11-3-2017

Teaching Introductory Statistics to Graduate Students in the Social Sciences: A Mixed Method Investigation of the Effectiveness of Simulations in Statistics Education

Liuli Huang
Louisiana State University and Agricultural and Mechanical College

TEACHING INTRODUCTORY STATISTICS TO GRADUATE STUDENTS IN THE SOCIAL SCIENCES: A MIXED METHOD INVESTIGATION OF THE EFFECTIVENESS OF SIMULATIONS IN STATISTICS EDUCATION

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University
And Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

in

The School of Education

by
Liuli Huang
B.A., Huazhong University of Science & Technology, 2011
M.A., Louisiana State University, 2016
December 2017

ACKNOWLEDGEMENTS

I would never have been able to finish my dissertation without the guidance of my committee members, help from friends, and support from my family.

First and foremost, I wish to thank my advisor, professor Eugene Kennedy, for his guidance, patience and caring in supervising my research. He provides me the opportunities to collaborate with many different groups around and to learn from different people from conferences and projects. I feel deeply grateful and fortunate to have the opportunities to have professor Kennedy as my advisor.

I also wish to thank my committee members, professor Keena Arbuthnot, professor Bin Li, professor Lin He, for their great ideas, patience, and time for my research.

This dissertation would not be possible without the help from my colleagues and friends. I wish to thank Renée Elissa Lastrapes, my former colleague in our group, who helped me a lot in my research; I wish to thank Marvin Broome, the editor from the writing center of LSU, who helped me a lot with my writing during my dissertation. I also wish to thank my friends outside the group. I wish to thank Enzhi Li and Mengxi Wu for their technical help during the research. I thank Erin Scott-Stewart, Deanna Kay Rice, and Shaofei Han for their support and encouragement.

And I also wish to thank Fang He, Qun Tang, Biao Yang, and Daoshi Luo, my best friends from elementary school until college, who have always supported me and are willing to help me.

Finally, I thank my parents and little brother for their love and support. I also wish to thank my boyfriend, Mengxi Wu for his great ideas, passion, encouragement, support, and accompanying in my life.

TABLE OF CONTENTS

ABSTRACT

The primary purpose of this study was to determine the effectiveness of using simulations as an instructional tool in an introductory doctoral level statistics course. The study focused on the impacts of simulations on students' attitudes and understanding of statistical concepts, as well as how the simulations could inspire students' positive attitudes and improve statistics performance or would fail to help. In addition, since the statistics anxiety has been a primary obstacle to students' statistics education, and "statistics anxiety" is experienced by as many as 80% of graduate students (Onwuegbuzie, 2004). The researcher was interested to explore the details of the statistics anxiety related attitudes of this group of students, including examining their anxiety levels before and after the introductory statistics course. Whether their anxiety levels diminished after the introductory statistics course, and what actions could be taken to release their anxiety. Moreover, the course has a hybrid online or flipped structure, and the target population for this study was social sciences adult learners, with limited background in statistics or mathematics. Given the prevalence of the online course, especially considering the constraints and background of this target population, the researcher was interested to determine the preferred statistics learning style of the social sciences adult learners, whether in-class or online, as well as the factors leading to the particular preference.

The mixed method research approach was used in this study, combing both quantitative and qualitative research methods. A total of twenty-two social sciences adult learners was involved in this study, five of which were from the Spring semester, while seventeen of the remaining were from the Fall semester.

The quantitative method of Mann-Whitney U test and Kruskal Wallis test, together with the qualitative method of thematical analysis, produced some impressive findings. The use of

simulations could inspire social sciences adult learners' positive attitudes toward statistics, develop a higher self-efficacy, and improve the understanding of the statistical concept of Central Limit Theorem (CLT), even though not significant. In addition, the social sciences adult students' anxiety levels diminished after the introductory statistics course. Lastly, the online learning style was inappropriate for the introductory statistics course for adult learners from social sciences.

CHAPTER 1
INTRODUCTION

The Importance of Statistical Literacy

Developments in information technology over the past several decades have been profound. Almost every aspect of contemporary life has a digital footprint. Whether the focus is education, business, medical or even personal, digital technologies play an increasingly important role in how people interact and the mega datasets generated are a virtual goldmine of information. Statistical tools play a critical role in sorting, organizing, and synthesizing this information for both individuals as well as organizations. Statistical literacy is thus increasingly recognized as one of the indispensable skills of graduates of post-secondary institutions. Statistical literacy entails an understanding of basic statistical terms and concepts, the ability to organize and extract information from data using available technologies, and the ability to critically evaluate statistical analyses and reports (Garfield, 1999; Snell, 1999; Rumsey, 2002). In 2016, Ben-Zvi and Makar stated that there is a growing public and policy consensus that being able to make reliable and persuasive inferences from data is a crucial skill all citizens of the twenty-first century should have.

Background and Existing Research in Statistics Education

In the current educational environment, there is growing consensus that statistics education is in need of improvement. Snee (1993) stated that statistics teaching has traditionally focused on developing knowledge and skills instead of statistical thinking. This problem still exists, especially among students of the social sciences, who typically do not have an extensive background knowledge in statistics or mathematics. In general, researchers have identified four key challenges associated with statistics education: (1) statistical concepts are abstract and difficult, (2) students lack the ability to think in statistical terms, (3) misconceptions hinder students' statistics education, and (4) students' limited backgrounds and negative attitudes hinder statistics education. Statistics is a difficult subject for many students, particularly those whose majors are not related to statistics or mathematics. Many university instructors find statistics frustrating and unrewarding to teach. In K12 schools, mathematics teachers often view statistics as a marginal strand in the mathematics curriculum and therefore minimize or ignore its teaching (Ben-Zvi & Makar, 2016).

Statistics Concepts are Abstract and Difficult

Many statistical concepts and rules are abstract, complex, counterintuitive and are difficult to define in words. For example, probability, p-value, and confidence intervals are all difficult to the beginning statistics students since they are abstract, and no interpretation of these concepts are at once simple, intuitive and correct (Greenland et al., 2016). Without an understanding of these basic concepts, the statistics learning process becomes more difficult, especially when teachers or statisticians routinely use these terms in the classroom or workplace. Moreover, teachers often underestimate the difficulty of statistics for many students. In 1995, Joan Garfield argued that such concepts as the hypothesis, probability, z distribution, t distribution, and error rates are often far more difficult for students than teachers expect them to be. Similarly, in the K-12 setting, studies exploring students' understanding of basic concepts, such as data (e.g., Ben-Zvi & Arcavi, 2001), distribution (e.g., Pfannkuch, 2006; Prodromou & Pratt, 2006; Reading & Reid, 2006), variability (e.g., Bakker, 2004; Ben-Zvi, 2004b; Hammerman & Rubin, 2004; Reading, 2004; delMas & Liu, 2005), and probability (e.g., Abrahamson et al., 2006; Pratt, 2005) also suggested these concepts are often more complex and difficult for students to learn than their teachers expect. When this mismatch between teacher assumptions/expectations and students' understanding occurs, the impact on statistics education can be significant and negative. Students taught in such settings are likely to have very negative views of statistics and will result in low levels of achievement.

Students Lack the Ability to Think Statistically and Critically

Many students lack the ability to think statistically. Ben-Zvi and Makar (2016) argued that statistics education should entail teaching students' skills of statistical and critical thinking. Ennis' taxonomy (Ennis & Millman, 1985) indicated that critical thinking entails raising questions, having doubts and exploring the definitions of the essential notions. Similarly, Watson and Moritz (1997) supported the idea by saying that there are three levels of understanding of statistical concepts, with the highest level being "to be able to raise questions about the improper use of statistics observantly." Also, Both Gal (1997) and Watson (1997) emphasized that critical evaluation of statistical information is one of the most important aspects of statistical literacy. Two key concepts or overarching ideas in statistical thinking relevant to the critical assessment are manipulations of data by reduction (Kröpfl, Peschek, & Schneider, 2000) and dealing with statistical variation (e.g., Watson & Callingham, 2003). Successfully manipulating data by reduction requires the awareness that, for example, calculating a mean value affords an overview of the original data, but it reduces the initial information. When students fail to demonstrate the understanding of such concepts, we characterize this as a failure to think statistically. The available evidence suggests that such failures are common in K12, as well as post-secondary education.

Nikiforidou, Lekka, and Pange (2010) stated that all statistics related terms, inclusive of statistical literacy, reasoning, and thinking, converge to the principle that statistical citizenship develops from school settings and then most importantly relate mainly to the process of evaluating, interpreting and communicating data.

Student Misconceptions Can Hinder Statistics Education

There are many misconceptions regarding fundamental statistical concepts among students, which are often difficult to overcome. Garfield and Ahlgren (1988) argued not only that misconceptions about fundamental statistical ideas are widespread and persistent, but also exist among students at almost all levels, and even among experienced researchers. Some critics (e.g., Garfield, 1995; Gigerenzer, 1996; Sedlmeier, 1999) claimed that the cause of many identified misconceptions is the inability of students to use appropriate statistics knowledge, while the root reason is that students do not understand the logics behind the basic statistical concepts.

Student Backgrounds and Attitudes Can Hinder Statistics Education

Valero-Mora et al. (2011) argued that students' limited backgrounds and negative attitudes toward statistics impact their statistics learning in a significant way. Most students from the social sciences lack an extensive background in statistics or mathematics. As a result, they find the subject challenging and thus often associate it with negative attitudes and emotional states (Ratanaolarn, 2016). This limited background in statistics is a major factor leading to student anxiety in statistics. 80% of graduate students experience statistics anxiety (Onwuegbuzie, 2004). Moreover, some studies reported that undergraduate students are likely to experience severe anxieties in their encounters with concepts, questions, or tests related to statistics (Zeidner, 1991; Onwuegbuzie, 1998; Onwuegbuzie & Leech, 2003). Researchers opined that anxiety in statistics is regarded as the primary obstacle in acquiring a degree (Onwuegbuzie, 1998; Onwuegbuzie & Leech, 2003). Furthermore, many students often do not have an enthusiastic attitude toward statistics or mathematics. Bush and Menzies (2009) argued that many statistics teachers find motivating and engaging social sciences students a persistent challenge.

Adult students are one of the most rapidly growing segments of today's college student population (Chronicle of Higher Education Almanac, 1999-2999). Ross-Gordon (2005) noted that adult students, most typically defined as those over 24 years of age, now constitute a majority of the undergraduate student population. Presently, education for adult learners is becoming more and more important in the global educational system. According to OECD Adult Education (2017) is found overwhelmingly on a worldwide scale, while the percentage of tertiary education for adult learners, ranging in age from 25 to 64 years, has increased significantly from 2000 to 2015. This trend is steadily on the rise. The adult students opting for tertiary education in the United States increased from 39.49% in 2000 to 44.63% in 2015. This indicator is relative to the highest level of tertiary education completed by a 25 to 64-year-old population.

The target population for this study was adult learners in the social sciences. Most undergraduate and graduate students in social sciences are required to take statistics courses as part of their program. These individuals need statistical skills to read academic reports and papers, design experiments, and analyze quantitative data collected from surveys or test results. When analyzing data, these students usually encounter significant problems, due to the lack of familiarity with statistical skills such as the analysis of variance (ANOVA), the analysis of covariance (ANCOVA), regression, exploratory data analysis, multivariate analysis techniques, etc. (Gould, 2010). However, this group of students displays a minimal background in statistics or mathematics. This adds to the difficulty of statistics education even more. As a result, statistics anxiety levels among these students may be higher than those students from statistics or mathematics natured areas (Zeidner, 1991). Pan and Tang (2005) also stated that students with limited prior statistical or mathematical training might show noticeably higher levels of statistics anxiety.

In addition, this study focused on adult learners, defined as graduate students ranging in age from 25 to 64 years. Compared to traditional learners, adult learners usually have life situations and constraints, such as part- or full-time jobs, and often need to deal with family issues, including caring for children and/or elders. The primary limitation in statistics learning for the adult students could be the shortage of time (Lundberg, 2003).

Besides the background of this target population, the adult learners have some unique traits that may hinder or help their statistics learning. According to Pappas (2013), adult learners have the following eight characteristics. (1) Adult learners are self-directed. They feel the need to take responsibility for their lives and decisions, and as a result, they desire control over their learning. This characteristic is a potential strength for the adult learners. (2) Adult learners are practical and results-oriented. They often resent theory and desire information that can be immediately applicable to their professional needs. Adult learners prefer practical knowledge that will improve their skills, facilitate their work and boost their confidence. (3) Adult learners are less open-minded, and thus more resistant to change, such as transferring from traditional teaching method to virtual online teaching method. This is a potential challenge for the adult learners. (4) Adult learners are slower learners, yet more integrative of knowledge. (5) Adult learners usually use personal experience as a resource. (6) Adult learners have strong self-motivation, so their learning is typically voluntary. (7) Adult learners generally have multi-level responsibilities, including family, friends, work, and the need for personal quality time. This is another potential challenge for adult learners. (8) Adult learners have high expectations, and they expect to be taught about skills that will be useful to their work or research, and expect to have immediate results, and seek courses that are worth their investment of time and money.

Attention to diverse learning styles offers a promising pathway for educators to enhance statistics education (Blackmore, 1996). Instructors should incorporate a variety of approaches in statistics education, since individuals are varied in multiple ways and tend to learn differently (Curriculum Renewal Across the First Two Year (CRAFTY) Statistics Report (Moore and Peck and Rossman, 2000)). With contemporary developments in technology, educators are better positioned than ever before to be responsiveness to the variety of learning styles. Some of the more popular strategies are web-based or online delivery, hybrid classes, and flipped classrooms. The flipped methods in teaching styles are growing in popularity relative to traditional lecture classes, the definitions and elements of a flipped classroom teaching are varied, yet research as to which methods are most effective has not yet provided clear answers (Allen, Seaman, & Garret 2007; Bowen, Chingos, Lack, & Nygren 2012).

Some of the components for the flipped classroom include online technology, self-paced learning, video lectures outside of class, engaging, and inquiry-based learning environment (Ziegelmeier & Topaz, 2015; Novak, Kensington-Miller, & Evans, 2017; Love, Hodge, Corritore, & Ernst, 2015; McGee, Stokes, & Nadolsky, 2016).

Online teaching has become a critical concern in higher education. According to the 2011 Sloan Survey of Online Learning (Allen & Seaman, 2011; Škrinjarić, 2014), the number of students taking one or more online courses surpassed 6.1 million during the Fall 2010 semester, increasing from 3.94 million in Fall 2007 to 5.6 million in Fall 2009. The online learning style has become such an integral part of higher education that 65% of the institutions of higher education include online learning as a critical part of their long-term strategy (Allen & Seaman, 2011). Online courses have become more and more prevalent and thus may prove to be indispensable in the near future. Presently, learners in modern society choose online course primarily for two reasons, to balance their time and space limitations, or because of their preference for the online course. In this study, the researcher is interested to identify the social sciences adult learners' preferred statistics learning style, whether in-class or online.

Simulation as a Promising Approach for Statistics Education

The challenges to statistics education continue to plague many students. However, several strategies to address these problems have been put forth in the statistics education literature. Bush and Menzies (2009) noted that educators and researchers in statistics are working on new teaching methods and at the same time sharing a significant and growing collection of tools and ideas on the Web. One approach mentioned with increasing regularity in the literature is the use of simulations in statistics teaching and learning. Of particular focus for this study, many researchers suggested the use of computers, graphs, simulations, and hands-on activities in statistics teaching (e.g., Feinberg, 1979; Kosslyn, 1985; Pedro M. Valero-Mora, Ruben D. Ledesma, 2011). Garfield (1995), for example, argued that computer graphics can help students visualize and explore data by providing different ways to represent a given data set. Beyond simple graphic displays, simulations can include graphics as part of a pedagogical approach in which students explore relationships and patterns. As noted by Jones et al. (2004), most students prefer simulations to didactic instruction:

> 'I found it to be self-explanatory and helpful to work with because I am a visual learner and it is a good visual tool.'
> '[Visual Sampling Distributions] is more concise and more focused towards what we do in class. It is also more universally usable to be able to run the simulations quickly and derive a result.'
> 'It is very helpful to be able to configure different samples and see the different results.'

The study from Hagtvedt, Jones, and Jones (2007) found that pedagogical simulations help students understand such essential statistics concepts as the Sampling Means Distributions and the Central Limit Theorem (CLT). Mills (2003) and other researchers in education and psychology proposed that students learn well by actively building or constructing their knowledge and making sense out of this knowledge. All in all, simulation is a tool that permits students to actively participate in the process of building, constructing, and generating knowledge.

Ben-Zvi and Makar (2016) suggested that the most effective method of statistics instruction is to allow students to participate in a statistical process wherein they gain an understanding of the role of statistics in addressing real questions. Simulations may encourage students to consider the conceptual underpinnings of why and what by imitating the real-world process over time? For example, "Why stratified sampling but not simple random sampling? What are the advantages and disadvantages of each of the two sampling techniques?" These authors suggested that students' understanding and thinking emerges from their involvement in collecting samples, calculating the statistics, constructing graphs and comparing the results generated by each sampling technique (Hodgson & Burke, 2000). Similar results regarding improving reasoning and understanding have been reported by other researchers (e.g., Ben-Zvi & Amir, 2005; Cobb et al., 2003b; Pfannkuch, 2006). In addition to gains in understanding and reasoning, simulations have the potential to change students' misconceptions. This is possible as students are able to explore various strategies for solving problems and obtain feedback on the accuracy of their ideas. If this new information is discernible and can be viewed as beneficial, then students may change their erroneous ideas. Students who are able to construct and conceptually alter their incorrect beliefs may have a better chance of becoming a more effective problem solver.

Statistical Concept of Central Limit Theorem (CLT)

The ideas associated with the CLT are challenging for introductory students to understand (Mulekar, 2006). The CLT is one of the most important concepts taught in an introductory statistics course. However, it may be the least understood by students. Students can enter numbers into a formula and solve problems, but conceptually, not understand what the CLT is about (Ruggieri, 2016). Moreover, the CLT is a fundamental concept that many other statistics concepts are inferred from, like z-test, t-test, ANOVA, and so on. Without understanding the underlying logic behind the CLT concept, students can be expected to struggle with statistics built upon the CLT theorem. In this study, the focus is on social sciences adult learners' understanding of the CLT concept.

Statement of the Problem

Over the last 20 years, there has been increasing attention given to the teaching and learning aspects of statistics education (Koparan, 2015). It is necessary for educators and researchers to better understand the challenges in statistics education and to develop effective solutions as statistical literacy is expected to grow in importance. Despite the expanding number of studies on diverse challenges and approaches in statistics education, there continue to be limitations and gaps in the current literature.

Statistics education for social science students is an important topic since most students from the social sciences tend to have limited background in statistics or mathematics, while such a lack of background knowledge makes statistics comprehension difficult. Furthermore, statistics itself is not an easy subject. The inherent mathematical difficulties of statistical language and abstract statistical concepts tend to make statistics learning even more of a challenge. However, most studies of these issues have been based on undergraduate students, such studies as undergraduate students' statistics anxiety, performance and self-efficacy (Keeley, Zayac, & Correia, 2008). Statistics education for adult learners with an increasing population for tertiary education are rarely discussed. Adult learners, which can be characterized by traits of self-directed, strong motivation, less open-minded, multi-level responsibilities, and high expectations (Pappas, 2013). They can be expected to have different learning experiences compared with that of younger students.

In this study, the researcher would review the literature and address the shortcomings. To begin with, most of the previous studies related to simulations are conducted either with the qualitative or quantitative approach, the mixed methods lacking. The mixed methods with both quantitative and qualitative methods are used in this study to thoroughly explore students' statistics related attitudes, perceptions, and achievements.

Second, although many researchers have recommended using simulations in statistics education and many studies have supported the effectiveness of using simulations to enhance students' understanding of the basic, abstract, and complex statistical concepts, very few empirically and theoretically based studies indicate what measures should be used to assess the effectiveness of the simulations. The study from Jamie (2004) evaluated the effectiveness of the simulations based on students' understanding of seven open-ended questions based on the CLT. Another study from Reidar et al. (2007) assessed the effectiveness of simulations based on students' experience of using simulations, such as time spent on explaining the statistical concept, time spent on experimenting with parameters, how much students learned, the user-friendly nature of the software, etc. However, no one of the measures alone is enough to evaluate the effectiveness of simulations on students' statistics education. In this study, the researcher will evaluate the effectiveness of simulations from a mixture of four aspects: (1) open-ended questions designed based on the properties related to CLT, (2) surveys concerning students' self-efficacy toward CLT, (3) students' attitudes toward statistics, and (4) clinical interview from students' first-hand experience.

Third, there has been limited research on the effects of how simulations impact students' attitudes toward statistics. Most previous research has focused on students' perceptions and attitudes toward the use of simulations, as well as how the attitudes impact students' performances (Valero-Mora et al., 2011). This study will measure whether the use of simulations would inspire students' positive attitudes toward statistics, thus further improve statistics performances.

Fourth, as an instructional tool, many researchers have recommended simulations for a range of statistics topics: the binomial distribution (Shibli, 1991), regression analysis (Franklin, 1992), sampling means distribution (delMas et al., 1999; Marasinghe et al., 1996; Weir, McManus, & Kiely, 1990), hypothesis testing (Flusser & Hanna, 1991), and concepts related to survey sampling (Chang, Lohr, & McLaren, 1992; Kalsbeek, 1996; Schwarz, 1997). Liu, Lin, and Kinshuk (2010) noted that even though simulation-based learning has the potential to help students understand statistical concepts (e.g., Morris & Scanlon, 2000; Morris, 2001), it is still far from ideal (e.g., Yu et al., 1995; Hodgson & Burke, 2000; Morris, 2001; Morris et al., 2002; Kadijevich et al., 2008). Also, although simulations have been widely developed and applied in statistics education, few empirical studies have been discussed on how the simulations help students' statistics learning (Mills, 2002; Morris et al., 2002). Moreover, in a review of 48 studies, Mills (2002) indicated that most of the existing studies lack theoretical foundations of how simulations work to improve students' statistics learning. To that end, the current study seeks to investigate how simulations improve students' understanding of the fundamental statistical concept of CLT, and their attitudes toward statistics thoroughly.

Gal and Ginsburg (1994) stated that the introductory statistics course should include the goal to prepare students to take higher-level statistics courses. However, limited research is available regarding students' anxiety related attitudes toward statistics both before and after the introductory statistics course. Most previous studies concerning students' pre- and post- attitudes toward statistics are conducted during the middle of the semester, which could not reflect students' attitudes after they finished the introductory statistics course (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014). Even during the semester, most of the studies are focused on undergraduate students (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014). In this study, students' attitudes toward statistics at the very beginning, and after the introductory statistics course will be discussed and compared, and whether students plan on taking higher level statistics courses will also be checked.

Next, some studies focus on students' statistics anxiety and actions to reduce anxiety levels, conducted with a quantitative approach. Yet too little qualitative research exists in this area. The difference between undergraduate and graduate students in statistics learning is even less discussed, which may lead to a bias in statistics education since undergraduate and graduate students are very different regarding their backgrounds, learning motivations, learning habits, etc. As a result, insufficient qualitative research is available on social sciences adult learners' statistics anxiety related attitudes, and actions to release anxiety and make the statistics learning process enjoyable. This study is conducted to fill the gap in this area by focusing on a qualitative research approach to explore the statistics learning experiences of social sciences graduate students.

Furthermore, previous studies, even though very few, focusing on students' preferred learning styles are conducted with a quantitative approach. Yet too little qualitative research exists in this area. Moreover, little research has focused on factors leading to students' preferred learning styles. As a result, very limited qualitative research is available on students' preferred statistics learning style, inclusive of possible factors leading to the particular preference. In addition, studies focusing on social sciences students often target undergraduate students. Most of the modern students in the social sciences range from 25 to 64 years of age and have strikingly different characteristics, compared to undergraduate students. This study, conducted to fill that gap, will focus on a qualitative approach by means of not only exploring the rarely discussed aspects from students' perspectives, but also by focusing on adult learners from social sciences.

The goal of this study is to address the shortcomings in the literature described above. It is expected that this study would not only point to the value, or lack thereof, of these enhancements, but provide guidance on effective education approaches to targeting the specific population of students to develop their interests in statistics. Moreover, this study would provide insights into the unique factors involved in statistics education for adult learners and the development of their knowledge and understanding over time, such as provides guidelines for this group of the population to deal with statistics anxiety and gain confidence in their statistics education.

Purpose of the Study

The primary purpose of this study is to determine the effectiveness of using simulations as an instructional tool in an introductory doctoral level statistics course. The study focuses on the impact of simulations on students' attitudes and understanding of statistical concepts, as well as how the simulations would inspire students' positive attitudes and improve statistics performance or would fail to help. In addition, since the statistics anxiety has been a primary obstacle to students' statistics education, and "statistics anxiety" is experienced by as many as 80% of graduate students (Onwuegbuzie, 2004), the researcher was interested to explore the details of the statistics anxiety related attitudes of this group of students, including examining their anxiety levels before and after taking the introductory statistics course. Specifically, the researcher would explore whether students' anxiety levels diminish, and what actions could be taken to release the statistics anxiety. Moreover, the course that was the focus of this study has a hybrid online or flipped structure, and the target population for this study was social sciences adult learners, with limited background in statistics or mathematics. Given the prevalence of the online course, especially considering the constraints and background of this target population, the researcher was interested to determine the preferred statistics learning style of the social sciences adult learners, whether in-class or online, as well as the factors leading to the particular preference.

Research Questions

The following five major objectives guided this study:

1. The first objective of this study is to determine if the simulations have effects on inspiring students' positive attitudes toward statistics, and improving students' self-efficacy toward the statistical concept of CLT.
2. The second objective is to explore whether the simulations would help improve students' understanding of the particular statistical concept of CLT.
3. Based on the results from the first and second research questions, the third research question is to determine how the simulations helps or fails to help in students' statistics learning process.

4. The fourth objective is to explore students' anxiety related attitudes toward statistics before and after the introductory statistics course. Whether students' anxiety levels diminish or not, and what actions could be taken to release students' statistics anxiety.
5. The fifth objective is to identify the social sciences graduate students' preferred statistics learning style, in-class, or online; specifically, what are the factors leading to the particular preference?

CHAPTER 2
REVIEW OF THE LITERATURE

To date, the integration of technology into education is a topic of interest at many instructional and administrative levels of education (Nicolle, 2005). This is also true in statistics education. The growing and pervasive development of technology and the increasing attention to statistical literacy have produced a body of literature focused on the challenges in statistics education, and how different research designs evaluate the effectiveness of using technology, including simulations, in statistics education. In addition, students with social science backgrounds frequently face challenges learning statistics, including limited backgrounds in statistics or mathematics, and negative attitudes toward statistics (Dempster & McCorry, 2009; Schneider, 2011).

Adult education, according to a recent report (OECD Adult Education, 2017), is growing on a global scale and tertiary education for adult learners, ranging in age from 25 to 64 years, has increased significantly from 2000 to 2015. The adult students opting for tertiary education in the United States increased from 39.49% in 2000 to 44.63% in 2015. Adults bring a number of unique challenges to statistics education and to the integration of technology in statistics education.

Finally, whether younger students or adults, learning styles and preferences play a role in the statistics education process. Attention to diverse learning styles offers a promising pathway for educators to enhance statistics learning (Blackmore, 1996). Accordingly, it has been recommended that instructors incorporate a variety of approaches in statistics education since individuals are varied in multiple ways and tend to learn differently (Curriculum Renewal Across the First Two Year (CRAFTY) Statistics Report (Moore, Peck, & Rossman, 2000)). Online courses, as a delivery modality for statistics education, are growing in popularity. However, student preference for online or in-class statistics courses remains a topic of debate. These major themes in statistics education (incorporation of simulations, students with social sciences background, adult learners, and preferred learning styles) will shape the review of the current literature.

The literature review is organized into seven topics: (1) the use of simulations in statistics education, (2) students' attitudes toward statistics, (3) social sciences adult students' anxiety related attitudes toward statistics, (4) actions educators can take to reduce or help students release statistics anxiety, (5) characteristics of adult learners that may help or hinder statistics learning, (6) student preferences for online versus in-class statistics education, and (7) the explanation of why the concept of CLT will be used as the example to be simulated in this study. The final section of the literature review focuses on research methods that have been used to evaluate the effectiveness of simulations in statistics learning.

Simulation as a Promising Approach in Statistics Education

Simulations have been suggested as a potentially valuable tool for statistics educators. The theoretical framework for simulations is constructivism. The theory of constructivism suggested that knowledge cannot be passed to students from textbooks or lectures in a passive manner, but is constructed by the active participation of the learner (Glasersfeld, 1987). In the constructivist perspective, positive interaction and discussion are critical components of the learning process (Eggen & Kauchak, 2001). Mills (2003) explored the theoretical foundations for teaching statistics with simulations. With simulations students have the opportunity to learn by constructing their ideas and knowledge about statistical concepts. Mills (2003) stated that students who are able to build their ideas by actively interacting with simulations and to use simulations to modify and change their thinking are on their way to becoming a more effective problem solver.

Simulations Enhance Students Understand Basic, Abstract, and Complex Statistical concepts

Understanding basic and abstract statistical concepts are the root challenges for most statistics beginning learners. There are many reasons why understanding basic statistical concepts plays a critical role in the process of statistics learning. Most statistical inference relies heavily on basic concepts, such as sampling means distribution and CLT. For example, confidence intervals and hypothesis tests proceed from the sampling means distribution, so that understanding this concept is essential to understanding these inferential techniques.

Simulations help Students Change Misconceptions

Students' misconceptions not only obstruct their comprehension of statistical concepts, but also hinder their application of statistical skills (Cohen et al., 1996; Liu et al., 2009). Researchers have found that students often hold many misconceptions about statistics. Some studies focused on topics, such as probability (e.g., Fast, 1997; O'Connell, 1999; Hirsch & O'Donnell, 2001; Batanero & Sanchez, 2005; Tarr & Lannin, 2005), contingency tables (Batanero et al., 1996), sampling means distributions (Yu & Behrens, 1995), significance tests (e.g., Falk & Greenbaum, 1995), etc., indicated that misconceptions and faulty intuitions used by students and adults are stubborn and difficult to overcome. However, statistics, as a scientific discipline, needs students to understand statistical concepts and utilize them to solve practical problems, and make judgments and decisions when faced with uncertainty. Therefore, correcting students' misconceptions in statistical concepts is another primary task that scholars and researchers should emphasize.

As revealed by Morris (2001) although simulations can correct misconceptions, such programs may also lead to new misconceptions for learners. Moreover, most of the existing studies lack theoretical background (Mills, 2002). Liu, Lin, and Kinshuk (2010) introduced the theoretically designed simulation known as Simulation-Assisted Learning in an effort to determine if the program could help correct misconceptions. This method was developed with a learning model based on cognitive conflict theory to correct students' misconceptions and to enhance statistical understanding (Liu, Lin, & Kinshuk, 2010). The study from Liu et al. (2009) was designed to establish whether simulations could help correct students' misconceptions and improve understanding of statistical concepts. The statistical topic of "correction" was targeted since it has been found to be suitable for learning with simulation-based method (Morris, 2001), and misconceptions about this topic are commonly held by students (Liu et al., 2009). Seventy-two 12th grade students were randomly assigned to either the experimental group or the control group. Students in the experimental group used the simulation-based method, while the control group students were taught with the traditional lecture approach. The results showed that the simulation-based method could effectively improve students' performances and help in correcting misconceptions.

