A CORRELATIONAL STUDY ON COMPONENTS OF HYBRID COURSE DELIVERY AND STUDENT SUCCESS IN INTRODUCTORY STATISTICS

by

Gail Moore McGowan

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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APPROVED BY:

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ABSTRACT

Hybrid course delivery has become a popular course design in general education large enrollment courses. While the benefits of hybrid course design are detailed in many studies, little research has been conducted on the contribution specific components make toward student success. In this quantitative research study, a correlational design with a multiple regression technique was used to examine the relationship between average weekly quiz grade, number of weekly quiz attempts, weekly lab attendance, weekly time spent in class with the professor and student conceptual understanding in the introductory statistics course. This research study was conducted at a private university located in the eastern United States with 15,000 residential students. The sample was taken from twelve sections of an introductory general education statistics class. This research study found that the average weekly quiz grade had a significant positive correlation with conceptual understanding in an introductory statistics class. The multiple regression analysis indicated that the average weekly quiz grade was the only independent variable to make a statistically significant contribution to the prediction of the CAOS score. Further research on the specific components of hybrid course delivery could add to the core knowledge about the hybrid course format and help future course redesigns maximize student conceptual understanding as well as identify students in need of remediation.

Keywords: hybrid course, blended course, emporium model, introductory statistics

Dedication

I dedicate this dissertation to my family, as I could not have accomplished this without their support and love. I owe this accomplishment to my parents, Margaret and Ed Moore, who taught me the importance of family, hard work, and love of God. I also want to thank my sister, Mitzi Halleck, whose unfailing love, support and encouragement helped me keep going when I wanted to quit. I also appreciate my children, Thomas, Randi, and Emily, who never ceased to believe in me and their positive encouragement and ability to help me laugh at myself made this process easier. Above all, I'd like to thank my husband, Tom, who happily and without complaining took over many of my usual tasks in order to give me time to work and was always a loving and supportive partner during this process.

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

Course Management System (CMS)

Learning Management System (LMS)

National Center for Academic Transformation (NCAT)

Science, technology, engineering, or mathematics (STEM)

Virginia Polytechnic Institute (VPI)

Virtual Learning Environment (VLE)

Comprehensive Assessment of Outcomes in Statistics (CAOS)

Statistical Package for the Social Sciences (SPSS)

Variance Inflation Factor (VIF)

CHAPTER ONE: INTRODUCTION

Background

Lecture is considered by the academic world to be the most impressive form of scholarly delivery of information (DeRogatis et al., 2014). Lecture as a form of content delivery dates back to the beginning of education. However, in the early 20th century, experts in learning theory and cognitive development, such as John Dewey, began gathering data that a student actively engaged in course content is having a more successful learning experience than a student that is passively receiving information in the form of lecture (DeRogatis et al., 2014). Of the many approaches to teaching in higher education, using a traditional lecture has been associated with a number of undesirable outcomes (Lochner, Wieser, Waldboth, & Mischo-Kelling, 2016; Yadav, Subedi, Lundeberg, & Bunting, 2011). Traditional lecture is often considered ineffective and inefficient and has very little interaction between students and professors (Matheson, 2008).

Studies have found that upon entering the workforce, students need more communication and problem solving skills (King, 2012). This information has prompted institutions of higher learning to search for more effective teaching methods in order to better prepare students to be capable at communication and problem solving (Matheson, 2008). University administrators did not want to reduce class size in order to promote more active learning when it would further increase costs (Twigg, 2003). One solution considered was a switch to hybrid or blended course design, which promotes more active learning as well as reducing costs (O'Rourke, Main, & Cooper, 2014; Rais-Rohani & Walters, 2014; Twigg, 2003; Vaughan, 2007; Young, 2002).

A blended course design helps bridge the gaps left by traditional lecture by improving student communication with faculty and peers as well as developing communication skills (Aspden & Helm, 2014; Biddix, Chung, & Park, 2015; Vaughan, 2007). Blended courses also promote active learning and higher student engagement because students in courses with this format assume a greater responsibility for their own learning (Twigg, 2011; Wilder & Berry, 2016).

A traditional lecture delivery of course content fails to accommodate for individualized skills and learning approaches (Lage, Platt, & Treglia, 2000; Wilder & Berry, 2016). Learning styles can vary greatly and are influenced by a student's emotional, social, and psychological preferences (Dunn et al., 2009). If an instructor's teaching style does not match a student's learning pattern then the student's achievement can be negatively impacted (Borg & Shapiro, 1996; Guskey, 2007; Lage, Platt, & Treglia, 2000; Olic & Adamov, 2016; Ziegert, 2000). The emporium model which is a specific type of blended course design uses computer-based learning resources, engages students in active learning, helps students work toward mastery of concepts, and students can receive help as needed (Twigg, 2003; Twigg, 2011; Wilder & Berry, 2016). The emporium model of course delivery is by nature a flexible model (Twigg, 2003; Twigg, 2011). Institutions of higher learning can structure their version of the emporium model as it best fits their unique educational situation (Twigg, 2013).

The emporium model includes many components including a *course management system* (CMS) (Twigg, 2003; Twigg, 2011). The CMS allows professors to organize, create, and assemble course content and structure the course (Rais-Rohani & Walters, 2014; Twigg, 2003; Vaughan, 2007; Witkowsky, 2008) while managing the administrative tasks as well (Al-Qahtani & Higgins, 2013; Gleason, 2012; Helms, 2014; Graf, Liu, & Kinshuk, 2010; Twigg, 2003; Twigg, 2011; Witkowsky, 2008). Using a CMS allows the instructor to create a course that is more student-centered, engages the students using active learning, is often self-paced, and encourages collaborative and cooperative learning (Costen, 2009; Felder & Brent, 1996; Lowry

& Flohr, 2004; Olgun, 2009; Shiu-Li & Jung-Hung, 2012). The CMS also often has adaptive learning programmed into the software, and educational stakeholders agree that educational needs are met better when learning is more individualized (Bloom, 1984; Johnson & Samora, 2016; Lou & Abrami, 1996). The math emporium model of course design also seeks to meet diverse needs of students by organizing learning into modular units, requiring students to spend time each week in a central computer lab, peer-tutoring, encouraging collaborative learning and a sense of community (Twigg, 2003; Twigg, 2011; Twigg, 2013).

Because of a shift in popular choices for a major that requires a large amount of science, technology, engineering, or mathematics (STEM) classes, universities found that they had general education math classes with an overflowing enrollment and often low pass rates (Swap & Walter, 2015; Witkowski, 2008). To accommodate the large number of students and also provide reasonable academic support while keeping costs low, university administrators began exploring possible solutions (Wilder & Berry, 2016; Witkowsky, 2008). One of these solutions was the development of STEM courses with a hybrid or blended format (Swap & Walter, 2015; Witkowsky, 2008). A hybrid or blended course design combines some traditional face-to-face instruction with computer-based activities, which can replace some of the time students would traditionally spend in class (Scida & Saury, 2006). A blended or hybrid course design has student-to-student interaction and student to teacher interaction face-to-face in a classroom; some of this interaction occurs in an online environment (Helms, 2014). Both blended course design and hybrid course design use a combination of elements of traditional lecture and computer-assisted instruction (Nakayama, Mutsuura, & Yamamoto, 2016; Tucker King, Keeth, & Ryan, 2018).

A variety of benefits result from redesigning a course from the traditional format to a blended learning environment. Many studies have shown that blended learning results in improved learning outcomes (Al-Qahtani & Higgins, 2013; Rais-Rohani & Walters, 2014; Vaughan, 2007; Wilder & Berry, 2016; Yadav et al., 2011). Both students and faculty enjoy a greater flexibility in the learning environment. Students can progress faster if they are successful in understanding the course content (Vaughan, 2007; Wilder & Berry, 2016). Blended courses improve student communication with faculty and peers as well as developing communication skills that will contribute to success on the job after degree completion (Aspden & Helm, 2014; Biddix et al., 2015; Vaughan, 2007). The convenient and easy access to course materials is important to students as well (Biddix et al., 2015). Blended courses promote active learning and higher student engagement. Students in courses with this format assume a greater responsibility for their own learning (Twigg, 2011; Wilder & Berry, 2016).

Not only is a hybrid course format beneficial for students and faculty, but it benefits administrators as well (Ayala, 2009; Frimming, Bower, & Chulhwan, 2013; Gleason, 2012; Helms, 2014; Lim, Kim, Chen, & Ryder, 2008; Picciano, 2006; Rais-Rohani & Walters, 2014; Sorden & Munene, 2013; Twigg, 2003; Vaughan, 2007; Witkowski, 2008). Blended courses operate at a lower cost for universities, as one teacher can manage more course sections (Rais-Rohani & Walters, 2014; Vaughan, 2007). Even the emporium model of blended learning, which most often includes the operation of a large-scale math computer lab, offers a significant reduction in costs (Twigg, 2011).

In the late 1990s, college administrators were faced with the problem of improving access to higher education, improving student learning, and containing or reducing the rising costs (Twigg, 2003; Twigg, 2011). Improving one of the three mentioned areas always made the other two areas worse (Twigg, 2003). For example, if a college worked to improve learning, then that often reduced access because of raised costs (Twigg, 2003). The addition of technology did not improve these problems (Twigg, 2003). A grant from Pew Charitable Trusts established the Program in Course Redesign to address these issues facing colleges and universities (Twigg, 2003). The goal of the Program in Course Redesign was to support colleges and universities in their efforts to redesign instruction using technology to achieve quality learning as well as reduce costs (Twigg, 2003).

Selected from a national competition, 30 colleges were chosen to participate in redesigning large introductory courses that would affect a large number of students as well as generate significant cost savings (Twigg, 2003). The subjects covered in these courses include English, mathematics, psychology, sociology, and biology, as well as many more (Twigg, 2003). All institutions that participated reduced costs by an average of 40 percent as well as increasing completion rates, student satisfaction, and content retention (Twigg, 2003). This beginning of a course redesign movement then resulted in the establishment of the National Center for Academic Transformation (NCAT) (Twigg, 2011). This course redesign movement was also the beginning of the emporium model of course delivery (Twigg, 2003). As of 2011, course redesigns of college level math courses by the NCAT increased successful course completion by an average of 25% and reduced the cost of instruction by an average of 37% (Twigg, 2011).

Studies have shown that blended courses have higher retention rates as well as higher student satisfaction (Frimming et al., 2013; Vaughan, 2007). Offering a blended course also can enhance a college or university's reputation by helping students achieve degree completion quicker while also giving more access to educational opportunities (Twigg, 2011; Vaughan, 2007).

Blended learning has been growing steadily due to the educational and administrative benefits it offers universities (Hill, 2012). A specific variation of blended learning is the emporium model of course delivery. Virginia Polytechnic Institute developed the emporium model of course delivery in 1999 (Twigg, 2011). Students meet with a professor once a week and also use computer-assisted instruction to learn concepts. Tutors and professors are available for tutoring and to give assistance in the math emporium, a large math computer lab, when students don't understand a concept (Twigg, 2011). Most math emporium classes require a minimum amount of time be spent in the math emporium each week with participation points tied to the emporium time (Twigg, 2011). This time requirement can be anywhere from two to four hours (Ningjun & Herron, 2012). Students can work faster than the course pace if their skills are strong and they understand the material (Wilder & Berry, 2016). Because of the use of technology, students have multiple attempts on homework and quizzes and a required minimum test review score in order to take a test (Twigg, 2003).

Twigg (2011) states that the emporium model is successful for several reasons. Students spend most of their time doing math rather than listening to someone talk about math. Students spend more time on content that they do not understand. Students get help as soon as they have problems. Because participation points are tied to attendance in the math emporium, students are more likely to actually do the math. The NCAT is an independent non-profit organization dedicated to using interactive technology to improve learning outcomes and reduce costs in higher education (Twigg, 2011). As of 2011, NCAT had conducted large-scale redesign project in mathematics that involved 37 institutions of higher learning (Twigg, 2011).

While the emporium style delivery has all of the benefits of blended learning as well as its own unique benefits, conflicting research exists on the effectiveness of blended instruction.

In a comparison of online, blended, and face-to-face instruction, researchers found that there was a significant difference in the success of students with students in the blended course format having the least success (Ashby, Sadera, & McNary, 2011). In a comparison of hybrid course delivery and traditional course design in a college introductory statistics course, no significant difference was found in student's success although there was a significant difference in student satisfaction with those in the blended course having the highest satisfaction (Kakish, Pollacia, Heinz, Sinclair, & Thomas, 2012).

Colleges offer a variety of course formats including traditional, blended, and online. The popularity of computer-assisted instruction is high. Blended courses can meet the individualized needs of students while reducing the cost for colleges and universities. Students and faculty recognize many benefits to this type of course delivery, although some negative aspects do exist. All educational stakeholders involved in course redesign and curriculum decisions as well as those involved with blended instruction need a thorough understanding of the benefits and disadvantages of this mode of course delivery.

Problem Statement

When examining research about learning outcomes of the emporium model or even the broader topic of learning outcomes of blended courses, the results are mixed. A large number of studies resulted in the conclusion that learning outcomes are improved when a course is redesigned into a blended delivery format (Al-Qahtani & Higgins, 2013; Rais-Rohani & Walters, 2014; Vaughan, 2007; Wilder & Berry, 2016; Yadav et al., 2011). However, some studies exist that report no significant difference in learning outcomes when comparing traditional course format versus hybrid course format (Frimming et al., 2013; Kakish et al., 2012; Tucker King et al., 2018).

More importantly, very few studies examine what components of the emporium course format contribute to successful student achievement. Ningjun & Herron (2012) found that the amount of time college algebra students spent in the math emporium had a positive linear relationship with their final exam scores. Another study found that successful blended courses have high levels of instructor presence (Shea, Joaquin, & Gorzycki, 2015). Within the emporium course format, many variations of the components exist from one university to another. Even within the same university, diversity exists concerning the details of emporium course design. A thorough understanding of which components are effective is necessary in order to offer students an emporium course designed to maximize their ability to learn.

Purpose Statement

The purpose of this study was to examine specific components of a hybrid format college introductory statistics course and determine if there is a significant relationship between those components and student success in the course. The subjects of the study were university undergraduate students enrolled in a hybrid general education introductory statistics class. The specific components examined in this study were the number of weekly quiz attempts, weekly math lab attendance, weekly quiz average, and weekly time in a classroom with a professor. Student success was measure by the use of a verified instrument designed to measure introductory statistics content knowledge.

Significance of the Study

In examining specific components of the emporium course format, important knowledge was gained concerning that component's effect on student learning. While one study currently existed that showed the importance of the weekly emporium hours requirement in a college algebra class (Ningjun & Herron, 2012), no information has been found about the effect the requirement of weekly math lab hours has on any other subject. This study aimed to obtain valuable information about the amount of time spent in the math lab and its importance in student success. Also, research has established the importance of face time in a classroom with a professor (Biddix et al., 2007; Braxton & Milem, 2000; Eimers, 2001; Komarraju, Musulkin, & Bhattacharya, 2010; Kuh & Hu, 2001; Micari & Pazos, 2012; Pascarella & Terenzini, 1979; Umbach & Wawrzynski, 2005; Vogt, 2008; Wilson, 2008; Yoon, 2002). However, no research currently existed that studied the importance of classroom time with a professor in an emporium course format. This study examined the effect of weekly classroom time on student learning.

Most emporium format courses use some type of software that has various instructional tools as well as administers assignments and assessments. Many of these programs have the flexibility to allow multiple attempts on assignments and assessments. This study examined the effect that multiple attempts on a quiz have on student success in an emporium class as well as their weekly quiz average. This information may help identify the specific characteristics of an emporium class that are most helpful to students.

Blended learning is growing steadily due to the numerous benefits it affords students, faculty, and administrators (Al-Qahtani & Higgins, 2013; Aspden & Helm, 2014; Biddix, Chung et al., 2015; Frimming et al., 2013; Hill, 2012; Rais-Rohani & Walters, 2014; Vaughan, 2007; Wilder & Berry, 2016). Since emporium format courses have a wide range of possible components, it is important for the educational community to fully understand the importance and impact of each component. This knowledge will enable colleges and universities to design courses that will have the most effective blended format containing the components that influence the greatest success of the students.

Research Questions

This study will investigate the answers to the following research question. It is as follows:

RQ1: Will the number of weekly quiz attempts predict student conceptual learning outcomes in an introductory statistics course?

RQ2: Will the weekly mathematics lab attendance predict student conceptual learning outcomes in an introductory statistics course?

RQ3: Will the weekly quiz average predict student conceptual learning outcomes in an introductory statistics course?

RQ4: Will the amount of weekly face-to-face time with an instructor predict student conceptual learning outcomes in an introductory statistics course?

Definitions

1. *Blended course delivery* – A blended course has some student to student and student to teacher interaction in a face-to-face classroom setting and some interaction in an online environment (Helms, 2014).
2. *Emporium model* – A class designed using the emporium model minimizes lecture time and uses interactive computer software combined with one-on-one on-demand assistance (Twigg, 2011).
3. *Hybrid course delivery* – A hybrid course is a class where instruction takes place in a classroom setting with additional computer-based or online activities which replace some class time (Scida & Saury, 2006).
4. *STEM* – A STEM course is a class that is associated with a concentration in science, technology, engineering, or mathematics (YunJeong & Seung Won, 2014).

CHAPTER TWO: LITERATURE REVIEW

Overview

Educators and college administrators discouraged by low pass rates and dissatisfied students in their developmental and general education math courses, as well as rising costs, began to look for ways to transform the learning experience for students without pushing costs higher (Twigg, 2003). A hybrid course format has been shown to have many benefits in student learning, student satisfaction, and cost reduction. A specific type of hybrid course is the emporium model of course delivery. A review of the literature shows almost no research focused on the specific components of the emporium model that are vital for student success. A greater understanding of which component in the emporium model promotes students learning can help administrators and educators as they modify courses to maximize student success.

Theoretical Framework

The study of education and human intellectual development has long been divided into three main categories of empiricist, rationalist, and historic-cultural theories (Case, 1987). The category that best applies to this topic of study is the rationalist theory. The rationalist theory of intellectual development began with the writings of Kant (McCarty, 2008), who believed that humans gain knowledge by imposing their own structure on it instead of using the structure present in the content they are learning (Case, 1987).

One of the most well known and widely accepted proponents of this realm of thought was Jean Piaget. The classical logical structure theory by Piaget explained that many sequences of intellectual development are universal (Case, 1987). His work established a framework for understanding how children grow and develop the skills needed to solve problems (Knight & Sutton, 2004). Piaget's theory was widely accepted until empirical evidence began to show that some areas needed modification (Knight & Sutton, 2004). Some rejected Piaget's ideas when data seemed to contradict his theory, however, neo-Piagetians chose to modify and expand his theory (Knight & Sutton, 2004).

Neo-Piagetians began to synthesize the theory about structure with the theory about processes (Case, 1987). They wanted to "specify how environments have similar and differing effects as a function of human structures and motivations" (Fischer & Silvern, 1985, p. 625). Neo-Piagetian theory and research is based on Piaget's original work and contains many tools and ideas that could contribute to educator's success when teaching adults (Knight & Sutton, 2004). Unfortunately, these tools and ideas have been mostly unavailable to educators due to scattered publication and studies not focusing on educational practices (Knight & Sutton, 2004).

Neo-piagetians believe that cognitive structures are actively created by learners who construct and build knowledge. These structures become more complex through intellectual growth and knowledge building. Neo-piagetians believe that cognitive structures tend to be domain specific in nature, unlike Piaget's original theory (Knight & Sutton, 2004). Understanding the process of knowledge building can help educators that design and create courses do so in a way that will best provide students the opportunities needed to acquire the course knowledge (Knight & Sutton, 2004). While many studies have shown that blended learning contributes to improved learning (Al-Qahtani & Higgins, 2013; Rais-Rohani & Walters, 2014; Vaughan, 2007; Wilder & Berry, 2016; Yadav et al., 2011), the specific components of blended learning that influence this success have not been the focus of most studies. This study intends to examine several components of the emporium model, a specific type of blended course format, to determine which component(s) contributes to student success.

