3015). ALL RESEARCH PROJECTS THAT ARE CARRIED OUT BY INVESTIGATORS AT UHCL ARE GOVERNED BY REQUIREMENTS OF THE UNIVERSITY AND THE FEDERAL GOVERNMENT. (FEDERALWIDE ASSURANCE # FWA00004068)

APPENDIX C:

TEST ANXIETY INVENTORY

mind garden

www.mindgarden.com

To whom it may concern,

This letter is to grant permission for the above named person to use the following copyright material;

Instrument: ***Test Anxiety Inventory***

Author: ***Charles D. Spielberger, Ph.D.***

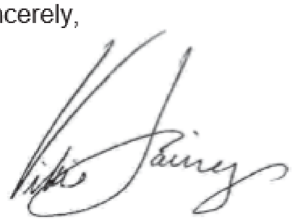
Copyright: ***1980 Consulting Psychologists Press, Inc.***

for his/her thesis research.

Five sample items from this instrument may be reproduced for inclusion in a proposal, thesis, or dissertation.

The entire instrument may not be included or reproduced at any time in any other published material.

Sincerely,



Vicki Jaimez
Mind Garden, Inc.
www.mindgarden.com

TEST ANXIETY INVENTORY

1 = Almost Never 2 = Sometimes 3 = Often 4 = Almost Always

1. I feel confident and relaxed while taking tests…………………………..	1	2	3	4
2. While taking examinations I have an uneasy, upset feeling………	1	2	3	4
3. Thinking about my grade interferes with my work on tests…..….	1	2	3	4
4. I freeze up on important exams……………………………………….………	1	2	3	4
5. During exams I wonder whether I'll get through school…………..	1	2	3	4

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[complete survey not included due to copyright restrictions]

APPENDIX D:

COLLEGE ALGEBRA FINAL EXAMINATION

QUESTION 1 — 5 points — Save Answer

Solve the inequality. Write the solution set in interval notation.

$14(x - 3) - 13x \geq -12$

- $[30, \infty)$
- $(-\infty, 30]$
- $[-9, \infty)$
- $(30, \infty)$

QUESTION 2 — 5 points — Save Answer

Solve the system.

$$\begin{aligned} 15x - y &= 1 \\ 15x + 2y &= 34 \end{aligned}$$

- $\{(x, y) \mid y = 15x - 1\}$; The equations are dependent.
- $\{(0, -1)\}$
- $\left\{\left(\frac{4}{5}, 11\right)\right\}$
- { }; The system is inconsistent.

QUESTION 3 — 5 points — Save Answer

Determine the vertical asymptote(s) of the graph of the function.

$$h(x) = \frac{x + 5}{2x^2 + 3x - 14}$$

- $x = \frac{7}{2}$ and $x = 2$
- $x = -\frac{7}{2}$ and $x = 2$
- $x = 5$ and $x = -2$
- $x = \frac{7}{2}$ and $x = 7$

QUESTION 4

5 points Save Answer

Solve the equation.

$2 + \sqrt{4x + 5} = 4$

- $\left\{-\frac{1}{4}\right\}$
- $\left\{\frac{31}{4}\right\}$
- $\left\{\frac{9}{4}\right\}$
- $\{1\}$

QUESTION 5

5 points Save Answer

Solve the problem.

A model rocket is launched from a raised platform at a speed of 176 feet per second.
Its height in feet is given by
$h(t) = -16t^2 + 176t + 20$
After how many seconds does the object reach its maximum height?

- 7.5 seconds
- 2.75 seconds
- 5.5 seconds
- 20 seconds

QUESTION 6

5 points Save Answer

Solve the system.

$$\begin{aligned} 3x - 7y - 4z &= -1 \\ x + 5y + 7z &= 0 \\ -4x + 3y - 5z &= 23 \end{aligned}$$

- {(0, 0, 0)}
- Infinitely many solutions; dependent
- No solution; inconsistent
- {(9, 8, -7)}

QUESTION 7

5 points Save Answer

Solve the problem.

A pie comes out of the oven at 400°F and is placed to cool in a 70°F kitchen. The temperature of the pie T (in °F) after t minutes is given by $T = 70 + 330e^{-0.015t}$. The pie is cool enough to cut when the temperature reaches 130°F. How long will this take? Round to the nearest minute.