Simulation helps Develop Statistical Thinking and Critical Thinking

The importance of statistical thinking can be traced to the very beginning of statistics curriculum (Alabama State Department of Education, 1989). At the end of the nineteenth century, Wells claimed that "statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write" (quoted in Castles, 1992, p. v). With the rapid growth in technology and statistics, the emphasis on statistical thinking can be seen everywhere. Statistics thinking includes: (1) knowing how and why to use a particular method, measure, design or statistical model, and/or (2) a deep understanding of statistical processes and methods as well as the constraints and limitations of statistics and statistical inference, and finally the ability to critically evaluate the statistical methods, and designs.

According to Ennis' taxonomy (Ennis & Millman, 1985), one crucial element of critical thinking is raising questions. Critical thinking relies on self-regulation of the thinking processes, construction of meaning and detection of patterns from disorganized structures (Kröpfl, Peschek, & Schneider, 2000) and, in statistics, dealing with statistical variation (e.g., Watson & Callingham, 2003). Watson and Moritz (1997) proposed that there are three levels in the understanding of statistical concepts, and the highest level is "to be able to observantly raise questions for the improper use of statistics." (eg., Polya, 1945; Schoen feld, 1987, Garfield & Gal, 1999). Ted and Burke (2000) stated that the simulations activity encourage students to consider the conceptual underpinnings of why and what? Such as why stratified sampling technique but not simple random sampling, and what are the advantages and disadvantages of each of the two sampling techniques? All these actions correspond to the crucial elements of critical thinking and statistical thinking.

Tintle et al. (2015) also stated that the use of simulations is burgeoning in popularity as a means of introducing statistical inference in undergraduate statistics courses. Increasing evidence suggested that the use of simulations could develop students' statistical and critical thinking from several aspects, including (1) clearly presenting the complex logic of inference, (2) strengthening ties between statistics and mathematics concepts, (3) encouraging a focus on the entire research process, (4) inspiring students to think about advanced statistical concepts, (5) encouraging more time to explore, do, and talk about real research and messy data, and (6) offering a firmer foundation on which to build statistical intuition.

Students' Attitudes Toward Statistics

Students' attitudes toward statistics play an important role in their statistics education. The attitudes primary focus on (1) Affect (being scared by statistics), (2) Cognitive Competence (confidence in learning statistics), (3) Difficulty (students' attitudes about the difficulty of statistics as a subject), (4) Effort (amount of work students expends to learn statistics), (5) Interest (students' level of individual interest in statistics), and (6)Value (students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life) (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014).

Positive attitudes may enable students to develop statistical thinking skills, apply knowledge acquired in daily life, enjoy the course content, show full effort in the subject, have confidence in the subject, and enjoy the course experience. Therefore, positive attitudes encourage students to obtain more achievement in statistics. Negative feelings, attitudes, beliefs, interest levels, expectations, and motivations, in contrast, can be expected to contribute to students' difficulties in learning basic concepts in statistics. Studies indicated that negative attitudes would weaken students' interests in the statistics course, which leads to the consequence that students feel the course difficult, will not use the knowledge in future career, do not plan to take more advanced statistics courses, and the like (Ghulami, Hamid, & Zakaria, 2015). These difficulties have been widely documented over the last two decades (Gal & Ginsburg, 1994). Students' feelings about statistics education, and the effects of these feelings on resulting learning, knowledge and further interests in statistics should occupy a central role in the minds of statistics educators (Benson, 1989; Harvey, Plake, & Wise, 1985; Roberts & Bilderback, 1980).

In 2015, Ghulami, Hamid, and Zakaria conducted a study to analyze students' attitudes toward statistics. Thirty-seven indicators were clustered into six latent variables: Affect, Cognitive Competence, Difficulty, Value, Interest, and Effort. Results indicated that the undergraduate students majoring in engineering felt more positive on all six components.

In 2016, Ratanaolarn conducted a study to investigate the effects of students' attitudes toward statistics, statistics anxiety and teaching quality on graduate students' statistics achievement. The participants were 246 master's degree students registered in the statistics course. The results indicated that the positive attitudes toward statistics and teaching quality have a significantly positive direct effect on achievement and statistics anxiety has a significantly negative direct effect on achievement.

Students' Anxiety Related Attitudes Toward Statistics

Different from students' attitudes toward statistics, which include Affect, Cognitive, Difficulty, Effort, Interest, and Value, students' anxiety related attitudes were a particular focus for this study. Students' statistics anxiety has been a dominant obstacle for social science students in their statistics learning process. For example, students who are anxious in a statistics course can be expected to be less involved in interactions with other students or the instructor, while confident students can be expected to take a more active role in the learning process (McLaren, 2004; Ward, 2004). Moreover, students with high levels of statistics anxiety usually delay enrolling in statistics courses as long as possible, which often leads to failure to complete their degree programs (Onwuegbuzie, 1997).

"Statistics anxiety" is experienced by as many as 80% of graduate students (Onwuegbuzie, 2004), and statistics anxiety is severe among students, as described by Perney and Ravid (1991, p.2) during the statistics learning:

> Statistics courses are viewed by most college students as an obstacle standing in the way of attaining their desired degree. It is not uncommon to see students who delay taking the statistics courses until just before graduation. . . College professors who teach the research and statistics course are all too familiar with the high level of anxiety exhibited by the students on the first day of the term.

Gal and Ginsburg (1994) stated that the introductory statistics course should have a goal that prepares students to take higher level statistics courses, even though most students experience severe statistics anxiety at the beginning of the course. Thus, students' attitudes after the introductory statistics course become very important.

A study from Ramirez and Bond (2014) was designed to measure students' pre- and post-attitudes toward statistics for two different teaching methods, randomization-based curriculum (n=425), and traditional teaching method (n=2200) for an introductory statistics course. The components included Affect, Cognitive Competence, Difficulty, Effort, Interest, and Value. The results revealed that undergraduate students' attitudes became more negative from pre-test to the post-exam except for more confidence in statistics, even though not significantly different. The negative attitudes included being more afraid of statistics, statistics being more difficult than expected, not planning to work hard on statistics, reluctance to use statistics in everyday life. In addition, a similar study from Swanson, VanderStoep, and Tintle (2014), based on the Project-based teaching method (n=78) and Hybrid Course (n=119), indicated similar results in that students' attitudes became more negative from pre-test to post-test.

Actions Taken to Release Statistics Anxiety

Dillon (1982) demonstrated that students' statistics anxiety could be alleviated by talking about their fears. In addition, Schacht and Stewart (1991) suggested that collecting real data from students and having students perform simple calculations (obtaining the mean, etc.) aids in reducing anxiety levels and increasing motivation with the result becoming involved in the class.

Teachers may contribute to the reduction of statistics or mathematics anxiety and thus enhance learning by integrating more efficient instructional strategies into their teaching (Smith, 2000; Pan & Tang, 2005). Chiou, Wang, and Lee (2014) found that a one-minute paper strategy could reduce students' statistics anxiety significantly and thereby improve students' statistics learning achievement.

Additionally, Alfred North Whitehead (1916) suggested that teachers should focus on teaching a few very important ideas as "thoroughly" as possible. Attempting to "cover" too many ideas leads to one becoming an expert in none of them, and everyone should "possess…expert knowledge in some special direction…" (Whitehead, 1916). Therefore, reducing the amount of material covered may reduce anxiety levels.

In addition, Garfield and Everson (2009) offered the following recommendations for instructors of introductory statistics courses: (1) instructors should emphasize statistical literacy and understanding of basic statistical concepts. This action works to teach graduate students statistics, even prepares graduate students to teach, as teaching assistants or follow academic careers in mathematics or statistics; (2) instructors should stress conceptual understanding rather than mere knowledge of procedures; (3) instructors should use real data related to students' area; and, finally, (4) instructors should use technology for developing conceptual understanding and analyzing data.

The Characteristics of Adult Learners That Hinder or Help Statistics Learning

Ross-Gordon (2005) revealed that adult students, most typically defined as those over 24 years of age, now constitute a majority of the undergraduate student population. Presently, education for adult learners is becoming more and more important in the global educational system. According to OECD Adult Education (2017), is found in overwhelming numbers on a worldwide scale, while the percentage of tertiary education for adult learners, ranging in age from 25 to 64 years, has increased significantly from 2000 to 2015. The adult students opting for tertiary education in the United States increased from 39.49% in 2000 to 44.63% in 2015.

The target population for this study was graduate students in the social sciences. These individuals need statistical skills to read academic reports and papers, design experiments, and analyze quantitative data collected from surveys or test results. However, these students usually encounter significant problems in their research or work, due to the lack of familiarity with statistical techniques such as the analysis of variance (ANOVA), the analysis of covariance (ANCOVA), regression analysis, exploratory data analysis, multivariate analysis techniques, etc. (Gould, 2010). In addition, this study focuses on adult learners, defined as graduate students ranging in age from 25 to 64 years. Compared to traditional learners, adult learners usually have life situations and constraints, such as part- or full-time jobs, and also need to deal with the issues of a family, including caring for children or/and elders, thus, the primary limitation in statistics learning for the adult student could be the shortage of time (Lundberg, 2003).

Besides the background of this target population, adult learners have unique traits that may hinder or assist their statistics learning. According to Pappas (2013), these characteristics include: (1) Adult learners are self-directed. They feel the need to take responsibility for their lives and decisions and, as a result, they desire control over their learning. This characteristic is a potential strength for the adult learners. (2) Adult learners are practical and results-oriented. They often resent theory and desire information that can be immediately applicable to their professional needs. Thus, adult learners prefer practical knowledge that will improve their skills, facilitate their work and boost their confidence. (3) Adult learners are less open-minded, and thus are more resistant to change, such as transferring from a traditional teaching method to virtual online teaching method. This is a potential challenge for the adult learners. (4) Adult learners are slower learners since aging does affect learning, yet more integrative of knowledge. (5) Adult learners usually use personal experience as a resource. (6) Adult learners have strong self-motivation, so their learning is typically voluntary. (7) Adult learners usually have multi-level responsibilities, including family, friends, work, and the need for personal quality time. This is another potential challenge for adult learners. (8) Adult learners have high expectations, and they expect to be taught about skills that will be useful to their work or research, hope to have immediate results, and seek courses that are worth their investment of time and money. The shortage of time is the primary constraint for adult learners, which is the cause for some of the statistics anxiety (Pappas, 2013).

Preferred Learning Style: Online Course or In-Class Course

Attention to diverse learning styles offers a promising pathway for educators to enhance their students' statistics learning process (Blackmore, 1996). The last three decades of teaching and learning literature highlight the importance of involving students in the learning process and attending to their learning preferences (Chickering & Gamson 1987; Trigwell, Prosser, & Taylor 1994; Haidet, Morgan, O'Malley, Moran, & Richards 2004). Based on this literature, instructors should incorporate a variety of approaches in statistics education, since individuals are varied in multiple ways and tend to learn in different ways (Curriculum Renewal Across the First Two Year (CRAFTY) Statistics Report (Moore, Peck, & Rossman, 2000)). With contemporary developments in technology, educators are better positioned than ever before to be responsive to a variety of student learning styles. Some of the more popular strategies are web-based or online delivery, hybrid classes, and flipped classrooms. The online and flipped methods in teaching styles are growing in popularity relative to traditional lecture classes, yet research as to which methods are most effective has not yet provided clear answers (Allen, Seaman, & Garret, 2007; Bowen, Chingos, Lack, & Nygren, 2012).

Many research studies have indicated that there is no significant difference between the traditional teaching method and the flipped classroom teaching method. Ziegelmeier and Topaz (2015) conducted a study with one section taught in a traditional lecture-based format and another one taught as a flipped classroom. The data related to students' performance, as well as perceptions of the approach and attitude toward statistics were collected and analyzed. The results indicated that students in both sections scored similarly on components of the course, and the majority of students were comfortable with the format of each section. Moreover, a study from Van Sickle (2015) also revealed that the flipped classroom teaching and traditional teaching methods resulted in similar final exam results. Furthermore, a study with flipped classroom teaching and traditional teaching method by Zack, Fuselier, Graham-Squire, Lamb, and O'Hara (2015) revealed that many students have negative opinions of the flipped model, and attitudes toward mathematics, in general, tend to decline, comparatively, for students in the flipped class. However, students in traditional lecture style classes had more positive attitudes toward statistics, and showed much higher scores in reasoning, as well as much lower scores in misconceptions, even though not significantly different (Gundlach et al., 2015)

Many researchers have reached similar conclusions (e.g., Gonzalez, 2003; Van Sickle, 2015; Ziegelmeier & Topaz, 2015; Yong, Levy, & Lape, 2015). For these studies, there are different definitions and elements for the flipped classroom, but the general idea refers to moving lectures outside of the classroom to incorporate other activities into a class during its standard meeting time, to promote more in-depth learning and understanding through engagement, with the aim of instilling some passion for the subject (Ziegelmeier & Topaz, 2015; Novak, Kensington-

Miller, & Evans, 2017). Some of the critical components for the flipped classroom include online technology, self-paced learning, video lectures outside of class, engaging, inquiry-based learning environment (Ziegelmeier & Topaz, 2015; Novak, Kensington-Miller, & Evans, 2017; Love, Hodge, Corritore, & Ernst, 2015; McGee, Stokes, & Nadolsky, 2016).

Online teaching has become a critical concern in higher education. According to a 2011 Sloan Survey of Online Learning (Allen & Seaman, 2011; Škrinjarić, 2014), the number of students choosing one or more online courses surpassed 6.1 million during the Fall 2010 semester, increasing from 3.94 million in Fall 2007 to 5.6 million in Fall 2009. It has become an integral part of higher education in that 65% of the institutions of higher education include online education as a critical part of their long-term strategy (Allen & Seaman, 2011). Online courses have become more and more prevalent and may prove to be indispensable in the near future. Learners in modern society choose online courses primary for two reasons: to balance their time and space limitations, or because of their preferences for the online format. In this study, the researcher was interested to identify the social sciences adult learners' preferred learning style, whether in-class or online, and what actions lead to the particular preference.

Researchers have noted that online course is not always up to students' expectations, and both traditional learners and online learners perceive online learning as convenient, but not necessarily conducive to their learning (Burns, 2013). Moreover, Zhang (2002) stated that the online course is not appropriate for introductory statistics courses from three aspects: the lack of face-to-face interactions; inability to motivate students and identify students needing help immediately; and the need for students to have certain technical skills, which is not usually met. Speed and Hardin (2001) also identified the inability to communicate mathematics in "real-time" and problems presenting mathematics formulas on the internet as challenges for the online format.

Thirunarayanan, Bayo, and Slater (2014) argued that there is a relationship between content areas and the preferred learning style for different courses. An overwhelming majority, of more than 80%, of the students in their study prefer the face to face setting in statistics (n=93, 82.3%), calculus (n=99, 87.6%), physics (n=92, 81.4%), and trigonometry (n=93, 82.3%) courses.

The Importance of the Central Limit Theorem (CLT) in Introductory Statistics Course

Understanding basic and abstract statistical concepts are challenging for most statistics beginning learners. There are many reasons why understanding the basic statistical concept of CLT plays a critical role in the process of statistics learning. First, the population for this study is adult students from educational or social sciences backgrounds. The content of statistics for research at this level of education has two general components: (1) descriptive statistics (e.g., frequency distributions, central tendency, and the measure of dispersion), and (2) inferential statistics (e.g., z-test, t-test, ANOVA, and regression). One of the most significant and important topics at this level is the CLT (Novak, 2014). The CLT is the foundation for many other statistical concepts (Turner & Dabney, 2014). For example, confidence intervals and hypothesis tests proceed from the CLT or sampling means distribution.

While the CLT is one of the most important concepts taught in an introductory statistics course, it may be the least understood by students. Students can enter numbers into a formula and solve problems, but conceptually, they do not understand the logic behind the CLT (Ruggieri, 2016). In addition, the CLT (or sampling means distribution) is one of the most challenging topics to teach (Turner & Dabney, 2014). Furthermore, the probability ideas involving sampling variation from the CLT are challenging for introductory students to understand (Mulekar, 2006). It is true that understand the CLT (or sampling means distribution) is imperative before one can understand the concepts underlying these inferential techniques. Without understanding the CLT, students could hardly learn statistics further and deeply. In this study, social sciences adult learners' statistics learning conditions will be discussed from several aspects based on the CLT concept.

Measures Best Evaluate the Effectiveness of Simulations in Statistics Education

Jamie (2004) conducted a study to determine whether simulations enhance students' understanding of the statistical concept of CLT. When comparing outcomes for students from the simulation and control groups, the mixed-model analysis indicated a significant improvement for students from the simulation group. In the study, thirty-one students enrolled in an introductory level statistics course were randomly divided into two groups, the "traditional" group (fourteen students), and the "experimental" group (seventeen students). The Microsoft Excel-based simulation was applied for students in the experimental group. Seven open-ended questions covering content related to properties of the CLT concept were designed to measure students' statistics achievement. The effectiveness of the simulations on CLT learning was evaluated based on students' response to these questions. The same questions were administered before (pre) and after (post) the intervention of the treatment. The mixed model analysis revealed that results for students from the simulation and control groups differed. For the simulation group, students scored significantly higher on the post measure, indicating that simulations help students understand the CLT concept. No significant differences existed for students' pre- and post- measures for the control group. Then, the ATIU (affective measure to measure student attitudes toward their instructional unit) survey indicated that students in the simulation group had a positive attitude toward their instructional unit compared to students in the control group.

Although many researchers have recommended using simulations and many studies have indicated that simulations could enhance students' understanding of basic, abstract, and complex statistical concepts, very few empirically and theoretically based studies indicate what measures should be used to assess the effectiveness of simulations, the study from Jamie (2004) evaluated the effectiveness of simulations based on students' understanding using open-ended questions based on the CLT concept. Reidar et al. (2007) also conducted a study to determine whether simulations help students understand the concepts of sampling means distribution and CLT. Contrary to the study of Jamie (2004), the study form Reidar et al. (2007) examined the effectiveness of simulations from another aspect, students' experience in using simulations. Fifty-eight students from introductory statistics were divided into two groups. Twenty-eight students were asked to evaluate the simulation software with an essay and by responding to a survey. These students form the treatment group. The remaining thirty students had access to a different program, a traditional method. These students form the control group. Students from both groups were asked the same survey questions: (1) how much time students spent on the explanation (explain time), (2) how much time students spent on experimenting with parameters (experiment time), (3) how well the students felt the software explained the concept of sampling distributions (explain topic), (4) how much they learned (learning experimenting), (5) the value of the time required (time required) to use the program compared to their increased understanding, and (6) how user-friendly (user-friendly) the software is perceived to be. The results revealed that students from the treatment group did significantly better than students from the control group on problems related to the two statistical concepts.

Summary of Literature

The studies reviewed above have provided a summary of research focused on how simulations help students' learning in statistics, including understanding basic statistical concepts, changing misconceptions, improving statistical and critical thinking, and inspiring positive attitudes toward statistics. These areas of research form an interrelated framework for this investigation of the selection and implementation of simulations focused on CLT; social sciences adult learners' attitudes toward statistics with and without simulations; social sciences adult learners' anxiety related attitudes toward statistics before and after the statistics course; as well as the preferred statistics learning style for this target population.

Specifically, the previous studies pointed to limitations in the literature. Firstly, Liu, Lin, and Kinshuk (2010) provided extensive reviews that simulations could improve students' performances and help correct misconceptions. However, the study form Liu, Lin, and Kinshuk (2010) focused on participants from senior high school students. Here, the focus moves from high school students to students in higher education. In addition, previous studies of the effectiveness of using simulations on statistics achievement have either been predominantly quantitative or qualitative. For example, the qualitative dominated study from Reidar et al. (2007) cannot address the cause-effect relationship of the effectiveness of using simulations in statistics education. The mixed research design with both quantitative and qualitative methods covering almost all aspects of the social sciences adult learners' statistics related experience, perceptions, and achievements is a better choice for this study. These aspects include open-ended items regarding CLT, survey data about students' attitudes toward statistics, self-efficacy toward the CLT, and a thorough and detailed clinical interview exploring the factors leading to the specific conclusions.

The statistics education for social sciences students has been a topic of interest since most students from the social sciences tend to have limited backgrounds in statistics or mathematics, and such a lack of background knowledge makes statistics comprehension difficult. Furthermore, statistics itself is not an easy subject. The inherent mathematical difficulties of statistical language and abstract statistical concepts tend to make statistics learning even more of a challenge. However, most of these previous studies are focused on undergraduate students, such studies as undergraduate students' statistics anxiety, performance, self-efficacy (Keeley, Zayac, & Correia, 2008). Statistics education for adult learners with an increasing population for tertiary education were also discussed. Adult learners with the traits of self-directed, strong motivation, less open-minded, multi-level responsibilities, and high expectations (Pappas, 2013) can be expected to have very different learning experiences compared with their counterparts of social sciences undergraduate students.

In this study, the researcher reviewed the literature, and addressed the shortcomings. To begin with, most of the previous studies related to the simulations are conducted either with the qualitative or quantitative approach, the mixed methods lacking. The mixed methods with both quantitative and qualitative methods is used in this study to thoroughly check students' statistics related attitudes, perceptions, and achievements.

Second, although many researchers have recommended using simulations in statistics education and many studies have supported the effectiveness of using simulations to enhance students understanding of basic, abstract, and complex statistical concepts, very few empirically and theoretically based studies indicate what measures should be used to assess the effectiveness of the simulations. The study from Jamie (2004) evaluated the effectiveness of simulations based on students' understanding of seven open-ended questions designed based on the CLT. Another study from Reidar et al. (2007) assessed the effectiveness of simulations based on students' experience of using simulations, such as time spent on explaining the statistical concepts, time spent on experimenting with parameters, how much students learned, the user-friendly of the software, etc. However, neither one of the measures alone is enough to evaluate the effectiveness of simulations on students' statistics education. In this study, the researcher would evaluate the effectiveness of simulations from a mixture of four aspects: (1) open-ended questions designed based on the CLT, (2) surveys concerning students' self-efficacy toward CLT, (3) students' attitudes toward statistics, and (4) clinical interview from students' first-hand experience.

Third, there has been limited research on the effects of how simulations impact students' attitudes toward statistics. Most previous research has focused on students' perceptions and attitudes toward the use of simulations, as well as how the attitudes impact students' performances (Valero-Mora et al., 2011). This study would measure whether the use of simulations will inspire students' positive attitudes toward statistics, thus further improve statistics performances.

Fourth, as an instructional tool, many researchers have recommended simulations for a range of statistics topics: the binomial distribution (Shibli, 1991), regression analysis (Franklin, 1992), sampling means distribution (delMas et al., 1999; Marasinghe et al., 1996; Weir, McManus, & Kiely, 1990), hypothesis testing (Flusser & Hanna, 1991), and concepts related to survey sampling (Chang, Lohr, & McLaren, 1992; Kalsbeek, 1996; Schwarz, 1997). Liu, Lin, and Kinshuk (2010) noted that even though the simulation-based learning has the potential to help students understand statistical concepts (e.g., Morris & Scanlon, 2000; Morris, 2001), it is still far from ideal (e.g., Yu et al., 1995; Hodgson & Burke, 2000; Morris, 2001; Morris et al., 2002; Kadijevich et al., 2008). Also, although simulations have been widely developed and applied in statistics education, few empirical studies have been discussed on how the simulations help students' statistics learning (Mills, 2002; Morris et al., 2002). Moreover, in a review of forty-eight studies, Mills (2002) indicated that most of the existing studies lack theoretical foundations of how the simulations work to improve students' statistics learning. To that end, the current study seeks to thoroughly investigate how the simulations improve students' understanding of the fundamental statistical concept of CLT, and their attitudes toward statistics.

Moreover, Gal and Ginsburg (1994) stated that the introductory statistics course should include the goal to prepare students to take higher level statistics courses. However, limited research is available regarding students' anxiety related attitudes toward statistics both before and after the introductory statistics course. Most previous studies concerning students' pre- and post- attitudes towards statistics are conducted during the middle of the semester, which may not reflect students' attitudes after they finish the introductory statistics course (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014). Even during the semester, most of the studies are focused on undergraduate students (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014). In this study, students' attitudes toward statistics before and after the introductory statistics course will be discussed, and whether students plan on taking higher level statistics courses will also be checked.

Next, some studies focus on students' statistics anxiety and actions to reduce anxiety levels, conducted with a quantitative approach. Yet too little qualitative research exists in this area. The difference between undergraduate and graduate students in statistics learning is even less discussed, which may lead to a bias in statistics education since undergraduate and graduate students are very different regarding their backgrounds, learning motivations, learning habits, etc. As a result, insufficient qualitative research is available on social science adult learners' statistics anxiety related attitudes, and actions to release anxiety and make the statistics learning process enjoyable. This study is conducted to fill the gap in this area by focusing on a qualitative research approach to explore the statistics learning experiences of social sciences graduate students.

Furthermore, the previous studies, even though very few, focusing on students' preferred learning styles are conducted with a quantitative approach. Yet too little qualitative research exists in this area. Moreover, little research has focused on factors leading to students' preferred learning styles. As a result, very limited qualitative research is available on students' preferred statistics learning style, inclusive of possible factors leading to the particular preference. In addition, studies focusing on social sciences students often focus on undergraduate students. Most of the modern students of social sciences from 25 to 64 years of age have strikingly different characteristics, compared to undergraduate students. This study would be conducted to fill that area gap, by focusing on a qualitative approach not only by exploring the rarely discussed aspects from students' perspectives, but also by targeting adult learners from social sciences.

This target population, by combining social sciences, adult learners, online course, and statistics education, provided a basis for statistics education to be viewed as unique and worthy of emphasis. The goal of this study is to address the shortcomings in the literature described above. It is expected that this study would not only point to the value, or lack thereof, of these enhancements, but also provide guidance on effective education approaches to targeting the specific population of students to develop their interests in statistics. Moreover, this study would provide insights into the unique factors involved in statistics education for adult learners and the development of their knowledge and understanding over time, such as provide guidelines for this population group to deal with statistics anxiety and gain confidence in their statistics education.

In order to overcome the current limitations and potential bias, this study built on the previous literature and attempts in several ways: to determine the effectiveness of using simulations in statistics education; whether simulations help inspire students' positive attitudes toward statistics; social sciences adult learners' attitudes before and after the introductory statistics course; how statistics anxiety may hinder students' statistics learning, actions that will release statistics anxiety, social sciences adult learners' preferred statistics learning style, and factors leading to the particular preference.

The mixed research design with both quantitative and qualitative methods would be used in this study. The data collected from the quantitative method, such as pre-, post- scores, and surveys would be used to make inferential statistics, while data collected from the qualitative method, such as clinical interview, would be used to help explain the unobserved factors. Students from two groups would be analyzed and discussed in this study, the simulation group, students attended both a lab session practicing with simulations and the traditional class review sessions, while the control group, students only attended the traditional class review.

CHAPTER 3
METHODOLOGY

The primary purpose of this study was to determine the effectiveness of using simulations as an instructional tool in an introductory doctoral level statistics course. The study focused on the impact of simulations on students' attitudes and understanding of statistical concepts, as well as how the simulations would inspire students' positive attitudes and improve statistics performance or would fail to help. In addition, since statistics anxiety has been a primary obstacle to students' statistics education, and "statistics anxiety" is experienced by as many as 80% of graduate students (Onwuegbuzie, 2004), the study will address statistics anxiety. The researcher was interested to explore the details of statistics anxiety related attitudes of this group of students, including examining their anxiety levels before and after the introductory statistics course. Whether students' anxiety levels diminish or not, and what factors could be taken to release the anxiety. Moreover, the course has a hybrid online or flipped structure, and the target population for this study was social sciences adult learners, with limited background in statistics or mathematics. Given the prevalence of the online course, especially considering the constraints and background of this target population, the researcher was interested to determine the preferred statistics learning style of the social sciences adult learners, whether in-class or online, as well as the factors leading to the particular preference.

In this study, a mixed-methods research design was utilized to combine quantitative and qualitative research techniques into a single study (e.g., de Waal, 2001). The goal was to examine the statistics related topics for social sciences adult learners from different aspects. The rationale for using the mixed research approach is that neither the quantitative nor qualitative method alone is adequate to address the research questions in this study (Creswell & Clark, 2007).

This chapter includes a detailed description of the research methodology, which will be described in the following sections: (1) Research Design, (2) Participants (3) Instrumentations, and (4) Data Analysis.

Research Design

Mixed methods research, as the third research paradigm in educational research, was designed to draw on the strengths and minimize the weaknesses of both quantitative and qualitative methods, if used alone (Johnson & Onwuegbuzie, 2004). According to Creswell and Clark (2007), interaction, priority, timing and integration need to be considered when mixed method research designs are used. Interaction refers to how the quantitative and qualitative components work with each other in the study, independently or interactively. In this study, the quantitative and qualitative elements were independent of each other. The phases of collecting data from the quantitative and qualitative methods were separate. After data collection and analysis, the results from both methods were converged to provide a comprehensive explanation of the effectiveness of using simulations in statistics education. For some of the research questions, the quantitative method was utilized first to get a general conclusion, and then the qualitative method was used to explore the reasons leading to the particular outcome. For the rest of the research questions, only the qualitative method with interview data was utilized to analyze some phenomenon.

Priority concerns the weighing of the qualitative and quantitative methods in answering the research questions. In this study, the qualitative method played a major role in answering some of the research questions. The quantitative method provided the general results first, and then the qualitative method played a complementary role to explore the details leading to the conclusions. Timing refers to whether the collection and analysis of qualitative and quantitative data occur concurrently, sequentially, or with a combination of those mentioned above. For this study, the timing was sequential. The collection and analysis of data from the qualitative method were as a follow-up of the course to explore students' perceptions, attitudes, and experience before and after the demonstration of simulations. Finally, integration refers to the process of mixing both methods to address the goals of the study. In this study, the quantitative and qualitative findings were analyzed separately, and then were combined using theoretical considerations. This step of mixing the results is known as inferences, and the conclusions were drawn based on both the quantitative and qualitative findings (Creswell & Clark, 2007).

Participants

The target population for this study was social science graduate students, ages 24 to 55, also described as adult learners. The participants for this study were students enrolled in an introductory doctoral level statistics course during Spring and Fall semesters in a southern research university.

In this study, the doctoral level introductory statistics course involved is a "flipped" classroom. With the effort to better deliver the statistics concepts, increase students' time for active learning, the components of this course include such elements as class review videos, lab video, assignments, activities, projects, and the like. Students could either attend the in-class or online session freely. For students attending the in-class session, the format is that of the traditional teaching method. For the students choosing the online session and who did not attend the in-class review, the review sessions were recorded and made available online. All the recourses for this course are distributed via Moodle and emails.

A total of twenty-two students was included in this study, five students were from the Spring semester. These five students completed the surveys and were interviewed at the conclusion of their course. In the results section below, this group was also referred to as the after-course group.