Related Literature

Traditional Lecture Course Design

Lecture is considered by the academic world to be the most impressive form of scholarly delivery of information (DeRogatis et al., 2014). Lecture as a form of content delivery dates back to the beginning of education. However, in the early 20th century, experts in learning theory and cognitive development, such as John Dewey, began gathering data that a student actively engaged in course content is having a more successful learning experience than a student that is passively receiving information in the form of lecture (DeRogatis et al., 2014). Since those early days, colleges have come to prefer smaller class sizes and encourage their faculty to use active learning strategies (DeRogatis et al., 2014). For large universities, smaller class sizes are too costly to be realistic in their general education courses (DeRogatis et al., 2014).

Of the many approaches to teaching in higher education, using a traditional lecture has been associated with a number of undesirable outcomes (Yadav et al., 2011). A traditional lecture delivery of course content fails to accommodate for individualized skills and learning approaches (Borg & Shapiro, 1996; Lage et al., 2000; Wilder & Berry, 2016). If an instructor's teaching style does not match a student's learning pattern, then the student's achievement can be negatively impacted (Borg & Shapiro, 1996; Dunn et al., 2009; Guskey, 2007; Olic & Adamov, 2016; Shein & Chiou, 2011; Ziegert, 2000).

Courses offered in the traditional lecture format do not provide enough contact time for faculty to incorporate deep learning activities during class (Lochner et al., 2016). Students become passive recipients of information and then often delay study time (Lochner et al., 2016). Lectures can be ineffective and outmoded, do not allow for much interaction between instructor and student, and provide no feedback for instructors (Matheson, 2008). For maximum effectiveness, lectures need to be clear, well structured, expressive, and interactive (Matheson, 2008).

Research findings are diverse when comparing a course taught with traditional lecture versus a hybrid course or an online course. Some studies find that courses offered in the traditional format have less student success (Ashby et al., 2011; Lim et al., 2008; Vaughan, 2007). Other studies find that there is no significant difference in student achievement in a course offered with a traditional lecture format and the same course offered in a blended format (Frimming et al., 2013; Kakish et al.,2012; Tucker King et al., 2018). However, while there may be no significant difference in student's content knowledge in a comparison of a hybrid course and a traditional face-to-face course, several studies found a significant difference in student perception (Akyol, Garrison, & Ozden, 2009; Frimming et al., 2013).

In response to college students that are underprepared for college level math, secondary institutions enroll students in a math course, often called developmental math classes, designed to improve their math abilities and help them succeed in college (Bettinger, Boatman, & Long, 2013). In a study comparing developmental math courses offered in an online, blended, and face-to-face format, the percentage of students who completed the course was highest in the traditional face-to-face class and lowest in the blended course format (Ashby et al., 2011). However, when looking at the final grades of students that did complete the course, 85% of the online students earned a grade of 70% or higher while 69% of the blended format students and 63% of the traditional format students earned a grade of 70% or higher (Ashby et al., 2011).

Hybrid Course Design

Higher education faculty began to feel pressure to move away from traditional lecture delivery of a course to less traditional forms of content delivery as administrators dealt with changes in funding and resorted to operating universities more as a business (McLaren & Kenny, 2015). This resulted in a rapid growth of combining traditional class design with online components (Gosper, McNeill, & Woo, 2010). Anatomy students involved in a study comparing traditional lecture with a class incorporating e-learning activities perceived that they were more active during class, that they developed their ability to self-study, and that they retained the course content longer when the e-learning activities were used (Lochner et al., 2016). A quantitative study of a course offered as traditional lecture and also using online interactive components found that students overwhelmingly favored the course offering online interactive components because of flexibility, control, enjoyment, pacing, and the ability to re-watch information (O'Rourke et al., 2014). Some faculty preferred to re-design their courses to involve more problem-based learning and team-based learning activities in order to increase student engagement (Frame et al., 2015; Zahid, Varghese, Mohammed, & Ayed, 2016). A recent study found that students in these re-designed courses perceived that the new design increased critical thinking, problem-solving, and student-teacher engagement (Frame et al., 2015). The students in the problem-based course outperformed the students in the traditional curriculum course in overall grades and theoretical knowledge (Zahid et al., 2016).

Several factors contributed to the movement of developing a course design that combined the best parts of a traditional lecture class and the best parts of an online course. These factors included the increased pressure on universities to reduce costs (Gleason, 2012; Witkowsky, 2008) and a shift in STEM courses to problem-based learning in order to better meet the needs of students (Yadav et al., 2011). Educators also face larger class enrollments, which inhibit the ability to use active learning strategies (Kenney & Newcombe, 2011) and rising student failure rates (Bonham & Boylan, 2012; Twigg, 2003; Gleason, 2012).

Low rates of college completion are a major problem in the United States (Bettinger et al.,2013). Less than 60% of students at four-year institutions graduate within six years (Bettinger et al.,2013). One-third of high school graduates finish high school ready for college level academics (Bettinger et al., 2013). Colleges and universities have responded by placing approximately 35% - 40%of entering freshman into remedial or developmental courses, along with offering other academic support (Bettinger et al., 2013). The goal is to improve the student's abilities so they are better able to handle the college level material and therefore, experience more success (Bettinger et al., 2013). College administrators began exploring possible ways to deliver these developmental courses (Bettinger et al.,2013; Gleason, 2012; Kenney & Newcombe, 2011; Wilder & Berry, 2016).

To accommodate the large number of students, and also provide reasonable academic support while keeping costs low, university administrators and educators began exploring possible solutions (Gleason, 2012; Kenney & Newcombe, 2011; Wilder & Berry, 2016). One of these solutions was the development of courses with a hybrid format. A hybrid course combines some traditional face-to-face instruction with computer-based activities that can replace some of the time students would traditionally spend in class (Al-Qahtani & Higgins, 2013; Ayala, 2009; Helms, 2014; Kenney & Newcombe, 2011; Nakayama et al., 2016; Scida & Saury, 2006). A course is considered hybrid when it has 30% - 79% of its content delivered online (Allen & Seaman, 2007). Other terms that define a course format which is part traditional and part online are blended, web-enhanced, and mixed mode (Ayala, 2009).

A hybrid course is not just a traditional course design with an added technology portion (Picciano, 2006). A key component of blended course design is that classroom contact hours are reduced, although not eliminated completely (Al-Qahtani & Higgins, 2013; Ayala, 2009; Helms, 2014; Klotz & Wright, 2017). Classroom contact hours are desirable since research indicates that positive student-professor relationships are beneficial to student learning (Eimers, 2001; Heinemann, 2007; Kuh & Hu, 2001; Micari & Pazos, 2012; Umbach & Wawrzynski, 2005). A Course Management System (CMS) is used to deliver content by online video instruction or ebook and the majority of assignments including weekly assessments are delivered and graded by the CMS (Al-Qahtani & Higgins, 2013; Gleason, 2012; Helms, 2014; Twigg, 2003; Twigg, 2011; Witkowsky, 2008). While holding the position of president of Pennsylvania State University, Gordon B. Spanier called hybrid course design "the single-greatest unrecognized trend in higher education" (Young, 2002, p. A33).

According to Twigg (2011), six models for course redesign exist. One model is a supplemental design where resources and student support are added to the existing course design (Twigg, 2011). Another model for course redesign is the replacement model where face-to-face class time is blended with online activities (Twigg, 2011). The emporium model is a redesign model where the courses are moved to a lab setting (Twigg, 2011). The buffet model is a mix and match type of course design which gives students a choice of content delivery based on student preference (Twigg, 2011).

Several principles are considered important when redesigning a course (Twigg, 2011). The new design should encourage active learning and provide students with individualized assistance (Twigg, 2003; Twigg, 2011; Twigg, 2013). The new course design should also build in ongoing frequent assessment and automated feedback as well as ensure sufficient time is spent on task and student progress is monitored (Twigg, 2011). Twigg (2011) also suggests that the most successful course redesigns occur when the whole course is redesigned, and just adding extra support or new components onto an already existing course are not as impactful to student success (Twigg, 2011). However, the effectiveness of a course redesign is affected by many factors such as subject matter of the course, the student profile, the structure of the overall program, and the quality of the online component that is prepared (Shea et al., 2015; Sorgenfrei & Smolnik, 2016).

Benefits of Hybrid Course Design

Student and Faculty Benefits. A large number of benefits from a hybrid course design have been documented. These benefits not only affect the student population enrolled in hybrid courses, but also the faculty involved in teaching the courses. One of the biggest benefits of a hybrid course design is improved learning outcomes (Al-Qahtani & Higgins, 2013; Gleason, 2012; Helms, 2014; Kenney & Newcombe, 2011; Lim et al., 2008; Twigg, 2003; Vaughan, 2007; Wilder & Berry, 2016; Witkowsky, 2008; Yadav et al., 2011). Improved learning outcomes refer to improved pass rates, greater retention of content, and higher scores on assessments. Some studies noted an immediate jump in course pass rates when a traditional math course was redesigned as a hybrid course (Witkowski, 2008).

Another benefit of hybrid course design is the greater flexibility that students experience (Ayala, 2009; Hadjianastasis & Nightingale, 2016; O'Rourke et al., 2014; Vaughan, 2007; Wilder & Berry, 2016; Witkowsky, 2008). Students that understand the material and do not need as much practice can progress faster. Students that do not understand a certain concept can work homework exercises multiple times until they feel comfortable that they understand the content (Witkowsky, 2008). This flexibility also means that students are responsible for their own learning which contributes to improved persistence and positive self-efficacy beliefs (Slanger, Berg, Fisk, & Hanson, 2015). Students also appreciate the convenient and easy access to course materials (Biddix et al., 2015; Ayala, 2009).

With the availability of lecture capture software, one way educators can improve flexibility and create more class time for active learning is to record podcasts of core content that can be available to students on demand (Hadjianastasis & Nightingale, 2016). In a blended course format, the podcasts can provide extra support for students in need of more understanding (Hadjianastasis & Nightingale, 2016). The podcasts can also be a vehicle for delivery of core content, which is especially helpful in STEM courses, and helps free class time for more interactive learning (Hadjianastasis & Nightingale, 2016). Students using the podcasts can take notes at their own pace and identify and solve problems using other resources (Hadjianastasis & Nightingale, 2016).

Blended courses improve student communication with faculty and peers as well as developing communication skills that will contribute to success on the job after degree completion (Aspden & Helm, 2004; Biddix et al., 2015; Helms, 2014; King, 2012; Vaughan, 2007; Young, 2002). The development of communication skills also better prepares students for classroom discussions (Aspden & Helm, 2004). Studies have found that upon entering the workforce, students with a degree in a field that requires STEM college classes need more communication and problem solving skills than students graduating with a non-STEM degree (King, 2012).

Many studies have documented higher levels of student satisfaction in courses offered in the hybrid format (Ayala, 2009; Frimming et al., 2013; Gleason, 2012; Lim et al., 2008; Sorden & Munene, 2013; Twigg, 2003; Vaughan, 2007). High levels of student satisfaction are linked to academic success (Cliffton & McKillup, 2016). Students are in control of their own learning and enjoy more flexibility than in a traditional course (Ayala, 2009; Slanger et al., 2015; Spradlin

& Ackerman, 2010; Vaughan, 2007). The flexibility of a blended course is appealing to busy commuter students (Young, 2002).

Hybrid courses promote active learning and student engagement (Aspden & Helm, 2004; Ayala, 2009; Kenney & Newcombe, 2011; Spradlin & Ackerman, 2010; Twigg, 2011; Wilder & Berry, 2016; Vaughan, 2007). Current learning theories focus on the importance of students being active participants in the learning process instead of passive observers (Kintu & Chang, 2016; Olgun, 2009). Active learning is any instructional technique other than lecture that engages students in the process of learning (Prince, 2004). Active learning activities include class discussion, questions posed by faculty in class, cooperative learning, debates, and role playing (Braxton & Milem, 2000). According to Braxton and Milem (2000), active learning results in students having more time available for participation in social communities on campus as well as helping students develop new friendships and networks of peer support.

Since the concept of *pedagogies of engagement* was introduced by Russ Edgerton in 2001, educational institutions began introducing active learning into classrooms by the use of collaborative learning, cooperative learning, and problem-based learning (Jung, Ediger, & Donghun, 2017). In recent years, the push for active learning has been a less obvious movement toward redesigning courses to be hybrid in format (Rais-Rohani & Walters, 2014; Twigg, 2011; Wilder & Berry, 2016; Young, 2002). Studies have shown that active learning improves students' attitudes, raises student learning outcomes, and increases student engagement (Braxton & Milem, 2000; Ebert-May & Brewer, 1997; Jung et al., 2017; Kintu & Change, 2016; Marbach-Ad, Seal, & Sokolove, 2001; Prince, 2004). Student interactions with peers as well as with faculty, were found to be predictors of student persistence and quality learning (Braxton & Milem, 2000; Hurtado & Carter, 1997).

A student's sense of connection with the professor is an important part of a hybrid design (Biddix et al., 2015). Many faculty do not realize the important role they play in a student's satisfaction and achievement in college (Micari & Pazos, 2012; Vogt, 2008). According to Micari and Pazos (2012), there are three aspects to faculty-student relationships that correlate to positive student outcomes. These aspects include the student feeling comfortable approaching the professor, the student admiring the professor, and that the professor shows respect to students (Micari & Pazos, 2012). Several studies found that a professor demonstrating respect when interacting with students was an important component of a successful professor-student relationship (Micari & Pazos, 2012; Sanchez, Martinez-Pecino, Rodriguez, & Melero, 2011). Research by Hurtado and Carter (1997) reports that students who tutored other students and talked with faculty frequently tended to report a relatively higher sense of belonging compared to those who engaged in those activities less often.

Many studies have shown that a positive student-professor relationship has a significant impact on the student's final grade in the course (Eimers, 2001; Heinemann, 2007; Kuh & Hu, 2001; Micari & Pazos, 2012; Umbach & Wawrzynski, 2005). The teacher-student relationship is considered one of the key indicators of academic performance (Yoon, 2002). It follows that research has also revealed that a positive student-professor relationship also has a significant impact on student motivation, engagement, and persistence (Braxton & Milem, 2000; Eimers, 2001; Kuh & Hu, 2001; Pascarella & Terenzini, 1979; Umbach & Wawrzynski, 2005; Vogt, 2008; Wilson, 2008)

Research also indicates that a positive student-professor relationship also results in students having a higher confidence in one's ability to do well in the course (Eimers, 2001; Komarraju et al., 2010; Micari & Pazos, 2012; Vogt, 2008). Research into the relationships formed by students and faculty also shows that a positive student-faculty relationship results in higher student satisfaction (Kuh & Hu, 2001; Rosenthal et al., 2000). Faculty also have a greater job satisfaction when they have positive student relationships (Wilson, 2008).

Hybrid courses are structured so that diverse learning styles and content skills are recognized (Ayala, 2009; Twigg, 2011; Wilder & Berry, 2016). Blended courses also promote a sense of community, which leads to higher student satisfaction, retention, and increased academic success (Akyol et al., 2009; Ayala, 2009; Chen & Chiou, 2014; Helms, 2014; Rovai & Jordan, 2004). One study noted that students initially had problems with time management and lack of responsibility for their own learning (Vaughan, 2007). Another study that compared online delivery, blended format, and traditional course design in college developmental math reported that the blended courses had the lowest mean scores on assessments (Ashby et al., 2011). However, the number of studies showing improved student learning outcomes is far greater than the one mentioned previously (Al-Qahtani & Higgins, 2013; Gleason, 2012; Helms, 2014; Kenney & Newcombe, 2011; Lim et al., 2008; Twigg, 2003; Vaughan, 2007; Wilder & Berry, 2016; Witkowsky, 2008; Yadav et al., 2011). The benefits for students in hybrid courses include improved learning outcomes, greater flexibility, improved persistence and communication skills, higher satisfaction and academic success as well as many more far outweigh the few negative results that have been reported in research.

Benefits for administrators. Not only is a hybrid course design beneficial for students, it also benefits administrators as well (Ayala, 2009; Frimming et al., 2013; Gleason, 2012; Helms, 2014; Lim et al., 2008; Picciano, 2006; Rais-Rohani & Walters, 2014; Sorden & Munene, 2013; Twigg, 2003; Vaughan, 2007; Witkowski, 2008). One of the obvious benefits for university administrators of a hybrid course design is the reduced cost (Rais-Rohani &

Walters, 2014; Twigg, 2003; Vaughan, 2007; Young, 2002). One way a hybrid course design reduces costs involves classroom space (Twigg, 2003; Young, 2002). A transition to hybrid course design alleviates a shortage of classrooms that has been problematic for colleges and universities (Twigg, 2003; Young, 2002). If a course traditionally meets twice a week, but once redesigned into a hybrid format will only meet once a week, then it is possible for two courses to use the same classroom space that was traditionally used by one course (Young, 2002).

A second way to reduce costs involves the number of students enrolled in the course (Gleason, 2012; Twigg, 2003). In a situation where student enrollment in a certain course is stable, administrators can use technology such as a course management system (CMS) for aspects of the course where it would be more effective and have faculty only perform tasks that require a high level of expertise (Twigg, 2003). If student enrollment is growing in a certain course, administrators can increase the number of students enrolled without increasing costs (Gleason, 2012; Twigg, 2003). Also, the number of course repetitions attributed to student failure or withdrawal will be reduced (Twigg, 2003).

A CMS can automatically generate a tailored message that gives important information to students in a timely manner (Gleason, 2012; Spradlin & Ackerman, 2010; Twigg, 2003). A CMS can also suggest additional activities based on student performance and encourage greater participation in online discussions (Gleason, 2012; Spradlin & Ackerman, 2010; Twigg, 2003). It can also free faculty from the time-consuming task of grading homework, quizzes, and tests by automatically assessing these assignments (Twigg, 2003). A CMS can also provide a variety of resources such as online tutorials, guides, and examples for students (Twigg, 2003). It also facilitates shared resources among faculty as one faculty member can create or revise the course and assessments, prepare a syllabus to be posted in the software, and create separate class sections for each professor teaching that course (Twigg, 2003).

Large enrollment introductory courses became the focus of a movement from traditional to hybrid course redesign because of the ability to affect a significant number of student's learning outcomes and the possibility of generating a substantial cost savings (Twigg, 2003). In those initial course redesigns of approximately thirty courses, an average cost reduction of 40% was reported, as well as significant student success and higher retention rates (Twigg, 2003). Virginia Polytechnic Institute had a savings of 77% on the cost of a hybrid course design versus the traditional format (Twigg, 2011). The University of Alabama saw an initial savings of 28% when they converted teaching a developmental math course from the traditional method to a hybrid course format (Witkowski, 2008). They established a large math lab to provide on-demand tutoring six days a week for those students. As more math classes were redesigned to be hybrid courses, the savings increased since the math lab was already established (Witkowski, 2008).

Another benefit of hybrid courses for administrators is higher retention rates (Braxton & Milem, 2000; Gleason, 2012; Helms, 2014; Twigg, 2003; Vaughan, 2007) and student satisfaction (Ayala, 2009; Frimming et al., 2013; Gleason, 2012; Lim et al., 2008; Sorden & Munene, 2013; Twigg, 2003; Vaughan, 2007). Higher student satisfaction and higher student pass rates will lead to higher retention rates (Awang & Ismail, 2010). Active learning, an integral part of hybrid course design, has a positive influence on student's institutional commitment and persistence (Braxton & Milem, 2000). A third benefit of a hybrid course design for administrators is the expanded access to educational opportunities, which will improve a university's reputation and enrollment (Ayala, 2009; Picciano, 2006; Vaughan, 2007).

The features of hybrid courses that benefit university administrators are ultimately a benefit to students as lower costs and more efficient use of resources can keep tuition down.

The Emporium Model

An emporium course is a specific type of hybrid course that has gained in popularity since the late-90s, particularly in general education math courses (Twigg, 2011). Supported by a large grant from Pew Charitable Trusts, the Program in Course Redesign was created in 1999 to address some of these challenges facing colleges with rising costs and low student success (Twigg, 2003). The goal was to support colleges and universities in their efforts of course redesign using technology to enhance learning as well as lower costs (Twigg, 2003). This began a series of course redesigns at various universities of their large enrollment introductory classes (Twigg, 2003).

Thirty institutions of higher learning were selected from hundreds of applicants in a national competition (Twigg, 2003). Each of these thirty institutions received $200,000 (Twigg, 2003). All of the course redesign projects focused on large enrollment introductory courses, because undergraduate enrollment in the United States is heavily concentrated in just a few content areas such as English and mathematics (Twigg, 2003). These courses must be successfully completed in order to progress toward a degree, and yet, student success rates tended to be low (Twigg, 2003).