- 126 minutes
- 62 minutes
- 67 minutes
- 114 minutes

QUESTION 8

5 points Save Answer

Write the domain in interval notation.

$z(a) = \sqrt{a + 4}$

- $(-\infty, \infty)$
- $(-4, \infty)$
- $[-4, \infty)$
- $[0, \infty)$

QUESTION 9

5 points Save Answer

Solve the equation by using the quadratic formula.

$6y + 3 = -4y^2$

- $\left\{-\frac{9}{2}, \frac{1}{3}\right\}$
- $\left\{-\frac{1}{4} + \frac{\sqrt{105}}{12}, -\frac{1}{4} - \frac{\sqrt{105}}{12}\right\}$
- $\left\{-\frac{3}{4} + \frac{i\sqrt{3}}{4}, -\frac{3}{4} - \frac{i\sqrt{3}}{4}\right\}$
- $\{2 + \sqrt{3}, 2 - \sqrt{3}\}$

QUESTION 10

5 points Save Answer

Find the indicated function.

$m(x) = \sqrt{x - 2}$, $n(x) = x - 3$, $(m \circ n)(x)$

- $(m \circ n)(x) = \sqrt{x^2 + 6}$
- $(m \circ n)(x) = (x - 3)\sqrt{x - 2}$
- $(m \circ n)(x) = \sqrt{x - 2} - 3$
- $(m \circ n)(x) = \sqrt{x - 5}$

QUESTION 11

5 points Save Answer

Solve the system.

$2x + y = -5$
$-4x - 2y = 3$

- $\{(x, y) \mid 2x + y = -5\}$; The equations are dependent.
- {(1, -7)}
- { }; The system is inconsistent.
- {(0, -5)}

QUESTION 12

5 points Save Answer

Use the slope-intercept form to write an equation of the line that passes through the given points.

(-1, -2) and (-3, -5)

- $f(x) = -\frac{3}{2}x + \frac{11}{2}$
- $f(x) = \frac{2}{3}x - \frac{1}{2}$
- $f(x) = \frac{3}{2}x - \frac{1}{2}$
- $f(x) = -\frac{2}{3}x + \frac{11}{2}$

QUESTION 13

5 points Save Answer

Write the equation in logarithmic form.

$7^2 = 49$

- $\log_{49} 2 = 7$
- $\log_2 49 = 7$
- $\log_{49} 7 = 2$
- $\log_7 49 = 2$

QUESTION 14

5 points Save Answer

Solve the problem.

James wants to invest $14,000. He can invest the money at 7.4% simple interest for 20 yr or he can invest at 7.1% with interest compounded continuously for 20 yr. Which option results in **more** total interest?

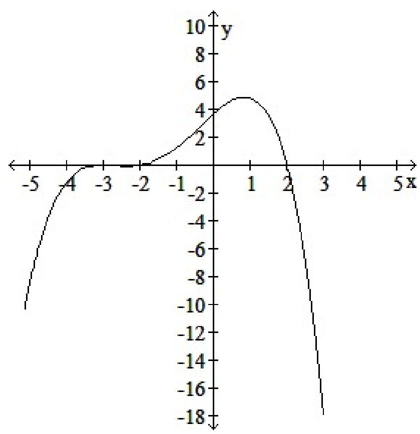
- 7.1% compounded continuously results in more total interest
- 7.4% simple interest results in more total interest