Seventeen students were from the Fall semester. These seventeen students were surveyed and interviewed at the very beginning of the course. Eight of the seventeen students only attended the traditional class review session. This group of students was called the control group. The remaining nine students both attended the traditional class review session and the lab session to practice with the simulations. This group of students was called the simulation group. After the surveys and tests, five students from each of the three groups were interviewed about their attitudes, perceptions, and experiences in the course. This is the overall structure of the study and all five research questions will be discussed and analyzed based on these twenty-two students. The graph for the general experiment is available at Graph 1.

The participating students reported the following for race/ethnicity: White, Black, Asian, and Other. The ages range from 24 to 55 years of age, with a mean age of 32.73, and SD = 8.195. Of the twenty-two students, eight of them were males, representing 36.4% of the sample, while fourteen of them were females, representing 63.6% of the sample. Each participant held a Bachelor or master degree and was pursuing a master or doctoral degree. Their majors included education and several social science areas. The various time demands of their employment included part-time and full-time jobs. Some had no background in statistics, and some had minimal statistics knowledge from a lower-level statistics course. The participants and research methods for each of the five research questions were explained with more details accompanying each of the research questions.

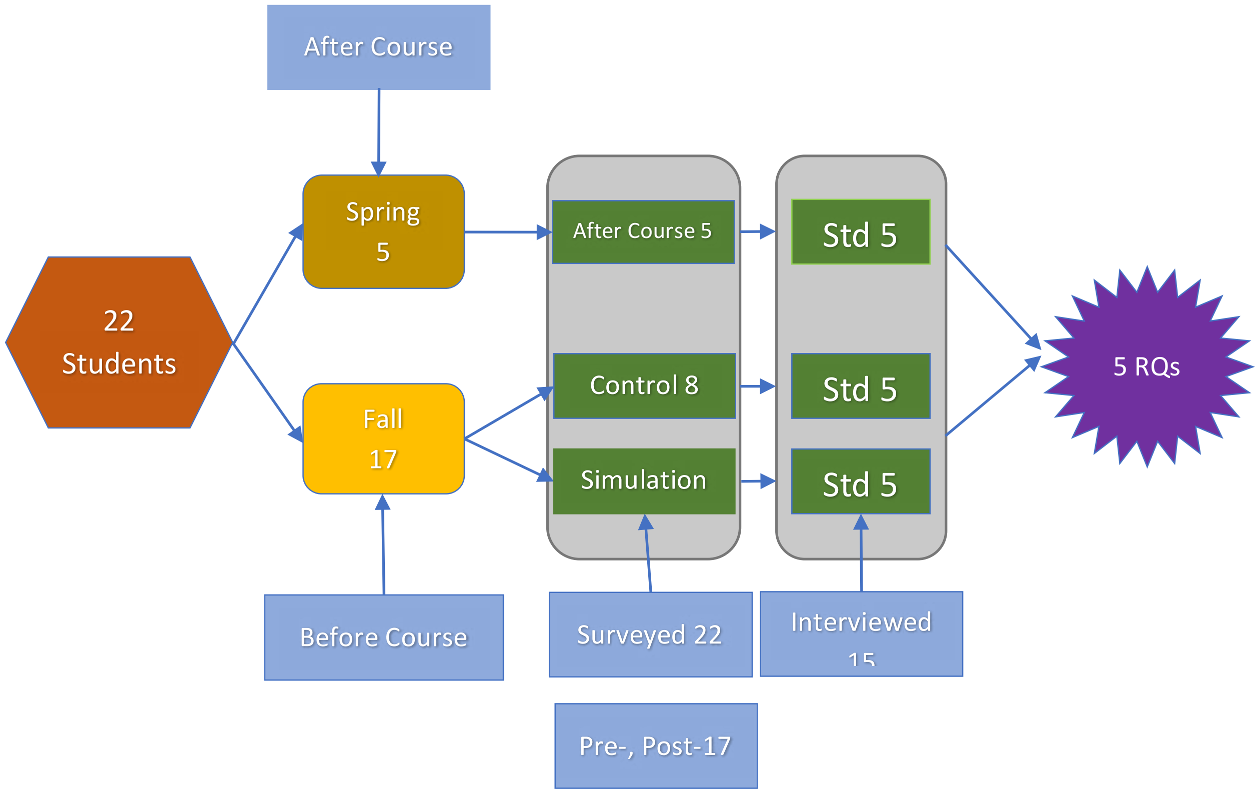


Figure 1. General Experiment for the Four Research Questions

Instrumentations

Both quantitative and qualitative data were collected and analyzed for this study. The quantitative data include surveys, pre-test, and post-test measures of students' attitudes toward statistics, self-efficacy toward statistics concept of Central Limit Theorem (CLT), as well as students' understanding of the questions related to the statistics concept of CLT. The qualitative data is collected from the clinical interview. Three different instruments were included in this study: two surveys, one pre-test and one post-test in the quantitative component, and the interview data in the qualitative component. The two surveys measured students' attitudes toward statistics, and self-efficacy toward the statistics concept of CLT, the pre-test and post-test measure students' knowledge about the statistics concept of CLT. The interviews address in-depth issues regarding student's experiences in the course. The surveys, interview measures, pre-test, and post-test were created by the researcher, developed and confirmed by the course instructor.

Exhibit 1. Students' Distribution for Gender

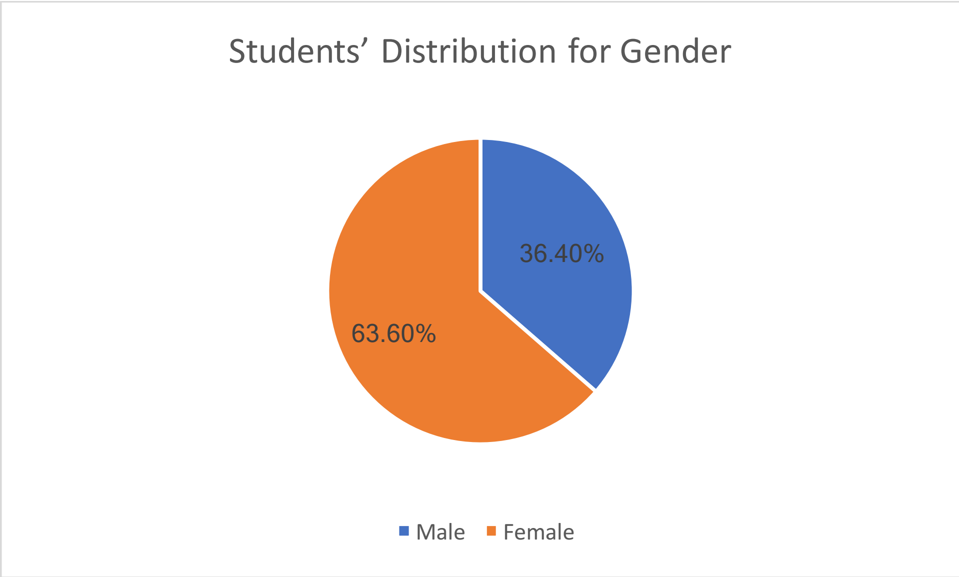


Exhibit 2. Students' Distribution for Race

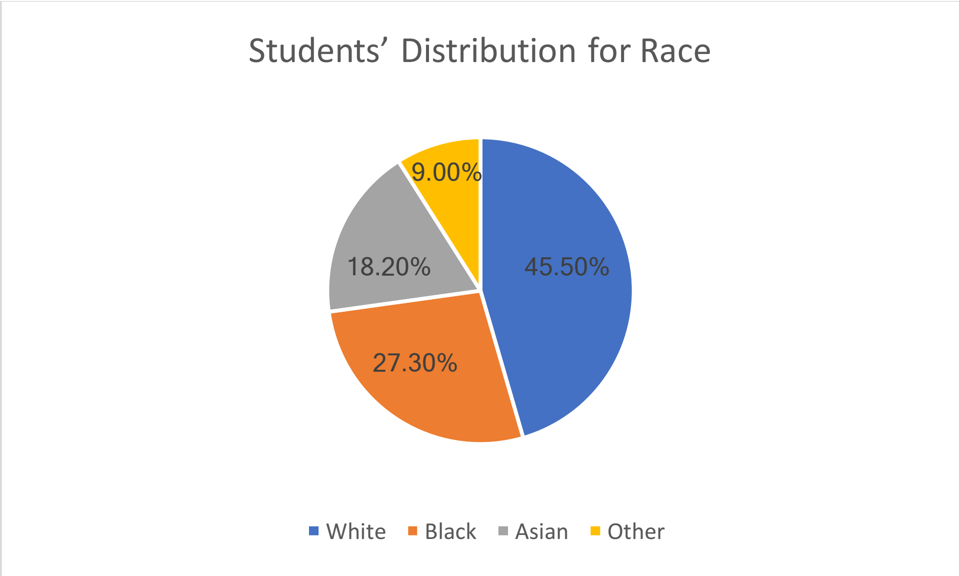
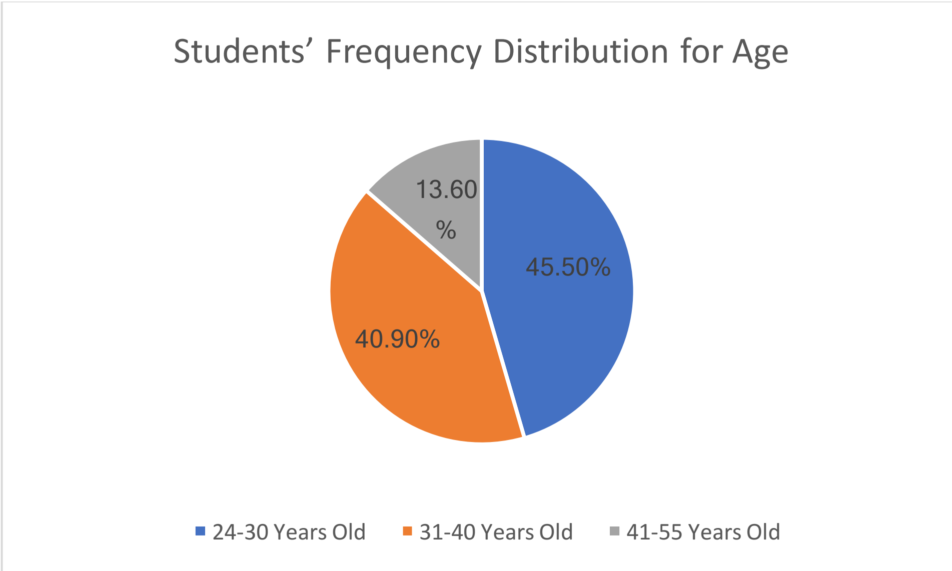


Exhibit 3. Students' Distribution for Age



Two phases of data were collected for this study. For participants from Spring semester, at the end of the introductory statistics course, after some screening criteria, five volunteers were selected. All five students were interviewed. Before the interview, each participant was asked to complete a survey related to their perceptions, attitudes, and their statistics learning experience. The five volunteers constituted male and female students with ages ranging from thirty to fifty-five years. The quantitative data from the survey and qualitative data from the interview were collected. For the participants from Fall semester, seventeen students were included in this study.

Quantitative data collection and measurements

At the very beginning of the Fall semester, all students attending the lab were determined as the simulation group (or treatment group). Students from the simulation group practiced the statistics concept of CLT with simulations and also attended the class review session. All students only attending the class review session were identified as the control group. This group of students was only taught with the traditional method. The sample size for the simulation group was nine, and for the control group was eight.

During the lab, all students were required to take the pre-test at the beginning of the class, and the pre-test included nine open-ended questions concerning the statistics concept of CLT. After the pre-test, the simulations demonstrating the statistics concept of CLT were followed, which was available at http://onlinestatbook.com/stat_sim/sampling_dist/. To begin with, the researcher walked through the instructions of the simulations with students. After students were comfortable with the simulations, the students were required to practice with a more complex version of the simulation. The only difference between the two simulations was that, for the first simulation, the bin size was big, which made it easy to recognize how the samples were drawn from the parent population. However, the distribution line was curved, which became difficult for students to observe some of the conclusions. The researcher then decreased the bin size for simulation to make the distributions look smooth as in Figure 2, which was easy for students to recognize the observations. Moreover, for the improved simulation, the researcher also added a choice button of 100 under the Sample, and options for large sample size choices such as N=30, and N=35, which made it easier to distinguish the different sampling means distributions based on sample sizes.

Students could start the simulations by clicking the Begin Button at the left top. There were four axes at the website page. The first axis was the parent population. Students could click the options from the right top button to determine the shape of the parent population, Normal, Uniform, Skewed, or Custom. Students could also change the shapes of the distributions by clicking on the distributions. By these actions, students could determine the mean, median, standard deviation, skew, and kurtosis of the parent populations, which are available on the left side of the distributions. These options offer the choices for the real conditions since the parent populations could be of any shapes.

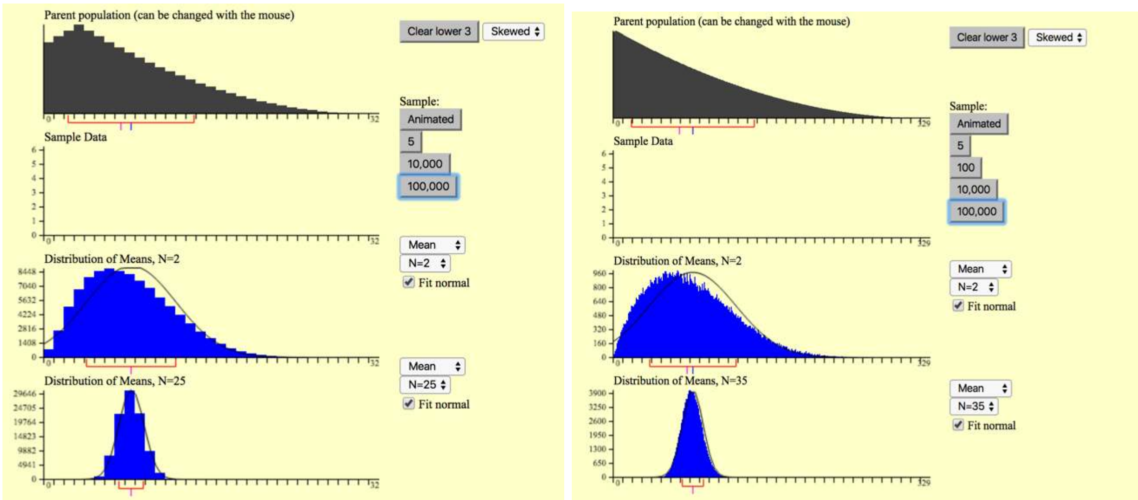


Figure 2. The CLT Simulations

The second axis demonstrated the detailed process of how samples were randomly drawn from the parent population. By clicking the “Animated” button, the specific cube with specific values would be drawn from the parent population to the sample data axis. For example, if the sample size N=2, then two cubes from the parent population would fall to the sample data axis with corresponding value scale. Next, the mean would be calculated, and this is one mean to the third distribution. (Students could also select the median or standard deviation by clicking the corresponding “Median,” or “STD” button, but for the sampling means distribution and CLT, the Mean option is usually used). If students click the “Animated” button, the whole process would be demonstrated step by step, including how the random samples are drawn from the parent population, how the mean is calculated, and how the mean cube would fall to the sampling means distribution. Students could speed up the process by clicking the corresponding replication button. The “5” button indicates replicating the process five times, the same thing to “100”, “10,000”, and “100,000” button. The fourth axis is the same as the third one. Students could choose “Mean” option for both the third and fourth axes but with different sample sizes, which is the crucial point to compare how these two distributions would look if everything is the same but with different sample sizes. For example, to determine how the distributions of sampling means differ if everything else is the same but only with different sample sizes, students could choose sample size N = 2 for the third axis and sample size N = 5 for the fourth axis (or any other sample sizes). Students could get familiar with the simulations after several times of trying.

During the simulations, the researcher walked around to observe the process and offered help if students had problems. This process lasted about 30 minutes, and all students could recognize some critical points of the CLT, including the relationship between the sample size and the shape of sampling means distribution, the relationship between the sample size and the variability of the sampling means distribution, and relationship between the shape of parent population and the sampling means distribution…

After practicing with the simulations, at the end of the class, all students were required to complete two surveys, one regarding students' attitudes toward statistics, and the other one concerning students' self-efficacy toward CLT concept. After the lab, during the class later the same day, a class review for the statistical concept of CLT is conducted for all students. All students except those who attended the lab earlier are identified as the control group. Two weeks later, a post-test with identical questions is distributed to all students. After the quantitative experiment from the control group and the simulation group, five participants from each of the two groups are selected for the clinical interviews of the qualitative part.

Pre-test and Post-test

The pre-test and post-test questions were developed by the researcher based on the previous literature. According to Mulekar (2006), when checking students' understanding of the CLT, the properties related to CLT should include: (1) population versus sample, (2) population mean versus sample mean, (3) random sampling, (4) variability or variation, (5) a pattern of all possible values that we could possible observe for the sample mean, (6) a population distribution versus sampling distribution, (7) effect of sample size on the variability of sample means, (8) diminishing difference between the actual sampling distribution and the limiting normal distribution, and (9) distribution in limit. Moreover, Newton and Harvill (1977) also described that when checking the fundamental objectives behind the CLT concept, the objectives should be tested include: (1) the shape of the distribution of the sampling means, each computed from a different, randomly selected sample, is approximately normal (or bell-shaped), (2) the mean of the sampling means distribution is the mean of the parent distribution, (3) as the sample size increases, the shape of the sampling means distribution becomes more symmetric, (4) as the sample size increases, the shape of the sampling means distribution becomes narrower, (5) for skewed parent distributions, larger sample sizes are needed for the sampling means distribution to become approximately normal, and (6) there is no such major number as 25, 30, 50, or 100, as suggested by so many textbooks, above which the approximation is adequate.

Based on the discussion above, nine open-ended questions were developed to measure students' understanding of the CLT concept. The nine questions were identical for both pre-test and post-test. The questions items are as below:

1. What is a parent population?
2. What is a sample?
3. What is a sampling means distribution?
4. What will the sampling means distribution look like if the parent population is normal?
5. What will the sampling means distribution look like if the parent population is not normal?

6. What will the sampling means distribution look like if the sample size is small?
7. What will the sampling means distribution look like if the sample size is large?
8. Please list at least one difference between a parent population and the sampling means distribution?
9. Please list at least one difference between two sampling means distributions with different sample size (e.g. n=5, n=35)

The validity needs to be check when the pre-test and post-test were conducted. The validity refers to the appropriateness or accuracy of the interpretations of test scores (Cecil, Ronald, & Victor, 2011). If these validities are not addressed, construct underrepresentation or construct-irrelevant variance may happen. Validity is threatened when a test measures either less (construct underrepresentation) or more (construct-irrelevant variance) than the construct it is supposed to measure (AERA et al., 1999). The validity of the pre-test and post-test is assumed since these nine items were designed to check students' understanding of basic objectives of the CLT concept. Moreover, the validity of post-test would be threated if students memorize the answers from the pre-test. Actually, there are three reasons why the pre-test and post-test could be identical and would not threaten the validity for students' memorization of the answers from the pre-test. First, all the nine items were open-ended items, thus it was difficult to memorize the answers without understanding. Second, this experiment was conducted at an introductory statistics course, it is assumed that students don't have much background about this concept, and the pre-test results confirmed this assumption. The focus of this experiment was not the pre-test. This pre-test is only added to control students' background. Third, the post-test was conducted two weeks later after the pre-test, and students were not informed prior to take the pre-test and post-test. The validity of the test items was assumed since these nine questions designed were accurate to test students' understanding of the fundamental objectives of the CLT concept, neither more nor less, and the pre-test didn't impact students' performance during the post-test.

Survey instruments

Two surveys were conducted in this study. The first survey consisted of seven items measuring students' attitudes toward statistics. The seven items were designed based on the Survey of Attitudes Toward Statistics (SATS-36, Copyright © C. Schau, 1996, 2003), which has six attitudinal components: Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort. This survey instrument has been used in statistics education research due to its reliability, validity and well-known psychometric properties (Hilton, Schau, & Olsen, 2004; Tempelaar, Schim van der Loeff, & Gijselaers, 2007; Vanhoof, Kuppens, Sotos, Verschaffel, & Onghena, 2011). Different from the Survey of Attitudes Toward Statistics (SATS-36, Copyright © C. Schau, 1996, 2003), seven items instead of attitudinal components are developed for this study since the small sample size for this study. The seven statements measuring these six attitudinal components are:

1. Difficulty – "Statistics is very easy."
2. Interest – "Statistics is very interesting."
3. Cognitive Competence – "I am very confident that I can learn statistics well."
4. Affect – "I hate statistics."
5. Affect – "I think statistics is boring."
6. Affect – "I am scared of statistics."
7. Affect – "I get nervous going to statistics class."

The 5 Likert scale was used for the first survey: 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree. For the first three items, the higher values indicated more positive attitudes, while for the last four items, the lower values indicated more positive attitudes.

Several more items concerning Affect were designed since statistics anxiety has been an obstacle for statistics education, which was discussed in one particular session. Moreover, items related to Value and Effort were also discussed, but were not included at the survey part, but during the qualitative interview session. The items related to Value are: (1) Learning statistics is very important presently; (2) I will apply the knowledge of statistics in my future research/work. The item related to Effort is: how much time do you think you will spend on this course on average each week? ("how much time did you spend on this course on average each week" for the Spring semester students)

The second survey was designed to measure students' self-efficacy toward the concept of CLT. Similar to the pre-test and post-test, the items measuring students' self-efficacy were also designed based on the basic objectives of CLT that students should master (Mulekar, 2006; Newton & Harvill, 1977). The six items concerning students' self-efficacy are as below:

1. Knowing what each value at the parent population represents.
2. Knowing what each value at the sampling means distribution generates.
3. Knowing the relationship between the parent population and the sampling means distribution.
4. Knowing the difference of sample sizes and the drawing times at the sampling means distribution.
5. Knowing how sample size at the sampling means distributions impacts the distribution.

6. Knowing how drawing times at the sampling means distribution impacts the distribution.

The 5 Likert scale was used for this second survey. With values from 1 to 5, the self-efficacy increased gradually from “not confident,” to “very confident.” The higher mean values indicated more confidence.

Qualitative data collection and measurements

Husserl formally introduced phenomenology in the first half of the twentieth century to provide a philosophical foundation for the sciences (Sokolowski, 2000). Husserl believed that experience as perceived by human consciousness has worth and should be the object of scientific study. According to Lopez and Willis (2004),

“…subjective information should be important to scientists seeking to understand human motivation because human actions are influenced by what people perceive to be real. As human beings generally go about the business of daily living without critical reflection on their experiences, Husserl believed that a scientific approach was needed to bring out the essential components of the lived experiences specific to a group of people (p. 727)”.

The clinical interview data were collected for this qualitative part. There were three types of interviews, highly structured, semi-structured, and unstructured (Merriam, 2009). The highly structured interview refers to use of predetermined questions to obtain demographic information. The semi-structured interview refers to less structured questions (Merriam, 2009, P.90). The unstructured interview includes open-ended questions, which is usually used when there is very little known about the phenomenon.

The qualitative data from a series of interviews were collected for fifteen of the twenty-two students, with all five students from the Spring semester, while the remaining ten students were drawn from the Fall semester. The researcher, who also was a teacher assistant for a doctoral level introductory statistics course, conducted all the interviews for this study. The researcher has been a teaching assistant in an introductory statistics course for several years, with primary responsibility for teaching students how to conduct statistics tests with the software package, Statistical Package for the Social Sciences (SPSS). In addition to operating a statistics lab, the researcher has routinely worked with students in this type of course during schedule office hours, 5 hours per week. The researcher had similar experiences to those of the students in the study and is thus a good fit for conducting the clinical interview for this study. After collecting the interview data, the thematical analysis was then used to analyze the data.

When conducting the interview, the researcher combined both semi-structured and in-depth interviews. With the semi-structured interview, the interviews were conducted on the basis of a loose structure, which was guided by different topics and open-ended questions. The guiding topics included demographic information, previous statistics background, attitudes toward statistics, experiences in statistics classroom, group study versus study alone, online versus in-class courses, and the experience of using simulations in the statistical topic of CLT. With the in-depth interviews, the researcher sought to explore participants' perceptions and experiences in greater details.

Before the interviews with participants in the study, the researcher conducted a pilot interview with an acquaintance, who relates to this study as well. The purpose of the pilot interview was to ascertain whether these questions make understood and whether the participants would respond in meaningful ways. After this pilot interview, small changes were applied to the questions.

A total of fifteen participants were interviewed in a setting familiar to the students and the researcher. Being familiar with the setting, it is possible that the interviewees would find such surroundings more comfortable. With such an atmosphere, the possibility exist that the participants would feel relaxed and more inclined to speak. Soft drinks were also provided in case of need. The audiotape was used via iPhone during the interview. When the interview began, the researcher placed the iPhone on the desk between them. With the participants' prior permission, the researcher started the audiotape in front of them, with the explanation that the audiotape would aid in recording their communications correctly, with the added assurance that the participants could stop the interview or recording any time if they felt uncomfortable. The researcher stated that he/she would keep the recording confidential. This process went very smoothly, and all the participants seemed quite comfortable with the interview and the audiotape.

After recording the fifteen interviews, the researcher uploaded the recordings to a computer and deleted them from iPhone to make sure that no transcripts were lying around, and that no one else could access those materials. The researcher transcribed the recordings via the website www.swiftscribe.com. With the general transcripts from the website, a literal sentence-by-sentence correction was gained, based on the audio.

Data Analysis

In this study, the qualitative portion played the role to explore and explain students' perceptions and attitudes towards statistics, preferences on statistics learning, and experience of using simulations in statistics learning. The quantitative research in this study focused on identifying and assessing the causes that influence the outcome (Creswell & Clark, 2011; Creswell, 2009; Merriam, 2009; Gall & Gorg, 2007), and comparing the difference between the control group and the simulation group, students' anxiety levels before and after taking the introductory statistics course.

For the quantitative part, the quantitative data from surveys, pre-test, and post-test were collected. The Mann-Whitney U test and Kruskal Wallis test were used to analyze these quantitative data. The Mann-Whitney U test and Kruskal Wallis test are the nonparametric counterparts for the independent two-sample t-test and one-way ANOVA. First, this was appropriate since the total number of participants for this study is twenty-two, and the sample size for each group is even smaller. In addition, the Likert items from the surveys were collected for this study. The response values were ordinal with 5-point scales from "strongly disagree" through to "strongly agree" and "not confident" through to "very confident." Therefore, the dependent variables were ordinal, which was not appropriate for the parametric test of independent two-sample t-test and one-way ANOVA. Moreover, the assumptions of normality and equality of variance required for the parametric tests were not met. Considering these various conditions, the quantitative nonparametric Mann-Whitney U test and Kruskal Wallis test were good fit for this study. In addition, the Resampling method was used for this nonparametric tests to check whether this Resampling method could improve the quantitative results. The Resampling involves the selection of randomized cases with replacement from the original data sample in such a manner that each number of the sample drawn has a number of cases that are similar to the original data sample. When conducting the resampling routine, the method generally ignores the parametric assumptions and is based on nonparametric assumptions. There is no specific sample size requirement. However, the larger the sample, the more reliable the confidence intervals will be generated. The Permutation routine were conducted from the RStudio. Furthermore, since several hypotheses (several items) were being performed simultaneously on a single factor (independent variable), the Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of hypotheses tests. The familywise error rate was .05/number of hypotheses tests. In contrast to the parametric test, the mean rank instead of mean value was compared among the different groups. Also, the Mann-Whitney effect size r was computed for each of the comparisons to determine the strength of the difference. The measures of the effect sizes were based on the explanation from Cohen (1988), where the r value equal to or greater than 0.1, indicating a small effect size, the r value equal to or greater than 0.3, indicating a medium effect size, and the r value equal to or greater than 0.5, indicating a large effect size. The sign of the r value is of no difference. The effect size η^2 for the Kruskal Wallis test was also computed for each of the items to determine how much variance was accounted for by difference between the groups. Finally, the descriptive statistics for each of the items was calculated to describe students' attitudes and self-efficacy, whether they agreed or disagreed, had confidence, or had no confidence.

For the qualitative part, fifteen cases were included. A case study was a form of qualitative research that focuses on providing detailed information which was difficult to attain with the quantitative method, such as students' attitudes and perceptions toward a phenomenon. The analysis unit can be an event, program, activity, or more than one individual. The method of collecting data was semi-structured interviews with participants from both the simulation and the control groups. These interviews focused on the participants' experiences in the course, attitudes toward statistics, and the factors that may have helped or hindered their achievements.

For each of the five research questions, the participants and research methods varied, based on different objectives. Since the aim of this qualitative portion is to understand students' experiences and perceptions of statistics learning, the Crotty's (1998) model for qualitative data analysis is incorporated into this portion. Like Crotty's (1998) model, this study model is composed of four parts: (1) epistemology, (2) theoretical perspective, (3) methodology, and (4) methods. This model is guided by constructivism, defined as the belief that people efficiently construct the meaning of the reality around them through their interactions with one another, and with objects in the environment (Malik, 2015). The theoretical perspective in this study is interpretivism, a means of understanding and explaining human and social reality, which explores students' beliefs about during their statistics learning experience (Crotty, 1998). The methodology of phenomenology is the best fit since the emphasis of this study rests on the statistics learning experience of social sciences graduate students. Phenomenology refers to the study of people's subjective and everyday experiences (Crotty, 1998). In a phenomenological study, the researcher seeks to explore the useful information and structure patterns of a phenomenon by analyzing data drawn from the participants' first-hand experience of the phenomenon (Yeh & Lehman, 2007).

Ethical issues

Before conducting the study, the researcher obtained University approval from the institutional review board for this study. In the dissemination of the volunteer information to students, the purpose of the study is disclosed to the participants. After selecting the volunteers and before the interview, all participants voluntarily signed the consent form approved by the university institutional review board. This form includes the purpose of the study, subject, study procedures, benefits, risks (no risks), right to refuse (Subjects may choose not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which they might otherwise be entitled), and privacy (results of the study may be published, but no names or identifying information will be included in the publication). Subject identity will remain confidential unless disclosure is required by law. The participants are identified using acronyms in the final paper.

CHAPTER 4
RESULTS

This study focuses on the statistics education of adult learners in the social sciences, a growing population that presents unique challenges to the statistics educators. Additionally, the study focuses on the attitudes and experiences of these students in the context of a hybrid (online and face-to-face), flipped, introductory statistics course. For purposes of this study, the computer-based simulations of the Central Limit Theorem (CLT) was introduced as an instructional tool.

The following five major objectives guided this study:

1. The first objective of this study is to determine if the simulations have effects on inspiring students' positive attitudes toward statistics, and improving students' self-efficacy toward the statistical concept of CLT.
2. The second objective is to explore whether the simulations would help improve students' understanding of the particular statistical concept of CLT.
3. Based on the results from the first and second research questions, the third research question is to determine how the simulations helps or fails to help in students' statistics learning process.
4. The fourth objective is to explore students' anxiety related attitudes toward statistics before and after the introductory statistics course. Whether students' anxiety levels diminish or not, and what actions could be taken to release students' statistics anxiety.
5. The fifth objective is to identify the social sciences graduate students' preferred statistics learning style, in-class, or online; specifically, what are the factors leading to the particular preference?