In the midst of this transition, data was collected on student outcomes as well as cost management in order to analyze the effects of the redesign (Twigg, 2003). While this type of hybrid course was developed in the beginning for large introductory math courses, it has been modified to be used for other subject areas as well (Twigg, 2011; Witkowsky, 2008). All thirty institutions reduced cost by an average of 40% and increased completion rates, improved retention, improved student attitudes toward the subject matter, and increased student satisfaction (Twigg, 2003). The Program in Course Redesign has been reorganized into the National Center for Academic Transformation (NCAT) which is an independent, not-for-profit organization dedicated to the use of technology to improve student learning and reduce costs in higher education (Twigg, 2011). As of 2011, NCAT has facilitated 120 large-scale redesigns in institutions of higher learning (Twigg, 2011).

In 2009, NCAT organized a developmental math course redesign study from a traditional course format to an emporium course format across multiple institutions of higher learning (Twigg, 2013). The redesigned courses were offered to students in the fall of 2011 (Twigg, 2013). NCAT originally accepted 38 institutions in the study, although only 32 colleges and universities fully completed the program (Twigg, 2013). If the institutions followed their advice, NCAT guaranteed that the course redesign would improve student learning, increase completion rates, prepare students to succeed in college level math, and reduce instructional costs (Twigg, 2013). Failure of institutions to require lab participation, award participation points to encourage student engagement, establish deadlines and clear expectations, and closely monitor student progress affected the institutions desired results (Twigg, 2013).

Twigg (2013) reported that 83% of the 32 institutions that completed the study showed significant student learning improvements from the traditional course format. All but one of the participating institutions reported a reduction of cost, with the average cost reduction being 20% (Twigg, 2013). Only 23% had higher completion rates than the traditional format (Twigg, 2013). When investigating the reasons for completion rates, NCAT found that several factors such as grade inflation in traditional courses, mastery learning, and several institutions awarding a making progress type of grade influenced this data (Twigg, 2013).

One of the benefits of redesigning courses to be an emporium delivery course is its flexibility. A college or university can adapt it to fit within their resources and constraints (Twigg, 2011; Vaughan, 2007). Lecture time may be reduced or eliminated and replaced with small group activities, individual activities, or assigned work that should be completed in a computer lab staffed by peer tutors, faculty, or staff tutors (Twigg, 2003). During one phase of the emporium model implementation, Virginia Polytechnic Institute eliminated all class meetings, while colleges in Alabama and Idaho established once a week class meetings (Twigg, 2011). Some colleges set up their courses to allow an unlimited amount of attempts on a single quiz while others allow only several attempts per quiz (Twigg, 2003). The centralized computer lab may be very large and arranged with individual workstations or it may be smaller with workstations grouped in small clusters (Twigg, 2011). The flexibility of the emporium model allows for a great deal of variety in its design and implementation (Twigg, 2011). However, several components are considered necessary for the success of the math emporium model (Twigg, 2011).

Course Management System. A Course Management System (CMS) is considered an integral part of the emporium model (Twigg, 2003; Twigg, 2011). A CMS supplies online lecture videos and tutorials as well as learning activities that students can access (Rais-Rohani & Walters, 2014; Twigg, 2003; Vaughan, 2007; Witkowsky, 2008). A CMS allows faculty to create, manage, and administrate courses by organizing and assembling learning materials, forums, and assessments (Al-Qahtani & Higgins, 2013; Gleason, 2012; Graf et al., 2010; Helms, 2014; Twigg, 2003; Twigg, 2011; Witkowsky, 2008). The CMS also allows faculty to handle course enrollment, grading, and monitoring student progress (Al-Qahtani & Higgins, 2013; Gleason, 2012; Helms, 2014; Graf et al., 2010; Twigg, 2003; Twigg, 2011; Witkowsky, 2008).

Other names that can be used for a CMS are learning management systems (LMS), e-learning platforms, and virtual learning environment (VLE) (Costen, 2009; Graf et al., 2010).

A CMS is structured to enable an instructor to create a course that is more student-centered (Costen, 2009; Felder & Brent, 1996; Lowry & Flohr, 2004; Shiu-Li & Jung-Hung, 2012). A student-centered course actively involves students in the learning process instead of passive learning that often occurs with a traditional lecture course (Costen, 2009; Felder & Brent, 1996; Lowry & Flohr, 2004; Olgun, 2009). A student-centered course holds students responsible for their learning (Costen, 2009; Felder & Brent, 1996; Slanger et al., 2015). A student-centered course is often self-paced, although that is not a requirement (Felder & Brent, 1996; Shiu-Li & Jung-Hung, 2012).

A course that is student-centered also enhances a student's motivation to learn and a student's appreciation of the subject (Felder & Brent, 1996). It also increases the depth of knowledge learned and the length of retention of the knowledge (Costen, 2009; Felder & Brent, 1996; Lochner et al., 2016). Student-centered learning also increases student satisfaction, which can have a positive ripple effect on the student experience (Cliffton & McKillup, 2016; Shiu-Li & Jung-Hung, 2012).

A CMS also encourages collaborative and cooperative learning (Costen, 2009; Felder & Brent, 1996; Lowry & Flohr, 2004). It provides a convenient way for students to communicate with each other and the professor, which builds community and social connectedness (Costen, 2009; Lowry & Flohr, 2004; Shiu-Li & Jung-Hung, 2012). Collaborative learning results in a higher level of accomplishment by all students involved in the collaborative process (Bonham & Boylan, 2012).

Students enjoyed being able to access course assignments and information from any computer when using a CMS (Costen, 2009). Students also agree that being able to access information from multiple sources is a positive aspect of using a CMS (Costen, 2009). If a student misses something in class, then one is able to get that information from another place (Costen, 2009; Ozyurt, Ozyurt, Baki, & Guven, 2013). Many core concepts are discovered by students through participating in activities designed as learning activities in the CMS, and students enjoyed the process of learning when they were discovering the ideas (Ozyurt et al., 2013). Students considered the ability to access grades at any time a positive aspect of a CMS (Costen, 2009). The negative aspects of using a CMS are caused by the difficulty of a bad internet connection or if the CMS software crashes (Costen, 2009). Another difficulty is that higher education faculty often do not complete CMS training programs, and therefore are not able to use the CMS to its full potential (Pereira & Wahi, 2017).

A CMS that is used in a math course provides the structure that student's need that requires them to actually do math in order to progress in the course (Twigg, 2011; Witkowsky, 2008). The CSM gives instant and continuous feedback to students as they work on homework assignments and quizzes (Gleason, 2012; Spradlin & Ackerman, 2010; Twigg, 2003; Twigg, 2011). In a math course using a CMS, students can do homework problems repeatedly until they are satisfied that they understand the concept (Witkowsky, 2008). In general education math courses, students spend more time doing math rather than listening to instructions on how to do math (Twigg, 2011).

Reduction of class time. A reduction of class time for courses is normally a component of the emporium model (Twigg, 2011). Some colleges eliminate class altogether, however, most university professors and administrators believe that weekly class meetings with the professor are beneficial (Gleason, 2012; Twigg, 2011; Vaughan, 2007). Positive faculty-student relationships have a direct correlation with increased learning, higher student confidence, increased student motivation, engagement, and persistence (Braxton & Milem, 2000; Eimers, 2001; Heinemann, 2007; Komarraju et al., 2010; Kuh & Hu, 2001; Micari & Pazos, 2012; Pascarella & Terenzini, 1979; Rosenthal et al., 2000; Umbach & Wawrzynski, 2005; Vogt, 2008; Yoon, 2002; Wilson, 2008). Class time is used to help student with areas of difficulty, as well as better establish the student and teacher relationship (Vaughan, 2007). Since the CMS grades assessments, faculty are free from cumbersome grading and have time to track student's progress and intervene when students have difficulty (Twigg, 2003; Vaughan, 2007; Witkowsky, 2008). The CMS also provides continuous assessment with immediate feedback on weekly quizzes as well as step-by-step instructions on problems when requested by the student (Twigg, 2013).

Adaptive learning. The CMSs used by most emporium courses contain adaptive features (Giotopoulos, Alexakos, Beligiannis, & Stefani, 2010). Adaptive learning uses student to computer interaction where content is presented according to prior knowledge and activity (Giotopoulos et al., 2010; Johnson & Samora, 2016). Most involved in the education process believe that a student's educational needs are better met when the process is more personalized (Bloom, 1984; Giotopoulos et al., 2010; Johnson & Samora, 2016; Lou & Abrami, 1996). Teachers do not have time to develop personalized programs for every student they teach. Adaptive learning as a component of a CMS is a possible alternative (van Klaveren, Vonk, & Cornelisz, 2017). The goal of adaptive learning is to simulate the advantages from one-on-one tutoring while not being as expensive as one-on-one tutoring (Giotopoulos et al., 2010).

Adaptive learning was developed from work with intelligent tutoring systems, educational data mining, and learning analytics (Al-Omari, Carter, & Chiclana, 2016; Johnson &

Samora, 2016). Adaptive learning can be performed in a CMS several ways that often overlap. It can personalize the learning process or the content being learned, or the CMS can adapt according to each learner's needs and preferences (Baneres, Baro, Guerrero-Roldan, & Rodriguez, 2016). Adaptive learning can be rule-based which uses a pre-determined fixed branching system. If a student answers a question correctly, he moves on. If he misses a question, he is given a hint, a chance to re-work the question, or directed to different content (Johnson & Samora, 2016). Adaptive learning can also be algorithm-based which uses mathematical functions to analyze student performance and determine what is next. These adaptive learning systems use Bayesian data analysis, knowledge tracing, Markov chain analysis, or item response theory (Johnson & Samora, 2016).

Students using a CMS with adaptive learning components reported an overall positive experience (Liu, McKelroy, Corliss, & Carrigan, 2017; Ozyurt et al., 2013). Students liked that the adaptive learning guided them to an easier question when they didn't understand a concept (Ozyurt et al., 2013). Students enjoyed the discovery of content using activities and liked that they learned according to their learning style (Ozyurt et al., 2013). Students also found that they did not have to depend on their teacher for learning (Costen, 2009; Ozyurt et al., 2013).

Research comparing adaptive learning systems versus non-adaptive learning systems found that students using the adaptive learning system outperformed those using the non-adaptive systems in terms of learning (Ching-H, 2014; Siddique, Durrani, & Naqvi, 2017). Students also spent less time learning course content when using the adaptive learning system versus the students using the non-adaptive learning systems (Kamceva & Goracinova-Ilieva, 2016). Adaptive learning CMSs were more effective in courses that had more practice involved in learning the concepts, such as a math class (van Klaveren et al., 2017). Overall, adaptive learning systems are a good educational environment and can be used to reinforce traditional classroom education (Ozyurt et al., 2013). Math emporiums often use adaptive features of a CMS to help students review concepts they had difficulty with before completing a second assessment over a module of learning.

Modular units of study. When the course is designed for the emporium model, most are set up as a series of modules, units, or segments (Gleason, 2012; Twigg, 2011). Modular design of curriculum is "a unit of instruction which involves self-directed learning of pre-defined skills involving a mix of multiple learning activities" (Chavda, Pandya, Solanki, & Dindod, 2016, p. 212). Students must complete one module before moving on to the next module. Many courses use a mastery learning technique that requires students to score a minimum grade in order to progress, although this is not a required component (Twigg, 2011). Usually students can move through the course at their own pace, faster when they are familiar with content and slower when working through concepts that are difficult for them (Twigg, 2003; Witkowsky, 2008). Of course, this design is flexible and colleges often adjust these guidelines to best fit their situation (Twigg, 2011; Vaughan, 2007).

Modular units of study have a number of advantages (Rogers, 2004). The appeal for educators is that modular units involve less preparation time, contain more universal skills, content is always current, flexibility when changing curriculum, and clear and concise testing (Rogers, 2004). The appeal to students is the independent learning component, they are engaged in real world problems, and the software has the ability to meet the individualized needs of students (Rogers, 2004). The appeal for administrators is the minimal cost (Rogers, 2004).

Central computer lab. A central computer lab is also part of the emporium model (Twigg, 2011). The computer lab, often called the "emporium", is a place where students can work on weekly assignments and get tutoring help as needed. The emporium is staffed by student tutors, graduate assistants, and a certain number of math faculty (Twigg, 2011). The size of the math emporium varies depending on the university's resources and space (Twigg, 2011). Since most emporium models reduce class time, a minimum amount of time spent weekly in the emporium is required. This reduces space requirements for classrooms (Twigg, 2003; Twigg 2011; Vaughan, 2007). Since the emporium can be used for multiple class sections of the same class and multiple courses, this shared resource reduces costs the cost of administration (Twigg, 2003; Vaughan, 2007). Most emporiums are open for six to seven days a week, which gives students much more one-on-one personalized assistance than the traditional course design (Gleason, 2012; Hodges & Brill, 2007; Twigg, 2011; Witkowsky, 2008). The use of tutors also decreases the anxiety that students feel when asking questions (Hodges & Brill, 2007). A tutor will guide a student to available resources so they can find a solution on their own or will spend time explaining a concept to a student to increase understanding (Hodges & Brill, 2007).

Another component of the emporium model is the ability to use staff substitutions in the math emporium for tutoring (Twigg, 2003; Vaughan, 2007). Highly trained faculty are not necessary for continuous emporium tutoring. Graduate assistants, student tutors, and staff tutors can be trained to perform many of the duties needed in the computer lab for a much lower cost (Vaughan, 2007).

Emporiums are usually open for students for long hours and most days of the week. Some emporiums are open for 24 hours a day (Twigg, 2003). Providing a continuous support for students helps students feel a part of a learning community (Twigg, 2003). The one-on-one tutoring in the lab and collaboration that is encouraged are beneficial for students (Costen, 2009; Felder & Brent, 1996; Lowry & Flohr, 2004; Twigg, 2003). Students tutored one-on-one using mastery learning techniques scored two standard deviations higher on standardized achievement tests than students who received traditional instruction (Bloom, 1984). In a normal distribution, a score that is two standard deviations above the mean is equivalent to being in the 98th percentile (Larson & Farber, 2015).

Peer Tutoring. Peer tutoring is a central idea in the math emporium model. Peer tutoring is "the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions" (Topping, 2005, p. 631). Many times the peer tutor involved has completed some type of training (Topping, 2005). It is also recommended that the age gap between tutors and the students they are helping not be too large because their interaction is based on friendship, which is a closer relationship than that between a student and teacher (Robinson, Scholfield, & Steers-Wentzell, 2005). In the math emporium model of the university in this study, peer tutors are undergraduate students that have completed the classes themselves and have been trained in how to help other students currently taking the course.

Numerous studies have been conducted on the social effects of peer tutoring as well as the academic impact. Peer tutoring has had a positive impact on student achievement in numerous studies and a variety of subject areas (Alzahrani & Leko, 2018; Bloom, 1984; Madrid, Canas, & Ortega-Medina, 2007; Greenwood & Delquadri, 1995; Kamps et al., 2008; Nawaz & Rehman, 2017; Scruggs, Mastropieri, & Marshak, 2012). In recent studies, peer tutoring has been shown to decrease learning anxiety and promote gains in self-esteem, self-worth, and self-competence (Baiduri, 2017; Miller, Topping, & Thurston, 2010). Peer tutoring has also developed student responsibility, communication skills, and teamwork (Baiduri, 2017; Madrid et al., 2007; Scruggs et al., 2012).

Collaborative learning. Collaborative learning is an educational practice in which a group of students are engaged in completing a common task or solving a problem, and the group members work together using the diverse skills and knowledge of the members of the group to complete the task or solve the problem (Cen, Ruta, Powell, Hirsch, & Ng, 2016; Ding & Harskamp, 2011). In a math emporium, a large computer math lab where students work on weekly homework and quiz assignments, collaboration is encouraged (Twigg, 2013). Many research studies have shown that collaborative learning results in higher achievement (Bonham & Boylan, 2012; Cen et al., 2016; Ding & Harskamp, 2011; Fakomogbon & Bolaji, 2017; Gallardo-Virgen & DeVillar, 2011; Hung, Young, & Lin, 2015; Ralston, Tretter, & Kendall-Brown, 2017; Saleh, Lazonder, & Jong, 2007; Wells & Arauz, 2006). Students and faculty that have engaged in collaborative learning have overwhelmingly reported it as a positive experience and felt it was beneficial (Hung et al., 2015; Robinson, Kilgore, & Warren, 2017; Saleh et al., 2007; Whatley & Bell, 2003). Collaborative learning also increases self-efficacy for learning course material (Saleh et al., 2007; Stump, Hilperty, Husman, Wen-Ting, & Wonsik, 2011).

Several drawbacks of collaborative learning have been noted, such as student group problems and an unbalance in labor (Ding & Harskamp, 2011; Saleh et al., 2006). If students are not given adequate oversight and guidance, they don't always produce an in-depth analysis or construct knowledge as desired (King, 1990). In online courses, teachers and students felt that collaborative learning was beneficial, but it took more time and the logistics was more difficult considering students were often dealing with different time zones (Robinson et al., 2017). Despite these difficulties, collaborative learning is broadly accepted as a positive learning experience (Ralston et al., 2017).

Sense of Community. The math emporium model emphasizes the importance of students' sense of community (Twigg, 2003). A sense of community is defined as a feeling of belongingness within a group (Osterman, 2000). Studies have shown that a students' sense of community in a course affects many dimensions of their learning experience (Osterman, 2000). A high sense of community increases students' overall satisfaction with their learning experience (Drouin, 2008; Liu, Magjuka, Bonk, & Lee, 2007; Hung & Yuen, 2010; Rovai, 2002). A sense of community also increases students' perceived cognitive learning (Liu et al., 2007; Rovai, 2002; Shea, Sau Li, & Pickett, 2006; Trespalacious & Perkins, 2016). A high sense of community reduces attrition rates (Luo, Zhang, & Qi, 2017; Rovai, 2002) and increases student motivation to master the content (Summers & Svinicki, 2007). Many professors and instructors in higher education do not realize the importance of the learning impact from a strong sense of community in a course (Liu et al., 2007). Research supports that the best way to increase students' sense of community is through social interaction using technology (Byrd, 2016; Chang, 2012; Matta Abdelmalak, 2015; Trespalacious & Perkins, 2016).

Mastery Learning. Mastery learning is an educational method promoted by educational theorists such as Bloom (1978) and Block (1971). It is a popular method with the emporium model of course delivery (Twigg, 2013). Master learning is an instructional method that structures a course in small units of learning and students must demonstrate mastery of that unit before moving on to the next concept (Boggs, Shore, & Shore, 2004; Diegelman-Parente, 2011; Lalley & Gentile, 2009; Mong Shan, Yeoh, Yee Ling, & Boulter, 2018). While mastery learning gained popularity many years ago, it was difficult to implement until current day technology and CMS were developed (Diegelman-Parente, 2011).

Several components of the math emporium model are the basis of the mastery learning instructional method. The course content should be organized into modules or small units of learning (Diegelman-Parente, 2011; Lalley & Gentile, 2009; Mong et al., 2018). Group instruction is used as students work on a unit of learning. That group instruction should be a collaborative effort between the instructor and the student (Diegelman-Parente, 2011). This instruction may include lecture, inquiry-based learning, team projects, or the use of technology (Diegelman-Parente, 2011; Lalley & Gentile, 2009; Twigg, 2013).

Students have a chance to demonstrate mastery of the content by completing a formative assessment. Formative assessments should be criterion-based which emphasizes reaching a pre-defined goal rather than norm-referenced assessments, which are comparative in nature (Diegelman-Parente, 2011; Lalley & Gentile, 2009). Mastery is usually defined as passing with a grade of 70% or 75% and higher (Boggs et al., 2004; Lalley & Gentile, 2009; Mong et al., 2018). A student that demonstrates mastery moves on to the next unit of learning, while a student that did not demonstrate mastery receives timely feedback on what was correct and incorrect and how to improve (Lalley & Gentile, 2009). Students may work on remedial exercises and also receive peer tutoring (Diegelman-Parente, 2011; Lalley & Gentile, 2009; Mong et al., 2018; Twigg, 2013). Mastery learning emphasizes that the time needed to learn concepts may differ per student and education should be structured in such a way as to allow the student the time needed to master a unit of learning (Bloom, 1978 Diegelman-Parente, 2011).