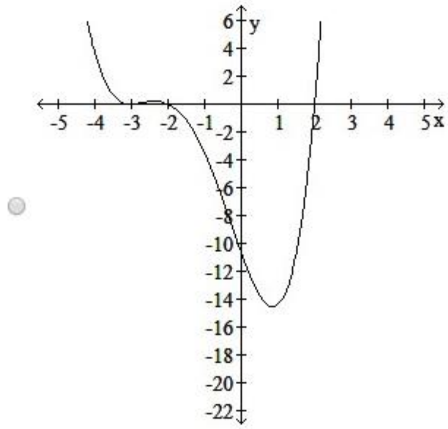
QUESTION 15

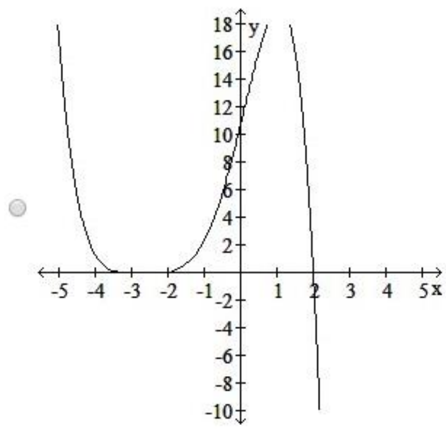
5 points Save Answer

Sketch the function.

$$m(x) = -\frac{1}{10}(x+2)(x-2)(x+3)^3$$




6
4
2
y
-5 -4 -3 -2 -1 1 2 3 4 5 x
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22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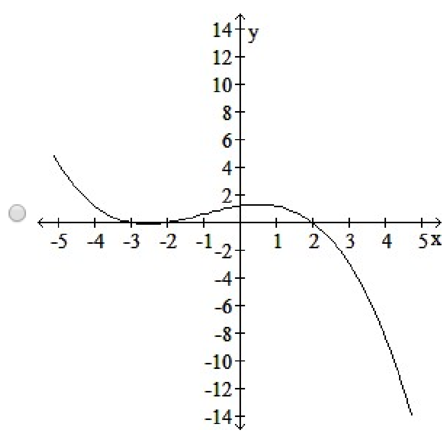
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-5 -4 -3 -2 -1 1 2 3 4 5 x
-2
-4
-6
-8
-10
-12
-14

QUESTION 16

5 points Save Answer

Solve the problem.

Factor $f(x) = 2x^3 - 3x^2 - 30x - 25$ given that 5 is a zero.

- $(x + 5)(2x^2 - 13x + 35)$
- $(x + 5)(2x - 5)(x + 1)$
- $(x - 5)(2x^2 - 13x + 35)$
- $(x - 5)(2x + 5)(x + 1)$

QUESTION 17

5 points Save Answer

Solve the inequality. Write the solution set in interval notation.

$$\frac{9}{m - 3} \geq 5$$

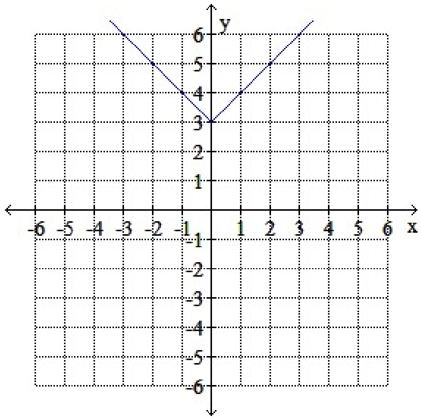
- $\left(-\infty, \frac{24}{5}\right]$
- No Solution
- $\left(3, \frac{24}{5}\right]$
- $(-\infty, 3) \cup \left[\frac{24}{5}, \infty\right)$