The target population for this study was defined as social sciences graduate students, from which twenty-two students from two doctoral level introductory statistics classes were included. Five of the students were from the Spring semester, while seventeen students were from the Fall semester. Interviews were conducted with all five students from the Spring semester. The Fall semester students were divided into two groups, a simulation group, and a control group. The simulation group consisted of nine students, while the control group consisted of eight students. The effectiveness of the simulations on statistics learning would be explored and discussed via the comparisons among students from three types of measurements: (1) two surveys regarding students' attitudes toward statistics, and students' self-efficacy toward the statistics concept of CLT, (2) a pre-test, and a post-test with open-ended questions regarding the statistics concept of CLT, (3) the clinical interview exploring students' experiences in statistics learning. The experiment for this first research question is available at Figure 3.

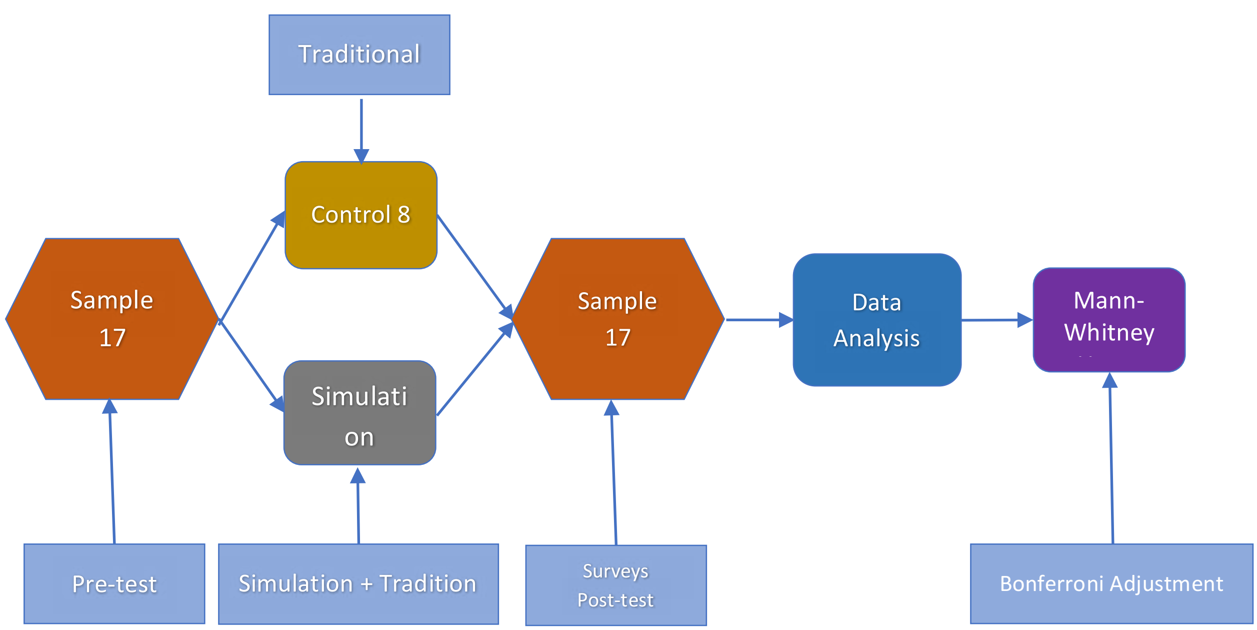


Figure 3. Experiment for the First Research Question

Of the twenty-two students in this study, nine were males, which representing 40.9% of the sample, while thirteen were females, constituting 59.1% of the total sample. Ten were White, constituting 45.5% of the total sample; Six were African American, representing 27.3%; Four were Asian, which representing 18.2%; And two were from Others, representing 9%. Each student held a Bachelor or master's degree and was pursuing a master or doctoral degree. All students were from the education or social sciences backgrounds. The various time demands of their jobs included part-time and full-time jobs, and the majority had family obligations. Some had no background in statistics, and some had minimal statistics knowledge from a basic-level statistics course.

Results of Research Question One

The purpose of the first research question was to determine if the simulations would inspire students' positive attitudes toward statistics, as well as strengthen confidence in statistics.

After the simulations and in-class review of the CLT concept, two surveys describing students' attitudes and self-efficacy toward CLT were distributed to all students. Findings suggested some differences, though not significant, between the control and simulation groups, males and females.

Statistics Attitudes & Self-Efficacy for Students from the Two Groups

The first survey included seven items measuring students' attitudes toward statistics. The seven items were: (1) Statistics is very easy, (2) Statistics is very interesting, (3) I am very confident that I can learn statistics well, (4) I hate statistics, (5) I think statistics is boring, (6) I am scared of statistics, and (7) I get nervous going to statistics class. The 5 Likert scale was used to describe students' attitudes toward the seven items. With values from 1 to 5, the responses changed gradually from "strongly disagree," "disagree," "neutral," "agree," to "strongly agree."

The values equal to, or greater than, 3 indicated agreeing with the statements. For the first three items, the higher values indicated more positive attitudes. For the last four items, the lower values indicated more positive attitudes.

Mann-Whitney U tests were conducted to compare the mean ranks for each of the seven items between students from the two groups. The Mann-Whitney U test is a counterpart for the independent two-sample t-test when the sample size is small, and the assumptions of normality, equality of variance required for the independent two-sample t-test are not met. When conducting the Mann-Whitney U test, the mean ranks, rather than the mean values from the independent two-sample t-test were compared. For the first three items, the higher mean ranks represented more positive attitudes. For the last four items, the lower mean ranks indicated more positive attitudes. The Mann-Whitney U tests after the permutation of the original data were also conducted. However, since this permutation of resampling did not change the significance, thus did not improve the results, which were not discussed in this study. The conditions were the same to the Mann-Whitney U tests and Kruskal Wallis tests later through this study.

Table 1 included the descriptive statistics for the seven attitudes items, including mean, standard deviation, minimum, maximum, and the total number of students. Table 2 was the Mann-Whitney U test output for the statistics tests. The desired alpha value of 0.05 (level of significance) was used to determine the significance. However, since seven hypotheses (seven items) were being performed simultaneously on a single factor (control group Versus simulation group), the Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of seven hypotheses tests. The familywise error rate was .05/7=.00714, indicating the probability of rejecting at least one true null hypothesis, and making at least one type I error.

From Table 2, students' attitudes were significantly different toward Item 6 (I am scared of statistics), since the Asymp 2-tailed Sig. value (.003) was less than the familywise error rate of .0074. All the remaining six tests were not significantly different between students from the two groups.

Table 1. Descriptive Statistics for Students' Attitudes Toward Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Att_1	17	2.41	.870	1	4
Att_2	17	3.24	.970	1	5
Att_3	17	3.65	1.222	1	5
Att_4	17	2.24	1.091	1	5
Att_5	17	2.00	.707	1	3
Att_6	17	2.94	1.391	1	5
Att_7	17	3.29	1.160	1	5
Group	17	1.47	.514	1	2

The details from Table 3 revealed that students from the simulation group held slightly more positive attitudes to all of the seven items, even though six of them were not significantly different. This was due to the fact that students from the simulation group generally had comparatively higher mean ranks for the first three items, while had comparatively lower mean ranks for the remaining four items, determined by the nature of how each item is stated. In addition, Cohen (1998) proposed the effect size r for the Mann-Whitney U test to determine the strength of the difference. The formula for the effect size is as below:

$$r = \frac{Z}{\sqrt{N}}$$

Where

Z indicates the Z values from the Mann-Whitney U test

N indicates the whole sample size

The Mann-Whitney effect sizes for each of the seven items were computed and presented in Table 4. The effect sizes were -0.138 (Item 1), -0.334 (Item 2), -0.181 (Item 3), -0.137 (Item 4), 0 (item 5), -0.713 (Item 6), and -0.350 (Item 7). According to Cohen (1988), the r value being equal to or greater than 0.1 indicates a small effect size, the r value being equal to or greater than 0.3 indicates a medium effect size, and the r value being equal to or greater than 0.5 indicates a large effect size. The sign of the r value is of no significance.

Table 2. Test Statistics[a] for Students' Attitudes Toward Statistics

	Att_1	Att_2	Att_3	Att_4	Att_5	Att_6	Att_7
Mann-Whitney U	30.5	22.5	28.5	30.5	36.0	6.5	21.5
Wilcoxon W	66.5	58.5	64.5	75.5	72.0	51.5	66.5
Z	-.568	-1.379	-.745	-.564	.000	-2.941	-1.443
Asymp. Sig. (2-tailed)	.570	.168	.456	.573	1.000	.003	.149
Exact Sig. [2*(1-tailed Sig.)]	.606[b]	.200[b]	.481[b]	.606[b]	1.000[b]	.002[b]	.167[b]

a. Grouping Variable: Group

b. Not corrected for ties.

Combined with the details from Table 3, and the Mann-Whitney effect sizes from Table 4, regarding the seven items, students from the simulation group showed slightly more positive attitudes toward statistics thusly: as 14.3% (one item), which was identical between the two groups; 42.9% (three items), which presented small to medium effect sizes; 28.6% (two items), which presented medium to large effect sizes; and 14.3% (one item), which displayed a significant difference.

Moreover, the mean values for each of the seven items from Table 5 were also calculated to describe the details of students' attitudes. Concerning Item 1, students from both of the two groups held an array of "neutral to against" attitudes toward the statement that statistics was very easy, with mean values of 2.56 and 2.25 out of 5, respectively. Interestingly, for Item 3, students from both groups agreed with the statement that they were confident at learning statistics well, showing means values of 3.89 and 3.38 out of 5, respectively. Concerning Item 4, students from both groups dis agreed with the statement that they hated statistics, with mean values of 2 and 2.5 out of 5, respectively. Neither did they agree with Item 5 that statistics was boring, with

Table 3. Students' Attitudes Toward Statistics Between the Two Groups (Mean Ranks)

Survey I: Perceptions & Attitudes Toward Statistics	Group	N	Mean Rank	Sum of Ranks
1. Statistics is very easy.	Simulation	9	9.61	86.50
	Control	8	8.31	66.50
	Total	17		
2. Statistics is very interesting.	Simulation	9	10.50	94.50
	Control	8	7.31	58.50
	Total	17		
3. I am very confident that I can learn statistics well.	Simulation	9	9.83	88.50
	Control	8	8.06	64.50
	Total	17		
4. I hate statistics.	Simulation	9	8.39	75.50
	Control	8	9.69	77.50
	Total	17		
5. I think statistics is boring.	Simulation	9	9.00	81.00
	Control	8	9.00	72.00
	Total	17		
6. I am scared of statistics.	Simulation	9	5.72	51.50
	Control	8	12.69	101.50
	Total	17		
7. I get nervous going to statistics class.	Simulation	9	7.39	66.50
	Control	8	10.81	86.50
	Total	17		

Table 4. Mann-Whitney Effect Sizes for Students' Attitudes Between the Two Groups

	r (Simulation-Control)	Effect Size
Att_1	-0.138	Small
Att_2	-0.334	Medium
Att_3	-0.181	Small
Att_4	-0.137	Small
Att_5	0.000	No difference
Att_6	-0.713	Large
Att_7	-0.350	Medium

mean values of 2 out of 5 for both groups. Students' attitudes concerning Items 2, 6, and 7 varied, even though not significant. Concerning Item 2, students from the simulation group tended to agree with the statement that simulation was interesting, with a mean value of 3.56, while students from the control group neither agreed nor disagreed with this statement, showing a mean value of 2.88. Also, concerning Item 6, students from the simulation group did not agree with the statement that "I am scared of statistics," by showing a mean value of 2, while students from the control group agreed with the statement, with a mean value of 4. Moreover, regarding Item 7, students from the simulation group tended to disagree with the statement "I get nervous going to the statistics class," with a mean value of 2.89, while students from the control group tended to agree with this statement, displaying a mean value of 3.75.

Table 5. Students' Attitudes Toward Statistics Between Two Groups (Mean Values)

Part I: Perceptions, self-concepts about Statistics	Group	N	Mean	Std. Deviation
1. Statistics is very easy.	Simulation	9	2.56	.527
	Control	8	2.25	1.165
2. Statistics is very interesting.	Simulation	9	3.56	.882
	Control	8	2.88	.991
3. I am very confident that I can learn statistics well.	Simulation	9	3.89	1.054
	Control	8	3.38	1.408
4. I hate statistics.	Simulation	9	2.00	.707
	Control	8	2.50	1.414
5. I think statistics is boring.	Simulation	9	2.00	.707
	Control	8	2.00	.756
6. I am scared of statistics.	Simulation	9	2.00	.707
	Control	8	4.00	1.195
7. I get nervous going to statistics class.	Simulation	9	2.89	.928
	Control	8	3.75	1.282

To conclude, students from both groups held the opinion that statistics was very important presently, and that they would apply statistics in their future research/work. However, statistics was neither easy nor boring; they did not hate statistics, but neither did they like statistics much. Rather, the students had confidence that they could learn statistics well. Notwithstanding, students from the simulation group held the opinion that statistics was interesting, and they were not too scared of statistics, neither were they nervous about attending the statistics class. The opinion for students from the control group varied. They did not think statistics was interesting, and were quite scared of statistics, and felt nervous about attending the statistics class.

In general, the relationship between using simulations in statistics and students' attitudes toward statistics are rarely discussed. The availability of the limited previous literature indicated that students with simulations had more enjoyable experiences in comparison to other learning activities, and also had more subjective enjoyment (Ratanaolarn, 2016). Moreover, the previous study also indicated that students from the simulation group had positive attitudes toward their instructional unit compared to students in the control group (Jamie, 2004). The results from this study are consistent with the previous literature, but not significant.

The second survey included six items concerning students' self-efficacy toward CLT concept. The six items were: (1) knowing what each value at the parent population represents, (2) Knowing what each value at the sampling means distribution generates, (3) knowing the relationship between the parent population and the sampling means distribution, (4) knowing the difference of sample sizes and the drawing times at the sampling means distribution, (5) knowing how sample size at the sampling means distribution impacts the distribution, and (6) knowing how drawing times at the sampling means distribution impacts the distribution. The 5 Likert scale is used to the six items. With values from 1 to 5, the self-efficacy increased gradually from "not confident," to "very confident." The higher mean values indicated more confidence.

The descriptive statistics of mean, standard deviation, as well as minimum and maximum values for each of the six items were available in Table 6. The Mann-Whitney U tests were conducted to compare the mean ranks for each of the six items between the two groups. Since six hypotheses were being performed simultaneously on a single factor, the Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of six hypotheses tests. The familywise error rate was .05/6=.0083, indicating the probability of rejecting at least one true null hypothesis, and making at least one type I error. From Table 7, the Asymp. 2-tailed Sig. values were compared to the familywise error rate of .0083. Since all the Asymp. Sig. values were greater than .0083, and all the null hypotheses were failed to reject, representing that students' self-efficacy were not significantly different, for any of the six items between the two groups.

Table 6. Descriptive Statistics for Students' Self-Efficacy Toward CLT

	N	Mean	Std. Deviation	Minimum	Maximum
Efficacy_1	17	3.94	.899	2	5
Efficacy_2	17	3.59	.870	2	5
Efficacy_3	17	3.47	.943	2	5
Efficacy_4	17	3.06	1.029	2	5
Efficacy_5	17	3.82	.809	2	5
Efficacy_6	17	3.65	.996	2	5
Group	17	1.47	.514	1	2

Table 8 revealed that students from the simulation group had higher mean ranks for five of the six items, representing a higher self-efficacy toward the CLT, even though not significantly different. The Mann-Whitney effect sizes were computed for each of the six items in Table 9. Students from the simulation group had a lower self-efficacy to only one of the six items, with a minuscule effect size (-0.012). However, they had a higher self-efficacy for the remaining five items, 50% of which had very small to small effect sizes, and 33.33% of which had medium to large effect sizes.

Table 7. Mann-Whitney U Test Statistics[a] for Students' Self-Efficacy Toward CLT

	Eff_1	Eff_2	Eff_3	Eff_4	Eff_5	Eff_6
Mann-Whitney U	23.5	33.0	35.5	33.5	22.0	32.0
Wilcoxon W	59.5	69.0	80.5	69.5	58.0	68.0
Z	-1.272	-.309	-.051	-.252	-1.474	-.401
Asymp. Sig. (2-tailed)	.203	.757	.960	.801	.141	.688
Exact Sig. [2*(1-tailed Sig.)]	.236[b]	.815[b]	.963[b]	.815[b]	.200[b]	.743[b]

a. Grouping Variable: Group

b. Not corrected for ties.

Table 8. Students' Self-Efficacy Toward CLT Between the Two Groups (Mean Ranks)

Survey II: Self-Efficacy about CLT	Group	N	Mean Rank	Sum of Ranks
1. Knowing what each value at the parent population represents.	Simulation	9	10.39	93.50
	Control	8	7.44	59.50
	Total	17		
2. Knowing what each value at the sampling means distribution is generated.	Simulation	9	9.33	84.00
	Control	8	8.63	69.00
	Total	17		
3. Knowing the relationship between the parent population & sampling means distribution.	Simulation	9	8.94	80.50
	Control	8	9.06	72.50
	Total	17		
4. Knowing the difference of sample size and drawing times at the sampling means distribution.	Simulation	9	9.28	83.50
	Control	8	8.69	69.50
	Total	17		
5. Knowing how sample size at the sampling means distributions impacts the distribution.	Simulation	9	10.56	95.00
	Control	8	7.25	58.00
	Total	17		
6. Knowing how drawing times at the sampling means distribution impacts the distribution.	Simulation	9	9.44	85.00
	Control	8	8.50	68.00
	Total	17		

Table 9. Mann-Whitney Effect Sizes for Students' Self-Efficacy Toward CLT Between the Two Groups

	r (Simulation-Control)	Effect
Item 1	-0.309	Medium to large
Item 2	-0.075	Very small to small
Item 3	-0.012	Very small to small
Item 4	-0.061	Very small to small
Item 5	-0.357	Medium to Large
Item 6	-0.097	Very small to small

In general, students from the simulation group had a higher self-efficacy toward the CLT concept and had slightly more positive attitudes toward statistics. This conclusion supports previous literature that students from the simulation group performed statistically significantly better than students from the control group on problems related to the statistics concepts (Reidar et al., 2007).

Statistics Attitudes & Self-Efficacy Between Males and Females

Students' attitudes and self-efficacy between males and females were conducted with Mann-Whitney U tests. The Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of seven hypotheses tests. The familywise error rate was .05/7=.00714, indicating the probability of rejecting at least one true null hypothesis, and making at least one type I error. From Table 10, none of the seven items was significantly different between males and females, since all Asymp. 2-tailed Sig. values were greater than the familywise error rate of .00714. However, the details from Table 11 indicated that males had slightly more positive attitudes, except for Item 5, even though not significant.

The Mann-Whitney U test effect sizes were computed to determine the strength of the difference regarding students' attitudes. The effect sizes were available in Table 12. Males held slightly more positive attitudes for all items except for Item 5, with a medium to large effect size.

For all of the remaining six items, males had more positive attitudes, 28.6% (two items) regarding very small to small effect sizes, small to medium effect sizes, and medium to large effect sizes, respectively.

Table 10. Mann-Whitney U Test Statistics[a] for Students' Attitudes Between Males and Females

	Att_1	Att_2	Att_3	Att_4	Att_5	Att_6	Att_7
Mann-Whitney U	33.5	30.5	20.0	21.0	28.5	20.0	31.0
Wilcoxon W	88.5	85.5	75.0	49.0	83.5	48.0	59.0
Z	-.157	-.466	-1.512	-1.457	-.697	-1.517	-.404
Asymp. Sig. (2-tailed)	.875	.641	.131	.145	.486	.129	.686
Exact Sig. [2*(1-tailed Sig.)]	.887[b]	.669[b]	.161[b]	.193[b]	.536[b]	.161[b]	.740[b]

a. Grouping Variable: Gender

b. Not corrected for ties.

Table 11. Students' Attitudes Toward Statistics Between Males and Females (Mean Ranks)

Survey I: Perceptions, attitudes about Statistics	Gender	N	Mean Rank	Sum of Ranks
1. Statistics is very easy.	Male	7	9.21	64.50
	Female	10	8.85	88.50
	Total	17		
2. Statistics is very interesting.	Male	7	9.64	67.50
	Female	10	8.55	85.50
	Total	17		
3. I am very confident that I can learn statistics well.	Male	7	11.14	78.00
	Female	10	7.50	75.00
	Total	17		
4. I hate statistics.	Male	7	7.00	49.00
	Female	10	10.40	104.00
	Total	17		
5. I think statistics is boring.	Male	7	9.93	69.50
	Female	10	8.35	83.50
	Total	17		
6. I am scared of statistics.	Male	7	6.86	48.00
	Female	10	10.50	105.00
	Total	17		
7. I get nervous going to statistics class.	Male	7	8.43	59.00
	Female	10	9.40	94.00
	Total	17		

Table 12. Mann-Whitney Effect Sizes for Students' Attitudes Between Males and Females

	r (Male-Female)	Effect
Att_1	-0.038	Very small to small
Att_2	-0.113	Small to medium
Att_3	-0.367	Medium to large
Att_4	-0.353	Medium to large
Att_5	-0.169	Small to medium
Att_6	-0.368	Medium to large
Att_7	-0.098	Very small to small

Moreover, the mean values for each of the seven items were also computed to describe the details of students' attitudes toward statistics. From Table 13, males had slightly more positive attitudes to all items, except for Item 5. Both males and females disagreed with the statement that "I think statistics is boring." However, males disagreed, displaying a neutral attitude with a mean value of 2.14, while females held more of an against attitude, revealing a strongly disagree to disagree attitude, with a mean value of 1.90. For the remaining six items, males hold more positive attitudes. Concerning Item 1, both males and females presented disagreeing to neutral attitudes toward statistics, with mean values of 2.43 and 2.40 for males and females, respectively, representing that statistics was not so easy. Concerning Item 2, both males and females showed neutral to agreeing attitudes that statistics is interesting, with mean values of 3.43 and 3.10 for males and females, respectively. Concerning Item 3, both males and females had confidence that they could learn statistics well, but on a varying scale. The mean values for males and females were 4.14 and 3.30 out of 5, respectively, representing that males agreed to strongly agreed with this statement, while females held a neutral to accept attitude toward this statement. Concerning Items 5, both males and females were against the statement that they hated statistics, while males had a mean value of 1.86, representing a strongly disagree to disagree attitude, females had a mean value of 2.50, in relation to disagree to neutral attitude.

Concerning Item 6, males and females had slightly different attitudes when asked whether they were scared of statistics. The mean value for males is 2.43, representing a disagreeing to neutral attitude. However, the mean value for females is 3.30, representing a neutral to agreeing attitude. Concerning Item 7, both males and females were somewhat nervous about attending statistics class, with mean values of 3.14 to 3.40, respectively.

Table 13. Students' Attitudes Toward Statistics Between Males and Females (Mean Values)

Part I: Perceptions, self-concepts about Statistics	Gender	N	Mean	Std. Deviation
1. Statistics is very easy.	Male	7	2.43	1.134
	Female	10	2.40	.699
2. Statistics is very interesting.	Male	7	3.43	.976
	Female	10	3.10	.994
3. I am very confident that I can learn statistics well.	Male	7	4.14	1.215
	Female	10	3.30	1.160
4. I think statistics is boring.	Male	7	2.14	.690
	Female	10	1.90	.738
5. I hate statistics.	Male	7	1.86	1.069
	Female	10	2.50	1.080
6. I am scared of statistics.	Male	7	2.43	1.512
	Female	10	3.30	1.252
7. I get nervous going to statistics class.	Male	7	3.14	1.574
	Female	10	3.40	.843

For the second survey regarding students' self-efficacy toward CLT, the Mann-Whitney U tests were conducted to compare the mean ranks for each of the six items between males and females. The Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of the six hypotheses tests. The familywise error rate was .05/6=.00833. Table 14 showed that all the Asymp. Sig. values were greater than the familywise error rate of .0083, thus all null hypotheses were failed to reject, thereby representing students' self-efficacy as significantly different for none of the six items between males and females. Table 15 revealed that males had higher mean ranks to five of the six items, representing a slightly higher self-efficacy to the CLT, even though not significantly different. The Mann-Whitney effect sizes were computed to each of the six items in Table 16. Males revealed a lower self-efficacy to only one of the six items with a very small effect size (-0.062). Males then showed a higher self-efficacy to the remaining five items, 50% of which showed small to medium effect sizes, and 33.33% of which showed medium to large effect sizes.

Table 14. Mann-Whitney U Test Statistics[a] for Students' Self-Efficacy Toward CLT Between Males and Females

	Eff_1	Eff_2	Eff_3	Eff_4	Eff_5	Eff_6
Mann-Whitney U	22.5	19.0	32.5	25.0	28.5	23.0
Wilcoxon W	77.5	74.0	60.5	80.0	83.5	78.0
Z	-1.290	-1.674	-.257	-1.024	-.694	-1.222
Asymp. Sig. (2-tailed)	.197	.094	.797	.306	.488	.222
Exact Sig. [2*(1-tailed Sig.)]	.230[b]	.133[b]	.813[b]	.364[b]	.536[b]	.270[b]

a. Grouping Variable: Gender

b. Not corrected for ties.

Table 15. Students' Self-Efficacy Toward CLT Between Males and Females (Mean Ranks)

Survey II: Self-Efficacy about CLT	Gender	N	Mean Rank	Sum of Ranks
1. Knowing what each value at the parent population represents.	Male	7	10.79	75.50
	Female	10	7.75	77.50
	Total	17		
2. Knowing what each value at the sampling means distribution is generated.	Male	7	11.29	79.00
	Female	10	7.40	74.00
	Total	17		
3. Knowing the relationship between the parent population & sampling means distribution.	Male	7	8.64	60.50
	Female	10	9.25	92.50
	Total	17		
4. Knowing the difference of sample size and drawing times at the sampling means distribution.	Male	7	10.43	73.00
	Female	10	8.00	80.00
	Total	17		
5. Knowing how sample size at the sampling means distributions impacts the distribution.	Male	7	9.93	69.50
	Female	10	8.35	83.50
	Total	17		
6. Knowing how drawing times at the sampling means distribution impacts the distribution.	Male	7	10.71	75.00
	Female	10	7.80	78.00
	Total	17		

In general, males had more positive attitudes toward statistics and showed a higher self-efficacy toward CLT concept. This is supported by the finding in 2009 by Cunningham and Hoyer (2015) that higher percentages of male graduates reported that they like mathematics or science and that mathematics or science is one of their favorite subjects. Moreover, among 2009 high school graduates who have earned credits in specific mathematics and science courses, males have a higher average in NAEP mathematics and NAEP science scale scores than females. These gaps widen (and become statistically significant) by age thirteen, and persist through secondary schooling and into the college years (Dee, 2007). In addition, men outperform and outnumber women in fields such as mathematics, the sciences, engineering, finance, and economics (Freeman, 2004).

Table 16. Mann-Whitney Effect Sizes for Students' Self-Efficacy Toward CLT Between Males and Females

	r (Male-Female)	Effect Size
Item 1	-0.313	Medium to large
Item 2	-0.406	Medium to large
Item 3	-0.062	Very small to small
Item 4	-0.248	Small to medium
Item 5	-0.168	Small to medium
Item 6	-0.296	Small to medium

Results of Research Question Two

The second purpose of this study was to explore whether the use of simulations could improve students' understanding of the particular statistics concept of CLT.

A pre-test and a post-test were distributed to students from both the simulation and control groups. The nine students from the simulation group both practiced with the simulation, as well as attended traditional class review session for the CLT, while the eight students from the control group only attended the traditional class review session. The pre-test and post-test consisted of nine open-ended questions. All the nine questions on the pre-test and post-test were identical.

The pre-test results indicated that most students from the two groups had little background knowledge in the statistical concept of CLT (See the Pre-Test portion from Table 17 to Table 25). The post-test was conducted two weeks later.

According to Newton and Harvill (1977), when checking the fundamental objectives behind the CLT concept, the objectives should be tested include: (1) the shape of the distribution of the sampling means, each computed from a different, randomly selected sample, is approximately normal (or bell-shaped); (2) the mean of the sampling means distribution is the mean of the parent distribution; (3) as the sample size increases, the shape of the sampling means distribution becomes more symmetric; (4) as the sample size increases, the shape of the sampling means distribution becomes narrower; (5) for skewed parent distributions, larger sample sizes are needed for the sampling means distribution to become approximately normal; and (6) there is no such major number as 25, 30, 50, or 100, as suggested by so many textbooks, above which the approximation is adequate. All the nine questions for the pre-test and post-test are designed based on these basic objectives. The validity of the test items was assumed since these nine items designed were accurate to test students' understanding of the basic objectives of the CLT concept, neither more nor less.

Finally, the nine questions were determined to check students' knowledge in CLT applying a step by step methodology. These open-ended questions were designed to expose students' knowledge with more details, including misconceptions, and confusions. Students need to understand the logics behind these questions before providing a correct answer, which is impossible with multiple choice questions.

The CLT represents one of the most important and fundamental statistical concepts that students need to assimilate before they learn statistics. The CLT defines that regardless of whether the parent population is normal or not, as the sample size increases, the sampling means distribution would become normal. Even as a very basic concept, students are usually become confused, and then draw misconceptions. The analysis and comparisons between the pre-test and post-test, the simulation and control groups were discussed, based on each of the nine questions. The simulations demonstrate the details of how the values (samples means) from the sampling means distribution draw from the parent population, and how the sample size thereupon impacts the shape, variance, and normality of the sampling means distribution.

The first two items were: (1) What is a parent population, and (2) What is a sample. These two beginning items had two functions. First, and theoretically, these two items were the basic objectives behind the CLT concept that students should master. This is supported by Mulekar (2006) that students should understand population versus sample when checking their knowledge of CLT. Moreover, these two items were also designed to transit students from a non-statistics background to a statistics course. Since this pre-test is taken at the onset of the course, the students would become anxious if they were stuck at the very beginning of the course. With knowledge of these two questions, even if students who took no previous statistics courses could define a parent population and a sample. However, the precision in the definition of these two terminologies revealed students' background in statistics.

From the responses to Items 1 and 2 for the pre-test and post-test, students from both groups know the definitions for a parent population and a sample. However, students from the control group had some misconceptions toward these terminologies. The first misconception was that a parent population was "umbrella" shaped. This definition revealed student's shortage in

Table 17. Pre-test and Post-test Responses for Question 1

	Group	Pre-Test	Post-Test
1. What is a parent population?	Simulation	1. A parent population is the original dataset that a sample is derived. 2. Whole population. 3. The primary "umbrella population." 4. The large group before a sample has been selected. 5. All cases available for a particular parameter.	1. A parent population is the original dataset that a sample is derived. 2. The whole people in which researcher is looking to. 3. All representatives of a group that one is interested in studying. 4. The large population which we take samples from inference statistics. 5. Include all cases for a particular parameter. 6. Whole population. 7. The entire population parameter that you will pool a sample from.
	Control	1. All the people from where samples will be pooled. 2. The population you are taking your samples from. 3. The group of individuals that make up the entire dataset. 4. A large population from which multiple sub-populations are derived. 5. The population from which samples are drawn. 6. Study group. 7. Where data derives from.	1. Population is where the sample is drawn from. 2. The population you want to study, but due to the size you can't study every person in it. 3. The overall population which a sample is extracted from. 4. Everyone relevant to the study: like all people who stutter. 5. The parent population is when the x-axis indicates all possible values and the y-axis indicates the frequency of each value. 6. The population you are taking your samples from. 7. A sample is a representation of population.

statistics background. The parent population could be normal ("umbrella"), skewed, uniform, or any other shapes. Moreover, if students were familiar with statistics, they would normally use the terminology of normal, or "bell-shaped," rather than "umbrella" shaped. Other responses were correct, but not to the point of this question. A second misconception was that a sample was "An equally represented portion of a large group. This portion is chosen in a manner to give all number the same probability of being chosen." A sample is not an equally represented portion of a large group (population), but an approximation of a large group.