After remediation and feedback, students have another opportunity to demonstrate mastery by taking another formative assessment that is parallel in content and structure to the first formative assessment (Boggs et al., 2004; Diegelman-Parente, 2011; Lalley & Gentile, 2009). These multiple assessments should be created prior to the start of the course in order to eliminate any type of bias that may occur when creating the multiple assessments on an as needed basis (Lalley & Gentile, 2009). The amount of work and time involved in creating multiple parallel assessments and the grading of multiple assessments was an obstacle that kept mastery learning from becoming a standard in education (Boggs et al., 2004). However, the development of CMS has greatly reduced the time and work involved in creating and grading multiple assessments over the same material (Diegelman-Parente, 2011).

Several factors have limited the implementation of mastery learning in many classrooms. The time and work required by instructors to create and grade multiple assessments over the same unit of learning can be daunting (Boggs et al., 2004). However, the use of CMS has reduced the concern of instructors (Diegelman-Parente, 2011). A second difficulty is scheduling a time for students to take multiple versions of the test, if needed, to reach mastery level (Boggs et al., 2004). A third obstacle is the difficulty of teaching students who are working on different learning objectives (Boggs et al, 2004). These difficulties are easily overcome when using the emporium model of hybrid course delivery (Twigg, 2013).

Mastery learning has contributed to an increase in student retention of concepts and a better transfer of knowledge (Mong et al., 2018). According to Bloom (1978), mastery learning also contributes to increased learning effectiveness in cognitive achievement, retention and higher mental processes. Mastery learning increases a student's confidence in their learning capabilities, contributes to improvements in student's mental health, enhances intrinsic motivation, and encourages a greater responsibility for learning in the student (Bloom, 1978; Changeiywo, Wambugu, & Wachanga, 2011; Guskey & Gates, 1986). Lalley and Gentile (2009) emphasize the importance of encouraging students to reach beyond initial mastery and work toward a deeper understanding and application of the acquired knowledge.

Components that contribute to student success. While proponents of the emporium model list a number of components felt to be necessary to the successful implementation of this specific hybrid design, there is not a lot of research on the components of the emporium model that are most influential in student success. One study examined the correlation of time spent weekly in the math lab and final exam scores in college algebra and found a significant linear relationship (Ningjun & Herron, 2012). This study seems to suggest that a minimum of required weekly time in the emporium contributes to student success. Further study on the particular components of the emporium model and their contribution to student success is needed.

Summary

Colleges and universities face challenges of high enrollments in general education math courses, low pass rates and retention rates, high costs, and low student satisfaction (Gleason, 2012; Wilder & Berry, 2016; Witkowsky, 2008). Changing the format of introductory courses from traditional to hybrid has been shown to overcome a number of these challenges (Gleason, 2012; Twigg, 2003; Twigg, 2011; Witkowsky, 2008). Learning outcomes improve as well as a higher retention of content (Al-Qahtani & Higgins, 2013; Gleason, 2012; Helms, 2014; Lim et al., 2008; Twigg, 2003; Vaughan, 2007; Wilder & Berry, 2016; Witkowsky, 2008; Yadav et al., 2011). Students enjoy the flexibility and easy access to course materials (Ayala, 2009; Hadjianastasis & Nightingale, 2016; Vaughan, 2007; Wilder & Berry, 2016; Witkowsky, 2008). Students are actively engaged in learning and are responsible for their own learning experience (Aspden & Helm; 2004; Ayala, 2009; Twigg, 2011; Vaughan, 2007; Wilder & Berry, 2016). Diverse learning styles and content skills can be addressed in a way that is beneficial for the student (Ayala, 2009; Twigg, 2011; Wilder & Berry, 2016). Hybrid course delivery promotes community and develops communication skills (Akyol et al., 2009; Aspden & Helms; 2004;

Ayala, 2009; Biddix et al., 2015; Helms, 2014; King, 2012; Vaughan, 2007; Young, 2002). Administrators see costs fall and retention rates rise (Rais-Rohani & Walters, 2014; Twigg, 2003; Twigg, 2011; Witkowsky, 2008; Young, 2002). The expanded access to educational opportunities is beneficial for a college's reputation (Ayala, 2009; Picciano, 2006; Vaughan, 2007).

Several drawbacks do exist for the math emporium model of course delivery. Some students have difficulty with time management and taking responsibility for their learning (Vaughan, 2007). When using a CMS, students will often *guess and check* their answers until they get it correct. The student then moves on without really understanding the concept. Students need to realize that properly understanding the concept is more important than just getting the assigned question correct and seek help when they do not understand a concept (Vaughan, 2007).

An emporium model of course delivery is a specific type of hybrid course. Many universities have redesigned their developmental and college level math courses and use the emporium model of delivery (Twigg, 2003; Twigg, 2011; Witkowsky, 2008). While much research exists on the increase in student success, and much information has been published about important components of an emporium model and the lower cost involved, little research exists on examining the specific components and their contribution to student success. Research that is focused on specific aspects of the emporium model and their contribution to student success is needed in order to design and modify courses to maximize student learning.

CHAPTER THREE: METHODS

Overview

This chapter provides an explanation of the methods and procedures used to guide this study. In this quantitative research study, a correlational design with a multiple regression analysis technique was used to examine the relationship between student achievement in an introductory statistics course as measured by the CAOS instrument and weekly quiz average, number of quiz attempts, weekly emporium attendance, and weekly face to face time with a professor in a classroom. This research study was conducted at a private university located in the eastern United States with a residential enrollment of approximately 15,000 students. The sample was taken from 12 sections of an introductory statistics class required for majors in a large variety of areas of study. The design, research questions, hypotheses, participants, instrumentation, procedures, and data analysis will be described in this chapter.

Design

This research was conducted using a correlational design with a multiple regression analysis technique to determine if a relationship exists between the success of a student in an introductory statistics course as measured by the *Comprehensive Assessment of Outcomes in Statistics* (CAOS) instrument and a student's weekly quiz average, average number of weekly quiz attempts, average weekly emporium attendance, and average weekly face time with a professor in a classroom. Gall, Gall, and Borg (2007) define correlational research as "studies in which the purpose is to discover relationships between variables through the use of correlational statistics" (p. 332). A multiple regression design was used in this study that sought to determine if a linear relationship exists between multiple independent variables and one dependent variable (Gall et al., 2007). The predictor variables were weekly quiz average, number of quiz attempts, weekly emporium attendance, and weekly time in a classroom with a professor. The outcome variable was the conceptual understanding score as measured by the CAOS instrument. Multiple regression analysis demonstrates the association between each of the predictor variables and the criterion variable (Warner, 2013).

A similar study sought to determine if a relationship existed between the time spent in a math computer lab and final exam scores in a college algebra course (Ningjun & Herron, 2012). A bivariate correlational design was used and a significant positive correlation existed between lab time and the final exam score in six of the seven semesters in which data was collected (Ningjun & Herron, 2012).

Research Questions

This study will investigate the answers to the following research questions:

RQ1: Will the number of weekly quiz attempts predict student conceptual learning outcomes in an introductory statistics course?

RQ2: Will the weekly mathematics lab attendance predict student conceptual learning outcomes in an introductory statistics course?

RQ3: Will the weekly quiz average predict student conceptual learning outcomes in an introductory statistics course?

RQ4: Will the amount of weekly face-to-face time with an instructor predict student conceptual learning outcomes in an introductory statistics course?

Hypotheses

The null hypotheses for this study is:

H_o1: There will be no statistically significant predictive relationship between the number of weekly quiz attempts in an introductory statistics course and the dependent variable (conceptual learning out comes as measured by the CAOS instrument).

H_o2: There will be no statistically significant predictive relationship between the weekly math lab attendance in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

H_o3: There will be no statistically significant predictive relationship between the weekly quiz average in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

H_o4: There will be no statistically significant predictive relationship between the weekly face-to-face time with an instructor in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

Participants and Setting

Participants in this study will be undergraduate residential college students enrolled in a three-credit general education introductory statistics class that is offered in a hybrid format of course delivery. The students attend a private university in the eastern United States, which has a residential enrollment of approximately 15,000 students. A convenience sample of 12 sections of the course was used in the fall semester of 2018 because of the accessibility of the student population and the correlation of this group with the selected instrument. Each section had approximately 30 students, which created a sample size ranging from 300 to 348. Students were asked to volunteer to participate in the study by taking the online assessment (CAOS) that measured statistical comprehension. Volunteer rates were approximately 23.9% with 82 out of the possible 343 completing the online assessment and demographic data survey.

The sample consisted of 34 males and 48 females with a mean age of 18.96. The sample consisted of 54.9% freshmen, 28% sophomores, 14.6% juniors, and 2.5% seniors. The sample also contained a broad range of student majors, all arranged into the general categories of psychology, business, communication, criminal justice, government, journalism, language, medical, science, and technology. For this study, the minimum number of participants required for an adequate sample size was 82, which according to Tabachnick & Fidell (2007) is the minimum needed for testing multiple correlations with four independent variables that will ensure adequate statistical power to detect medium effect sizes.

Instrumentation

The instrument that was used in this study of student achievement in introductory statistics is the CAOS developed by delMas, Garfield, Ooms, and Chance (2007). The CAOS was developed to measure conceptual understanding of a wide range of concepts in introductory statistics as opposed to detailed calculations. The National Science Foundation (NSF) funded the ARTIST (Assessment Resource Tools for Improving Statistical Thinking) project (DUE-0206571). The instrument was developed using multiple revisions over the course of several years and has 40 multiple-choice items. Eighteen expert raters were unanimous in their approval of the final CAOS instrument. The CAOS internal validity was tested using a sample of 1470 students from 33 institutions in 21 states, with 25 different instructors. The scores had a minimum of 18 and a maximum of 100. The mean score was 55.77 with a standard deviation of 16.134. The median was 53.75. The CAOS is reliable with a Cronbach's alpha coefficient of 0.82 (delMas et al., 2007).

In a number of research studies where introductory college statistics achievement needed assessing, the CAOS instrument was used as the instrument to measure student achievement

(Tintle, VanderStoep, Holmes, Quisenberry, & Swanson, 2011; Zonnefeld, 2015). The CAOS instrument is accepted as a valid instrument in measuring the conceptual understanding of college students enrolled in introductory statistics (Hannigan, Gill, & Leavy, 2013; Ziegler, 2014). The CAOS assesses the conceptual understanding of topics such as sampling distributions, data collection, data representation, measures of center and spread, confidence intervals, normal distribution, bivariate quantitative and categorical data, and hypothesis testing (delMas et al., 2007). The CAOS is available online, and is usually completed by students in 30 to 45 minutes. Permission to use the instrument is granted when a college instructor registers on the ARTIST website and submits the form requesting an access code to distribute to students taking the CAOS assessment. The instructor can determine the length of days the assessment will be available to students. Reports are available to the instructor upon request after the access to the test is closed. One report contains the correct percent for each student. The second report details the percentage of students who selected each response for each test item.

Procedures

Permission to conduct this research was secured from the Institutional Review Board of the university and was granted in August 2018. The study was designed for dissemination beyond the participant institution and the results are intended for use by other researchers. All students enrolled in the residential introductory statistics course at the university were contacted via email to explain the importance of this research, and the email included an explanation of the role of the participants and assurance of confidentiality. After receiving approval from the appropriate administration and the professors that teach the class sections, the researcher spoke to each class section briefly in order to inform them in person of the information included in the email and answer questions. All students agreeing to participate in the study signed a letter of consent, which remained locked in a file cabinet in the researcher's office.

Data from the participant's emporium time each week was recorded using software and was stored in a database developed by the university. A weekly report was requested by the researcher and recorded in an Excel spreadsheet. The Excel file was password protected on a laptop computer that was also password protected and used only by the researcher. Data from the students' quiz attempts and quiz grades each week, as well as the weekly time spent in class, was downloaded from the course management software used by the introductory statistics classes to complete class assignments each week. To find the average weekly quiz grade, the researcher averaged the grade on all attempts for that week. Then each week's average was summed and divided by the total number of quiz averages. The data was identified by each student's assigned unique identification number and transferred to the Excel file that contains the weekly emporium times. The researcher completed all data collection and assimilation. Students in the researcher's statistics class did not participate in the study.

The CAOS assessment was administered online during the eleventh through the fourteenth week of a fifteen-week semester. The ARTIST project assigned an access code to the researcher that allowed student access to the instrument for the weeks specified by the researcher. The researcher emailed each student with the dates the instrument was available and also with the access code. In the few days following the assessment administration, two reports on student performance were available for access by the researcher by the ARTIST project managers. The data was identified only by the assigned identification number. The first report is an Excel file containing the correct percent for each student. The second report is a Word document that presents the test items along with the percent of students who selected each response for each item. These reports were saved as a password protected file on a password protected laptop. A pilot study was not needed since the CAOS instrument had been in existence and had established reliability and validity (delMas et al., 2007). No training was needed in implementing the assessment since it is delivered online.

Data Analysis

The data analysis for this study used correlation and a multiple linear regression technique. A Pearson product-moment correlation coefficient is used to describe the strength and direction of the linear relationship between two variables (Warner, 2013). A Pearson product-moment correlation coefficient, *r*, is designed for use with continuous variables (Pallant, 2010). The multiple regression analysis calculated a Pearson product-moment correlation coefficient for each independent variable to represent the correlation between that independent variable and the dependent variable, the CAOS score. The multiple regression analysis also calculated a Pearson correlation coefficient to measure the relationship between each of the independent variables.

Standard multiple regression was used to assess the ability of the average weekly quiz grade, the average weekly time in class with the professor, the average weekly number of quiz attempts, and the average weekly time spent in the math emporium to predict the criterion variable, the CAOS online assessment scores while also measuring for interactions between the independent variables (Warner, 2013). In standard multiple regression, the predictor variables are all entered into the equation simultaneously (Pallant, 2010). Each independent variable is evaluated for its predictive power and how much unique variance in the dependent variable is caused by each of the independent variables (Pallant, 2010).

A comparison of standard multiple regression models using all possible combinations of the four independent variables in this study with the dependent variable, the CAOS score, was conducted to identify a model with prediction accuracy and significance. A parsimonious model of multiple regression compares all possible combinations and subsets of independent variables in order to identify a model with a similar accuracy of dependent variable prediction as the full model that includes all independent variables (Hastie, Tibshirani, & Friedman, 2009). This parsimonious model strives to create a balance between prediction accuracy and significance while including as few variables as possible (Hastie et al., 2009).

Each of the predictor variables of student weekly quiz average, weekly quiz attempts, weekly math lab attendance, and weekly face-to-face time with a professor have a ratio level of measurement. The criterion variable of conceptual understanding from the CAOS instrument is also a ratio level of measurement. Data that is extreme relative to the sample of the study is considered an outlier (Warner, 2013). Outliers are evaluated in hierarchical regression with respect to the criterion variable and each of the predictor variables. Outliers can have a significant impact on the outcome of multiple linear regression (Tabachnick & Fidell, 2007). Histograms were used to detect outliers. In this study, each of the predictor variables had a limited range, so there was little chance of extreme values.

The assumption of normality of the outcome variable and each predictor variable was assessed using a histogram as well as the Kolmogorov-Smirnov test for normality. These distributions are considered a problem only if they differ dramatically from the normal and the sample size is smaller than 30 (Warner, 2013). The variables are independent. The assumption of linearity and homoscedasticity of the variables was checked using a scatterplot (Warner, 2013). Data was analyzed using the Statistical Package for the Social Sciences (SPSS).

The relationship between all pairs of variables should be linear. Scatterplots were used to check for linearity between each of the independent variables and the dependent variable as well between each of the independent variables and each other. Scatterplots were also used to check for homoscedasticity of the variables as well as bivariate outliers (Warner, 2013).

A multiple regression analysis was run using SPSS to examine the relationship between each of the predictor variables and the criterion variable: (a) student's weekly quiz average and conceptual understanding of statistics, (b) student's weekly quiz attempts and conceptual understanding of statistics, (c) student's weekly lab attendance and conceptual understanding of statistics, (d) student's weekly face-to-face time with a professor, and (e) conceptual understanding of statistics. The multiple regression test calculated a Pearson product-moment correlation between all of the variables in the study. This correlation measured the strength and direction of the linear relationship (Warner, 2013). The students' weekly quiz average variable had a possible range from 0 to 100. The student's average number of weekly quiz attempts had a range in value from 0 to 3, and the student's average weekly emporium time ranged in value from 0 to 5 hours. The average weekly time each student spent in class with a professor had a possible range from 0 to 50 minutes. Scores measured by the CAOS assessment (delMas et al., 2007) had a possible range in value from 0 to 100.

In correlational studies, the effect size is reported by r^2 (Warner, 2013). An r^2 of 0.01 or less is considered a small effect size, while an r^2 of .09 is considered medium, and an r^2 greater than .25 is considered large (Cohen, 1988). An alpha of .05 was used (Warner, 2013).

Next, the standard multiple regression analysis was used to assess (a) the ability of the average weekly quiz grade, (b) the average weekly time in class with the professor, (c) the average weekly number of quiz attempts, (d) and the average weekly time spent in the math emporium to predict the criterion variable, the CAOS online assessment scores while also measuring for interactions between the independent variables (Warner, 2013). The predictor variables were all entered into the equation simultaneously (Pallant, 2010). The variance of the CAOS score was examined and the r^2 was reported. An analysis of variance (ANOVA) was used to discuss the significance of the multiple regression.

After analyzing the standard multiple regression where all of the independent variables were entered simultaneously, the researcher conducted a multiple regression with every possible combination of one, two, and three independent variable(s) with the dependent variable. The researcher analyzed each of the models created by the multiple regression tests and chose the model that balanced the ability to significantly predict the dependent variable while using the least amount of variables (Hastie et al., 2009).

CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to determine if the number of weekly quiz attempts, weekly lab attendance, weekly quiz average, and/or weekly face-to-face time with an instructor could predict student conceptual understanding as measured by the Comprehensive Assessment of Outcomes in Statistics (CAOS) instrument in a general education introductory statistics course. This chapter includes the research questions considered in this study, the null hypotheses, descriptive statistics of the four independent variables and one dependent variable, and the results of the study.

Research Questions

This study investigated the answers to the following research questions:

RQ1: Will the number of weekly quiz attempts predict student conceptual learning outcomes in an introductory statistics course?

RQ2: Will the weekly mathematics lab attendance predict student conceptual learning outcomes in an introductory statistics course?

RQ3: Will the weekly quiz average predict student conceptual learning outcomes in an introductory statistics course?

RQ4: Will the amount of weekly face-to-face time with an instructor predict student conceptual learning outcomes in an introductory statistics course?

Null Hypotheses

The null hypotheses for this study is:

H_o1: There will be no statistically significant predictive relationship between the number of weekly quiz attempts in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

H_o2: There will be no statistically significant predictive relationship between the weekly math lab attendance in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

H_o3: There will be no statistically significant predictive relationship between the weekly quiz average in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

H_o4: There will be no statistically significant predictive relationship between the weekly face-to-face time with an instructor in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument).

Descriptive Statistics

Data used for this study was collected during the fall 2018 semester from residential students enrolled in a private university located on the east coast of the United States. The independent sample was drawn from residential students enrolled in an introductory statistics class. Data from a total of 82 participants on the study revealed that they were nearly evenly split with approximately 41.5% men and 58.5% women. Descriptive statistics showed that the ages ranged from 18 to 24, but the most popular ages were 18 to 19, which made up approximately 77% of the sample. Descriptive statistics showed that the majority of the students were majoring in business, with eleven different majors represented in the sample (see Table 1). Descriptive statistics also showed that approximately 54.88% of the sample was classified as freshman, 28.05% were sophomores, 14.63% were juniors, and 2.44% were seniors (see Table 1).