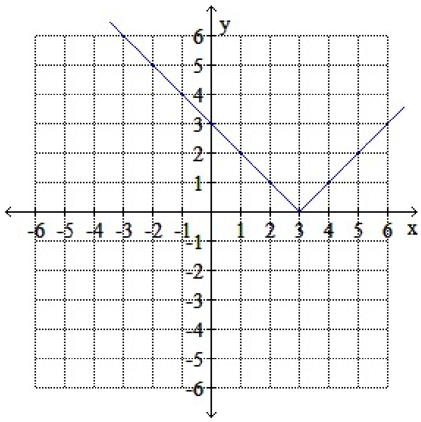
QUESTION 18

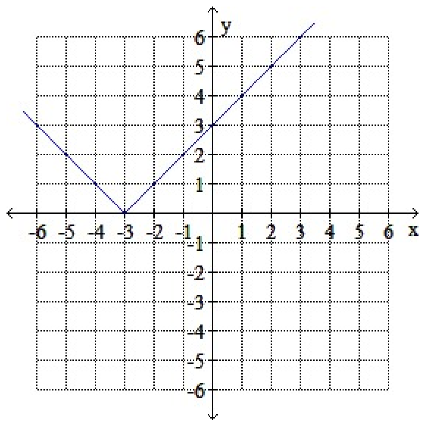
5 points Save Answer

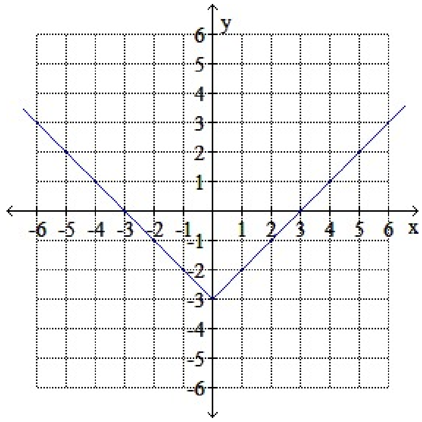
Graph the equation by plotting points.

$y = |x - 3|$









QUESTION 19 5 points Save Answer

A one-to-one function is given. Write an expression for the inverse function.

$f(x) = 6x^3 - 7$

- $f^{-1}(x) = \dfrac{x - 7}{6}$
- $f^{-1}(x) = \dfrac{x + 7}{6}$
- $f^{-1}(x) = \left(\dfrac{x + 7}{6}\right)^3$
- $f^{-1}(x) = \sqrt[3]{\dfrac{x + 7}{6}}$

QUESTION 20 5 points Save Answer

Solve the system.

$2x + 5y = 5$
$7x + 2y = -29$

- {(-5, -3)}
- {(5, 3)}
- {(5, -3)}
- {(-5, 3)}

APPENDIX E:

BUSINESS CALCULUS FINAL EXAMINATION

QUESTION 1 — 5 points — Save Answer

Find the marginal revenue when x = 8. $R(x) = -2x^2 + 72x - 145$

- -32 dollars per unit
- -4x+72 dollars per unit
- -4x-72 dollars per unit
- 40 dollars per unit
- none of these

QUESTION 2 — 5 points — Save Answer

Find the derivative of the function using the quotient rule. $f(x) = \frac{3x - 10}{x + 4}$

- $f'(x) = \frac{22}{(x+4)^2}$
- $f'(x) = -\frac{7}{5}$
- $f'(x) = \frac{3}{(x+4)^2}$
- $f'(x) = 3$
- $f'(x) = \frac{2}{(x+4)^2}$

QUESTION 3 — 5 points — Save Answer

Use the product rule to find the derivative of the function. $y = 5xe^{-x}$

- $-5e^{-x}$
- $5e^{-x}(1-x)$
- $-5xe^{-x}$
- 5
- $5e^{-x}$

QUESTION 4

5 points Save Answer

The profit P from selling x units of a product is given by $P(x) = 520x - 0.4x^2$. The sales are increasing at a rate of 5 units per day. Find the rate of change of profit (in dollars per day) when x = 200 units.

- $1000 per day
- $2520 per day
- $200 per day
- $1800 per day
- $88000 per day

QUESTION 5

5 points Save Answer

If the total revenue for a blender is $R(x) = 50x - 0.25x^2$, determine the number of units x that maximizes the revenue R.

- 2500
- 50
- 100
- 150
- 1875

QUESTION 6

5 points Save Answer

Find the indefinite integral. $\int (7x^2 - 3x - 7)dx$

- $\frac{7}{3}x^3 - \frac{3}{2}x^2 - 7x + C$
- $21x^3 - 6x^2 - 7x + C$
- $\frac{7}{3}x^3 - \frac{3}{2}x^2 + \frac{49}{2}x + C$
- $\frac{7}{3}x^3 - \frac{3}{2}x^2 - \frac{49}{2}x + C$
- $14x - 3 + C$

QUESTION 7

5 points Save Answer

Evaluate the definite integral. $\int_2^5 (2x+6)\,dx$

- 39
- -6
- -4
- 13
- 18

QUESTION 8

5 points Save Answer

The marginal cost of serving an additional client at a law firm can be modeled by $\frac{dC}{dx} = 675 + 0.5x$ where x is the number of clients. Find the change in cost C (in dollars) when x increases from 50 to 51 clients.