Table 18. Pre-test and Post-test Responses for Question 2

	Group	Pre-Test	Post-Test
2. What is a sample?	Simulation	1. It is a subset of the population. 2. A sample is a group of the population. 3. Size of each subject. 4. A sample is a group taken from a population used to make generalizations about a population. 5. A portion of a population. 6. Choose some population out of parent population. 7. A sample is a group that reflects the population.	1. It is a subset of the population. 2. A group randomly pooled from population to do research. 3. The subject we randomly picked and used to do the test. 4. A sample is a group pooled from the population. It is used to make generalizations about the population. 5. An equally represented portion of a large group. This portion is chosen in a manner to give all number the same probability of being chosen. 6. Collected people or objects from the parent population. 7. A sample is a representation of population.
	Control	1. A small number of students you will study taken from the parent population. 2. Students in a study that from a population. 3. The objects of the group used. 4. The sample is the mean of values. 5. Who is being tested. 6. A group selected from the population. 7. A small selection of a large set of data.	1. Sample is a randomly selected group you pull out of the parent population to draw inferences about the parent population. 2. A representative group of students from the population. 3. The number of study population within amount of time. 4. A selected group from within a population. 5. A group of subjects collected from the large population. 6. A randomly selected group from a parent population.

In general, students from both groups could described what the parent population was and what a sample was in a non-professional way, but after practicing with the simulations and the class review about CLT concept, students from both groups could define these items in a more precise way. The use of simulations couldn't distinguish these two groups of students clearly regarding these two questions.

The probabilities ideas involving a sampling variation from the CLT remain difficult for introductory students to understand (Mulekar, 2006). The CLT concept was one of the most important concepts taught in an introductory statistics course. However, it may be the least understood by students. Although students could enter numbers into a formula and solve problems, they conceptually do not comprehend what the CLT presents (Ruggieri, 2016). Students who do not know the logics behind the CLT are impossible to understand how the sampling means distribution is generated based on the parent population. The sampling means distribution is a statistics terminology. In particular, Questions 3 was designed to check whether students understand what the CLT is saying. The CLT was usually seen as an abstract concept to students, since the details of how a sampling means distribution was determined were not available for students, from the traditional reading materials alone.

For the pre-test part in Table 19, students' responses from both groups were incorrect or imprecise to the questions "What is a sampling means distribution?" The pre-test responses were similar for students from both groups since students had minimal background in the sampling means distribution. The post-test responses varied considerably between these two groups of students. Most students from the simulation group not only provided much more precise explanations but also introduced the critical points of CLT. However, most students from the control group either explain incorrectly or imprecisely, contrary to the students from the

Table 19. Pre-test and Post-test Responses for Question 3

<table>
<tr><th></th><th>Group</th><th>Pre-Test</th><th>Post-Test</th></tr>
<tr><td rowspan="2">3. What is a sampling means distribution?</td><td>Simulation</td><td>1. It is the distribution of the means from numerous samples all pooled from the same population.
2. Samples from large variates to smaller them.
3. Multiple means taken from the sample.
4. Equal distribution based on the means of various samples.
5. To see how far or close each sample is posing.</td><td>1. It is the distribution of many sample means pulled from the same population.
2. All the means are calculated from the individual samples taken from large population, form a distribution.
3. Showing the spread of the sample.
4. The distribution of means collected from a population.
5. A group of means calculated from multiple samples.
6. How far the means of sample are dispersed.
7. The distribution of means of different samples taken from a population.</td></tr>
<tr><td>Control</td><td>1. How the scores are distributed among the sample population.
2. How large the randomly picked.
3. The results of who was tested in a distribution, bell curve.
4. The average values of a sample set.
5. 95% confidence interval.</td><td>1. The sampling mean is the average data point where the sample population falls, the remainder of the scores are distributed around the mean.
2. It is the bell-shaped curve that shows the distribution of the collected data.
3. The way the average from multiple groups are spread out.
4. Distribution of means of subjects.
5. The collection of means of samples of size n from a parent population.</td></tr>
</table>

simulation group, who in general were more likely to consider the critical points of the CLT. The finding was that even after the class review, students from the control groups were likely to have misconceptions, while students from the simulation group were expected to provide the more precise explanations.

Some of the responses from the simulation group are listed as below.

[1] All the means are calculated from the individual samples taken from large population, form a distribution
[2] The distribution of means collected from a population
[3] A group of means calculated from multiple samples

Questions 4 and 5 were designed to explore students' knowledge about CLT concept, when the parent populations were of different shapes, normal and not normal. This was one of the critical points for the CLT that when the parent population is skewed, the sample sizes impact the shape of the sampling means distribution. Newton and Harvill (1977) stated that for the more skewed parent distributions, larger sample sizes are needed in order for the sampling means distribution to become approximately normal.

The conditions when the parent populations are not normal are usually ignored, or under-emphasized by instructors and students. During statistics learning, most statistical topics are inferred based on normal distribution. Some students even adopted the misconception that the parent population is usually a normal "umbrella population." More importantly, the un-normal distribution presents an abstract statistical topic. As a result, students were not aware of how an un-normal distribution may look like. However, some of the details of these abstract concepts could be provided by the demonstration of simulations, thus allowing students to visualize the possible abstract ideas about the parent populations. The researcher was interested in students' observations from Questions 4 and 5, noting that when the parent population is not normal, the different sample sizes thus impact the shapes of the sampling means distribution. When the sample size is large, the sampling means distribution is always normal, whether the parent population is normal or not. When the parent population is normal, the sampling means distribution is always normal, ignoring the sample size. Question 4 offered a reliable comparison to Question 5. From the responses in Table 20, students did not have many problems when the parent population was normal. However, the researcher found in Question 5, that when the parent population was not normal, only students from the simulation group recognized to consider the sample sizes. No students from the control group considered the sample size.

Table 20. Pre-test and Post-test Responses for Question 4

	Group	Pre-Test	Post-Test
4. What will the sampling means distribution look like if the parent population is normal?	Simulation	1. Bell curve. 2. Bell shape. 3. Bell curve. (draw a normal distribution). 4. Very similar to one bell. 5. Sampling mean presents a parent population. 6. It will make a bell curve.	1. Dependent on the size of the sample. 2. A normal distribution. 3. Bell shaped curve. 4. (draw a normal distribution). 5. Bell curve. 6. Sampling means distribution will be likely to normal like parent population. 7. The sampling means distribution will follow a normal shape.
	Control	1. It will be normal, and the value will be 0. 2. Sampling means distribution will be normal. 3. If the parent population is normal, the sampling means distribution is normal. 4. A bell curve. 5. It depends. But it will look normal.	1. The sampling means distribution would look normal. 2. Bell-shaped curve, higher in the middle. 3. Even. 4. Normal. 5. A bell curve. 6. The distribution has a bell shape with mean centrated focused on middle. 7. Normal.

The responses for the post-test from simulation group include:

[1] Dependent on the size of the sample.
[2] Could be skewed to the left or right when sample size is small.
[3] Could be called kurtosis based on the sample size (different shapes).
[4] Might be skewed if sample size is small.

[5] The sampling means distribution will be skewed if sample size is small

Table 21. Pre-test and Post-test Responses for Question 5

	Group	Pre-Test	Post-Test
5. What will the sampling means distribution look like if the parent population is not normal?	Simulation	1. Skewed. 2. Not like a bell shape. 3. (draw a left skewed and a right skewed distributions). 4. random. 5. Can be distorted, so need large number of samples. 6. Distorted like skewed.	1. Dependent on the size of the sample. 2. Could be skewed to the left or right when sample size is small. 3. Could be called kurtosis based on the sample size. 4. (different shapes). 5. Might be skewed if sample size is small. 6. (draw a flatten distribution). 7. Skewed. 8. The sampling means distribution will be skewed if sample size is small.
	Control	1. It will be distributed on both sides of the mean, maybe more genitive or positive scores. 2. Look different as the parent population. 3. (Left skewed or right skewed). 4. The sampling mean will be skewed and not look normal.	1. It would be skewed either to the right or left depending upon the distribution of scores. 2. Skewed, not symmetrical. 3. Uneven. 4. Shape changes. 5. The curve would be skewed. 6. The shape of the distribution may be skewed. 7. Normal.

Questions 6, 7, 8, and 9 were designed to explore students' understanding and application regarding the relationship between the sample size and the variation of the sampling means distribution. These four questions were created based on the fundamental properties of CLT that (1) effect of sample size on the variability of sample means, (2) as the sample size gets larger, the sampling means distribution becomes more symmetric, (3) as the sample size gets larger, the sampling means distribution becomes narrower, (4) for more skewed parent distributions, larger

Table 22. Pre-test and Post-test Responses for Question 6

	Group	Pre-Test	Post-Test
6. What will the sampling means distribution look like if the sample size is small?	Simulation	1. Ketosis. 2. Very few variates. 3. Not fully represent. 4. It will have a low peak. 5. (draw a very picked normal distribution).	1. It will mirror the parent population distribution. 2. Will not be a close to a normal distribution; would become normal if sample size is large. 3. The curve is not smooth and not look normal. 4. Flattened bell curve. 5. Hard to represent and generate the research question. 6. The distribution will be narrow.
	Control	1. The scores will be widely distributed. 2. Look the same as the parent population. 3. Not a bell curve. 4. The mean will be less representative of the population. 5. Standard deviation become large.	1. It will be dispersed throughout the distribution and not really centered around the mean. 2. Wil not look like the normal distribution. Not most scores in the middle. 3. It will be more variant, spread out. 4. If the sample is small and normal, the distribution may be more flatten. 5. There will be more variability, spread out from the mean.

sample sizes are needed in order for the sampling means distribution to become approximately normal, and (5) there is no such primary number as 25, 30, 50, or 100, as suggested by so many textbooks, above which the approximation is adequate (Newton & Harvill, 1977; Mulekar, 2006). When the sample size increases, the variant decreases. From the responses to Questions 6 and 7, most students from the control group and the simulation group understood some key points. The simulations made no difference between the students from the two groups.

Nevertheless, in referring to the general idea and abstract idea from Questions 8 and 9, students from the simulation group showed a more precise and thorough understanding.

Table 23. Pre-test and Post-test Responses for Question 7

<table>
<tr><th></th><th>Group</th><th>Pre-Test</th><th>Post-Test</th></tr>
<tr><td rowspan="2">7. What will the sampling means distribution look like if the sample size is large?</td><td>Simulation</td><td>1. Ketosis.
2. More variants.
3. Can get satisfying resolute which are close to fact.
4. The sampling means distribution will have a high peak.</td><td>1. It will mirror the normal distribution. It has less variability.
2. (students draw 2 distributions, the distribution is peak when sample size is large, distribution is flat when sample size is small.)
3. Bell shaped and curved is smooth.
4. Large, bell curve.
5. More likely to close to means of the parent population.
6. The distribution will be wide.</td></tr>
<tr><td>Control</td><td>1. The scores will be clustered around the mean in the center.
2. The narrow.
3. Normal distribution.
4. The mean will be more representative of the sample of population.
5. Standard deviation getting small.</td><td>1. It would be smaller and more concentrated around the mean.
2. Will look closer to a normal distribution, bell-shaped curve. Most scores in the middle.
3. It will look the same as the parent population.
4. The curve of the bell will be wide leaning more to less of a bell shape.
5. There will be less variability, stacked up around the mean.</td></tr>
</table>

Table 24. Pre-test and Post-test Responses for Question 8

	Group	Pre-Test	Post-Test
8. Please list at least one difference between a parent population and the sampling means distribution?	Simulation	1. The quantity of variants will be smaller with sampling means distribution.	1. Sampling means distribution has less variability than the parent population. 2. Sample means will be close to the mean on both sides through the parent population. 3. Parent population could be in different shapes; sampling means distribution could bell shaped. 4. Sampling means distribution will have a bell-shaped curve. 5. Parent population is more condensed; sampling means distribution is more spread-out. 6. Sampling means are taller and narrower in the shapes.
	Control	1. The parent population should have a greater distribution of scores around the mean. 2. The parent population maybe large or small. 3. Means distribution is a bell curve? 4. (Parent population is flatten, and sampling distribution is peaked).	1. Sampling means distribution would be small (flatten) or curve, where as a parent population shape would be taller in the center. 2. A parent population should be a wider distribution because the sampling distribution is based on a collection of means and should concentrate along the middle. 3. The parent population will contain rare subjects and therefore may not have a standard bell curve distribution. 4. The sampling means distribution will be more normal and stacked around the mean. The population distribution will be more narrow.

Table 25. Pre-test and Post-test Responses for Question 9

	Group	Pre-Test	Post-Test
9. Please list at least one difference between two sampling means distributions with different sample size (e.g. n=2, n=25)	Simulation	1. Curve shape. 2. N=2 will be flatten; n=25 will have a more steep arc.	1. N=2, more variability, n=25, less variability. 2. Different standard deviation; different variance, different shape. 3. N=2 might look wide and not smooth, look not normal because of the sample size is too small; n=25 would be more bell-shaped curve and smooth. 4. When n=2, only 2 samples were chosen, whereas with n=25, 25 samples are taken to come up with the means. 5. Less number, more skewed. 6. As n gets larger, the sampling means distribution begin to approximate to a normal distribution.
	Control	1. There will be a greater variant in the scores for the sample size with 5. 2. The shape will be different. 3. There are more students in one than the other with less students, it will be hard to achieve statistically significant result. 4. N=2, lower number to sample mean will be the half of the 2; n=25 more number to sample and the mean will possibly give a more representative mean to the sample of population.	1. The sample size 5 will have a smaller distribution. (small variability). 2. The means will not be similar, and will not look follow around distribution. 3. The wide a higher degree of variance among the smaller sample. 4. The smaller sample size will be spread out more, while the large sample size will stack up more around the mean.

In general, students from the simulation group had a more precise understanding toward the CLT concept. This conclusion is consistent with the previous literature that the simulations assist students in understanding such essential statistical concepts as the sampling means distributions and the CLT (e.g., Cobb et al., 2003b; Ben-Zvi & Amir, 2005; Pfannkuch, 2006; Hagtvedt, Jones, & Jones, 2007), by actively building or constructing their knowledge and making sense out of that knowledge (Mills, 2003). Moreover, previous literature also reveals that the computer-based simulations could correct students' misconceptions (Morris, 2001).

Results of Research Question Three

The focus of this study considered qualitative explanations and explorations of students' attitudes, experience, and perceptions toward statistics. After noting some differences between students from two groups, the researcher was interested to know the factors and reasons leading to those differences. From the discussion of the first research question, findings suggested that stimulations could inspire students' positive attitudes, even though not significant. Moreover, from the discussion of the second research question, students from the simulation group demonstrated a more precise and clear understanding of the CLT concept.

In this portion of the study, the objective was to identify the factors which lead to those positive results for the use of simulations. Toward the end, interviews were conducted with students in both the control and simulation groups, choosing five from each group. First, for the students from the simulation group, five students' experiences of using simulations were analyzed. Second, for the five students from the control group, even though they were not exposed to the simulations at the beginning. However, after the interview which focus on statistics learning with the traditional method, the researcher showed the simulations to this group of students at the end of the interview, and discussed their subsequent perceptions and reactions. Their statistics learning experiences of using the simulation and traditional method versus using the traditional method alone were analyzed and compared between these two groups. The experiment for this third research question is available at Figure 4.

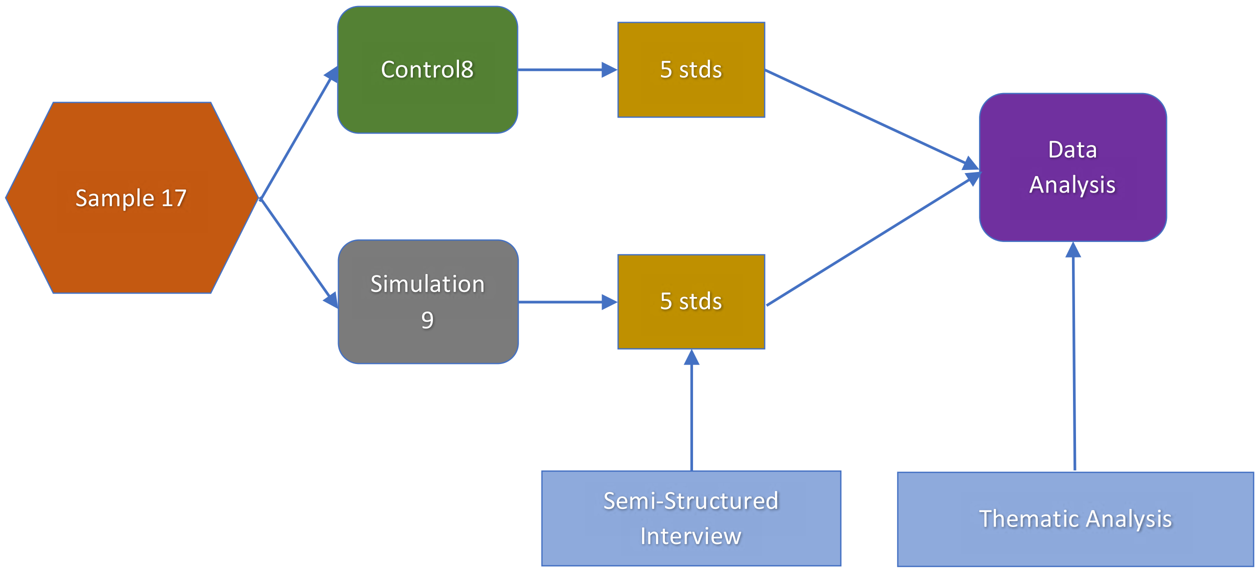


Figure 4. Experiment for the Third Research Question

Students' Opinions in Using Simulations in Statistics Education

From the interview data, all ten students were satisfied with the use of simulations, whether for students from the simulation group, or for students from the control group, but all have the simulations demonstrated at the end of the interview. All of them hope that the simulations could be used for other statistical concepts, and hold the idea that simulations were very helpful in statistics learning. The comments are listed as below:

[1_Lab] It (the simulation) helped me a lot from the very beginning of the class to the end really, because when we first started doing it, it looks cool but I don't understand it, but then you gave us another distribution, where we could tell the real distance between the different distributions, and it started to make more and more sense to me, and then once I went to class on that same day, some of the things that the professor told us tied into back, so it made more sense, so whenever I went home and started playing around with it, I got more and more comfortable with it, so it definitely helped understand.
[1_Lab] I definitely think it helps out with the more complex problems, complex details.

[3_Lab] I think I could understand it, I think like that concept, like I really grasped and I definitely understood it.
[4_ Lab] That was interesting. It helped with the concept, it definitely did give more confidence.
[1_Class] I think the animation helps because it shows how the shape of the distribution is affected by the sample size.
[3_Class] I think it's helpful. I guess just seeing it multiple forms and then you can watch the process as it unfolds.
[4_Class] The simulation was good, it is very interesting to see it, like to be able to see how the samples can be dropped down, and how they can make the mean, and it was very interesting.

In addition, when asked whether they want the simulations to be used in other statistics topics, all evidenced with very positive attitudes, and their comments are shown below.

[2_Lab] That would be really helpful. Pretty much all of them.
[3_Lab] Sure, why not, it will only help.
[1_Class] If it was, that would be great. I'd like to see how the simulation is used, for different topics even advanced statistics. If you use this in advanced statistics, I think it would make it make sense, I would love to see logistic regression in a simulation.
[1_Class] I like that process, yes, if all statistics was kind of like this process, I think I get it better because I see it happening in real time in front of me.

Moreover, the participants even thought the simulations to be necessary for statistics learning, due to the importance of providing multiple methods in learning abstract statistical concepts. Their comments follow below.

[1_Lab] I think the situation should be used in as many topics as possible, because it's just that extra component that's going to be the supplemental way to what we are already learning. Lots of people may not think that they need it for their specific statistical area, but if they were to see the benefits of it, I think they will like it.
[2_Lab] I would take for people like me, the simulation is necessary for statistics learning, then there's probably a lot of people like me because everybody in the class seems up in intensity about learning all this.
[2_Lab] Any other learning methods that might make it easier for people to learn statistics, I would say you would have to do like reading coupled with simulation, coupled with like YouTube videos, like you'd have to have a whole package I think to understand it.
[3_Lab] I think it's necessary, I think it's good, I'm a visual kind of learner, so it helped me a lot, because I don't think about things.

[4_Lab] It gave a visual to go with the wording, it was able to give for learners like me who are visual learners, it gave me something to see as that concept, so it wasn't as abstract.
[4_Lab] I found it interesting when I looked on con economy they were using the same thing to explain a concept.
[5_Lab] I think definitely it's necessary.
[1_Class] I think this simulation makes it better for me, I need to see visually what happens, I think this is A perfect tool to use.
[3_Class] I don't think it would be necessary, I think it'd be beneficial. I think someone can learn it without it but I think it would be very beneficial for them to have this.

Beneficial Activities of Using Simulations in Statistics Education

Regarding the first two research questions, students from the simulation group had more positive attitudes and clearer understanding of the statistical concept of CLT. The analysis of the qualitative interview data from ten students revealed four major themes that leading to the positive effects of using simulations in statistics education, as well as one barrier to use the traditional method alone as being not enough to demonstrate the statistical concepts. These four beneficial activities are: (1) the use of simulations allow students to visualize the abstract statistical concepts, (2) the simulations provide more details of the statistical concepts, which are not available by means of the traditional method of reading alone, (3) the individual interactive role from the simulations provides students the opportunity to raise questions and explore answers by themselves, thus develop students' statistical and critical thinking, and (4) the simulations make the statistics education more enjoyable.

For the first beneficial activity of using simulations, comments from the ten students indicated that the visualization of simulations was critical and useful to demonstrate the abstract statistical concepts.

[1_Lab] I was so used to doing things like that by hand, where you don't really see those animations of how (the samples) actually falls out, but to see it working by just a push of a button, like oh, I see how the distribution look like.

[1_Lab] The simulation definitely helps, especially when it's very abstract, and it's hard to grasp it, just of wording whatever, you can utilize a different procedure, like the simulation, I think it really helps, because you need words for certain things, but then you need visual.
[2_Lab] It provided concrete evidence and show me with numbers, how it links to the theory.
[2_Lab] It's something that you can see in front of you, you can see the distributions changing, you can visualize, and you don't have to imagine it. You can see the process, you can see the difference between the 2 sample sizes, that's hard to imagine, you can't simultaneously imagine the sample size of 2 in the distribution changing and a sample of 35 in the distribution changing, like this is too much to imagine, especially with someone you don't have a good background on, or you don't really understand it, you're not going to think too complicated things like that.
[2_Lab] It (the simulation) shows the meaning behind the definition, literally in front of you, you can see the meaning. If I read the textbook there is no meaning, that's just the definition, but if you look at the simulation, you can understand, oh, this is what that definition means.
[4_Lab] We were able to look at the simulation and get more understanding of the distribution, the mean, and the curve, and see how it was going to be normal.
[4_Lab] It was good to see it visually, we should have had that in (lower-level course) too, to see that concept, because it was good, and it brought to life instead of just the vats that were pulling stuff out of you know.
[1_Class] I can see what I was learning, so I knew from the parent population that I randomly selected the two samples…that's what I like, that I could see it step by step happening. I like being able to see how changing the shape of the curve from normal to skewed, to uniform, affect how the distribution looked on the curve.
[5_Lab] I think just visually, I can see the bell shape, how the data change, the taller shapes when sample size increase.
[3_Class] I think it would definitely help just seeing a visual as opposed to reading out of the textbook.

[4_Class] A visual to see what happens when you got the smaller sample size versus the larger sample size, and you can manipulate it, and it shows what they look like when you get finished.
[4_Class] I can better understand it when seeing the diagrams, and stuff, I can see it a whole lot better, it makes sense and makes connections. I think it's very helpful especially like me who I can't see it, to be able to see it is very helpful.
[4_Class] when I read the definition, I mean now that I understand it with the class and everything I get it, but just like a lot of things when I read it, I can't see it, I can't visualize it, I don't understand what it's saying, so if I saw it, it would make a lot more sense.

Next, the simulations provided more details of statistical concepts which were not available from the traditional method alone, which in turn made more sense to them. The comments are listed below.

[2_Lab] The video just said how is the sampling distribution of means was conducted, but it didn't show the difference between the sample sizes. So, if you had a smaller sample size versus a larger sample size that particular video didn't go into detail about that. But this simulation did then.
[2_Class] It shows a lot of details.
[3_Class] It gives you a visual, so you can learn through multiple and you can do it by keying in the number, so you're getting tactile you're getting a visual, so you hit using multiple forms of learning.

Third, the individual interactive role from the simulations provided students the opportunity to raise questions and explore answers by themselves, which had the potential to develop students' statistical and critical thinking further. The comments are listed below.

[1_Lab] While working on the simulation, the more and more and more and more and more and more you clicked it (draw the sample many times), it started to be more like the actual parent population, so seeing that and you are not really knowing that would happen previously, it inspires me to okay, so what if I had to this, or what if the population is skewed to this side, what the sample distribution actually looked like, so it's something that I'm still in a process of learning, but is definitely excited me, excite me to want to know more in, and continue to use it to discover more.
[1_Lab] It's such a great asset to keep me learning, and it really allows to slip out of my mind.
[5_Lab] I think it's just to try by ourselves, see the difference, just compare by ourselves, just click, and see what happen.
[1_Class] I like that about the simulation that it shows me what happened to the distribution if I skew the parent population or if the parent population is normal, and then we can even look at what changes if we increase our sample size, and it shows you what changes, I like seeing it.
[1_Class] I think it helps me to ask questions because it makes me want to know what would happen if I took a larger sample of subjects, or if I wanted to increase the number in my sample, it makes you question what the shape would be and then, you question of why is the shape that way, so it makes me want to ask questions and then kind of find out the answer.
[3_Class] I think that's the problems especially beneficial that way you have more options, and you can see it in different ways, and you can see how larger samples versus small samples are affected.

[4_Lab] Because it's a visual, a visual aid is visual representation, you are able to play with it, you can know what you want to do, then you can try to figure out your mean, your median, and all that good stuff.
[4_Lab] (Simulation) helped, we were able to go in and pick what we wanted, so we could do some comparing, and like some research for say, just to see different ones.

Fourth, comments from students also indicated that simulations made statistics learning enjoyable by allowing them to initiative interact.

Last, data from the interview indicated that the traditional method alone was not enough to make sense of the statistical concepts. All five students from the simulation group thought that the traditional approach alone was not enough to readily understand the CLT concept. Also, even have some of the students from the control group initially thought the class review was somewhat sufficient at understanding the CLT concept, after seeing the simulations demonstrated, all of them changed their original view and stated that the traditional method alone was not enough to show all the details of CLT.

When asked whether the traditional method alone was enough to allow a clear understanding of the CLT, the comments from the five students of the simulation group are as follows.

[2_Lab] No, no, not at all. In fact, I had to look at YouTube video to try to figure out what the textbook was saying.
[2_Lab] There is no visualization, I mean there's no visual, I can't see what happens if I decrease my sample size with this major, what happens when I increase my sample size.
[2_Lab] (With the traditional method alone) I could probably memorize that information, but whether or not I'd actually truly understand it, conceptualize it would be a as different story. I could do rote memorization and just know those facts, but I don't think I'd be able to visualize this fact or understand its meaning that's not trying to say. I wouldn't understand the meaning, I would just understand that the variability decreases as sample size increase is so could just a memorize the facts, but it's not going to have a meaning to me.
[2_Lab] I would not have learned the definition that is it. Even the definition had a bunch of parts to it, I don't even know what that means, I'm going to forget that part.
[3_Lab] No, that's a complicated theory.

[3_Lab] I'm just not a reading (person), I feel like it was an information overload, like the textbook is so hard to read from. It's so hard to like understand the phrasing, to me they say the same thing so many different ways in more complicated ways, it's not like a concrete thing.
[4_Lab] I don't know, for me I just need more.
[4_Lab] No, the textbook isn't going, I mean what you did in a lab (simulation) helped.
[5_Lab] I think just read the definition, it's easy to forget, and I cannot exactly understand.

Before having the simulations demonstrated, some students from the control group thought that the traditional method alone was enough to aid them in understanding the CLT concept. However, after a demonstration of the simulation, all students felt that the traditional method was no longer enough. The comments both before and after the simulations are listed below.

Comments from the control group students before the simulations:

[1_Class] Yes, but it's difficult for me to explain smoothly.
[1_Class] A very clearly is relative for me, I don't really, the topic always confuses me, but I think the notes and the additional resources help.
[2_Class] Yes, yes, it's good enough. I think that's all enough.
[3_Class] Kind of. It's an aid you know. I do think there is deficient in the way I understand it just by reading it, but it does help, but I have to watch the videos, and read the textbook, and read the notes to be able to get it. If I had to learn it to give me a general idea, I believe it is, to just give a basic idea, but to get a satisfactory grade in this class, it may not be, but in just general terms, it could be.
[3_Class] Sometimes I can read it over and over over again, but I still just can't figure out like what the little symbols mean, and all that stuff, and I feel like it assumes that I know more than what I know.
[4_Class] I think the class review (traditional method) is enough, very clearly. Because we did go over that and (a lower-level course), and so I do, once the professor started talking about it, I do I remembered what he was saying.

The comments from the control group students after the simulation:

[1_Class] Yeah, I can absolutely try right now, but it's going to be based on my visual, this visual in my mind it's going to be, okay if the parent population is normal, I can …...
[1_Class] I think I can understand it, but it won't be as clear as me seeing it. I get the premise behind it what they want me to understand and that's fine, but when I'm able to visualize it, I actually be able to see it happening and I think that makes it stick, right now when someone asks

me about the CLT, I am like, oh I know, I have to …… like oh, that makes sense. Because I watched it happen. Whereas in reading the textbook and looking at the notes you're learning it, but you're not watching it happen. I think this makes it stick for me.
[1_Class] I think the textbook and the notes a kind of shows it, but I like having it be manipulated in front of me, so the textbook and the notes do a good job, but I think the simulation kind of captures maybe what they're missing, that showing the student in real time what happens.
[2_Class] No
[3_Class] No, I think you need to have multiple avenues to learn from.
[4_Class] For some people, not for me so much. Not enough for the details and the comparison.
[4_Class] Kind of have a picture in my head already. I like the simulation. I like seeing this side by side.