Table 1

Descriptive Statistics for the Participants

		Total (N = 82)	
Variable	Category	*N*	%
Gender	Male	34	41.46
	Female	48	58.54
Age	18-19	63	76.83
	20-21	14	17.07
	22-23	3	3.66
	24-25	2	2.44
Major	Aviation	1	1.22
	Business	42	51.22
	Communications	1	1.22
	Criminal Justice	2	2.44
	Government	1	1.22
	Journalism	1	1.22
	Language	1	1.22
	Medical	3	3.66
	Psychology	14	17.07
	Science	13	15.85
	Technology	3	3.66
Classification	Freshman	45	54.88
	Sophomore	23	28.05
	Junior	12	14.63
	Senior	2	2.44

Descriptive statistics for each of the predictor variables, average weekly quiz grade, average weekly time in class with the professor, average weekly number of quiz attempts, and average weekly time spent in the math emporium, and the criterion variable, the CAOS assessment score were evaluated (see Table 2). The mean of the CAOS assessment scores of this sample (*M*=42.13) was lower than the CAOS instrument's reported mean of 55.77 (delMas et al., 2007). The possible range for the average weekly quiz grade is 0 to 100 and this sample's range of average weekly quiz grade was 34.74 to 96.37. The possible range for the average weekly time in class with a professor in minutes was 0 to 50 and this sample's average weekly time in class with a professor had a range of 34.62 to 50. The possible range for the number of quiz attempts per week was 0 to 3 and this sample's range of average weekly quiz attempts was 0.64 to 2. The possible range for weekly time spent in the math emporium in hours was 0 to 78 hours since the math emporium was open approximately 78 hours each week. Students were allowed to be in the math emporium any time it was open and there was no maximum limit to the amount of time per week the student could work in the math emporium. Students were also required to spend two hours each week in the math emporium. This time counted for participation points and also as attendance. For this sample, the range of average weekly math emporium attendance in hours was 0.77 to 5.09.

Table 2

Descriptive Statistics for the Variables

	Total (N = 82)				
	M	*SD*	*IQR*	*Max*	Min
Average weekly quiz grade	74.84	13.30	16.10	96.37	34.74
Average weekly time in class with professor	47.41	3.45	3.85	50	34.62
Average weekly number of quiz attempts	1.25	0.30	0.45	2	0.64
Average weekly time in the math emporium	1.91	0.73	0.69	5.09	0.77
CAOS scores	42.13	11.84	13.1	82.5	2.5

Note. The units for time with the professor in the above table are in minutes. The units for time in the emporium are in hours.

Results

Data Screening

Volunteers were required to be a minimum age of 18 years. Volunteers were asked to complete the online CAOS assessment as well as a short demographic survey. A total of 120 volunteers completed the CAOS online instrument, however, only 82 completed both the CAOS instrument and the online demographic survey. The volunteers that completed the CAOS instrument but not the online demographic survey were removed from the study.

The four-predictor variables and the criterion variable were checked for outliers. The criterion variable, the CAOS score, had two values that could be classified as outliers with standardized residual values above 3.3 or below -3.3 (Tabachnick & Fidell, 2007). The minimum CAOS score had a standard residual value of -3.885 and the maximum CAOS score had a standard residual value of 3.35. These scores do not skew the CAOS results an extreme amount and the difference in the mean CAOS score of 44.737 and five percent trimmed mean of the CAOS score of 41.988 is negligible (Pallant, 2010). Also, the Mahalanobis distance value of 20.405 is only slightly higher than the critical value of 18.47 used when an analysis has four independent variables and an alpha value of .001 (Tabachnick & Fidell, 2007). The maximum value for Cook's Distance was .219, which is less than 1 and suggests no major problems with the outliers having undue influence on our results (Tabachnick & Fidell, 2007). Therefore, the decision was made to keep these two outliers.

Assumption Tests

The four predictor variables, average weekly quiz grade (Figure 1), average weekly time in class with the professor (Figure 2), average weekly number of quiz attempts (Figure 3), and average weekly time spent in the math emporium (Figure 4), were assessed for normality using a histogram. None of the four-predictor variables appear normal in shape from the histograms. The average weekly quiz grade has a negative skew (skewness = -0.936, *SE* = 0.266), and the average weekly time in class with a professor also has a negative skew (skewness = -1.375, *SE* = 0.266). The average number of weekly quiz attempts has a slight positive skew (skewness = 0.265, *SE* = 0.266). The average weekly time spent in the emporium has a stronger positive skew (skewness = 1.765, *SE* = 0.266). The Kolmogorov-Smirnov test of normality also shows that the assumption of normality is not met (see Table 3). However, distributions are considered a problem only if they differ dramatically from the normal and the sample size is smaller than 30 (Warner, 2013).

Figure 1. Histogram for Average Weekly Quiz Grade ($N = 82$).

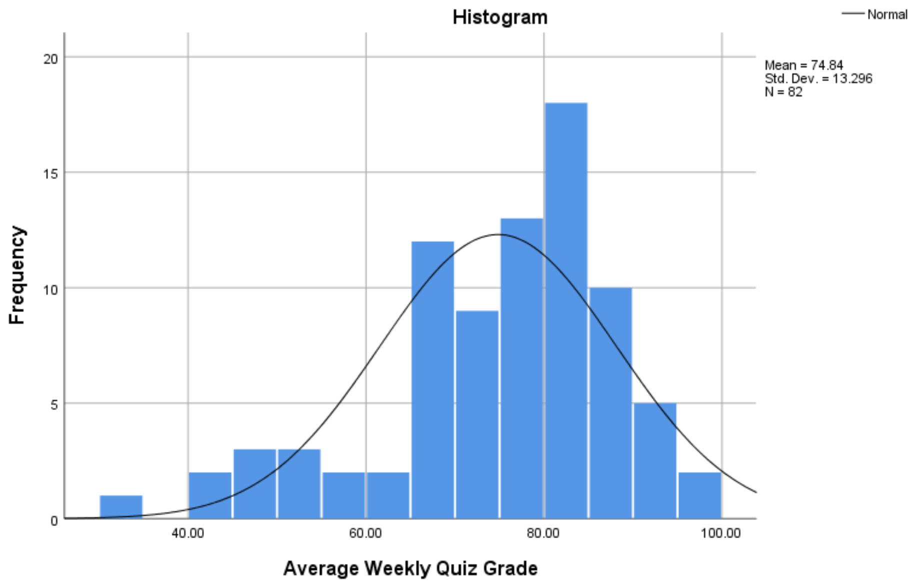


Figure 2. Histogram for Average Weekly Time in Class with a Professor in Minutes ($N = 82$).

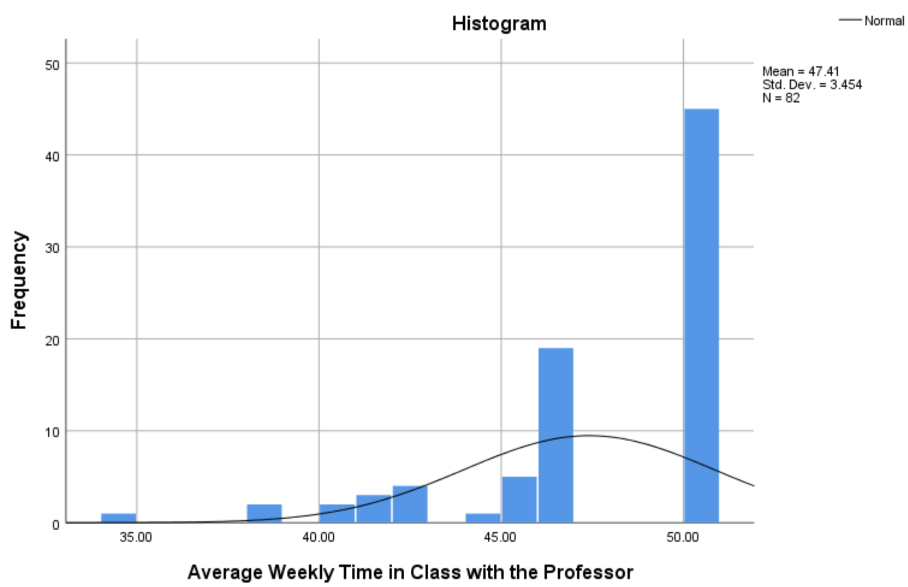


Figure 3 .Histogram for Average Number of Weekly Quiz Attempts (*N* = 82).

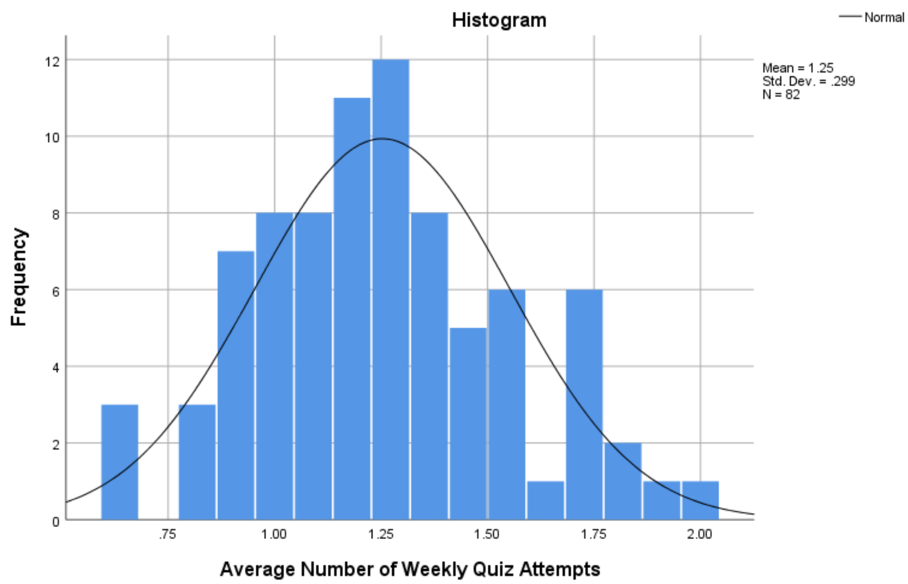


Figure 4. Histogram for Average Time Spent in the Math Emporium in Hours (*N* = 82).

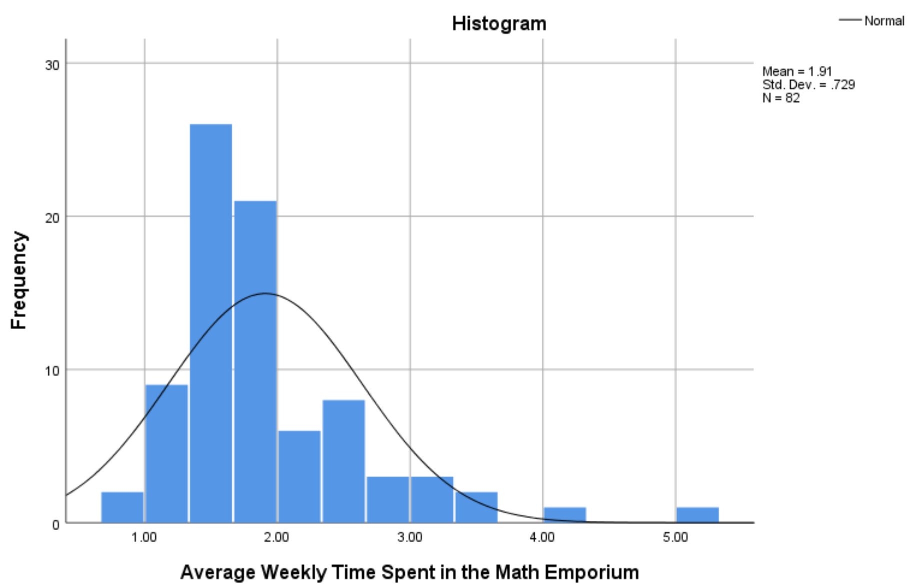


Table 3

Kolmogorov-Smirnov Test of Normality for the Predictor Variables

	Statistic	*df*	*p*
Average weekly quiz grade	0.110	82	0.016
Average weekly time in class with professor	0.332	82	0.000
Average weekly number of quiz attempts	0.108	82	0.020
Average weekly time in the math emporium	0.174	82	0.000

The criterion variable, the CAOS scores (Figure 5) was assessed for normality using a histogram. The CAOS scores do not appear normal in shape, although the distribution is more normal than most of the predictor variables. The Kolmogorov-Smirnov test of normality also shows that the assumption of normality is not met (see Table 4). However, as stated previously, distributions are considered a problem only if they differ dramatically from the normal and the sample size is smaller than 30 (Warner, 2013).

Figure 5. Histogram for the CAOS Score (*N* = 82).

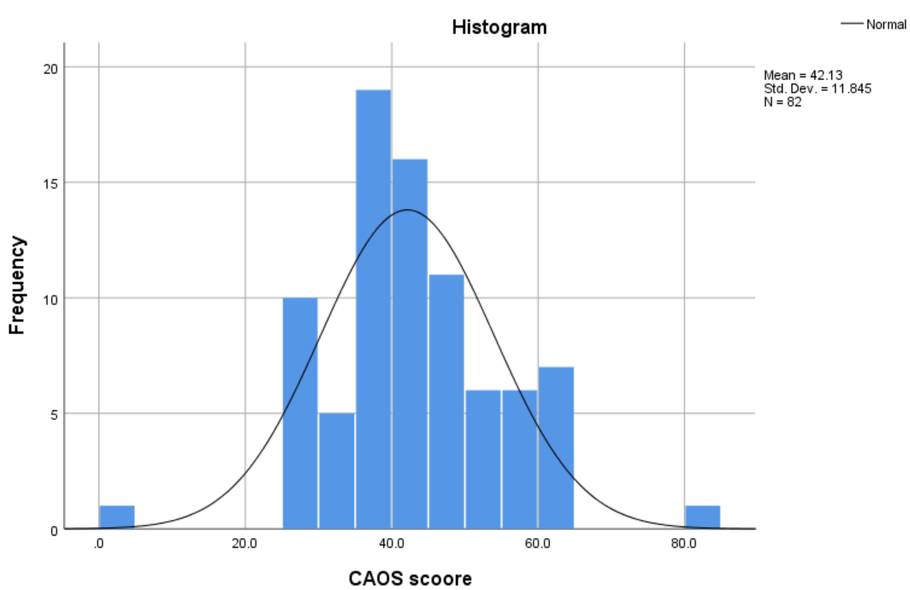


Table 4

Kolmogorov-Smirnov Test of Normality for the Criterion Variable

	Statistic	*df*	*p*
CAOS score	0.110	82	0.016

Next, scatterplots were used to check for bivariate normal distribution, bivariate linearity, and homoscedasticity (see Figures 4.6, 4.7, 4.8, and 4.9). The scatterplot show the relationships to be roughly linear. Assumptions of bivariate normality and homoscedasticity are tenable as the scatterplots of cigar-shaped and the variance is roughly uniform in each scatterplot (Warner, 2013). A few outliers are apparent, but have been discussed in the previous section on data screening.

Figure 6. Bivariate Scatterplot of Weekly Average Number of Quiz Attempts and the CAOS Score.

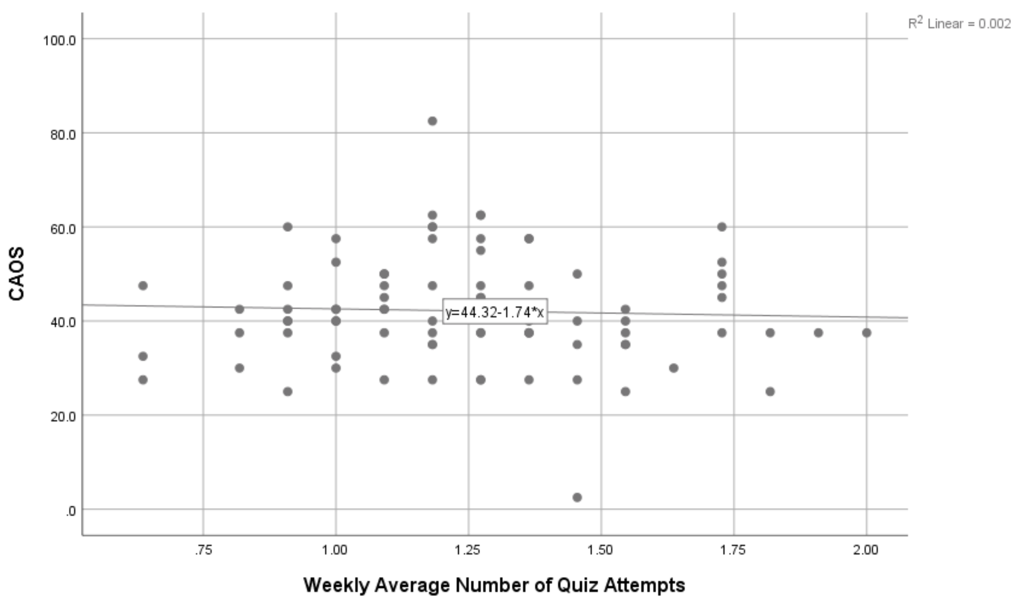


Figure 7. Bivariate Scatterplot of Weekly Average Math Lab Attendance and the CAOS Score.

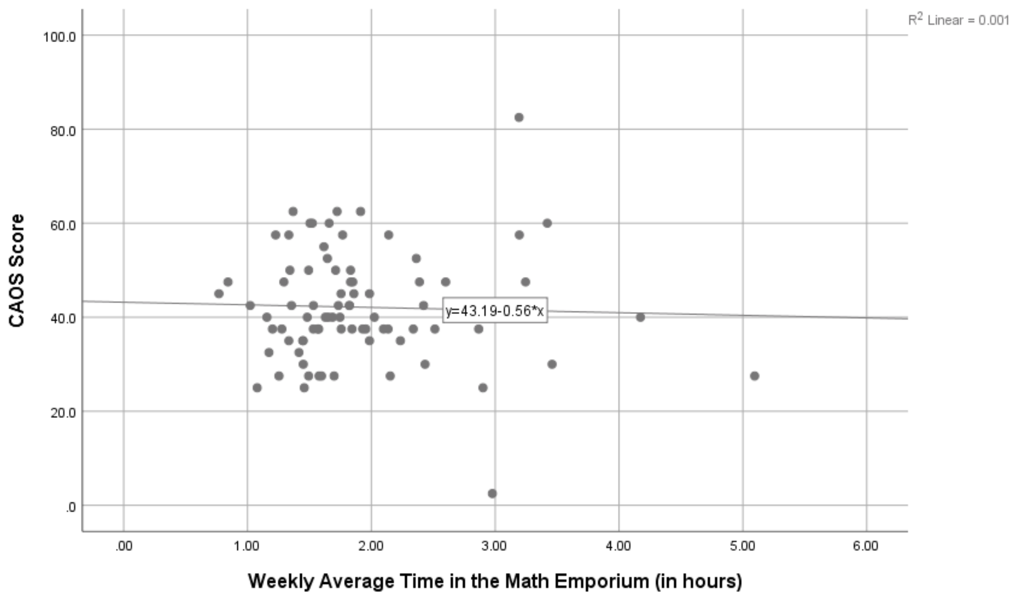


Figure 8. Bivariate Scatterplot of Weekly Average Quiz Grade and the CAOS Score.