- none of these
- $0.50
- $8.32
- $776.00
- $700.25

QUESTION 9

5 points Save Answer

What is the Fundamental Theorem of Calculus?

- $\int_a^b f(x)\,dx = f(b) - f(a)$
- $\int_a^b f(x)\,dx = F(a) - F(b)$
- $\int_a^b f(x)\,dx = f(a) - f(b)$
- $\int_a^b f(x)\,dx = F(b) - F(a)$
- Calculus is awesome.

QUESTION 10

5 points Save Answer

Find the distance between the points (3,4) and (7,7). Round your answer to the nearest hundredth.

- 14.87
- 2.65
- 4.58
- 5.00
- 25.00

QUESTION 11

5 points Save Answer

Determine the open intervals on which the function $f(x)=4x^2-3x+2$ is decreasing.

- $\left(-\infty,\frac{3}{8}\right)$
- none of these
- $(0,\infty)$
- $\left(\frac{3}{8},\infty\right)$
- $(-\infty,\infty)$

QUESTION 12

5 points Save Answer

A small business recaps and sells tires. The business has a revenue function $R(x)=115x$ and a cost function $C(x)=3500+80x$, where x represents the number of sets of tires recapped and sold. Find the number of sets of recaps that must be sold to break even.

- 100
- 700
- 35
- 80
- 500

QUESTION 13

5 points Save Answer

Find the exponential function $y = Ce^{kt}$ that passes through the two points (0,8) and (7,9).

- $y = 8e^{0.0168t}$
- $y = 7e^{-0.0168t}$
- $y = 8e^{-0.0168t}$
- $y = e^{-0.0168t}$
- $y = e^{0.0168t}$

QUESTION 14

5 points Save Answer

Write the equation of the line passing through the given pair of points (3,10) and (9,4).

- $y = -x - 5$
- $y = -13x + 13$
- $y = -5x + 13$
- none of these
- $y = -x + 13$

QUESTION 15

5 points Save Answer

To help their son buy a car, a boy's parents invest $1600 on his 12th birthday. If the investment pays an annual rate of 11% compounded continuously, how much is available on his 18th birthday.

- $22,421.13
- $2992.66
- $3095.67
- $3068.20
- $2656.00

QUESTION 16

5 points Save Answer

Find the constant a such that the function is continuous on the entire real number line.

$$f(x)=\begin{cases} -x+1, & x \le 3 \\ ax-8, & x>3 \end{cases}$$

- 8
- $\frac{10}{3}$
- undefined
- 14
- 2

QUESTION 17

5 points Save Answer

The total cost function for a product is $C(x)=200+5x+0.07x^2$ dollars. Find the minimum average cost.

- \$13.10
- \$12.48
- \$12.92
- \$20.00
- \$19.00

QUESTION 18

5 points Save Answer

Find the equation of the tangent line to the graph of $f(x)=2x^2+6$ at the point $(3,24)$.

- $y=12x-12$
- $y=12x+60$
- none of these
- $y=4x$
- $y=4x+24$

QUESTION 19

5 points Save Answer

Find the x-value where the absolute minimum of $f(x) = x^3 - 27x + 6$ occurs on the closed interval $[-9,4]$.

- 3
- 0
- -9
- -3
- 4

QUESTION 20

5 points Save Answer

A piece of ancient charcoal contains only 18% as much of the radioactive carbon as a piece of modern charcoal. How long was the tree burned to make the ancient charcoal? (The half-life of Carbon-14 is 5715 years.) Round your answer to the nearest integer.

- 2,310 years
- 14,139 years
- 2,315 years
- 7 years
- 33,123 years

APPENDIX F:

DISCUSSION BOARD PROMPTS

1. Where did you take Test #1? Did you experience any challenges in that environment?
2. What, if anything, do you like about taking unproctored tests in an online course?
3. What, if anything, do you dislike about taking unproctored tests in an online course?
4. Do you feel like you experienced any anxiety before or during the unproctored test? Why or why not?
5. Do you think students in online math courses are ever tempted to cheat on unproctored tests? Why or why not? Do you think cheating is related to test anxiety? Why or why not?
6. What, if anything, did you like about taking a proctored final examination? What, if anything, did you dislike about taking a proctored final examination?