Comments when asked about the difference before and after the simulation:

[1_Class] Before the simulation, I probably would have struggled to use it, only because I couldn't explain it, but after the simulation, now I can see how it used, so I can visualize how I'm using it to apply it to another topic.

In general, four major beneficial activities from the use of simulations could inspire students' positive attitudes and improve students' statistics achievements, including (1) the use of simulations allow students to visualize the abstract statistical concepts, (2) the use of simulations provide more details of the statistical concepts, which are unavailable from the traditional method of reading alone, (3) the individual interactive role from the simulations provides students the opportunity to raise questions and explore answers by themselves, thereby develop students' statistical and critical thinking, and (4) the use of simulations makes the statistics education more enjoyable. These four activities support the previous literature. First, the dynamic interactive simulations could be helpful in teaching and learn most of the important ideas and techniques of introductory statistical concepts by encouraging students to visualize and to further understand statistical concepts, including randomness, confidence intervals, hypothesis testing, and regression analysis (Gordon & Gordon, 2009). Next, the use of simulations provided important information about statistical phenomena that would be impossible to assess otherwise.

The use of simulations could also provide a hands-on method for students to become acquainted with complex statistical concepts. (Sigal & Chalmers, 2016). Third, increasing evidence suggested that the use of simulations could improve students' statistical thinking from several aspects: (1) clearly presenting the complex logic of inference, (2) strengthening ties between statistics and mathematics concepts, (3) encouraging a focus on the entire research process, (4) inspiring students to think about the advanced statistical ideas, (5) promoting more time to explore, do, and talk about real research and messy data, and (6) offering a firmer foundation on which to build statistical intuition (Tintle, Chance, Cobb, Roy, Swanson, & VanderStoep, 2015). Fourth, students with simulations had more enjoyable experience in comparison with other learning activities (Ratanaolarn, 2016). Last but not the least, previous research indicated that many students experience difficulties in mastering basic concepts of probability and statistics either with the lecture notes or traditional reading materials alone (Groeneboom, de Jong, Tischenko, & van Zomeren, 1996). Thus, the traditional lecture notes or reading materials alone are not enough to understand statistics concepts.

Results of Research Question Four

Statistics anxiety has been a principal obstacle for social sciences graduate students in the statistics learning process. Different from the first research question, focusing on students' attitudes toward statistics, the primary purpose for this portion was to focus on students' anxiety related attitudes. How would students' anxiety impact their statistics learning process? Did students' anxiety levels diminish after the introductory statistics course? If yes, what actions could be taken to release the statistics anxiety?

The participants for this research question were twenty-two social sciences graduate students. Both quantitative survey and qualitative interview data were conducted for these twenty-two students. However, the five students from Spring semester, taught with the traditional method only, were interviewed and surveyed after they completed the introductory statistics course. For the students from the Fall semester, nine students were from the simulation group, who were taught with the traditional method and simulations to demonstrate the statistics concept of CLT. This group of students was called the simulation group. The rest eight students were taught with the traditional method only, called the control group. At the end of the experiment, five students from each of the simulation and control groups were interviewed about their anxiety related attitudes and experiences in their statistics learning process. The experiment for both the quantitative and qualitative phases were available at Figures 5 and 6.

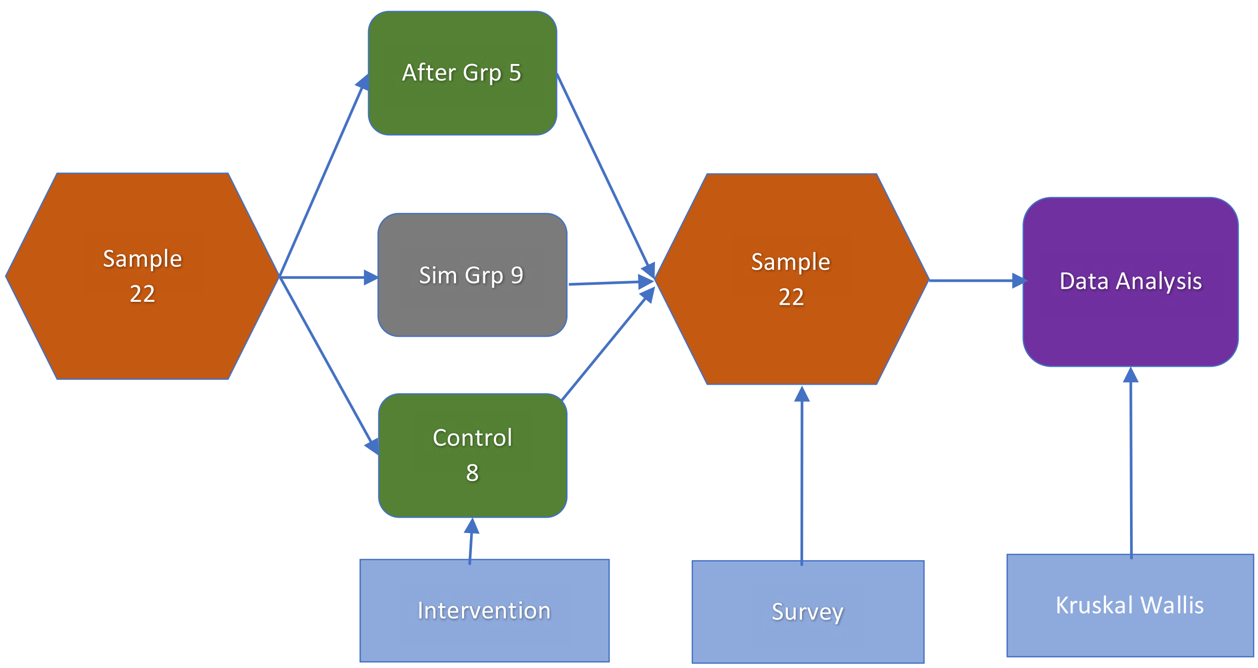


Figure 5. Experiment of Quantitative Phase for the Fourth Research Question

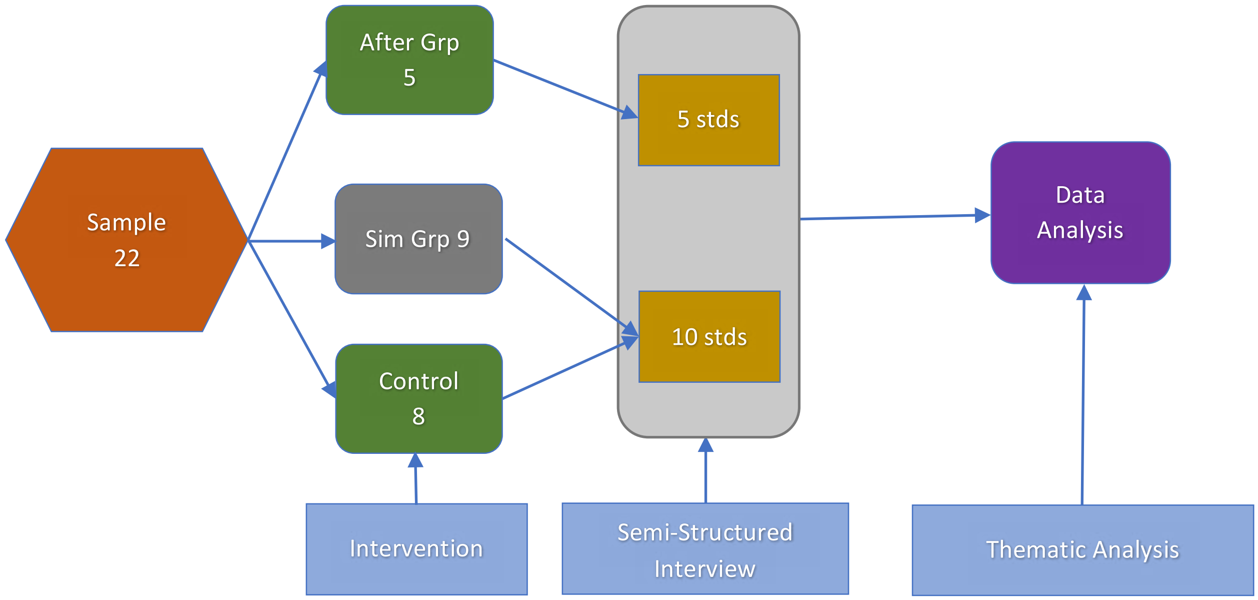


Figure 6. Experiment of Qualitative Phase for the Fourth Research Question

Statistics Anxiety Impacts Statistics Learning

Before analysis ensued regarding statistics anxiety related attitudes, the researcher was interested to see how the statistics anxiety impacts students' statistics learning process.

From the thematical analysis of the interview data, the primary disadvantages of statistics anxiety from the responses of the fifteen students were divided into three main themes: (1) statistics anxiety would stop students from asking questions, which represents one of the essential components in statistics learning, (2) statistics anxiety would stop students interacting with the professor or classmates in class or any other styles, such as a discussion forum on Moodle, and (3) statistics anxiety would discourage students' confidence in statistics, by assuming that others know more than themselves, which further added stress and anxiety to them. These findings are consistent with previous research found that the confident students appeared to take more accountability toward learning the course materials and participation (Ward, 2004). Students who were less successful, or wre more frightened of the course, would not be involved, or would not participate in the discussions with the instructor or other students (McLaren, 2004).

Addressing the first hindrance of statistics anxiety, when asked whether asking questions was important and useful for this course, all students interviewed, listed a 100% certainty, as shown below.

[1_Lab] Exponentially, so many of us think we know it all, we can be too confident some areas, but if you don't ask questions you can never learn more, you don't have questions you can never obtain clarification when you may have thought you knew it right, but maybe if you have just a sliver of a doubt ask a question, and get it clarified, and I feel that questions are so vitally important, too many people are too timid to ask those questions, and that's only going to hold them back. I will not be that person.
[3_Class] If you don't understand something, the only way you're going to be able to understand is by asking questions, and by talking to you, it's pretty obvious that a lot of people aren't really understanding what is going on, so the best way to find something out is just to ask, whether you feel comfortable or not.

However, when asked whether they would ask questions in class, or post questions or comments in the discussion forum on Moodle, students' comments vary. The students with less anxiety tended to feel more comfortable about asking questions in class, while students with more anxiety were unconfident to express themselves in public.

The comments are listed as below.

[1_Lab] Lots of people are afraid of how they'll be viewed by others, they see okay if I proposed this question this person is going to think I don't know what I'm doing, or think less of me.
[2_Lab] Usually I'll try to figure it out on my own, like look at YouTube videos, see if I can figure it out, and then as a last resort, I probably had to ask the professor, but I would ask him in person during the class or maybe even during office hours rather than in front of other people.
[3_Lab] I don't like asking questions because I feel like they're stupid questions, and like everyone already knows what they are, because I just feel like sometimes I don't understand the very first principal of something, and so I don't want to ask about it.
[4_Lab] I have to process it a little bit, like if I'm seeing something up there, I don't know how to ask my question, does that make sense, I don't know how to formulate my question because it's all just kind of running around up there, and I have to process it, and have to take a long time, and then I can come back with some questions.
[3_Class] I'll be honest, in a graduate setting, when you don't feel like you know anything, it is uncomfortable to ask questions in front of other people who are also in a graduate level about

things, like that you’re unsure of because you don’t want to come off as an idiot, because you assume everybody else knows what they’re talking about.
[3_Class] I guess using the discussion form, reading through it, and having my book out and trying to do it, and then I also kind of start the internet to see how other people do it.

For the second hindrance involving statistics anxiety, students with limited backgrounds and high levels of statistics anxiety admitted that they were not comfortable interacting with either the professor or classmates in the classroom. The responses are listed as below.

[3_Lab] I feel like everything I say is this stupid, because I don’t know how like word things intelligently, because I can just be the guy don’t get this, I don't understand like this concept, so I just haven’t posted anything yet.
[3_Lab] I don’t like participating in like the discussion forum that the professor has on Moodle, because they all know something but I don’t know. I just like internalize it, and I just get more anxious, because I don’t actually ask something.
[1_Class] statistics isn't my friend, so I could be grossly wrong.
[1_Class] I should post it, but I don’t want to be wrong. It may not be the right answer.
[1_Class] I may not, just because I’m scared that I’m wrong.
[3_Class] Probably not, I am afraid I was wrong, I don’t want to be in the wrong direction, if I know it 100% concrete I would, but if I wouldn’t 100% positive I probably wouldn’t, because I don’t want to mess somebody else up.
[3_Class] I posted on there like twice, three times, but I feel like everything I say is this stupid, because I don’t know how like word things intelligently, because I can just be the guy don’t get this, I don’t understand like this concept, so I just haven’t posted anything yet.

For the third hindrance of statistics anxiety, students with limited backgrounds and high levels of statistics anxiety usually assumed other people know more than themselves, which tended to add more stress to them. The comments are listed as below.

[3_Lab] I don’t like asking questions because I feel like they’re stupid questions, and like everyone already knows what they are, because I just feel like sometimes I don’t understand the very first principal of something.
[3_Lab] They don’t know how to explain it, or like they don’t understand why I don’t understand it, because they just like know how to do it, and they’re like how do you not know how to do that.
[3_Class] I’ll be honest, in a graduate setting, when you don’t feel like you know anything, it is uncomfortable to ask questions in front of other people who are also in a graduate level about things like that you’re unsure of because you don’t want to come off as an idiot, because you assume everybody else knows what they're talking about.
[3_Class] I almost feel like some people know a lot more than me, and my questions might be a little bit more elementary, so I don’t want to come off as a dumb person, but it is what it is. when

I was in my master degree, I assumed everybody in the Ph.D. program know more than me, because they were in the PH.D. program. But they didn't understand that now.

Social Sciences Adult Learners' Statistics Anxiety Before and After the Introductory Statistics Course

During first research question, seven items describing students' attitudes toward statistics are analyzed. However, since the purpose of this research question focused on students' anxiety related attitudes toward statistics, only two of the seven items describing students' anxiety conditions were discussed in this portion at the beginning and after students completed the statistics course. The two items were (1) I am scared of statistics, and (2) I get nervous going to statistics class. The participants involved were students from the after-course group, and the control group, who were taught only with the traditional method. Moreover, while the use of simulations in statistics was also an interest in this study, the simulation group was also analyzed in this study, yet was not the focus as an objective. The descriptive statistics information of sample size, mean, standard deviation, as well as minimum and maximum for these two items, were available in Table 26. The nonparametric Kruskal Wallis tests were conducted to compare the significance among the three groups. The Kruskal Wallis test reflected the counterpart nonparametric statistics of the one-way ANOVA when the sample sizes for each group were small, and as a result, the assumptions of normality, and homogeneity required for the one-way ANOVA were not met. Moreover, since two hypotheses tests (two items) were being performed simultaneously on a single factor (independent variable), the Bonferroni adjustment was made to the P value to keep the desired alpha value to .05. The familywise error rate was .05/2=.025, indicating the probability of rejecting at least one true null hypothesis, and making at least one type I error. Kruskal Wallis test results from Table 27 indicated that both items were significantly different among students from the three groups, with Asymp. Sig. value of .011 and .005 less than the familywise error rate of .025.

Table 26. Descriptive Statistics for Students' Anxiety Related Attitudes Toward Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
1. I am scared of statistics.	22	2.82	1.368	1	5
2. I get nervous going to statistics class.	22	2.82	1.368	1	5

Table 27. Kruskal Wallis Test Statistics[a,b] for Students' Anxiety Related Attitudes Toward Statistics

	Att_1	Att_2
Chi-Square	9.044	10.707
df	2	2
Asymp. Sig.	.011	.005

a. Kruskal Wallis Test

b. Grouping Variable: Group

Table 28 provided the details of the comparisons among the three groups. The lower mean ranks indicated more positive attitudes. From Table 28, students from the after-course group held more positive attitudes than students from the control group. However, students from the simulation group had the most positive attitude for one of the items, followed by students from the after-course group closely. Students from the control group always held the least positive attitudes. The effect sizes were computed for each of the items to determine how much variance was accounted for by the difference between the groups. The formula for the effect size is as below.

$$\eta^2 = \frac{x^2}{N-1}$$

Where

x^2 indicates the Chi-Square value from the Kruskal-Wallis Test

N indicates the total sample size.

The effect sizes η^2 for each of the two items were presented in Table 29. It meant that for each of the two items, the variance accounted for by the difference between group were 43.1% and 51.0%, indicating high percentages of variances from difference are accounted by the groups.

Table 28. Students' Anxiety Related Attitudes Before and After the Statistics Course (Mean Ranks)

Survey I: Perceptions, attitudes about Statistics	Group	N	Mean Rank
1. I am scared of statistics.	Simulation	9	7.72
	Control	8	16.75
	After-Course	5	9.90
	Total	22	
2. I get nervous going to statistics class.	Simulation	9	12.00
	Control	8	15.69
	After-Course	5	3.90
	Total	22	

Table 29. Effect Sizes η^2 for Students' Anxiety Related Attitudes Toward Statistics

Items	η^2
I am scared of statistics.	0.431
I get nervous going to statistics class.	0.510

The focus of this research question was the comparison of students' attitudes before and after the statistics course. As a result, the Mann-Whitney U tests were conducted to students from the control group and the after-course group, and represent students' attitudes before and after the statistics course, and students from both groups were taught without simulations. The Bonferroni adjustment was made to the P value to keep the desired alpha value to .05. The familywise error rate was .05/2=.025. The Mann-Whitney U test results from Table 30 indicated that one of the two items was significantly different between students from control and after-course groups, with Asymp. 2-tailed Sig. value of .004 less than the familywise error rate of .025.

The Mann-Whitney effect sizes were also computed to determine the strength of the difference. The effect size from Table 31 indicated that students from the after-course group had lower levels of statistics anxiety, both with very large effect sizes.

Table 30. Mann-Whitney U Test Statistics[a] for Students' Anxiety Related Attitudes Toward Statistics

	Item 1	Item 2
Mann-Whitney U	7.5	1.0
Wilcoxon W	22.5	16.0
Z	-1.888	-2.857
Asymp. Sig. (2-tailed)	.059	.004
Exact Sig. [2*(1-tailed Sig.)]	.065[b]	.003[b]

a. Grouping Variable: Group
b. Not corrected for ties.

Table 31. Mann-Whitney Effect Sizes for Students' Anxiety Related Attitudes Toward Statistics

	r (After Course - Control)	Effect Size
Item 1	-0.524	Very Large
Item 2	-0.792	Very Large

Generally, students from the after-course group had more positive attitudes, but their opinions remained unknown. In more details, the mean values for each of the two items were provided in Table 32 to demonstrate students' anxiety levels from each of the two groups. Concerning Item 1, the mean value for students from the after-course group was 2.40, indicating that students held a disagreeing to neutral attitude to the statement that they were scared of statistics, while the mean value for students from the control group was 4, indicating that the students agreed with this statement. Concerning Item 2, the mean value for students from the after-course group was 1.2, showing that students tended to disagree with the statement that they got nervous at the thought of going to statistics class. The mean value for students from the control group was 3.75, indicating that the students held a neutral to agree with attitude to this statement.

To conclude, students' attitudes differed between the two groups. At the beginning of the course, students had higher levels of statistics anxiety, with mean values of 4 and 3.75 out of 5 regarding the statement of (1) I am scared of statistics, and (2) I get nervous going to statistics class. However, students' attitudes diminished after they completed the statistics course, being against to the statement with mean values of 2.4 and 1.2, respectively.

Table 32. Students' Anxiety Related Attitudes Before and After the Statistics Course (Mean Values)

	Group	N	Mean	Std. Deviation
1. I am scared of statistics.	Control	8	4.00	1.195
	After Course	5	2.40	1.342
2. I get nervous going to statistics class.	Control	8	3.75	1.282
	After Course	5	1.20	.447

Follow-up interviews were conducted to all fifteen students to explain their statistics anxiety related attitudes. The interview indicated that most students from the Fall semester, interviewed at the beginning of the statistics course, had high levels of statistics anxiety. Most of them took this statistics course since it was required, while almost all of them did not plan to take any higher level statistics courses at that moment if not needed. However, all of the five students interviewed at the end of the statistics course also had serious statistics anxiety at the beginning of the statistics course, but after they completed the course, they were not anxious about statistics so much, and all of them planned to take some higher level statistics courses. The interview findings are consistent with the quantitative survey results that before taking the statistics course, the social sciences adult learners had much higher levels of statistics anxiety, while students' statistics anxiety related attitudes were relinquished after they completed the introductory statistics course, and the students became somewhat interested in statistics.

These results are against with previous findings from Ramirez and Bond (2014) that the undergraduate students' statistics anxiety related attitudes became negative from pre-test to the post-exam, and even though not significantly different, the negative attitudes included being more scared of statistics, statistics being more difficult than expected, not planning to work hard on statistics, and being reluctance to use statistics in daily life. Moreover, another study from Swanson, VanderStoep, and Tintle (2014) also indicated that students' attitudes became more negative from the pre-test to post-test both for both the Project-based Course (n=75) and the Hybrid Course (n=118), a mix of traditional and online learning courses. The statistics anxiety related attitudes for the population in this study, combined with social sciences, found adult learners to be entirely different from the previous literature.

Traits of Social Sciences Adult Learners' May Help or Hinder Their Statistics Education

Although prior research indicated that students had severe statistics anxiety, and studies suggested that students' statistics anxiety related attitudes became more negative from the pre-test to post-test (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014). The findings from this study contradict with previous literature. In this portion, the researcher was trying to explore the possible reasons leading to the differences.

The study population, when combined with social sciences and adult learners, resulted in many different traits. The researcher became interested in seeing what were the different characteristics of the social sciences adult learners compared to their counterparts of undergraduate students, or other groups of people.

Graduate students' attitudes toward statistics varied before and after the introductory statistics course. The factors leading to the different conclusion for this population emanated from five aspects. These five aspects presented to the different reasons leading to the adult students' statistics anxiety, as well as their characteristics which helped their statistics learning.

First, the comments from the social sciences adult learners indicated that the major anxiety the adult students experience was related to not having sufficient time to prepare for classes and exams. Second, social sciences graduate students' anxiety toward statistics was due to a limited background in statistics. However, adult learners' traits could help them overcome these challenges in their statistics education. To begin with, adult learners were self-directed, and they opted to take personal responsibility for their lives and decisions, which related to their choice to have control over their learning (Pappas, 2013). Evidence indicated that students from the after-course were reported taking an average of 13.4 (SD = 1.14) hours each week, besides class time. Next, adult learners showed a persistence in dealing with the difficulties of statistics courses.

The comments on the trait of persistence are as below.

[1] I was intrigued every time we went to the next chapter because I couldn't understand, but I want to do statistics too. Because I know it is not that difficult, it is that once you haven't gotten the very basics, it is very hard to, you know, to really get yourself, well in a place where you can understand what is been taught.

[2] I think it's a subject that is challenging to me and that I strive to learn, and to really, you know, I strive to learn it, I want to learn it. It's (statistics) not difficult, it is just not something that is …comfortable. Because, you know, I don't know the background. I cannot say it's difficult. Right? It's not difficult. To me, it is right now, it is not comfortable. But I think for somebody who gets the background in, someone like you, for instance, you know it's not that difficult for you to come within the numbers on those formulas, and so on and forth.

[1_Lab] I think a little anxiety as healthy because it keeps you from being complacent. I'm a little anxious but every time I come to class, I come to the lab it helps, put that anxiety to the side, because I'm really ok learning this. I know this, I can do this, so the anxiety just slowly, falls away.

Finally, all of the fifteen adult learners exhibited strong motivations to learn statistics well, and in dealing with difficulties in the statistics course, since learning in adulthood was usually voluntary (Pappas, 2013). This was due to the fact that all these fifteen students interviewed for this study revealed that they need statistical skills to read papers, analyze data from research, and conduct statistics for their dissertations, or for their future careers. Even though most of the students were required to take this course, their decision may change since they found that they wanted to be able to read papers and conduct statistics independently in their research, dissertations, or work. This high desire was also supported by the learning assumption from Knowles (1984) that adult learners were ready to learn, and that adult learners' motivation to learn was internalized. The comments as to why students have high motivations to learn statistics well are listed below.

[1] Well, I would like to know what I am doing when I am doing the research. I hear that some people can hire somebody to do, you know, the statistics for them when they are researching. I think I would like to be able to do that work on my own, to call it my own. I want to understand, to say this work was done by me, and I can sign my name on the documents that says so. I want to understand what those numbers mean.

[2] Even if my department says you don't need to learn statistics, I think I would want to learn statistics. I think it's also important if you are going to be a researcher, to help you understand what you're reading and to also apply it to your own research.

[3] I'm glad to take this statistics course. Well, I know that I decide to take the (an advanced statistics course) during the summer because, when I was writing up my proposal for another class, I feel that I really do need the information. I need to know how to do the general linear model, and how to work with multiple variables, so I do need it.

[4] Oh, it is required now, it's required, and I'm glad that it's required, because I need it.

These attitudes signaled differences in how undergraduate and social sciences graduate students view statistics. Statistics anxiety for undergraduates occurred as a result of encountering statistics problems in any form and at any time in class (Onwuegbuzie, DaRos, & Ryan, 1997). The anxiety undergraduate students experience was more about their unknown about the area of statistics, which would stop or delay undergraduate students from entering the field of statistics. When undergraduate students chose to delay the enrollment in a statistics course until just before graduation (Perney & Ravid, 1991, p.2), the stress of completing the degree or searching for a job when approaching the end would further add anxiety, even leading to the failure in either statistics or a degree program (Onwuegbuzie, 1997). The statistics anxiety would even be a factor leading to the failure in other things, which in turn, made undergraduate students more frightened of statistics.

However, the graduate students also experienced statistics anxiety at the beginning, because of time considerations on preparing a course or exam (Lundberg, 2003), or possibly a limited background. None of the graduate students reported feeling anxious after the introductory statistics courses. Yet the graduate students were self-directed, which would allow them to enter the area of statistics first, even though they were anxious about statistics at the very beginning, which is a key to a successful completion. Moreover, graduate students had an extreme willingness to learn statistics, coupled with a high persistence in dealing with difficulties. As a result, the graduate students did not easily give up when confronted by difficulties. All these valuable traits from the social sciences adult students played the supportive role to release the statistics anxiety levels.

Moreover, more evidences prove that students' anxiety levels released and they tended to like statistics more. Four of the five students indicated that although they were somewhat anxious before taking the introductory statistics class, they found the subject to be interesting and enjoyable after the class. After students become familiar with statistics, it seemed easier for them to enjoy statistics. As a result, they gained a stronger sense of achievement compared to other courses.

[1] I don't think I would have taken it (the advanced statistics course), like at the beginning of my program, not knowing how to do things, I would not have just spontaneously taken it, but I know now I want to have it, yes, I want the information, I think it's very important.

[2] I have liked it, but I think I was more afraid of statistics before. I didn't think I would enjoy it as much as I like now. I was like thinking I might do bad, but I feel because I didn't do bad, I feel like it's meaningful, now I kind of like it more than I thought I would like it.

[3] I think this was very beneficial and helpful for some of the research studies that I need to do, and for my dissertation, it's definitely important, but I also don't think this course would have been important to me without having taken the courses (basis statistics course) I've taken. The statistics course made those courses more meaningful, and vice versa, this class made statistics more meaningful since we didn't get too much into the theory. I think it helps to have both sides, so understanding what were the math problems that we do, it's a lot more beneficial when you understand what they actually mean. So, have taken this class possibly, but if I didn't take the other courses before, probably not. Again, having taken those, they are pretty interesting too.

Actions to Release Anxiety and Make the Statistics Learning Enjoyable

Students interviewed at the end of the statistics course indicated that their statistics anxiety levels released, even when they were anxious about statistics at the very beginning. Most of them planned to take some higher level statistics courses. The social sciences graduate students' characteristics allowed them students to entered the area of statistics voluntarily, which was a key to a successful completion. However, the experiences and actions during the statistics learning process played an important role in releasing statistics anxiety, and in making the statistics learning enjoyable. The experiences of these five students were generalized into four actions that could release students' statistics anxiety: (1) emphasize the basic concepts to ensure mastery, (2) make more time for statistics learning, (3) focus on fewer materials at a time to increase learning, (4) relate statistics to students' research areas, and (5) involve the simulations in demonstrating the abstract statistical concepts.

The first action was to emphasize the fundamental concepts to ensure mastery. Comments from the students indicated that understanding the basics would lay sound foundations for statistics learning, make the instruction more enjoyable, and further develop their interests in statistics.

[1] It (the lower Level statistics course) is the first statistics class ever I took in my life. When I took this course, I learned the basics of statistics. I feel like if you understand the concepts, then it's very interesting. If you don't understand the concepts, then it would be very hard. It's interesting, I learned a lot. It (the higher Level statistics course) is much harder, but yeah, I managed to understand the concepts of statistics.

[2] If I understand, I like. If I don't understand anything, any concepts, then I start feeling like I don't like.

It's enjoying. I enjoy the class when I understand everything. But if I don't understand any concepts, then I get annoying.

[3] I think it's like once I learned it, if this make sense, then I do like it.

[4] Background in a more simple format is important.

[5] I mean I did well in this class. So, I find it useful and enjoying. I enjoy it. You enjoy at somewhere you did well.

[6] I always say like with math too, it's like a staircase, you know, in math and so if you go up the step one at a time, it's not hard.

[7] I always say like with math too, it's like a staircase, you know, in math and so if you go up the step one at a time, it's not hard, like a bit twelve inch steps one at a time. But the problem is when a couple of steps are missing, and then the students have to jump, like a big three-foot jump, it's difficult.

The second action was to make more time for statistics learning. The primary challenge for adult learners was the shortage of time. Comments from the students indicated that if they had more time for statistics, they would expect to find more success and enjoyment in statistics. On the other hand, limited time might increase anxiety while decreasing interest, success, and satisfaction. The comments reported that much of the anxiety they experienced was not related to statistics subject matter but to not having enough time to prepare before classes and exams. The interviewees expressed that if they had more time to study and practice with statistical concepts, they would enjoy the subject more.

[1] Because statistics is hard, so if you don't spend time, then it's difficult to learn, like you could just sit and read the book, and you know everything. You have to concentrate, you have to focus study, and then you are ok. Yes, I like statistics. I like reading statistics. At times, it's

stressful like when you have all other work to finish, and that time you also have to study statistics. That's stressful.

[2] Usually whenever I studied the book before go to the class, then I can easily understand the concepts. But if I don't study, and just go to the class, and sit there, then it's hard to understand, without reading the book.

[3] When I have a lot of pressure from other courses and from my research, then it's hard to read everything before going to the class. Then I don't like statistics.

[4] I think for this class, it's required that I would go back and forth, and look at from time to time, because everything flows like, I can't stop thinking about one thing, I feel like you need to know your basis to go forward.

[5] If I have time to study and I'm prepared, no anxiety.

[6] Actually, this is why I'm taking it during this summer too, because I had other deadlines (last semester). When I don't have other deadlines that I can just work on that, if I'm doing the problems, I kind of said getting the flow, you know, everything else is going to disappear, you know, it relaxes actually, I know that sounds strange, it's crazy. It relaxes me. But when I have a lot of other things that are due then I feel stressed, and then I don't enjoy doing statistics.