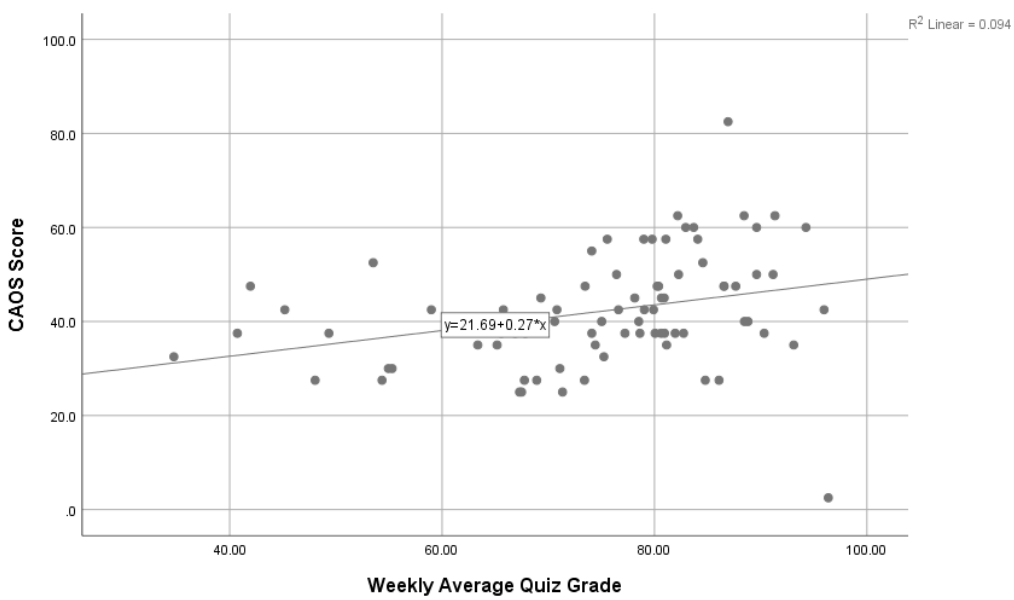
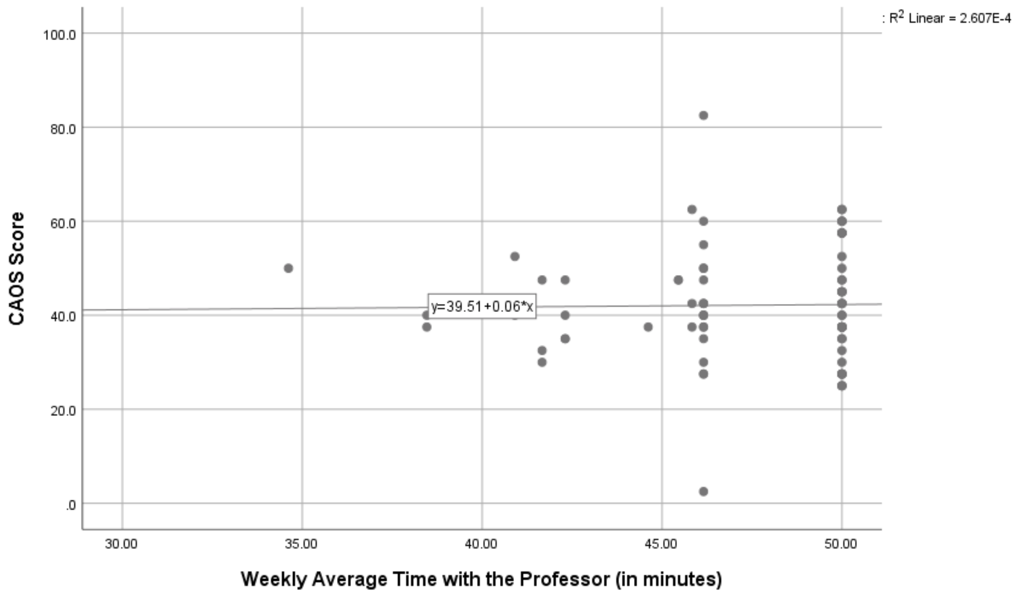


Figure 9. Bivariate Scatterplot of Weekly Average Face-to-Face Time with an Instructor and the CAOS Score.



The correlations table was evaluated to check for multicollinearity. The criterion variable, the CAOS scores, has a significant relationship with the average weekly quiz grade with a Pearson correlation of .307 (Pallant, 2010), which is of medium effect (Cohen, 1988). However, the CAOS scores do not have a significant relationship with any of the other predictor variables (see Table 5). The predictor variables do not have a significant relationship with each other (see Table 6). The tables (Table 5 and Table 6) also reveal that none of the variables have a high correlation (above .7), indicating there is no violation of the assumption of multicollinearity. To further check for multicollinearity, the coefficients table was examined (see Table 7). The tolerance was above .10 for each variable and the variance inflation factor (VIF) was not too high as it was below 10 for each variable (Pallant, 2010). These results also contribute to the conclusion that the assumption of multicollinearity is not violated.

Table 5

Pearson Product-Moment Correlations for Predictor Variables with the Criterion Variable of CAOS Scores

Variable	Pearson Correlation with CAOS score
Average weekly quiz grade	.307**
Average weekly time in class with professor	.016
Average weekly number of quiz attempts	-.044
Average weekly time in the math emporium	-.034

*$p < .1$ **$p < .05$ ***$p < .001$

Table 6

Pearson Product-Moment Correlations for predictor variables with each other

	Pearson Correlation			
	Quiz grade	Time with professor	Number of quiz attempts	Time in math emporium
Average weekly quiz grade		.061	.366***	.232**
Average weekly time in class with professor	.061		-.024	.068
Average weekly number of quiz attempts	.366***	-.024		.082
Average weekly time in the math emporium	.232**	.068	.082	

$*p < .1$ $**p < .05$ $***p < .001$

Table 7

Tolerance and VIF for the Independent Variables

Variable	Tolerance	VIF
Average weekly quiz grade	.864	1.216
Average weekly time in class with professor	.991	1.009
Average weekly number of quiz attempts	.822	1.157
Average weekly time in the math emporium	.943	1.060

The residuals were checked for linearity, normality, and homoscedasticity. The histogram showed that the residuals did not show normality (see Figure 10). The standardized residuals were graphed in a P-P plot (see Figure 11), which show approximate linearity. A scatterplot was used to check for homoscedasticity (see Figure 12). The scatterplot is somewhat rectangular about the mean, which demonstrates moderate homoscedasticity (Pallant, 2010). A few outliers are apparent, but have been discussed in the previous section on data screening.

Figure 10. Histogram of the Standardized Residuals for CAOS.

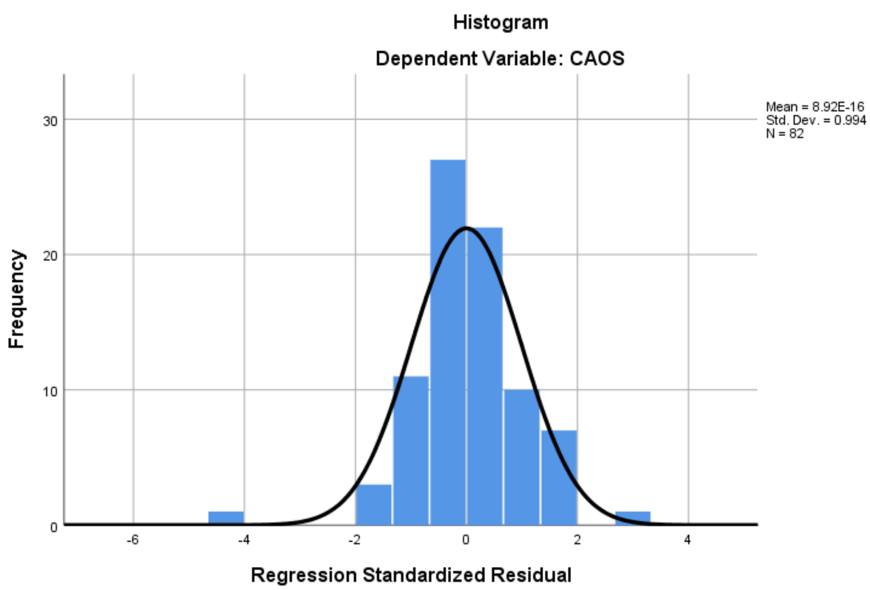


Figure 11. P-P Plot of Regression Standardized Residuals for CAOS.

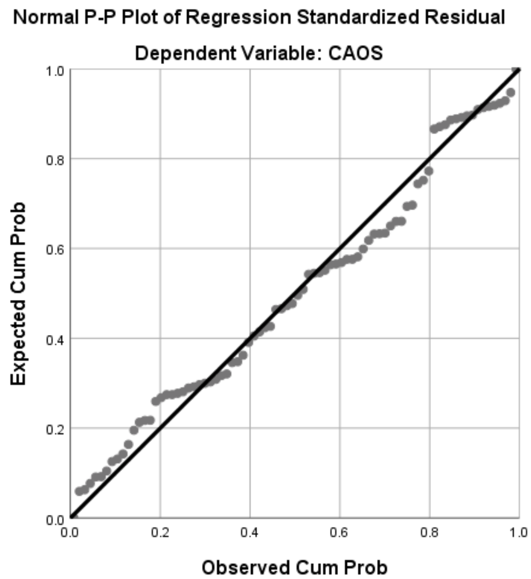
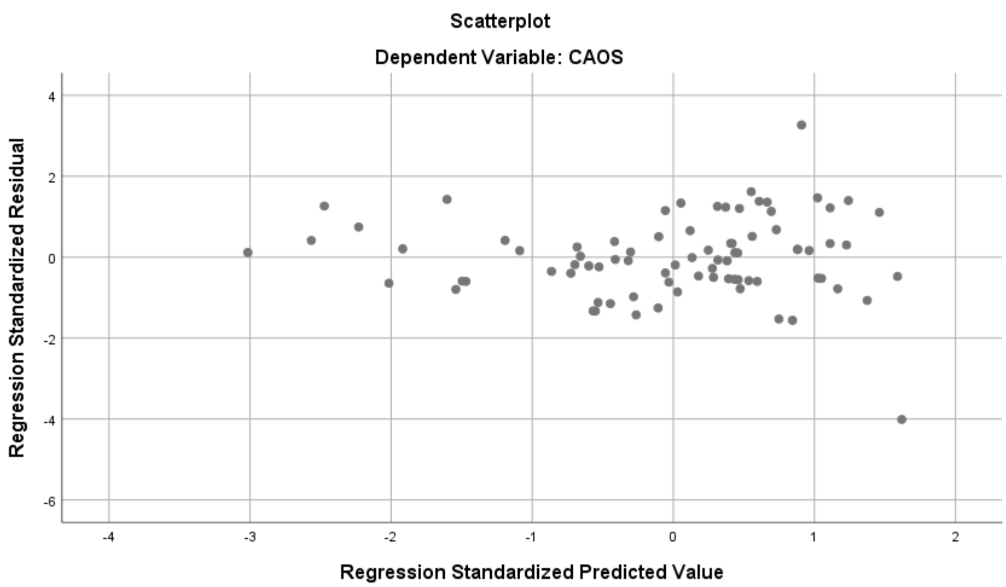


Figure 12. Scatterplot of Standardized Residuals for CAOS.



Results for Null Hypothesis One

A Pearson product-moment correlation coefficient is used to describe the strength and direction of the linear relationship between two variables (Warner, 2013). A Pearson product-moment correlation coefficient, *r,* is designed for use with continuous variables (Pallant, 2010). The first null hypothesis states there will be no statistically significant relationship between the number of weekly quiz attempts in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument). The multiple regression analysis results stated that the Pearson's correlation for the average number of weekly quiz attempts and the CAOS score was $r = -.044$ which indicates little if any provable correlation (Warner, 2013). The result was not significant with $p = .694$ (Warner, 2013). Therefore, the first null hypothesis was not rejected.

Results for Null Hypothesis Two

The second null hypothesis states there will be no statistically significant relationship between the weekly math lab attendance in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument). The multiple regression analysis results stated that the Pearson's correlation for the weekly math lab attendance and the CAOS score was $r = -.034$ which indicates little if any provable correlation (Warner, 2013). The result was not significant with $p = .760$ (Warner, 2013). Therefore, the second null hypothesis was not rejected.

Results for Null Hypothesis Three

The third null hypothesis states there will be no statistically significant relationship between the weekly average quiz grade in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument). There is significant evidence that there is a positive correlation of medium effect (Cohen, 1988) between a student's weekly average quiz grade and their CAOS score ($r(82) = .307$, $p < .01$). Therefore, the third null hypothesis was rejected. When evaluating statistical power according to Warner (2013), squaring Pearson's correlation coefficient and using tables, the statistical power is between 80% and 85%.

Results for Null Hypothesis Four

The fourth null hypothesis states there will be no statistically significant relationship between the weekly face-to-face time with an instructor in an introductory statistics course and the dependent variable (conceptual learning outcomes as measured by the CAOS instrument). The multiple regression analysis results showed that the Pearson's correlation for the weekly face-to-face time with an instructor and the CAOS score was $r = .016$ which indicates little or no provable correlation (Warner, 2013). The result was not significant with $p = .886$ (Warner, 2013). Therefore, the fourth null hypothesis was not rejected.

Results of Multiple Linear Regression

A multiple linear regression analysis was conducted in an effort to gather further information about the relationships between the variables involved. Standard multiple regression was used to assess the ability of the average weekly quiz grade, the average weekly time in class with the professor, the average weekly number of quiz attempts, and the average weekly time spent in the math emporium to predict the criterion variable, the CAOS online assessment scores while also measuring for interactions between the independent variables (Warner, 2013). In standard multiple regression, the predictor variables are all entered into the equation simultaneously (Pallant, 2010). Each independent variable is evaluated for its predictive power and how much unique variance in the dependent variable is caused by each of the independent variables (Pallant, 2010). Multiple regression allows an exploration of the interrelationship among a set of variables (Pallant, 2010). The amount of dependent variable variance uniquely predicted by each predictor variable when the other predictor variables are statistically controlled (Warner, 2013). Multiple regression is preferred over multiple significance tests in order to limit the risk of a Type I error (Warner, 2013). If multiple significance tests are used, the Bonferroni correction can be used to limit Type I errors (Warner, 2013). The Bonferroni correction divides the experiment-wise alpha by the number of significance tests being performed (Warner, 2013). If the number of significance tests is large, the adjusted alpha from the Bonferroni correction may be so small that very few outcomes will be judged statistically significant (Warner, 2013).

As discussed earlier, the predictor variables do not have a significant relationship with each other (see Table 6). The tables (Table 5 and Table 6) also reveal that none of the variables have a high correlation (above .7). The total variance in the CAOS score was 13.4% with $F(4, 77) = 2.981$, $p = .024$. An analysis of variance (ANOVA) showed that the model as a whole is significant (see Table 8). Furthermore, the Coefficient Table (see Table 9) indicated that the average weekly quiz grade was the only independent variable to make a statistically significant contribution to the prediction of the CAOS score (*beta* = 0.399, $p = .001$). The square of the semipartial correlation coefficient of .362 (see Table 9) for the average weekly quiz grade indicates that this one independent variable uniquely contributes to 13.1% of the total variance of the CAOS score (Pallant, 2010). The other three independent variables are making little to no contribution to the prediction of the CAOS score.

Table 8

ANOVA Table for the Dependent Variable, CAOS Score, using Standard Multiple Regression

	Sum of Squares	*Df*	Mean Square	*F*	Sig.
Regression	1523.754	4	380.938	2.981	.024
Residual	9840.270	77	127.796		
Total	11364.024	81			

Table 9

Coefficient Table for the Dependent Variable, CAOS Score, when using Standard Multiple Regression

Model	Unstandardized B	Unstandardized Std. Error	Standardized Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tol.	Collinearity Statistics VIF
(Constant)	28.726	18.697		1.536	.129					
Avg. Number of Quiz Attempts	-7.155	4.514	-.181	-1.585	.117	-.044	-.178	-.168	.864	1.157
Avg. Time in Emporium	-1.815	1.774	-.112	-1.023	.309	-.034	-.116	-.108	.943	1.060
Avg. Quiz Grade	.355	.104	.399	3.412	.001	.307	.362	.362	.822	1.216
Avg. Time with Professor	-.016	.365	-.005	-.044	.965	.016	-.005	-.005	.991	1.009

A parsimonious model of multiple regression compares all possible combinations and subsets of independent variables in order to identify a model with a similar accuracy of dependent variable prediction as the full model that includes all independent variables (Hastie et al., 2009). The parsimonious model will strive to create a balance between prediction accuracy and significance while including as few variables as possible (Hastie et al., 2009). A comparison of multiple regression models using all possible combinations of the four independent variables in this study with the dependent variable, the CAOS score, revealed that a multiple regression model using the average weekly quiz grade alone is the best prediction model (see Table 10). This result was further verified by a stepwise multiple regression which chose the average weekly quiz grade alone as the best prediction model for the CAOS score.

Table 10

A Comparison of the Top Models of Multiple Regression using a Variety of Combinations of Independent Variable(s) with the CAOS Score as the Dependent Variable

Model	R^2	F	Sig.
Avg. quiz grade	.094	8.305	.005
Avg. quiz grade & number of quiz attempts	.122	5.499	.006
Avg. quiz grade, number of quiz attempts, & avg. emporium time	.134	4.025	.01
Avg. quiz grade, number of quiz attempts, & avg. professor time	.122	3.623	.017
Avg. quiz grade & professor time	.094	4.101	.02

In the model using just the CAOS score and the average weekly quiz grade, the total variance in the CAOS score was 9.4% with $F(1, 80) = 8.305$, $p = .005$. An analysis of variance (ANOVA) showed that the model as a whole is significant (see Table 11). Additionally, the Coefficient Table (see Table 12) identifies the semipartial correlation coefficient equal to .307. The semipartial correlation coefficient squared is consistent with the results that the average weekly quiz grade (*beta* = .307, $p = .005$) uniquely contributes to 9.4% of the total variance of the CAOS score (Pallant, 2010).

Table 11

ANOVA Table for the Dependent Variable, CAOS Score, using Standard Multiple Regression and the Average Weekly Quiz Grade as the Independent Variable

	Sum of Squares	*Df*	Mean Square	*F*	Sig.
Regression	1068.829	1	1068.829	8.305	.005
Residual	10295.196	80	128.690		
Total	11364.024	81			

Table 12

Coefficient Table for the Dependent Variable, CAOS Score, when using Standard Multiple Regression

	Unstandardized		Standardized			Correlations			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tol.	VIF
(Constant)	21.687	7.205		3.010	.003					
Avg. Quiz Grade	.273	.095	.307	2.882	.005	.307	.307	.307	1	1

CHAPTER FIVE: CONCLUSIONS

Overview

Hybrid course design has become a popular course design in education with the development of many course management systems (Gosper et al., 2010). A deeper understanding of all components of hybrid course design would benefit all educational stakeholders involved in the development of new courses and the redesign of already existing courses. The purpose of this chapter is to discuss the findings of this study on the effect weekly quiz attempts, weekly lab attendance, weekly quiz average, and weekly time with a professor had on a student's conceptual understanding of statistics.

Discussion

The purpose of this study was to determine if the number of weekly quiz attempts, weekly lab attendance, weekly quiz average, and weekly face-to-face time with an instructor could predict student conceptual understanding as measured by the *Comprehensive Assessment of Outcomes in Statistics* (CAOS) instrument in a general education introductory statistics course offered in a hybrid format. The research questions under consideration were:

RQ1: Will the number of weekly quiz attempts predict student conceptual learning outcomes in an introductory statistics course?

RQ2: Will the weekly mathematics lab attendance predict student conceptual learning outcomes in an introductory statistics course?

RQ3: Will the weekly quiz average predict student conceptual learning outcomes in an introductory statistics course?

RQ4: Will the amount of weekly face-to-face time with an instructor predict student conceptual learning outcomes in an introductory statistics course?

The first research question examined whether the average number of weekly quiz attempts could significantly predict a student's conceptual understanding in an introductory statistics course as measured by the CAOS instrument. The results of this study found that the average number of weekly quiz attempts had little or no provable correlation with a student's conceptual understanding in an introductory statistics course. Allowing multiple quiz attempts is a mastery learning technique. Formative assessments, such as weekly quizzes, are created as criterion-based assessments (Diegelman-Parente, 2011; Lalley & Gentile, 2009). A student that demonstrates mastery moves on to the next unit of learning while a student that did not demonstrate mastery receives timely feedback on what was correct and incorrect and how to improve (Lalley & Gentile, 2009). Students may work on remedial exercises and also receive peer tutoring (Diegelman-Parente, 2011; Lalley & Gentile, 2009; Mong et al., 2018; Twigg, 2013).

In this study, students could complete a post-quiz review after the first quiz attempt. Each question in the review could be attempted an unlimited number of times. Tutoring was available before the second quiz attempt. Once the post-quiz review score reached 80%, the student could complete the weekly quiz a second time. The process of remediation and feedback before a second opportunity to demonstrate mastery of content is central to the technique of mastery learning (Boggs et al., 2004; Diegelman-Parente, 2011; Lalley & Gentile, 2009). The results of this study are surprising, since research has shown mastery learning techniques to be beneficial to student conceptual understanding (Bloom, 1984; Diegelman-Parente, 2011; Lalley & Gentile, 2009; Larson & Farber, 2015; Mong et al., 2018; Twigg, 2013). Students tutored one-on-one using mastery learning techniques scored two standard deviations higher on standardized achievement tests than students who received traditional instruction (Bloom, 1984). In a normal distribution, a score that is two standard deviations above the mean is equivalent to being in the 98th percentile (Larson & Farber, 2015). Mastery learning has been shown to increase retention of concepts, learning effectiveness, higher mental processes, increase student confidence, and enhance motivation (Bloom, 1978; Changeiywo et al., 2011; Guskey & Gates, 1986; Lalley & Gentile; 2009; Mong et al., 2018).

The second research question examined whether the weekly math lab attendance could significantly predict a student's conceptual understanding in an introductory statistics course as measured by the CAOS instrument. The results of this study found that the weekly math lab attendance had little or no provable correlation with a student's conceptual understanding in an introductory statistics course. This result is surprising, since previous research indicated weekly math lab attendance did have a correlation with student success in a college course (Ningjun & Herron, 2012; Twigg, 2013). Confounding variables may have affected the results. Students with natural math ability and better preparation for college math may not need to spend much time in the math emporium. In this study, students were required to spend at least two hours each week in the math emporium as part of the course attendance. Some students may be spending more time in the math emporium than they needed to be successful. Other students that were less successful, may not have wanted to spend more than two hours per week in the math emporium, even though it would have been beneficial. Students were monitored and were expected to work on the course assignments while in the math emporium. However, it is possible that students could have been in the math emporium for two hours a week but didn't use the time effectively.

The third research question examined whether the average weekly quiz grade could significantly predict a student's conceptual understanding in an introductory statistics course as measured by the CAOS instrument. The results of this study found that the average weekly quiz grade was significant in predicting a student's conceptual understanding as measured by the CAOS instrument. The correlation was positive and of medium effect. This significant result was expected in light of the importance of weekly formative assessments with repeated attempts in mastery learning (Boggs et al., 2004; Diegelman-Parente, 2011; Lalley & Gentile, 2009).

The fourth research question examined whether the weekly time in class with a professor could significantly predict a student's conceptual understanding in an introductory statistics course as measured by the CAOS instrument. The results of this study found that the weekly time in class with a professor had little or no provable correlation with a student's conceptual understanding in an introductory statistics course. In comparison with the other three independent variables in this study, the weekly time in class with a professor had the smallest correlation. This result was surprising considering the importance of the student-professor relationship in student satisfaction and student success is well researched and documented (Biddix et al., 2015; Braxton & Milem, 2000; Eimers, 2001; Heinemann, 2007; Hurtado & Carter, 1997; Kuh & Hu, 2001; Micari & Pazos, 2012; Pascarella & Terenzini, 1979; Wilson, 2008; Sanchez et al., 2011; Umbach & Wawrzynski, 2005; Vogt, 2008; Yoon, 2002).

Several factors may have influenced the results from this study. The time spent with a professor was only tracked by class attendance. This study did not track any interactions between a student and professor outside of class time. It is also possible that students attended class without really engaging in the class discussion or activities.

The results of this study demonstrated that little is understood about the components of hybrid course design. Student success cannot easily be predicted by the four independent variables included in this study. Only one of the four independent variables had a correlation with student conceptual understanding. The goal of this study was to contribute to knowledge of hybrid course design in order to design courses that facilitate student success. The ability to identify students that may need remediation prior to the course is optimal. A complete understanding of hybrid course design and the effect each component contributes to student success should be a priority.

Implications

This study validates the importance of frequent formative assessments. The positive correlation of a student's average weekly quiz grade with conceptual understanding of statistics reinforces the importance of frequent formative assessments. In particular, the ability to receive tutoring and feedback before a second quiz attempt is valuable. The lack of correlation between weekly lab attendance, weekly time with a professor, and number of weekly quiz attempts with a student's conceptual understanding does not necessarily mean that those components of a hybrid course are not important. A number of confounding variables such as a student's natural math ability and prior high school experience could affect the results.

This study collected a small amount of demographic data from participants such as gender, major area of study, final grade in the class, and average time spent studying outside of the math lab each week. Although included in the study, the researcher found that the average time spent studying outside the math emporium had a significant but small negative correlation to the student's conceptual understanding of statistics as measured by the CAOS instrument. A student's final grade had a medium positive correlation to the student's conceptual understanding of statistics as measured by the CAOS instrument. More research is needed to fully understand the importance of the components of hybrid course design. Further research could assist in the identification of students that may need remediation prior to the start of the class.

Limitations

This study had a number of limitations that should be considered. The assumption is that all weekly averages were correctly calculated and entered. However, human data-entry error or calculation could have created incorrect data. In the event of an attendance system failure, a student's math lab attendance was recorded in a separate file. The data then needed to be compiled with the data recorded by the attendance system. Human error could have occured during this process.

The sample size for this study is a possible limitation. The sample size of 82 just meets the minimum requirements for this type of study (Tabachnick & Fidell, 2007). This size sample may not be representative of the population since the volunteer rate was so low. Students were not required to participate as part of their course, and participation was voluntary. As a result, participation was low. A larger sample would contribute to a more robust study.

A multiple regression study is limited by several threats to validity. One internal threat to validity is that any predictive effects are valid only for the sample studied. A second internal threat to validity is the different environments caused by multiple sections of the course with multiple professors. These diverse environments could affect the variables being studied. A third threat to internal validity is omitted variable bias. A causal variable such as prior math experience or natural math ability could have been omitted. Sample selection bias is a fourth threat to the validity of this study. The sample in this study may not be representative of the population. Simultaneous causality bias is a fifth internal threat to the validity of this study.

Other factors may have influenced the outcome. Population validity and generalizability are external threats to validity. The variety of math emporium formats could inhibit the ability to replicate this study at another university.

Recommendations for Future Research

Further research is needed in order to expand the body of knowledge about specific components of hybrid course design. This would enable course creation and design to include the components that contribute to student's success. Further research would also contribute to discovering an efficient way to identify students in need of remediation. Remediation could then readied and available at the start of the course. This would prevent a lapse of time spent investigating and arranging for remediation when a student begins to struggle in a class. Further research may also uncover components that contribute to student success that have not yet been considered. Very little research has been conducted on the specific components of hybrid course design. This sample in this study came from one university. Continuing research at multiple and diverse universities would continue to add to the limited information gained from this study.

The use of technology is now integral in education. A complete understanding of how technology affects learning comprehension is indisputable. With the constant development of new technology, current research on it effectiveness is necessary. The goal of designing a class that uses technology to maximize student success and conceptual understanding is of prevailing importance.

REFERENCES

Akyol, Z., Garrison, D. R., & Ozden, M. Y. (2009). Online and blended communities of inquiry: Exploring the developmental and perceptional differences. *International Review of Research in Open & Distance Learning, 10*(6), 65-83.

Allen, I. E., & Seaman, J. (2007). Chapter 4: Blending in: The extent and promise of blended education in the United States. In A. G. Piccian & C. D. Dziuban (Eds.), *Blended learning: Research perspectives* (pp. 65-80). Needham, MA: The Sloan Consortium.

Al-Qahtani, A. A., & Higgins, S. E. (2013). Effects of traditional, blended and e-learning on students' achievement in higher education. *Journal of Computer Assisted Learning, 29*(3), 220-234.

Alzahrani, T., & Leko, M. (2018). The effects of peer tutoring on the reading comprehension performance of secondary students with disabilities: A systematic review. *Reading & Writing Quarterly, 34*(1), 1-17. doi:10.1080/10573569.2017.1302372

Ashby, J., Sadera, W. A., & McNary, S. W. (2011). Comparing student success between developmental math courses offered online, blended, and face-to-face. *Journal of Interactive Online Learning, 10*(3), 128-140.

Aspden, L., & Helm, P. (2004). Making the connection in a blended learning environment. *Educational Media International, 41*(3), 245-252. doi:10.1080/09523980410001680851

Awang, H., & Ismail, N. A. (2010). Undergraduate education: A gap analysis of students' expectations and satisfaction. *Problems of Education in the 21st Century, 21*, 21-28.

Ayala, J. S. (2009). Blended learning as a new approach to social work education. *Journal of Social Work Education, 45*(2), 277-288.

Baiduri. (2017). Elementary school students' spoken activities and their responses in math learning by peer-tutoring. *Aktiviti Pertuturan Pelajar Sekolah Rendah dan Respons mereka dalam Pembelajaran Matematik oleh tutor Rakan Sebaya, 10*(2), 145-160.

Baneres, D., Baro, X., Guerrero-Roldan, A. E., & Rodriguez, M. E. (2016). Adaptive e-assessment system: A general approach. *International Journal of Emerging Technologies in Learning, 11*(7), 16-23.

Bettinger, E. P., Boatman, A., & Long, B. T. (2013). Student supports: Developmental education and other academic programs. *Future of Children, 23*(1), 93-115.

Biddix, J. P., Chung, C. J., & Park, H. W. (2015). The hybrid shift: Evidencing a student-driven restructuring of the college classroom. *Computers & Education, 80*, 162-175.

Block, J. H. (1971). *Mastery learning: Theory and practice*. New York, NY: Holt, Rinehart & Winston.

Bloom, B. S. (1978). New views of the learner: Implications for instruction and curriculum. *Educational Leadership, 35*(7), 563-576.

Bloom, B. S. (1984). The search for methods of group instruction as effective as one-to-one tutoring. *Educational Leadership, 41*(8), 4.

Boggs, S., Shore, M., & Shore, J. (2004). Using e-learning platforms for mastery learning in developmental mathematics courses. *Mathematics & Computer Education, 38*(2), 213-220.

Bonham, B. S., & Boylan, H. R. (2012). Developmental mathematics: Challenges, promising practices, and recent initiatives. *Journal of Developmental Education, 36*(2), 14-21.

Borg, M. O., & Shapiro, S. L. (1996). Personality type and student performance in principles of economics. *Journal of Economic Education, 27*(1), 3-25.

Braxton, J. M., & Milem, J. F. (2000). The influence of active learning on the college student departure process. *Journal of Higher Education, 71*(5), 569-590.

Byrd, J. C. (2016). Understanding the online doctoral learning experience: Factors that contribute to students' sense of community. *Journal of Educators Online, 13*(2), 102-135.

Case, R. (1987). The structure and process of intellectual development. *International Journal of Psychology, 22*(5/6), 571.

Cen, L., Ruta, D., Powell, L., Hirsch, B., & Ng, J. (2016). Quantitative approach to collaborative learning: Performance prediction, individual assessment, and group composition. *International Journal of Computer-Supported Collaborative Learning, 11*(2), 187-225.

Chang, H. (2012). The development of a learning community in an e-learning environment. *International Journal of Pedagogies & Learning, 7*(2), 154-161.

Changeiywo, J., Wambugu, P., & Wachanga, S. (2011). Investigations of students' motivation towards learning secondary school physics through mastery learning approach. *International Journal of Science & Mathematics Education, 9*(6), 281333-1350. doi:10.1007/s10763-010-9262-z

Chavda, P., Pandya, C., Solanki, D., & Dindod, S. (2016). Is "modular" the way to go for small group learning in community medicine in undergraduate clinical postings? *International Journal of Applied & Basic Medical Research, 6*(3), 211-214. doi:10.4103/2229-516X.186970

Chen, B. H., & Chiou, H.-H. (2014). Learning style, sense of community and learning effectiveness in hybrid learning environment. *Interactive Learning Environments, 22*(4), 485-496. doi:10.1080/10494820.2012.680971

Ching-Huei, C. (2014). An adaptive scaffolding e-learning system for middle school students' physics learning. *Australasian Journal of Educational Technology, 30*(3), 342-355.

Clifton, I. D., & McKillup, S. C. (2016). Why such success? Nursing students show consistently high satisfaction with bioscience courses at a regional university. *Australian Journal of Advanced Nursing, 33*(3), 21-28.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Costen, W. M. (2009). The value of staying connected with technology: An analysis exploring the impact of using a course management system on student learning. *Journal of Hospitality, Leisure, Sport & Tourism Education (Oxford Brookes University, 8*(2), 47-59. doi: 10.3794/johlste.82.204

delMas, R., Garfield, J., Ooms, A., & Chance, B. (2007). Assessing students' conceptual understanding after a first course in statistics. *Statistics Education Research Journal, 6*(2), 28.

DeRogatis, A., Honerkamp, K., McDaniel, J., Medine, C., Nyitray, V.-L., & Pearson, T. (2014). Teaching very large classes. *Teaching Theology & Religion, 17*(4), 352-368. doi:10.1111/teth.12246

Diegelman-Parente, A. (2011). The use of mastery learning with competency-based grading in an organic chemistry course. *Journal of College Science Teaching, 40*(5), 50-58.

Ding, N., & Harskamp, E. G. (2011). Collaboration and peer tutoring in chemistry laboratory education. *International Journal of Science Education, 33*(6), 839-863.

Drouin, M. A. (2008). The relationship between students' perceived sense of community and satisfaction, achievement, and retention in an online course. *Quarterly Review of Distance Education, 9*(3), 267-284.

Dunn, R., Honigsfeld, A., Doolan, L. S., Bostrom, L., Russo, K., Schiering, M. S., Suh, B., Tenedero, H. (2009). Impact of learning-style instructional strategies on students' achievement and attitudes: Perceptions of educators in diverse institutions. *Clearing House*, *82*(3), 135-140.

Ebert-May, D., & Brewer, C. (1997). Innovative in large lectures--teaching for active learning. *BioScience, 47*(9), 601-607.

Eimers, M. T. (2001). The impact of student experiences on progress in college: An examination of minority and nonminority differences. *NASPA Journal, 38*(3), 386-409.

Fakomogbon, M. A., & Bolaji, H. O. (2017). Effects of collaborative learning styles on performance of students in a ubiquitous collaborative learning environment. *Contemporary Educational Technology*, *8*(3), 268-279.

Felder, R. M., & Brent, R. (1996). Navigating the bumpy road to student-centered instruction. *College Teaching, 44*(2), 43.

Fischer, K. W., & Silvern, L. (1985). Stages and individual differences in cognitive development. *Annual Review of Psychology, 36*(1), 613-648.

Frame, T. R., Cailor, S. M., Gryka, R. J., Chen, A. M., Kiersma, M. E., & Sheppard, L. (2015). Student perceptions of team-based learning vs traditional lecture-based learning. *American Journal of Pharmaceutical Education*, *79*(4), 1-11.

Frimming, R. E., Bower, G. G., & Chulhwan, C. (2013). Examination of a physical education personal health science course: Face-to-face classroom compared to online hybrid instruction. *Physical Educator, 70*(4), 359-373.

Gall, M.D., Gall, J.P., & Borg, W.R. (2007). *Educational research: An introduction* (8th ed). Boston, MA: Allyn & Bacon.

Gallardo-Virgen, J. A., & DeVillar, R. A. (2011). Sharing, talking, and learning in the elementary school science classroom: Benefits of innovative design and collaborative learning in computer-integrated settings. *Computers in the Schools, 28*(4), 278-290.

Giotopoulos, K., Alexakos, C., Beligiannis, G., & Stefani, A. (2010). Bringing ai to e-learning: The case of a modular, highly adaptive system. *International Journal of Information & Communication Technology Education, 6*(2), 24-35.

Gleason, J. (2012). Using technology-assisted instruction and assessment to reduce the effect of class size on student outcomes in undergraduate mathematics courses. *College Teaching, 60*(3), 87-94.

Gosper, M. V., McNeill, M. A., & Woo, K. (2010). Harnessing the power of technologies to manage collaborative e-learning projects in dispersed environments. *Journal of Distance Education, 24*(1), 167-185.

Graf, S., Liu, T. C., Kinshuk. (2010). Analysis of learners' navigational behavior and their learning styles in an online course. *Journal of Computer Assisted Learning, 26*(2), 116-131.

Greenwood, C. R., & Delquadri, J. (1995). Classwide peer tutoring and the prevention of school failure. *Preventing School Failure, 39*(4), 21.

Guskey, T. R. (2007). Closing achievement gaps: Revisiting Benjamin S. Bloom's "learning for mastery". *Journal of Advanced Academics, 19*(1), 8-31.

Guskey, T. R., & Gates, S. L. (1986). Synthesis of research on the effects of mastery learning in elementary and secondary classrooms. *Educational Leadership, 43*(8), 73.

Hadjianastasis, M., & Nightingale, K. P. (2016). Podcasting in the stem disciplines: The implications of supplementary lecture recording and 'lecture flipping.' *FEMS Microbiology Letters, 363*(4), 1-4. doi:10.1093/femsle/fnw006

Hannigan, A., Gill, O., & Leavy, A. M. (2013). An investigation of prospective secondary mathematics teachers' conceptual knowledge of and attitudes towards statistics. *Journal of Mathematics Teacher Education, 16*(6), 427-449. doi:10.1007/s10857-013-9246-3

Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The elements of statistical learning: Data mining, inference, and prediction* (2nd ed.). New York, NY: Springer.

Heinemann, M. H. (2007). Teacher-student interaction and learning in online theological education. Part four: Findings and conclusions. *Christian Higher Education, 6*(3), 185-206. doi:10.1080/15363750701283599

Helms, S. A. (2014). Blended/hybrid courses: A review of the literature and recommendations for instructional designers and educators. *Interactive Learning Environments, 22*(6), 804-810. doi: 10.1080/10494820.2012.745420

Hill, P. (2012). Online educational delivery models: A descriptive view. *Educause Review, 47*(6), 84.

Hodges, C. B., & Brill, J. M. (2007). Developing a training program for instructional assistants within a large-scale emporium-based environment: A nine-year evolution towards systemic change. *International Journal of Teaching & Learning in Higher Education, 19*(1), 93-104.

Hung, H. C., Yuen, S. C.-Y. (2010). Educational use of social networking technology in higher education. *Teaching in Higher Education, 15*(6), 703-714. doi:10.1080/13562517.2010.507307

Hung, H. C., Young, S. S.-C., & Lin, C.-P. (2015). No student left behind: A collaborative and competitive game-based learning environment to reduce the achievement gap of EFL students in Taiwan. *Technology, Pedagogy & Education, 24*(1), 35-49.

Hurtado, S., & Carter, D. F. (1997). Effects of college transition and perceptions of the campus racial climate on Latino students' sense of belonging. *Sociology of Education, 70*(4), 324-345.

Johnson, D., & Samora, D. (2016). The potential transformation of higher education through computer-based adaptive learning systems. *Global Education Journal, 2016*(1), 1-17.

Jung, H., Ediger, R., & Donghun, L. (2017). Students' satisfaction on their learning process in active learning and traditional classrooms. *International Journal of Teaching & Learning in Higher Education, 29*(1), 108-118.

Kakish, K. M., Pollacia, L., Heinz, A., Sinclair, J. L., & Thomas, A. (2012). Analysis of the effectiveness of traditional versus hybrid student performance for an elementary statistics course. *International Journal for the Scholarship of Teaching & Learning, 6*(2), 1-9.

Kamceva, E. S., & Goracinova-Ilieva, L. (2016). Adaptive model for discrete math of the e-learning system. *Vizione, 25*, 405-413.

Kamps, D. M., Greenwood, C., Arreaga-Mayer, C., Veerkamp, M. B., Utley, C., Tapia, Y., Bowman-Perrott, L., Bannister, H. (2008). The efficacy of classwide peer tutoring in middle schools. *Education & Treatment of Children, 31*(2), 119-152.

Kenney, J., & Newcombe, E. (2011). Adopting a blended learning approach: Challenges encountered and lessons learned in an action research study. *Journal of Asynchronous Learning Networks, 15*(1), 47-59.

King, A. (1990). Enhancing peer interaction and learning in the classroom through reciprocal questioning. *American Educational Research Journal, 27*(4), 664-687.

King, C. J. (2012). Restructuring engineering education: Why, how, and when? *Journal of Engineering Education*, 1- 5. Retrieved from http://ezproxy.liberty.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=71608314&site=ehost-live&scope=site

Klotz, D. E., & Wright, T. A. (2017). A best practice modular design of a hybrid course delivery structure for an executive education program. *Decision Sciences Journal of Innovative Education, 15*(1), 25-41. doi:10.1111/dsji.12117

Kintu, M. J., & Chang, Z. (2016). Student characteristics and learning outcomes in a blended learning environment intervention in a Ugandan university. *Electronic Journal of e-learning, 14*(3), 181-195.

Knight, C. C., & Sutton, R. E. (2004). Neo-piagetian theory and research: Enhancing pedagogical practice for educators of adults. *London Review of Education, 2*(1), 47-60. doi:10.1080/1474846042000177474

Komarraju, M., Musulkin, S., & Bhattacharya, G. (2010). Role of student-faculty interactions in developing college students' academic self-concept, motivation, and achievement. *Journal of College Student Development, 51*(3), 332-342.

Kuh, G. D., & Hu, S. (2001). The effects of student-faculty interaction in the 1990s. *Review of Higher Education, 24*(3), 309-332.

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *Journal of Economic Education, 31*(1), 30-43.