The third action, suggested by all students, was to focus on fewer materials at a time to increase learning. Alfred North Whitehead (1916) suggested that teachers should focus on teaching a few very important ideas as "thoroughly" as possible. Attempting to "cover" too many ideas leads to one becoming an expert in none of them, and everyone should "possess…expert knowledge in some special direction…" (Whitehead, 1916). In applying this idea to statistics education for graduate students, instructors might consider breaking down the statistics subject matter into smaller, more manageable lessons so that students have time to learn the material more deeply. This might, however, lead to expanding the same statistics material to two courses instead of one.

[1] I always read the book thoroughly, because I feel like just for to have good grades in the exam, just to look at the no sense stuff, just to know like a few topics, not everything. It's not good.

[2] For statistics, each of every step, you have to really, like understand, or you cannot move on.

[3] I wish they tackled a little less within a class, because there are days we could go through a lot, and then it's not enough time for me to process, but I like the labs, because I think the labs are very structured, it's only about one particular chapter, so it's easy to concentrate on it.

[4] Like the lectures, some days we do about 2 chapters, and I think it's hard for me, it's too much. I wish it was just one chapter each week, then we have enough time to read the whole chapter carefully.

[5] I think it kind of gives me like the basic foundation that's required to go forward, like the first (the lower Level statistics course) was like I have no idea about statistics so much, and I think the professor was like very slow, step by step until everybody got it, so that kind of gave me that initial input, that helps me go forward when I take the higher-level classes.

The fourth action was to relate statistics to students' research areas. Comments from the students indicated that applying topics from students' research areas might inspire their interests and connect their statistics learning to practical studies. These comments are also in accordance with the learning assumption of Knowles (1984), who asserted that adult learners were problem centered and had a perspective for immediate application of knowledge.

[1] It's like we are going to use this knowledge toward of our life as long as we do research.

[2] I mean because I want to definitely do research, I would use statistics to make decisions regarding the findings, so I would like every time I'm learning statistics, I would definitely need to understand it.

[3] In my current job, I'm finding it very useful. I find that the little bit the more specific stuff I need, it's at least prepared me enough to be able to do research on my own, to get deeper into that area that I need.

[4] I think many times people can't connect what they're learning in the class with what they need to do in the real world, and I like what in class when we are given examples from our own fields, I think that's really helpful, because we have to think, it makes us bring it into what we're reading in the literature and the type of work that we want to do, and I think when people see that it is related to what they're doing, that's helpful, and that I think students would be more interested. I'm imaging in class, I mean even the students, you know, whether they were music, the music examples, the education students gave education examples, you know, just depending on what their individual fields were, we heard different examples in class, and that was helpful.

[5] … you just don't do it like I think before in school times when we would do learn math, I don't think I practically use it for anything, I would just do it, but this I think it's practical I can actually use it for something, so that makes me like it.

Last but not least, was to involve the simulations in demonstrating the abstract statistical topics.

The first activity of emphasizing basic concepts to ensure mastery is consistent with the recommendation from Garfield and Everson (2009) that teaching should emphasize statistical literacy and basic concepts. This suggestion also worked for teaching graduate students statistics, even in preparing graduate students to teach, as teaching assistants or to follow academic careers in mathematics or statistics. For the second finding, the decision to leave more time for statistics learning is consistent with the previous finding that adult learners usually had many personal issues, such as family, friends, work, and the need for individual quality personal time. In fact, the shortage of time could be the primary constraint for adult learners, as the cause for some of the statistics anxiety (Pappas, 2013). The third finding was that focusing on fewer materials each time in order to increase learning is also consistent with the recommendation from Garfield and Everson (2009) who noted that a statistics course should stress conceptual understanding, rather than a mere knowledge of procedures. Moreover, this finding also supports the research from Pappas (2013) that aging does affect learning, and that although adult learners were slower learning, yet they acquired more integrative knowledge. Adults tended to learn less rapidly with age. However, the depth of learning tended to increase over time, navigating knowledge and skills to unprecedented personal levels. The fourth finding was to relate statistics learning to students' research areas, which also supports the recommendation from Garfield and Everson (2009) who advocated the use of real data. Last, the researcher found involving simulation technique in demonstrating abstract statistical concepts. This finding is supported by yet another recommendation from Garfield and Everson (2009) that technology was useful for developing conceptual understanding and analyzing data. Also, previous research indicated that students with simulation-based learning methods had more enjoyable experiences in comparison to other learning activities (Ratanaolarn, 2016). Moreover, more studies demonstrated that students from the computer-based simulation methods group carried a positive attitude toward their instructional unit compared to students in the control group (Jamie, 2004).

Results of Research Question Five

For this objective, the researcher is interested to know the preferred statistics learning style for the social sciences graduate students. In this flipped introductory statistics course, participants could either attend the in-class session or online session freely. All required materials, notes, class recordings, and the like are available online, and all assignments or announcements are informed via Moodle or email. The interviewed participants for this study are fifteen students. Most of the students have the online course experience. The experiment for this fifth research question is available at Figure 7.

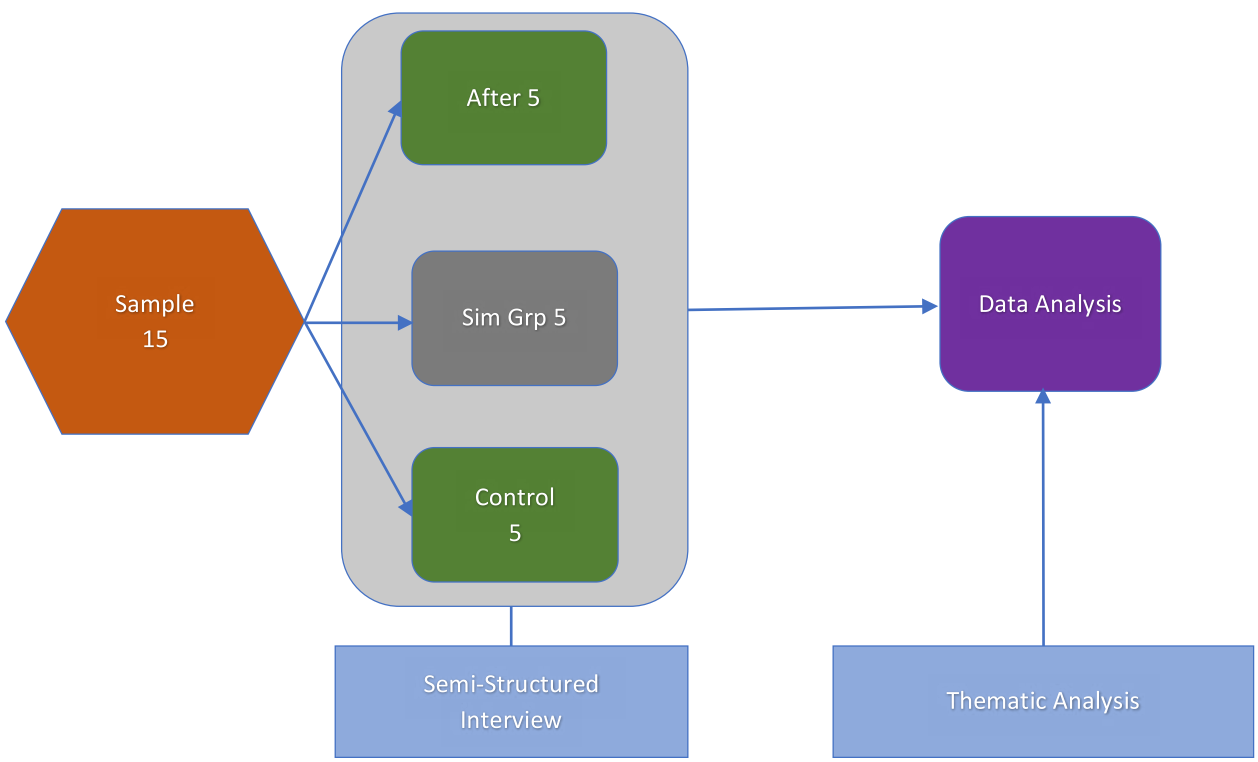


Figure 7. Experiment for the Fifth Research Question

Social Sciences Graduate Students' Preferred Statistics Learning Style

In response to the preferred statistics learning style, fourteen out of the fifteen participants responded with a firm, consensual preference for the in-class session, with one exception, the individual who displayed a good background in mathematics and statistics and also had the constraints of dealing with full-time work and family issues. During the interview, all fifteen students were asked about the advantages and disadvantages of both online and in-class courses. The question was whether students would select an online course if all their notions of the disadvantage regarding the online course were overcome, or whether students would remain in the in-class course, regardless of whatever improvements were made. Interestingly, despite some obstacles for the in-class course, students were still willing to pay the price for the in-class education, regardless of difficulties. The details are exemplified in the following statements:

[1] In class is much better. Because you can have interaction with someone, you can ask the professor if you have any problems you don't understand. But in online, there is no one, you just have to listen to the lecture; you have to learn it on yourself. I don't like online, because the professor is not available. There is no one to help.

[2] I would favor going to class, even though I am extremely tired at the end of the day. It is difficult after a long day's work, but I would favor for the statistics (in-class), I think I would benefit.

[3] If I were to choose the online course, it would have been solely because of the comfort of not having to go, to going to class takes 3 hours, 4 hours from my time, but I also think it's beneficial (to go to classroom), because you are listening to the lecture.

[4] I really think that coming to class is important, when I signed up for this course I went to this session 2, because I thought it was going to be solely in class. So, yeah, I do believe that coming to class is important.

[5] You know, the interaction between professor and student, to take doubts away, is quite important and this course is a very challenging course, it is a most important course to have, to really have a good grasp on, if you want to be successful working statistics, so an interaction between professor and student, I think, is quite important.

[6] If I have an option to turn a face to face course, probably not (choose online), because I prefer face to face. I think in this class, having a face to face class helped, because we were able to work out problems as a class, and have an immediate feedback from the professor and we could change the pace of the class, and where the class went, if everybody agreed that we wanted to focus more on this, so I think that's helpful too.

[7] If the choice is given, I would definitely take in-class course. I don't like online. I feel like if it's just online, it's easier to forget to listen to it, and you get piled up with so much work.

[8] Well, I would prefer in person still. I probably would prefer to come to class, I think the in-person learning is important.

[1_Lab] I prefer to be there, face to face, and get one introduction to everything, and then once I'm off on my own, I can still pull that material fine to refresh my memory, and I plan on being in every class. I definitely prefer sitting class face to face.
[2_Lab] I do not like online, you can tell, I don't like electronic communication. I'd rather face to face.
[3_Lab] I'm always in class, I can't do online, for all the course. I like being in classrooms, but for math especially like for statistics, especially like I feel like I have to be watching someone do it, because I have like and, it's pretty straight forward which I guess it needs to be.
[5_ Lab] I prefer the in-class teaching, just more details some times. Maybe because I don't have too much background, it's difficult for me to just listen to the recording, I need to go back, and listen again, read.
[1_Class] I do the online version because I have a class on Tuesdays. I knew I wasn't be able to make the class. if it were on a different night, I definitely would.
[3_ Class] if my time permits, I would rather go to class, because I can hear the professor, and talk to him verbally, so I can hear what's going on.
[4_Class] attend the class definitely.

Factors That Lead to the Preference of the In-Class Learning Style

The preference for the in-class learning style from all students could be categorized into three main themes: (1) the barrier of the online course, (2) the enablers for the in-class course, and (3) the inappropriateness of statistics or mathematics natured subjects online. These three main themes were common to almost all of the fifteen students. Each of the three main themes included one or more sub-themes.

The barrier for the online course was students' resistance to technology. Except for limited background in statistics or mathematics, most of the adult learners in social sciences had limited background in technology as well, which strongly hindered an affinity for online learning. Comments made by the students indicated that they were not comfortable with the concept of an online course with technology. This is consistent with the previous research that adult learners were less open-minded, and therefore more resistant to change (Pappas, 2013).

[1] I was not a person with technology. I think I come to in-class because technology, I feel like I'm very bad sometimes, I can't in case my computer doesn't work, so you never know there's a problem like that. Everything could all go wrong when you're doing it, so I would still think I prefer coming to class.
[2] When I try to just do it online, I felt overwhelmed. Like doing all this on Moodle, it's overwhelming, but going to class helps me to know, ok, this is what I need to do, and I kind of felt more in touch with the materials, and what we were doing, yeah.
[3] I mean that sometimes, oh, that was something else like Moodle, sometimes I couldn't get the videos to play, it was headache sometimes.
[4] I'm a computer nerd, so I pick up software pretty simple, and something like SPSS.

The enablers for an in-class course could be further categorized into a triad: (1) the availability to ask questions in class physically, (2) attending class as a must for the introductory statistics course, since the interaction between students and professors, as well as students and students, made significant impacts, and (3) human presence in teaching.

The first enabler for the in-class course was the availability of students to ask questions in class physically. Regarding the many perceived advantages of an in-class course, comments made by all fifteen students confirmed that asking questions played a crucial role in the statistics learning process. The freedom to enquire constituted a useful approach toward clearing confusion in class. Also, for those students who were comfortable with asking questions, explaining the problems could further aid in a better understanding. Moreover, even for those students who were uncomfortable with asking questions in class, confusion could be cleared by listening to other students who did enquire in the classroom.

[1] Because if you have any confusion, if you don't know properly about particular concepts, then you can ask your professor. Then you have come to know what the concepts are about. He/She offers more explanation about the book. The book doesn't clearly say about all the things.

[2] It's important to ask question, to understand further. I think attending class helps. Absolutely.

[3] I relied a lot on the questions were asked by other students.

[4] I think asking questions help you learn, so it's important. I always ask questions if I don't understand, I need to clarify but because some of the procedures are not in the book, so I can't really figure that out by reading the book.

[5] It may help other people, sometimes there might be a person who asks questions, and he had helped me sometimes, because I might have not also known the answer, or I might have thought of it in a different way, I think it's helpful. Being in class even if I don't have a question I feel I still sometimes learn from other people asking questions too, there might be a question that I never thought of, so I think in class is important which doesn't happen online.

[6] I would have to be able to ask questions immediately in class. I thought it was easy to understand when I'm able to ask questions. Reading the book doesn't help me as much as being in class and having a discussion.

[7] Sometimes asking a question makes me understand it even more, just like explaining it to someone helps me understand it more. Yes, just verbally saying things sometimes makes it clear.

[8] Because if I don't know something, I'm also an instructor, so I very much understand that if somebody has a question, chances are more than one person to have the same question, and I don't mind asking, so I'll ask on behalf of someone else even.

[9] A student may feel shy about asking a question, but if a classmate asks the question or a similar question, then that could help the other students feel more comfortable with asking their question.

The second enabler for the in-class course was that all students held the viewpoint that attending class was a must for the introductory statistics course, since the interaction between students and professors, students and students, made a significant impact. In addition to the advantages of asking questions, the in-class course also provided many other benefits that were not possible for the online course. The details for the second enabler are cited below.

[1] It makes difference in understanding. If you tried to work on the problems at home without any intervention, without coming to class, it is twice as hard. Going to class, I think, it is important, because this is where doubts are taken away.

[2] To me, I understood everything during class. I mean that going to class is, you know, it is a must.

[3] Sometimes I as a teacher, I feel like it's easy for us to read up students' faces to understand what is happening, so I think it's good for the professor to genuine need to be able to see whether students are perceiving the information, so that he could change the way that he is teaching, because I think that's what something I do in my class, this makes me see faces like, you know, do you want me to clarify? Does that help?

[4] It's so helpful, one click can be wrong. There are multiple ways of doing things and understanding what to click, and what not to click, but when we asked you why do we click this, and why not click this, is helpful, rather than just copying with someone does, I find it I like to know why we click this and not this, it's another reason I like to attend the labs.

[5] There was a time I was doing one of the problems until we got to the class, and then I realized it was one step wrong, and seeing it on the board was able to help with that.

[6] Sometimes I may have read something and I was interpreting it one way, but it wasn't coming out right, but when I asked in class, it helped clear up what I wasn't interpreting correctly.

[4_ Lab] because something you want to ask, you can do it right then and there, or the professor can you look at our faces like the other day, and he's like, oh, we need to go back, because he knew we were confused.

[1_ Class] I think the classroom environment helps students learn. I think the interaction with the professor is better in class, and the interaction with the other students, because online you're kind of quiet, you can do the discussion board but in class you get that real live discussion where you guys get kind of feel of each other as questions and answers.

[3_Class] I think it's better to be in the classroom, so I can interact with, faster and if I have questions, or anything like that, so I can see him put it on the board, and I can hear him say why it's on the board, and then I can do it at same time, so I'm doing its visuals auditory, and its tactile at the same time, I think it's the best way to do it.

The third enabler for the in-class course was that some students were used to the presence of a human being teaching, which provided students with a sense of presence and confidence. Since this target population has no solid background in statistics or mathematics, the existence of a human being played an essential role in making the students feel connected, and in strengthening confidence. This is consistent with the previous research that the student-instructor interactions were significantly contributing to student achievement (Diaz-Cortes, 2017).

[1] I think the explanation of human being for statistics is important to me. I can definitely do another course online, and I have done couple, but statistics to me, I think I need somebody there explaining.

[2] I really do think that it is a plus to have, you know, a mathematics course, you need to be there, in the class, you know, just going and looking at the online, it's difficult to really grasp everything.

[3] It's just important that having a real-life person standing in front of you. I think it's easier when a person is right in front of you, there's lots of information that doesn't come when you are just hearing a voice. I think it's just so got used to, always doing it, so it is sometimes a new concept to be doing it online.

[4] I usually attend the class, just because I like to be able to see things in person, I've in distance learning classes before, and even though we can watch and see, sometimes you can't always see everything, and being able to point to certain things sometimes, it's just a language barrier, the computer can be a language barrier sometimes between follow up and not. And if I have a question, it's immediate.

[5] Because it's easier to grasp in person I think, then just online, maybe because online I'm not as confident with asking questions. I feel disconnected, it just when I'm online, there's just a disconnected. I want to learn from someone. That's important.

[1_ Lab] I'm a visual learner, obviously, you get the visual component online, but just to be there and actually see the person writing the questions, you can write alone at the same time, and being able to stop them if you have a question about this or that, and then they can clarify it before going on to the next portion, because that's something especially as statistics, if you don't learn what these things mean, these things over here aren't going to make sense to you, so you have to learn from the beginning before you can get over here, and if you have the ability to stop the professor while they are in the process, and you can make sure that you grab this knowledge before you get over here, I think that's so much more important, whereas if you just viewing it online, you can pause it, but you're not getting the explanation, so being able to have that real time explanation whenever you do have a question, I think it is the biggest advantage of being in person, and you know vice versa not having that online is the deficit. I don't like online; this is the first online course I have ever taken. because I really really really enjoy, and feel that the face to face interactions are the most beneficial, because when it comes to communication, you utilize people's body language, voice inflections, and various different things whenever year you're learning and really grasping something that they're trying to give you, whereas you know some of the times you don't really see yourself or Dr. Kennedy, the voice inflections are that the body language, and those all that ties in together, when it comes to learning and just hearing a voice or just seeing you know the checks or whatever it is just not the same.

[4_Lab] I think that needs to be in person, I don't know, because it's such an abstract concept, I think you need to be there for this type of course.

The last factor leading to students' preference for in-class was the inappropriateness of the statistics or mathematics natured subject online. Almost all students had online course experience and enjoyed those courses as well. However, regarding statistics or mathematics natured courses, the comments from students indicated that the introductory statistics course for social science adult learners was not considered appropriate for the online style.

[1] I think I would favor to attend the class, only because it's very hard to do statistics online.

[2] I've taken online courses. I think it just depends on the topic, not every topic is great for online courses. Being there it's mathematical in nature. Yeah, to be able to do practice assignments, practice problems, online course is not appropriate.

[3] Doing a mathematics problem by myself, you could look at it, and say no, that's wrong, you need to do this, doing that, and an online class I can show my screen with you, or I can take a picture and send it to you, but that takes a lot of time.

[5_Lab] I think maybe the class contents I am pretty confident, I can do online, but if I'm not really confident, I like just going to class.

[4_Class] because I can't learn it online, I have to be able to see him, I like that he is there, do it, I need to be in the course, and talk to him.

In general, social sciences graduate students preferred the in-class learning style rather than the online learning style. This finding is consistent with the previous research showing that an online course was not always up to students' expectations. Both traditional learners and online learners perceived online learning as convenient, but not necessarily conducive to their learning (Burns, 2013). Also, "older" students enrolled in traditional full-time degree programs were more likely to be successful (Dutton & Dutton, 2005). Moreover, student-student interactions, as well as student-instructor interactions were significant contributors to students' achievements (Diaz-Cortes, 2017). In addition, the online course was not appropriate for introductory statistics course from the three aspects: lack of face-to-face interactions, an inability to motivate students and/or identify students needing help immediately, and the need for students to have specific technical skills – a requirement which is not usually met (Zhang, 2002). Next, the findings that statistics or mathematics natured courses were inappropriate for an online learning style also support the results from Speed and Hardin (2001) that an inability existed toward communicating mathematics in "real-time," and toward problems in presenting mathematics formulas on the internet.

Furthermore, Thirunarayanan, Bayo, and Slater (2014) supported that there was a relationship between the content areas and students' preferred learning style for taking the courses. An overwhelming majority of more than 80% of the students preferred the face to face setting for statistics (n=93, 82.3%), calculus (n=99, 87.6%), physics (n=92, 81.4%), and trigonometry (n=93, 82.3%) courses.

CHAPTER 5
CONCLUSIONS

The primary purpose of this study was to determine the effectiveness of using simulations as an instructional tool in an introductory doctoral level statistics course. The study focused on the impacts of simulations on students' attitudes and understanding of statistical concepts, as well as how the simulations would inspire students' positive attitudes and improve statistics performance or would fail to help. In addition, since the statistics anxiety has been a primary obstacle to students' statistics education, and "statistics anxiety" is experienced by as many as 80% of graduate students (Onwuegbuzie, 2004). The researcher was interested to explore the details of the statistics anxiety related attitudes of this group of students, including examining their anxiety levels before and after the introductory statistics course. Whether students' anxiety levels diminished after the introductory statistics course, and what actions could be taken to release the anxiety levels. Moreover, the course has a hybrid online or flipped structure, and the target population for this study was social sciences adult learners, with limited background in statistics or mathematics. Given the prevalence of the online course, especially considering the constraints and background of this target population, the researcher was interested to determine the preferred statistics learning style of the social sciences adult learners, whether in-class or online, as well as the factors leading to the particular preference.

Research Questions

The following five major objectives guided this study:

1. The first objective of this study is to determine if the simulations have effects on inspiring students' positive attitudes toward statistics, and improving students' self-efficacy toward the statistical concept of CLT.

2. The second objective is to explore whether the simulations would help improve students' understanding of the particular statistical concept of CLT.
3. Based on the results from the first and second research questions, the third research question is to determine how the simulations helps or fails to help in students' statistics learning process.
4. The fourth objective is to explore students' anxiety related attitudes toward statistics before and after the introductory statistics course. Whether students' anxiety levels diminish or not, and what actions could be taken to release students' statistics anxiety.
5. The fifth objective is to identify the social sciences graduate students' preferred statistics learning style, in-class, or online; specifically, what are the factors leading to the particular preference?

Summary of Methodology

The mixed method research approach was used in this study, combing both quantitative and qualitative research methods. A total of twenty-two social sciences adult learners was involved in this study, five of which were from the Spring semester, while seventeen of the remaining were from the Fall semester.

The quantitative data from surveys, pre-test, and post-test were collected. The Mann-Whitney U test and Kruskal Wallis test were used to analyze these quantitative data. The Mann-Whitney U test and Kruskal Wallis test are the nonparametric counterparts for the independent two-sample t-test and one-way ANOVA. First, since the total number of participants for this study was twenty-two, and the sample size for each group was even smaller. In addition, the Likert items from the surveys were collected for this study. The response values were ordinal with 5-point scales from "strongly disagree" through to "strongly agree" and "not confident" through to "very confident." Therefore, the dependent variables were ordinal, which was not appropriate for the parametric test of independent two-sample t-test and one-way ANOVA. Moreover, the assumptions of normality and equality of variance required for the parametric tests were not met. Considering these various conditions, the quantitative nonparametric Mann-Whitney U test and Kruskal Wallis test were good fits for this study. Furthermore, since several hypotheses (several items) were being performed simultaneously on a single factor (independent variable), the Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of hypotheses tests. The familywise error rate was .05/number of hypotheses tests. In contrast to the parametric test, the mean rank instead of mean value was compared among the different groups. Also, the Mann-Whitney effect size r was computed for each of the comparisons to determine the strength of the difference. The measures of the effect sizes were based on the explanation from Cohen (1988), where the r value equal to or greater than 0.1, indicating a small effect size, the r value equal to or greater than 0.3, indicating a medium effect size, and the r value equal to or greater than 0.5, indicating a large effect size. The sign of the r value is of no difference. The effect size η^2 for the Kruskal Wallis test was also computed for each of the items to determine how much variance was accounted for by difference from the groups. Finally, the descriptive statistics for each of the items was also calculated to describe students' attitudes and self-efficacy, whether they agreed or disagreed, had confidence, or had no confidence.

The qualitative data from a series of interviews were collected for fifteen students, with all five students from the Spring semester, while the remaining ten students were drawn from the Fall semester. The researcher conducted all the interviews for this study, who played the role of both a teacher and a researcher for the doctoral level introductory statistics course. The researcher has been a teaching assistant for this course for about four years, who was primary responsible for teaching students how to conduct the statistics tests with SPSS, including one sample t-test, independent two-sample t-test, paired two-sample t-test, analysis of variance (ANOVA), analysis of covariance (ANCOVA), simple liner regression, multiple liner regression, Chi-Square test, and the like. Besides the lab-teaching time, the researcher also had office hours each week, about five hours on average, being responsible for clarifying students' confusions, and difficulties in this course. In addition, the researcher was also one particular sample of this target population, being an adult student from the educational background, who took the same doctoral introductory statistics course and got a masters' degree in applied statistics at the end. Being experienced in this course, has dual degrees in both education and applied statistics, and also shared the similar experience as this target population, the researcher was a good fit conducting the clinical interview for this study. After collecting the interview data, the thematical analysis was then utilized to analyze and generalize data.

For each of the five research questions, the participants and research methods varied based on different objectives. Since the aim of this qualitative portion was to understand students' experiences and perceptions of statistics learning, the Crotty's (1998) model for qualitative data analysis was incorporated into this portion. Like Crotty's (1998) model, this study model is composed of four parts: (1) epistemology, (2) theoretical perspective, (3) methodology, and (4) methods. This model is guided by constructivism, defined as the belief that people efficiently construct the meaning of the reality around them through their interactions with one another, and with objects in the environment (Malik, 2015). The theoretical perspective in this study is interpretivism, a means of understanding and explaining human and social reality, which explores students' beliefs during their statistics learning experience (Crotty, 1998). The methodology of phenomenology is the best fit since the emphasis of this study rests on the statistics learning experience of social sciences graduate students. Phenomenology refers to the study of people's subjective and everyday experiences (Crotty, 1998). In a phenomenological study, the researcher sought to explore the useful information and structure patterns of a phenomenon by analyzing data drawn from the participants' first-hand experience of the phenomenon (Yeh & Lehman, 2007).

The quantitative and qualitative phases were conducted separately. For some of the research questions, the findings from the quantitative data provided a basis for the conclusion, then the details from the qualitative data provided further explanations leading to the specific conclusions.

Summary of Findings

The first objective of this study was to determine whether the use of simulations could inspire students' positive attitudes toward statistics, and improve self-efficacy toward statistics concept of CLT. All seventeen students from the Fall semester were involved in this study, incorporating two groups—a control group and a simulation group. Eight students from the control group only attended the traditional class review session, while nine students from the simulation group both attended the traditional class review session and the lab session, practicing the CLT with the simulations that were particularly designed for this CLT concept and this population group. After both the lab and class review sessions, seventeen students from both groups were required to complete two surveys, one measuring students' attitudes toward statistics, and another one measuring students' self-efficacy toward the statistics concept of CLT.

The first survey included seven items measuring students' attitudes toward statistics. The seven items were: (1) Statistics is very easy, (2) Statistics is very interesting, (3) I am very confident that I can learn statistics well, (4) I hate statistics, (5) I think statistics is boring, (6) I am scared of statistics, and (7) I get nervous going to statistics class. The 5 Likert scale was used for the seven items. The higher values indicated that participants more agreed with the statements. Higher values for the first three items indicated more positive attitudes, while lower values for the last four items indicated more positive attitudes.

The Mann-Whitney U tests were conducted to compare the mean ranks for each of the seven items between students from the control and simulation groups. Since seven hypotheses (seven items) were being performed simultaneously on a single factor (control group Versus simulation group), the Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of hypotheses tests. The familywise error rate was .05/7 = .00714 for each hypothesis test. The Mann-Whitney U test results indicated that students' attitudes were only significantly different toward Item 6 (I am scared of statistics), since the Asymp 2-tailed Sig. value (.003) was less than the familywise error rate (.0074). All the remaining six tests were not significantly different between the two groups. Further details indicated that students from the simulation group held slightly more positive attitudes for all the remaining six items, even though not significantly different. The Mann-Whitney effect sizes were computed for each of the seven items to determine the strength of the difference. The results confirmed that students from the simulation group had slightly more positive attitudes toward statistics, 14.3% (one item), which was exactly the same between the two groups; 42.9% (three items) of which pertained to small to medium effect sizes; 28.6% (two items) of which pertain to medium to large effect sizes; and 14.3% (one item) of which pertained to a significant difference.

Furthermore, the mean values for each of the seven items were calculated to describe the details of students' attitudes. The results indicated that students from both groups held the opinion that statistics was very important presently, and that these students would apply statistics in future research/work. Statistics was neither easy nor boring, while they did not hate statistics, neither did they like statistics much. The students were confident that they could learn statistics well. However, students from the simulation group held the opinion that statistics was somewhat interesting, and found that they were not scared of statistics too much, neither were nervous going to statistics class. The opinion for students from the control group varied. These participants did not think statistics to be interesting, they were quite scared of statistics, and felt nervous going to statistics class.

The second survey included six items measuring students' self-efficacy toward the concept of CLT. The six items were: (1) knowing what each value at the parent population represents, (2) Knowing what each value at the sampling means distribution is generated, (3) knowing the relationship between the parent population and sampling means distribution, (4) knowing the difference of sample size and drawing times at the sampling means distribution, (5) knowing how sample size at the sampling means distribution impacts the shape of the distribution, and (6) knowing how drawing times at the sampling means distribution impacts the shape of the distribution. The 5 Likert scale was used to measure the six items. With values from 1 to 5, the self-efficacy increased gradually from "not confident" to "very confident." The higher mean values indicated more confidence.

The Mann-Whitney U tests were conducted to compare the mean ranks for each of the six items between the two groups. The Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of hypotheses tests. The familywise error rate was .05/6=.00833. Results indicated that students' self-efficacy was not significantly different for the six items between the two groups. The Mann-Whitney effect sizes were also computed to each of the six items. Results represented that students from the simulation group had lower self-efficacy to only one of the six items, with a miniscule small effect size (-0.012), yet there was a higher self-efficacy for the remaining five items, 50% of which rested with very small to small effect sizes, 33.33% of which were with medium to large effect sizes.