Lalley, J. P., & Gentile, J. R. (2009). Classroom assessment and grading to assure mastery. *Theory Into Practice, 48*(1), 28-35. doi:10.1080/00405840802577577

Larson, R., & Farber, B. (2015). *Elementary statistics: Picturing the world* (6th ed.). Boston, MA: Pearson Education.

Lim, J., Kim, M., Chen, S. S., & Ryder, C. E. (2008). An empirical investigation of student achievement and satisfaction in different learning environments. *Journal of Instructional Psychology, 35*(2), 113-119.

Liu, M., McKelroy, E., Corliss, S., & Carrigan, J. (2017). Investigating the effect of an adaptive learning intervention on students' learning. *Educational Technology Research & Development, 65*(6), 1605-1625. doi:10.1007/s11423-017-9542-1

Liu, X., Magjuka, R. J., Bonk, C. J., & Lee, S. (2007). Does sense of community matter? *Quarterly Review of Distance Education, 8*(1), 9-24.

Lochner, L., Wieser, H., Waldboth, S., & Mischo-Kelling, M. (2016). Combining traditional anatomy lectures with e-learning activities: How do students perceive their learning experience? *International Journal of Medical Education, 7*, 69-74. doi:10.5116/ijme.56b5.0369

Luo, N., Zhang, M., & Qi, D. (2017). Effects of different interactions on students' sense of community in e-learning environment. *Computers & Education, 115,* 153-160. doi:10.1016;j.compedu.2017.08.006

Lou, Y., & Abrami, P. C. (1996). Within-class grouping: A meta-analysis. *Review of Educational Research, 66*(4), 423.

Lowry, L. L., & Flohr, J. K. (2004). Technology and change: A longitudinal case study of students' perceptions of and receptiveness to technology enhanced teaching and learning. *Journal of Teaching in Travel & Tourism, 4*(1), 15-39. doi:10.1300/J172v04n01_02

Madrid, L. D., Canas, M., & Ortega-Medina, M. (2007). Effects of team competition versus team cooperation in classwide peer tutoring. *Journal of Educational Research, 100*(3), 155-160.

Marbach-Ad, G., Seal, O., & Sokolove, P. (2001). Student attitudes and recommendations on active learning. *Journal of College Science Teaching, 30*(7), 434.

Matheson, C. (2008). The educational value and effectiveness of lectures. *Clinical Teacher, 5*(4), 218-221. doi:10.1111/j.1743-498X.2008.00238.x

Matta Abdelmalak, M. M. (2015). Web 2.0 technologies and building online learning communities: Students' perspectives. *Online Learning, 19*(2), 87-106.

McCarty, R. (2008). Kant's incorporation requirement: Freedom and character in the empirical world. *Canadian Journal of Philosophy, 38*(3), 425-451.

McLaren, H. J., & Kenny, P. L. (2015). Motivating change from lecture-tutorial modes to less traditional forms of teaching. *Australian Universities' Review, 57*(1), 26-33.

Micari, M., Pazos, P. (2012). Connecting with the professor: Impact of the student-faculty relationship in a highly challenging course. *College Teaching, 60*, 41-42. doi:10.1080/87567555.2011.627576

Miller, D., Topping, K., & Thurston, A. (2010). Peer tutoring in reading: The effects of role and organization on two dimensions of self-esteem. *British Journal of Educational Psychology, 80*(3), 417-433.

Mong Shan, E., Yeoh, W., Yee Ling, B., & Boulter, T. (2018). Examining the effect of time constraint on the online mastery learning approach towards improving postgraduate students' achievement. *Studies in Higher Education, 43*(2), 217-233. doi:10.1080/03075079.2016.1161611

Nakayama, M., Mutsuura, K., & Yamamoto, H. (2016). Student's reflections on their learning and note-taking activities in a blended learning course. *Electronic Journal of e-Learning, 14*(1), 43-53.

Nawaz, A., & Rehman, Z. U. (2017). Strategy of peer tutoring and student's success in mathematics: An analysis. *Journal of Research & Reflections in Education, 11*(1), 15-29.

Ningjun, Y., & Herron, S. S. (2012). A correlation between hours spent in the math computer lab and final exam scores among computer-based college algebra students. *Review of Higher Education & Self-Learning, 5*(16), 26-30.

Olgun, Ö. S. (2009). Engaging elementary preservice teachers with active learning teaching methodologies. *Teacher Educator, 44*(2), 113-125. doi:10.1080/08878730902721772

Olic, S., & Adamov, J. (2016). Relationship between learning styles grammar students and school achievement. *Повезаност стилова учења ученика гимназије са школским успехом*, *40*(4), 1223-1240. doi:10.22190/TEME1604223O

O'Rourke, J., Main, S., & Cooper, M. (2014). Student perceptions of online interactive versus traditional lectures; Or how I managed not to fall asleep with my eyes open. *Journal of Online Learning & Teaching, 10*(3), 405-419.

Osterman, K. F. (2000). Students' need for belong in the school community. *Review of Educational Research, 70*(3), 323.

Ozyurt, O., Ozyurt, H., Baki, A., & Guven, B. (2013). Integration into mathematics classrooms of an adaptive and intelligent individualized e-learning environment: Implementation and evaluation of Uzwebmat. *Computers in Human Behavior, 29*(3), 726-238.

Pallant, J. (2010). *SPSS survival manual: A step-by-step guide to data analysis using SPSS version 15* (4^{th} ed.). Berkshire, UK: McGraw-Hill.

Pascarella, E. T., & Terenzini, P. T. (1979). Student-faculty informal contact and college persistence: A further investigation. *Journal of Educational Research*, *72*(4), 214-218.

Pereira, A. S., & Wahi, M. M. (2017). Course management system's compatibility with teaching style influences willingness to complete training. *Online Learning*, *21*(1), 36-59. doi:10.24059/olj.v21i1.763

Picciano, A. G. (2006). Online learning: Implications for higher education pedagogy and policy. *Journal of Thought, 41*(1), 75-94.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223-231.

Rais-Rohani, M., & Walters, A. (2014). Preliminary assessment of the emporium model in a redesigned engineering mechanics course. *Advances in Engineering Education*, *4*(1), 1-19.

Ralston, P. A., Tretter, T. R., & Kendall-Brown, M. (2017). Implementing collaborative learning across the engineering curriculum. *Journal of the Scholarship of Teaching & Learning, 17*(3), 89-108.

Robinson, D. R., Scholfield, J. W., & Steers-Wentzell, K. L. (2005). Peer and cross-age tutoring in math: Outcomes and their design implications. *Educational Psychology Review*, *17*(4), 327-362.

Robinson, H. A., Kilgore, W., & Warren, S. J. (2017). Care, communication, learner support: Designing meaningful online collaborative learning. *Online Learning, 21*(4), 29-51.

Rogers, M. E. (2004). A comparison of the effectiveness of modular drafting instruction versus contemporary drafting instruction on collegiate technology education students. *Journal of Industrial Teacher Education, 41*(2), 6-6.

Rosenthal, G. T., Folse, E. J., Alleman, N. W., Boudreaux, D., Soper, B., & Von Bergen, C. (2000). The one-to-one survey: Traditional versus non-traditional student satisfaction with professors during one-to-one contacts. *College Student Journal*, *34*(2), 315.

Rovai, A. P. (2002). Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks. *Internet & Higher Education, 5*(4), 319.

Rovai, A. P., & Jordan, H. M. (2004). Blended learning and sense of community: A comparative analysis with traditional and fully online graduate courses. *International Review of Research in Open & Distance Learning, 5*(2), 1-12.

Saleh, M., Lazonder, A. W., & Jon, T. D. (2007). Structuring collaboration in mixed-ability groups to promote verbal interaction, learning, and motivation of average-ability students. *Contemporary Educational Psychology, 32*(3), 314-331.

Sanchez, M., Martinez-Pecino, R., Rodriguez, Y. T., & Melero, P. T. (2011). Student perspectives on the university professor role. *Social Behavior & Personality: An International Journal, 39*(4), 491-496. doi:10.2224/sbp.2011.39.4.491

Scida, E. E., & Saury, R. E. (2006). Hybrid courses and their impact on student and classroom performance: A case study at the University of Virginia. *CALICO Journal, 23*(3), 517-531.

Scruggs, T. E., Mastropieri, M. A., & Marshak, L. (2012). Peer-mediated instruction in inclusive secondary social studies learning: Direct and indirect learning effects. *Learning Disabilities Research & Practice (Wiley-Blackwell), 27*(1), 12-20. doi:10.1111/j.1540-5826.2011.00346.x

Shea, J., Joaquin, M. E., & Gorzycki, M. (2015). Hybrid course design: Promoting student engagement and success. *Journal of Public Affairs Education, 21*(4), 539-556.

Shea, P., Sau Li, C., & Pickett, A. (2006). A study of teaching presence and student sense of learning community in fully online and web-enhanced college courses. *Internet & Higher Education, 9*(3), 175-190.

Shein, P. P., & Chiou, W. B. (2011). Teachers as role models for students' learning styles. *Social Behavior & Personality: An International Journal, 39*(8), 1097-1104. doi:org/10.2224/sbp.2011.39.8.1097

Shiu-Li, H., & Jung-Hung, S. (2012). A user-centric adaptive learning system for e-learning 2.0. *Journal of Educational Technology & Society, 15*(3), 214-225.

Siddique, A., Durrani, Q. S., & Naqvi, H. A. (2017). Designing adaptive e-learning environment using individual differences. *Pakistan Journal of Science, 69*(1), 101-109.

Slanger, W. D., Berg, E. A., Fisk, P. S., & Hanson, M. G. (2015). A longitudinal cohort study of student motivational factors related to academic success and retention using the college student inventory. *Journal of College Student Retention: Research, Theory & Practice, 17*(3), 278-302. doi: 10.1177/1521025115575701

Sorden, S. D., & Munene, I. I. (2013). Constructs related to community college student satisfaction in blended learning. *Journal of Information Technology Education, 12*, 251-270.

Sorgenfrei, C., & Smolnik, S. (2016). The effectiveness of e-learning systems: A review of the empirical literature on learner control. *Decision Sciences Journal of Innovative Education, 14*(2), 154-184. doi:10.1111/dsji.12095

Spradlin, K., & Ackerman, B. (2010). The effectiveness of computer-assisted instruction in developmental mathematics. *Journal of Developmental Education*, *34*(2), 12-42.

Stump, G. S., Hilpert, J. C., Husman, J., Wen-Ting, C., & Wonsik, K. I. (2011). Collaborative learning in engineering students: Gender and achievement. *Journal of Engineering Education, 100*(3), 475-497.

Summers, J. J., & Svinicki, M. D. (2007). Investigating classroom community in higher education. *Learning & Individual Differences, 17*(1), 55-67. doi:10.1016/j.lindif.2007.01.006

Swap, R. J., & Walter, J. A. (2015). An approach to engaging students in a large-enrollment, introductory STEM college course. *Journal of the Scholarship of Teaching & Learning*, *15*(5), 1-21. doi:10.14434/josotl.v15i5.18910

Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (6th ed.). Boston, MA: Pearson.

Tintle, N., VanderStoep, J., Holmes, V., Quisenberry, B., & Swanson, T. (2011). Development and assessment of a preliminary randomization-based introductory statistics curriculum. *Journal of Statistics Education, 19*(1).

Topping, K. J. (2005). Trends in peer learning. *Educational Psychology, 25*(6), 631-645.

Trespalacious, J., & Perkins, R. (2016). Sense of community, perceived learning, and achievement relationships in an online graduate course. *Turkish Online Journal of Distance Education, 17*(3), 31-49.

Tucker King, C. S., Keeth, S., & Ryan, C. (2018). Collaborative curriculum design and assessment: Piloting a hybrid first-year writing course. *Journal of Interactive Online Learning, 16*(1), 41-62.

Twigg, C. A. (2003). Improving quality and reducing cost. *Change, 35*(4), 22.

Twigg, C. A. (2011). The math emporium: Higher education's silver bullet. *Change, 43*(3), 25-34.

Twigg, C. A. (2013). Improving learning and reducing costs: Outcomes from changing the equation. *Change, 45*(4), 6-14. doi:10.1080/00091383.2013.806169

Umbach, P. D., & Wawrzynski, M. R. (2005). Faculty do matter: The role of college faculty in student learning and engagement. *Research in Higher Education, 46*(2), 153-184. doi: 10.1007/s11162-004-1598-1

Van Klaveren, C., Vonk, S., & Cornelisz, I. (2017). The effect of adaptive versus static practicing on student learning – evidence from a randomized field experiment. *Economics of Education Review, 58*, 175-187. doi:10.1016/j.econedurev.2017.04.003

Vaughan, N. (2007). Perspectives on blended learning in higher education. *International Journal on E-Learning, 6*(1), 81-94.

Vogt, C. M. (2008). Faculty as a critical juncture in student retention and performance in engineering programs. *Journal of Engineering Education*, *97*(1), 27-36.

Warner, R.M. (2013). *Applied Statistics: From bivariate through multivariate techniques*. Los Angeles, CA: Sage.

Wells, G., & Arauz, R. M. (2006). Dialogue in the classroom. *Journal of the Learning Sciences, 15*(3), 379-428.

Whatley, J., & Bell, F. (2003). Discussion across borders: Benefits for collaborative learning. *Educational Media International, 40*(1/2), 139.

Wilder, S., & Berry, L. (2016). Emporium model: The key to content retention in secondary math courses. *Journal of Educators Online, 13*(2), 53-75.

Wilson, J. H. (2008). Instructor attitudes toward students: Job satisfaction and student outcomes. *College Teaching, 56*(4), 225-229.

Witkowsky, K. (2008). Increasing learning and reducing costs through technology: The University of Alabama story. *Change*, *40*(2), 32-39.

Yadav, A., Subedi, D., Lundeberg, M. A., & Bunting, C. F. (2011). Problem-based learning: Influence on students' learning in an electrical engineering course. *Journal of Engineering Education, 100*(2), 253-280.

Yoon, J. S. (2002). Teacher characteristics as predictors of teacher-student relationships: Stress, negative affect, and self-efficacy. *Social Behavior & Personality: An International Journal, 30*(5), 485-493. doi: 10.2224/sbp.2002.30.5.485

Young, J. R. (2002). 'Hybrid' teaching seeks to end the divide between traditional and online instruction. *Chronicle of Higher Education, 48*(28), A33.

YunJeong, C., & Seung Won, P. (2014). Exploring students' perspectives of college stem: An analysis of course rating websites. *International Journal of Teaching & Learning in Higher Education, 26*(1), 90-101.

Zahid, M. A., Varghese, R., Mohammed, A. M., & Ayed, A. K. (2016). Comparison of the problem based learning-driven with the traditional didactic-lecture-based curricula. *International Journal of Medical Education, 7*, 181-187. doi:10.5116/ijme.5749.80f5

Ziegert, A. L. (2000). The role of personality temperament and student learning in principles of economics: Further evidence. *Journal of Economic Education, 31*(4), 307-322.

Ziegler, L. A. (2014). *Reconceptualizing statistical literacy: Developing an assessment for the modern introductory statistics course* (Order No. 3630287). Available from ProQuest Dissertations & Theses Global. (1562784265).

Zonnefeld, V. L. (2015). *Mindsets, attitudes, and achievement in undergraduate statistics courses* (Order No. 3714377). Available from ProQuest Dissertations & Theses Global. (1734104481).

APPENDICES

Appendix A: Data Collection Procedures

The online CAOS assessment on conceptual introductory statistics knowledge was delivered online by a link sent in an email to each participant. The CAOS assessment takes approximately 30 to 45 minutes to complete. The researcher set the days the assessment was available to students. After the assessment was closed, the results were available to the researcher by request.

Appendix B: IRB Approval Letter

August 24, 2018

Dear Gail M. McGowan,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(1,2), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Please retain this letter for your records. Also, if you are conducting research as part of the requirements for a master's thesis or doctoral dissertation, this approval letter should be included as an appendix to your completed thesis or dissertation.

Your IRB-approved, stamped consent form is also attached. This form should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document should be made available without alteration.

Please note that this exemption only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether possible changes to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,

[redacted]

Administrative Chair of Institutional Research

The Graduate School

Appendix C: Consent Form

The Liberty University Institutional
Review Board has approved
this document for use from
8/24/2018 to --
Protocol # 3419.082418

CONSENT FORM

A Correlational Study on Components of Hybrid Course Delivery and Student Success in Introductory Statistics
Gail M. McGowan
Liberty University
School of Education

You are invited to be in a research study to examine the relationship between weekly components of a math emporium course and students' conceptual understanding of statistics. You were selected as a possible participant because you are enrolled in an emporium format introductory statistics course (Math 201/Busi 230) during the fall 2018 semester and are 18+ years old. Please read this form and ask any questions you may have before agreeing to be in the study.

Mrs. Gail M. McGowan, a doctoral candidate in the School of Education and a faculty member in the College of Arts and Sciences at Liberty University, is conducting this study.

Background Information: The purpose of this study is to examine the relationship between weekly components of a math emporium course and students' conceptual understanding of statistics.

Procedures: If you agree to be in this study, I would ask you to do the following things:

1. Complete a short survey that requests basic demographic information. The survey should take approximately 5 minutes.
2. Complete the online assessment that measures statistics comprehension. The assessment should take approximately 30 – 45 minutes.
3. Allow me to collect other data that includes your weekly emporium attendance, weekly classroom attendance, weekly quiz average, number of weekly quiz attempts, and final grade in the course. This data will remain confidential.

Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

Benefits: Participants should not expect to receive a direct benefit from taking part in this study.

The information obtained from the study may benefit society by helping future faculty and administrators design hybrid classes that include the elements found to contribute most to student success.

Compensation: Participants will be compensated for participating in this study. Twelve participants will be randomly chosen to each receive a twenty dollar gift card. To be eligible to receive the gift card, a participant must complete the survey, complete the online assessment of statistics comprehension, and complete the course. Compensation will be mailed to the participant within four weeks of the end of the semester.

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8/24/2018 to --
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Confidentiality: The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records. I may share the data I collect from you for use in future research studies or with other researchers; if I share the data that I collect about you, I will remove any information that could identify you, if applicable, before I share the data.

A coding system will be used for all data collected to protect participant identities. A codebook that links the code to the student will be stored in a locked safe. All digital data will be stored on a password-locked computer in a password-locked file. Any paperwork will be locked in a file cabinet in my locked office. Data may be used in future presentations or published research. After three years, all electronic records will be deleted and all paper records will be shredded.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

How to Withdraw from the Study: If you choose to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw, data collected from you, will be destroyed immediately and will not be included in this study.

Contacts and Questions: The researcher conducting this study is Gail McGowan. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at gmmcgowan@liberty.edu. You may also contact the researcher's faculty chair, Dr. Nathan Putney, at nputney@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

Statement of Consent: I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature of Participant Date

Signature of Investigator Date

Appendix D: Survey to Collect Demographic Data

The following survey was sent to students as a link in an email. The survey used Google Forms for collecting the data. Data was assembled, exported, and stored by the researcher in a password protected folder on a password protected computer used only by the researcher.

Last name:

First name:

Student ID number:

Math 201/Busi 230 section number:

Gender: (male/female/prefer not to respond)

Age (in years):

College Classification: (Undergraduate freshman/Undergraduate sophomore/Undergraduate junior/Undergraduate senior/Graduate Master's degree/Graduate Other

Major:

How much time (in minutes) would you estimate that you spend studying each week for Introduction to Statistics outside of the math emporium?

Appendix E: Email Sent to Students with CAOS link

Hello Math 201/Busi 230-004 students! Below you will find the link to the online statistics conceptual knowledge assessment that I talked to you about at the beginning of the semester. I have also attached the consent form so that you have access to all of the details of the dissertation study. Twenty dollar gift cards will be given to twelve randomly selected students. Those cards will be delivered within four weeks of the end of the semester.

All information is confidential, including the results of the assessment.

Do not worry if you do not understand all of the questions. Just answer each question to the best of your ability. The online assessment should take approximately 30 minutes to complete. After clicking the link to take the online assessment, you will need to enter the access code provided below.

Link to the online assessment:

XXXX (deleted by the researcher)

Access code: XXXXXXX (deleted by the researcher)

Thank you for your help! Should you have any questions, feel free to contact me.

Prof. Gail M. McGowan
email: gmmcgowan@liberty.edu