Students' attitudes, as well as self-efficacy between males and females, were also conducted with Mann-Whitney U tests, yet no significant difference was detected between males and females. However, the details revealed that males had slightly more positive attitudes except for Item 5 (I think statistics is boring), which was not significant. The Mann-Whitney U test effect sizes were computed to determine the strength of the difference concerning students' attitudes toward statistics. Males had more positive attitudes toward all items except for Item 5, showing a medium to large effect size. For all the remaining six items, males had more positive attitudes, 28.6% (two items) of which displayed very small to small effect sizes, small to medium effect sizes, and medium to large effect sizes, respectively.

For the second survey regarding students' self-efficacy toward the statistics concept of CLT, the Mann-Whitney U tests detected no significant difference between males and females. However, details also indicated that males had a higher self-efficacy to the CLT, even though not significant. The Mann-Whitney effect sizes revealed that males showed a lower self-efficacy to only one of the six items, with a very small effect size (-0.062). Yet the males had a higher self-efficacy to the remaining five items, 50% of which reflected small to medium effect sizes, while 33.33% of which presented medium to large effect sizes.

The second objective of this study was to determine whether simulations could improve students' understanding of the particular statistical concept of CLT. The participants for this study were the same seventeen students from the first research question, with eight students from the control group and nine students from the simulation group.

The CLT is one of the most important and fundamental statistics concept that students need to master before learning statistics. The CLT averts that no matter whether the parent population is normal or not, as the sample size increases, the sampling means distribution will become normal. Even though a very basic concept, students are usually confused, and have some misconceptions. The simulation demonstrates the details of how the values (samples means) from the sampling means distribution draw from the parent population, and how the sample size impacts the shape, variance, and normality of the sampling means distribution. The analysis and comparisons between pre-test and post-test, simulation and control groups are discussed, based on each of the nine questions.

At the very beginning of the introductory statistics course, all students were required to take a pre-test, including nine open-ended questions about the basic properties of CLT concept. Two weeks later, all the same students were required to take a post-test, the questions from which were identical to the pre-test. The findings from the pre-test revealed that students from both control and simulation groups had scant to no background knowledge in the CLT. They had some misconceptions about CLT, including "A sample is an equally represented portion of a large group," and "This portion is chosen in a manner to give all number the same probability of being chosen". However, students from both groups had great improvements during the post-test, while students from the simulation group showed a more precise and thorough understanding in the CLT related items by introducing some critical points. For example, one key point for the

CLT is that when the parent population is skewed, the sample sizes impact the shape of the sampling means distribution. However, referring to this question, only students from the simulation group considered the sample sizes, the critical point. In general, students from the simulation group had a much more thorough and clear understanding of the CLT concept compared to students from the control group.

The first two research questions revealed that the use of simulations could inspire students' positive attitudes toward statistics, and improve students' understanding of the statistical concept of CLT. The third objective of this study was to explore how the simulations could make such positive effects. The focus of this study was qualitative explanations and explorations of students' attitudes, experiences, and perceptions toward statistics. The data for this study were drawn from five interviews each regarding the control and simulation groups, with ten interviews in total. The qualitative comments from all of the ten students reached an affirmative conclusion that the simulations played a positive role in their statistics learning process. All participants hoped that the simulations could be used for other statistical topics, and they held the idea that the use of simulations could be necessary for the statistics learning. The comments from the ten interviews could be generalized into four beneficial activities of how simulations help their statistics education, including: (1) the simulations make students visualize the abstract statistics concepts available, (2) the simulations provide more details of the statistics concepts which are not available from the traditional method of reading alone, (3) the individual interactive role from the simulations provides students the opportunity to raise questions and explore answers by themselves, thus help develop students' statistical and critical thinking, and (4) the simulations make the statistics learning more enjoyable.

The fourth objective of this study was to explore the social sciences graduate students' anxiety related attitudes toward statistics. The participants for this study were twenty-two social sciences graduate students from the doctoral level introductory statistics course, from both Spring and Fall semesters. All these twenty-two students comprised of two groups. Five students, drawn from the Spring semester, who were taught with the traditional method only, named the after-course group, were interviewed and surveyed after they completed the introductory statistics course. Moreover, for the seventeen students from the Fall semester, eight students from the control group attended the traditional class review session only, while the nine students from the simulation group attended both the traditional class review session, as well as the lab session, practicing the CLT concept with the simulations. All these seventeen students were surveyed at the beginning of the course, while five students from each of the two groups—simulation and control groups--were interviewed about their anxiety related attitudes and experiences. Finally, a total of fifteen students were interviewed about their attitudes and statistics learning experiences.

Before analyzing students' statistics anxiety related attitudes, the researcher was interested in identifying how the statistics anxiety would hinder students' statistics learning. From the analysis of the interview data, the primary impacts of statistics anxiety from all of the fifteen students could be generalized into three main themes: (1) statistics anxiety would stop students from asking questions, with student queries considered to be one of the most important components in statistics learning, (2) statistics anxiety would stop students from interacting with the professor or classmates in class or other styles, such as a discussion forum on Moodle, and (3) statistics anxiety would discourage students' confidence in statistics, by means of assuming others knowing more than themselves, which further adds personal stress and anxiety.

After identifying the impacts of statistics anxiety on students' statistics education, the primary focus for this research question would be students' anxiety levels before and after the introductory statistics course, whether students' anxiety levels release or not. Two items related to students' statistics anxiety were discussed in this part. The two items were (1) I am scared of statistics, and (2) I get nervous going to statistics class. The participants involved were students from the after-course group, and the control group, who were taught only with the traditional method. Moreover, while the use of simulations in statistics was also an interest in this study, the simulation group was also analyzed in this study, but was not the focus as an objective.

The nonparametric Kruskal Wallis tests were conducted to compare the significance among the three groups. The Bonferroni adjustment was made to the P value to keep the desired alpha value to .05 for the whole family of hypotheses tests. The familywise error rate was .05/2 =.025. The results from the Kruskal Wallis tests indicated both items were significantly different among students from the three groups, with Asymp. Sig. value of .011 and .005 less than the familywise error rate of .025. Students from the after-course group had the most positive attitude to one of the item, while students from the simulation group had the most positive attitude to the second item, but followed by students from the after-course group closely. In general, students from the control group had the least positive attitudes in general. The effect size η^2 was computed for each of the two items to determine how much variance was accounted for by the differences between the groups. The results indicated that the variances accounted for by the groups were 43.1% and 51.0% for each of the two items, respectively, a relatively high variance.

In considering the focus of this primary objective, a comparison of students' attitudes before (control group) and after (after-course) the course become necessary. The Kruskal Wallis tests revealed that students from the after-course group had much more positive attitudes toward statistics than those of students from the control group. In more details, at the beginning of the course, students had higher levels of statistics anxiety, with mean values of 4 and 3.75 out of 5 regarding statements of (1) I am scared of statistics, and (2) I get nervous going to statistics class. However, students' attitudes released after the introductory statistics course, being against to the statements with mean values of 2.4 and 1.2, respectively.

Graduate students' statistics anxiety levels released, and students planned to take some more higher level statistics courses after they completed the introductory statistics course. This finding contradicts to the previous literature that students' anxiety related attitudes became negative from pre-test to post-test (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014). However, this contradiction could be due to the study population, when combined with social sciences and adult learners, resulted in many different traits. The researcher became interested in seeing what were the different traits for the social sciences adult learners compared to their counterparts in undergraduate students, or other groups of people. The results from the qualitative data revealed some commons among this group of population. The factors leading to the different conclusion for this population emanated from five aspects. These five aspects presented to the reasons leading to the adult students' statistics anxiety, as well as their characteristics which helped their statistics learning.

Firstly, the comments from the social sciences adult learners indicated that the major anxiety the adult students experience was related to not having sufficient time to prepare for classes and exams. Secondly, social sciences graduate students' anxiety toward statistics was due to a limited background in statistics. However, adult learners' traits would help them overcome these challenges in their statistics education. To begin with, adult learners were self-directed, and they opted to take personal responsibility for their lives and decisions, which related to their choice to have control over their learning (Pappas, 2013). Next, adult learners showed a persistence in dealing with the difficulties of statistics courses. Finally, the adult students showed an extreme willingness to learn statistics well and revealed high expectations.

These attitudes signaled differences in how undergraduate and social sciences graduate students view statistics. The anxiety undergraduate students experience was more about their unknown about the area of statistics, which would usually stop or delay undergraduate students from entering the area of statistics. When undergraduate students chose to delay the enrollment in a statistics course until just before graduation (Perney & Ravid, 1991, p.2), the stress of completing the degree or searching for a job when approaching the end would further add anxiety when taking the statistics course, even leading to the failure in either statistics or a degree. The statistics anxiety would even be a factor leading to the failure in other things, which in turn, made undergraduate students more frightened of statistics.

However, the graduate students also experienced statistics anxiety at the beginning, because of time considerations on preparing a course or exam (Lundberg, 2003), or possibly a limited background. None of the graduate students reported feeling anxious after they completed the introductory statistics courses. Yet the graduate students were self-directed, which would allow them to enter the area of statistics first, even though they were anxious about statistics at the very beginning, which was a key to a successful completion. Moreover, graduate students had an extreme willingness to learn statistics, coupled with a high persistence in dealing with difficulties. As a result, the graduate students did not easily give up when confronted by difficulties. All these valuable traits from the social sciences adult students played the supportive role to release the statistics anxiety levels.

These findings are consistent with the previous literature that statistics anxiety was less related to the statistics subject, but related to students' anxiety about the unknown area (Carleton, Norton, & Asmundson, 2007), and students' anxiety levels were far more beyond the difficult levels of statistics subject.

Furthermore, students interviewed at the end of the statistics course indicated that their statistics anxiety levels released, even when they were anxious about statistics at the very beginning. Most of them planned to take some higher level statistics courses. The social sciences graduate students' traits allowed the students to enter the area of statistics voluntarily, which was a key to a successful completion. However, the experiences and actions during the statistics learning process played an important role in releasing statistics anxiety, and in making the statistics learning enjoyable. The experiences of these five students were generalized into four actions that could further release students' statistics anxiety: (1) emphasize the basic concepts to ensure mastery, (2) make more time for statistics learning, (3) focus on fewer materials at a time to increase learning, (4) relate statistics to students' research areas, and (5) involve the simulations in demonstrating the abstract statistics topics.

These five activities were generated based on students' statistics learning experience, and survey results. The first action was to emphasize the basic concepts to ensure mastery. Comments from the students indicated that understanding the basics would lay good foundations for statistics learning, make it more enjoyable, and further develop their interest in statistics.

The second action was to make more time for statistics learning. The primary challenge for adult learners was the shortage of time. Comments from the students indicated that if they had more time for statistics, they would find more success and enjoyment in statistics. On the other hand, the limited time might increase anxiety, while decreasing interest, success, and enjoyment. The students reported that much of the anxiety they experience was not related to statistics subject matter, but in not having enough time to prepare before classes and exams. The interviewees expressed that if they had more time to study and practiced statistics, they would enjoy the subject more.

The third action, suggested by all students, was to focus on fewer materials at a time in order to increase learning. This action supports the suggestion from Alfred North Whitehead (1916) that teachers should focus on teaching a few very important ideas, as thoroughly as possible. Attempting to cover too many ideas leads to one's becoming an expert in none of them, and everyone should "possess…expert knowledge in some special direction…" (Whitehead, 1916). In applying this idea to statistics education for graduate students, instructors might consider breaking down the statistics subject matter into smaller, more manageable lessons, so that students have time to learn the material more deeply.

The fourth action was to relate statistics to students' research areas. Comments from the students indicated that using topics from students' research areas might inspire their interests and connect their statistics learning to practical studies. These comments were also in accordance with the learning assumptions of Knowles (1984), who asserted that adult learners were problem centered and had a perspective for immediate application of knowledge.

Last but not least, involve the simulation toward demonstrating the abstract statistics topics. The previous survey results revealed that students from the simulation group had much low anxiety levels compared to students from the control group.

For the fifth research question, the researcher was interested to know the preferred statistics learning style for the social sciences graduate students. In this flipped introductory statistics course, participants could either attend the in-class session or online session freely. All required materials, notes, class recordings, and the like were available online, and all assignments or announcements were informed via Moodle or email. The interviewed participants for this study were fifteen students. Most of the students had the online course experience. In response to the preferred statistics learning style, fourteen out of the fifteen participants responded with a firm, consensual preference for the in-class course, with one exception, the individual who displayed a good background in mathematics and statistics and also had the constraints of dealing with full-time work and family issues.

This qualitative analysis, in focus on social sciences adult learners, indicated that the online learning style was presently inappropriate for the introductory statistics course for adult learners from social sciences. Three major factors led to students' preference for the in-class learning style. These three major factors presented a barrier for an online learning style, yet were enablers for an in-class learning style, and the nature of statistics as a mathematics natured subject. The barrier then, for an online learning style, reflected the students' resistance to technology. This particular population was birthed before the global burst of information and technological development. The daily lives of these adult students were not as familiar with present-day technologies that were so commonplace with the youth of today. Moreover, the areas of interest of this specific population were not technology related. As a result, this target population had become resistant to an online learning style use of technology. The enablers that guide the in-class learning style included (1) the availability of asking questions in a real class, (2) the importance of attending a real class, and (3) the presence of a human being. The comments revealed that asking questions in class could clear confusions immediately, thus providing a benefit to the students who were not comfortable with asking questions in class, and enabling students to understand better when explaining problems to others. Finally, the comments from the participants indicated that the statistics or mathematics natured courses were inappropriate for an online learning style.

Conclusions and Recommendations

Based on the discussion and findings of this study, the researcher had derived the following conclusions and recommendations.

Conclusion One

The use of simulations in statistics education could inspire social sciences adult learners' positive attitudes toward statistics, develop a higher self-efficacy, and improve understanding of the statistics concept of CLT, even though not significant.

This conclusion is based on the findings from a study of two surveys, one pre-test, and one post-test. The first survey concerned students' attitudes toward statistics, the second survey concerned students' self-efficacy about the statistics concept of CLT, and the pre-test and post-test regarded students' understanding of the statistics concept of CLT. The participants for this study were seventeen social sciences graduate students, that age range from 24 to 45 years with a mean of 30.29 (SD = 4.947).

The results from the Mann-Whitney U tests revealed a significant difference between students from the control group and the simulation group regarding Item 6 (I am scared of statistics), with Asymp. 2-tailed Sig. value of .003, less than the familywise error rate of .00714. Students from the simulation group were not so scared of statistics compared to students from the control group. Further details indicated that students from the simulation group had slightly more positive attitudes regarding other six items, even though not significant, as follows: 14.3% (one item), which was exactly the same between students from the two groups, 42.9% (three items), which were with small to medium effect sizes, 28.6% (two items), which were with medium or large effect sizes, and 14.3% (one item) of which with a significant difference.

Moreover, results from the Mann-Whitney U tests also revealed that students from the simulation group had slightly higher self-efficacy toward the CLT concept, even though not significant. Among the six items, students from the simulation group had lower self-efficacy to only one of the six items, with a miniscule small effect size (-0.012). Yet the students showed a higher self-efficacy to the remaining five items, 50% of which had very small to small effect sizes, and 33.33% of which had medium to large effect sizes.

Finally, the results from the pre-test and post-test revealed that students from the simulation group had a relatively more precise and clear understanding of the statistics concept of CLT. This was due to the evidence that some students from the simulation group recognized to consider the critical points to some of the questions, while scare students from the control group recognized such essential points. For example, students from the simulation group considered the critical point of sample size referring to the question of how the sampling means distribution would look like when the parent population is skewed.

In general, the use of simulations could effectively inspire students' positive attitudes toward statistics, improve students' self-efficacy, and develop more precise and clear understanding of the CLT concept for this group of participants. This conclusion supports the limited previous research that students with simulation-based learning methods had more enjoyable experience in comparison to other learning activities, and had a more subjective enjoyment (Ratanaolarn, 2016). In addition, research also indicated that students from the simulation group had a positive attitude toward their instructional unit, compared to students in the control group with traditional method (Jamie, 2004). Moreover, this conclusion is consistent with the findings from Reidar et al. (2007) and Morris (2001) that students from the simulation group did statistically significantly better than students from the control group on problems related to the statistical concepts. Furthermore, the findings from this study revealed that students from the simulation group had more positive attitudes and had a higher self-efficacy, further supported the statement from Gal and Ginsburg (1994) that students' positive attitudes toward statistics could be assessed through students' self-concepts or confidence regarding statistical skills.

Negative feelings, attitudes, beliefs, interests, expectations, and motivations can conceivably contribute to students' difficulties in learning basic concepts in statistics and probability. These difficulties have been widely documented over the last two decades (Gal & Ginsburg, 1994). Students' feelings about statistics education and the effects of such feelings on learning, knowledge and further interests in statistics, as a result, should occupy a central role in the minds of statistics educators (Benson, 1989; Harvey, Plake, & Wise, 1985; Roberts & Bilderback, 1980). However, many researchers focus on improving the cognitive side of instruction, i.e., the skills and knowledge that students are expected to develop, scant regard has been given to non-cognitive issues such as students' feelings, attitudes, beliefs, interests, expectations, and motivations (Shaughnessy, 1992). Even though some researchers have discussed students' feelings, attitudes, beliefs, interests, expectations, and motivations in statistics learning, the activities of how to improve these positive attitudes are rarely discussed. In fact, the use of simulation as a highly recommended instructional tool in statistics education is even less discussed. This study sought to fill that gap by examining the effect of simulations on students' attitudes toward statistics, inclusive of feelings, attitudes, beliefs, interests, expectations, and the like. These findings became important for institutions to consider, in order to provide promising educational approaches to help develop students' positive feelings, attitudes, beliefs, interests, expectations, and motivations.

As mentioned earlier, even though the nonparametric Mann-Whitney U tests were utilized in this study, the sample size was still small. The researcher recommends that future research be conducted on a larger sample size. Moreover, this study targeted on a particular population, and focused on adult learners in social sciences, due to earlier findings suggesting that there were unique traits for this group of people. The researcher also recommends that future research be conducted on different target populations, such as elementary, high school, or undergraduate levels.

Conclusion Two

Males had slightly more positive attitudes toward statistics, and had higher self-efficacy in the statistics concept of CLT, even though not significant.

This conclusion is also based on two surveys concerning students' attitudes toward statistics and self-efficacy toward the statistical concept of CLT. The Mann-Whitney U tests revealed nonsignificant difference between males and females regarding these two surveys. Considering attitudes, males had slightly more positive attitudes toward statistics, 42.9% with very small to small effect sizes, 14.3% with small to medium effect sizes, and 42.9% with medium to large effect sizes. Considering self-efficacy, males had more confidence in the statistical concept of CLT than that of females, 40% with small to medium effect sizes, 40% with medium to large effect sizes, while 20% with large to very large effect sizes.

Gender differences in students' affective interests toward mathematics and science have always been a topic worth research, as well as differences in students' performances in mathematics or science, especially in math or science natured areas (Ceci et al., 2014; White

House Council on Women and Girls, 2011). In addition, the gender-specific learning differences are evident, even at an early age. The example from the National Assessment of Educational Progress (NAEP) documented that among nine-year-old, boys performed better than girls on mathematics and science related tests, but scored lower in reading. Moreover, Perepiczka, Chandler, and Becerra (2011) stated that statistics anxiety and attitude towards statistics were statistically significant predictors of self-efficacy to learn statistics, which is consistent with the findings that the males had higher self-efficacy in statistics and more positive attitudes toward statistics. These findings became important for institutions and higher education instructors to consider, in the quest to provide appropriate education approaches, based on the distribution of students' gender differences.

As mentioned earlier, even though the nonparametric Mann-Whitney U tests were utilized in this study, the sample size was small. There may exist some bias between males and females for this study. In addition, the two-way analysis between gender and treatments was not discussed, due to a limited sample size. Therefore, the researcher recommends that future research be conducted on a larger sample size discussing a two-way analysis between gender and treatments, or by balancing the backgrounds of males and females. Moreover, the researcher recommends that future research be conducted on more statistical concepts in order to reach a generalization. Furthermore, this study was targeted at a particular population that focused on social sciences adult learners. Earlier findings suggest that there were unique traits for this group of people. The researcher also recommends that future research be conducted on a different target population, such as elementary, high school, or undergraduate levels.

Conclusion Three

Simulations could enhance students' statistics learning from four aspects:

- The simulations allow students to visualize the abstract statistics concepts;
- The simulations provide more details of the statistics concepts, which are unavailable through the traditional method of reading alone;
- The individual interactive role from the simulations provides students with the opportunity to pose questions and explore answers by themselves, thus help develop students' statistical and critical thinking;
- The simulations make the statistics education more enjoyable.

This conclusion is based on a qualitative interview from ten social sciences adult learners. The comparisons between students with simulation and without simulation, as well as students' responses before and after the use of simulations were compared. Both comparisons reached the same conclusion--that simulations were helpful to the introductory statistics education for this population group.

This conclusion supports the previous findings that many students experienced difficulties in mastering basic concepts of probability and statistics with the lecture notes or traditional reading materials alone (Groeneboom, de Jong, Tischenko, & van Zomeren, 1996). However, the dynamic interactive simulations could be helpful in teaching and learning most of the important ideas and techniques of introductory statistics topics by helping students visualize and further understand statistical concepts including randomness, confidence intervals, hypothesis testing, and regression analysis (Gordon & Gordon, 2009). In addition, literature also supported that simulations provided important information about statistical phenomena that would be impossible to assess otherwise. The simulations could provide a hands-on method for students to become acquainted with complex statistical concepts. (Sigal & Chalmers, 2016). Moroever, Tintle et al. (2015) stated that the use of simulations was burgeoning in popularity by means of introductory statistics inference for all under-graduate statistics courses. Increasing evidence suggested that the use of simulations could develop students' statistical and critical thinking from several aspects, including: (1) clearly presenting the complex logic of inference, (2) strengthening ties between statistics and mathematics concepts, (3) encouraging a focus on the entire research process, (4) inspiring students to think about the advanced statistical concepts, (5) encouraging more time to explore, do, and talk about real research and messy data, and (6) offering a firmer foundation on which to build statistical intuition.

These findings offer compelling guidelines for institutions, higher education statistics instructors, and social sciences statistics beginning learners to consider, in order to provide an alternative approach to teach introductory statistics to social sciences adult learners.

This study provided effective activities of how the simulations help in students' statistics education. However, this conclusion was generated based on the statistical concept of CLT, focused on social sciences adult learners, with a small sample size, there may exist some limitations and bias. The researcher recommends that further research be conducted a larger sample size, and include more statistical concepts, such as simple linear regression, multiple regression, and the like. Moreover, this study targeted on social sciences adult learners. Since earlier findings suggested some unique traits for this group of people, the researcher recommends that future research be conducted on other target populations, such as elementary, high school, or undergraduate levels.

Conclusion Four

The responses from the social sciences adult learners could be generated into three common themes as to how statistics anxiety would impact students' statistics learning process:

- Statistics anxiety would stop students from asking questions, the most important component in statistics learning;
- Statistics anxiety would stop students' interaction with the professor or classmates, either in class or other styles, such as the discussion forum on Moodle;
- Statistics anxiety would discourage students' confidence in statistics, assuming that others would know more than themselves, which would further add stress and anxiety.

This conclusion is based on the qualitative interview data from fifteen social sciences adult learners, which is consistent with previous research that students being less successful were more scared of the course, would not be involved, or would not participate in the discussions with the instructor or other students (McLaren, 2004). These findings became important for institutions, higher education statistics instructors, statistics beginning learners to consider, in order to find appropriate education approaches to deal with the impacts of statistics anxiety.

Even though the qualitative method was utilized for this part, the sample size was small in generating such findings. The researcher recommends that future research be conducted on a larger sample size. In addition, the interview data about students' performances were subjective, so the researcher recommends that future research be conducted with the qualitative data from observations added by providing a more objective view of students' performance, such as the frequency students asking questions, interacting with professors and students, as well as the level of anxiety that would discourage students' confidence. Moreover, this study targeted on a particular population focused on social sciences adult learners. This target population shared a unique trait, a tendency to avoid expressing themselves in public when not 100% confident, which led to particular conclusions in this study, the comments are as below. The researcher also recommends that future research be conducted with a different target population, such as elementary, high school, or undergraduate levels.

> "I'll be honest, in a graduate setting, when you don't feel like you know anything, it is uncomfortable to ask questions in front of other people who are also in a graduate level about things, like that you're unsure of because you don't want to come off as an idiot, because you assume everybody else knows what they're talking about."

Conclusion Five

The social sciences graduate students' statistics anxiety levels released after they completed the introductory statistics course, even though they also experienced severe statistics anxiety at the beginning of the course.

This conclusion is based on the combination of quantitative Kruskal Wallis (or Mann-Whitney U) tests and the qualitative thematical analysis. The interview data also indicated that all five students from the after-course group had registered or planned to take some higher level statistics courses.

This conclusion contradicts the findings from the previous literature that undergraduate students' anxiety related attitudes became more negative from pre-test to the post-exam, even though not significantly different. The negative attitudes included being more scared of statistics, finding statistics to be more difficult than expected, not planning to work hard on statistics, and being reluctance to use statistics daily (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014).

Gal and Ginsburg (1994) stated that the introductory statistics course should have the goal that prepares students to take higher level statistics courses, even though most students experienced severe statistics anxiety at the beginning of the course. Students' attitudes at the end of the statistics course were very important. Most previous researchers exploring students' pre- and post- attitudes during the semester, at the beginning of the semester, and before the end of the same semester (Ramirez & Bond, 2014; Swanson, VanderStoep, & Tintle, 2014), which could not reflect students' attitudes after the introductory statistics. Moreover, students tended to have negative attitudes during the post-test time, since students were about to take the final exam, which was not a good time to analyze students' attitudes toward statistics then. Thus, the research analyzing and comparing students' attitudes toward statistics at the beginning, and after the introductory statistics course are lacking.

As mentioned earlier, the sample size for this study was small. The researcher recommends that future research be conducted on a larger sample size. Moreover, the population of this study, combined with social sciences adult learners, resulted in many different traits, compared to their counterparts. The researcher recommends that future research be conducted on undergraduate students. In addition, students before and after the introductory course should be paired, and the participants should be the same. However, students from the control and the after-course groups were different participants in this study, and the individual variate would be very large. The researcher recommends the future research be conducted on the same paired group of people at the beginning of the course, and after the course. Furthermore, the findings also revealed that students at the beginning of the course from the simulation group had more positive attitudes and higher self-efficacy, following the students from the after-course group closely. The researcher recommends that future research be conducted on a two-way analysis of four groups, students at the beginning with and without the use of simulations, and students in the after-course group, with and without the use of simulations.

Conclusion Six

Unique traits of social sciences adult learners helped their statistics learning.

This conclusion is based on the qualitative study of fifteen students. The social sciences adult learners were quite anxious about statistics at the onset of the statistics course, especially when they did not have much mathematical background or had not used statistics for a long time. However, the adult students' statistics anxieties released a lot after the introductory statistics course, the students came to like statistics, and planned to take higher level statistics courses. The results from the qualitative data indicated that the social sciences adult learners primarily had different reasons leading to the statistics anxiety, and some of their unique traits contributed to the positive changes when compared to their counterparts in undergraduate students, or other groups of people.

The qualitative data revealed some commons among this group of population. The factors leading to the different conclusion for this population emanated from five aspects. These five aspects presented to the reasons leading to the adult students' statistics anxiety, as well as their characteristics which helped their statistics learning.

First, the comments from the social sciences adult learners indicated that the major anxiety the adult students experienced was related to not having sufficient time to prepare for classes and exams. Second, social sciences graduate students' anxiety towards statistics was due to a limited background in statistics. However, adult learners' traits would help them overcome these challenges in their statistics education. To begin with, adult learners were self-directed, and they opted to take personal responsibility for their lives and decisions, which related to their choice to have control over their learning (Pappas, 2013). Next, adult learners showed a persistence in dealing with the difficulties of statistics courses. Finally, the adult students showed an extreme willingness to learn statistics well and revealed high expectations.

These attitudes signaled differences in how undergraduate and social sciences graduate students view statistics. The anxiety undergraduate students experienced was more about their unknown about the area of statistics, which would usually stop or delay undergraduate students from entering the field of statistics. When undergraduate students chose to delay the enrollment in a statistics course until just before graduation (Perney & Ravid, 1991, p.2), the stress of completing the degree or searching for a job when approaching the end would further add anxiety when taking the statistics course, even leading to the failure in either statistics or a degree. The statistics anxiety would even be a factor leading to the failure in other things, which in turn, made undergraduate students more frightened of statistics.

However, the graduate students also experienced statistics anxiety at the beginning, because of time considerations on preparing a course or exam (Lundberg, 2003), or possibly a limited background. None of the graduate students reported feeling anxious after the introductory statistics courses. The graduate students were self-directed, which would allow them to enter the area of statistics first, even though they were anxious about statistics at the very beginning, which was a key to a successful completion. Moreover, graduate students had an extreme willingness to learn statistics, couple with a high persistence in dealing with difficulties. As a result, the graduate students do not easily give up when confronted by difficulties. All these valuable traits from the social sciences adult students played the supportive role to release the statistics anxiety levels. These findings support the previous literature that statistics anxiety was less related to the statistics subject but related to students' anxiety about the unknown area

(Carleton, Norton, & Asmundson, 2007), and students' anxiety levels were far more beyond the difficulty levels of statistics subject.

These findings became essential for institutions, higher education instructors, and social sciences students to consider, even though statistics anxiety was severe among students, as described by Perney and Ravid (1991, p. 2). This was common among most students before they entered the area of statistics. However, the unique traits of adult learners played a supportive role in their confronting a challenging statistics course.

Conclusion Seven

The social sciences adult learners had a positive attitude toward statistics after the introductory statistics course. Five activities were generalized based on their statistics learning experience to reduce statistics anxiety and make statistics learning enjoyable. These five activities are:

- Emphasizing the basic concepts to ensure mastery;
- Leaving more time for statistics learning;
- Focusing on fewer materials each time to increase learning;
- Relating statistics learning to students' research areas;
- Involving the simulations in demonstrating of the abstract statistics topics.

This conclusion is primarily based on five students interviewed at the end of the statistics course. The results indicated that students were not so scared of the statistics course at that point, even if they were quite anxious about statistics at the very beginning. Most of them planned to take higher level statistics courses. The social sciences graduate students' traits allowed students to enter the area of statistics voluntarily, a critical point. The experiences during the statistics learning process further played a vital role to release statistics anxiety and made the statistics learning enjoyable.

The first action was to emphasize the basic concepts to ensure mastery. Comments from the students indicated that understanding the basics would lay sound foundations for statistics learning, thereby making the course more enjoyable, which could further develop their interest in statistics. This first activity supports the recommendation from Garfield and Everson (2009) that instructors should emphasize statistical literacy toward understanding the fundamental statistical concepts, this action worked, not only to teach graduate students statistics, but also to prepare graduate students to teach as teaching assistants or to follow academic careers in mathematics or statistics.

The second action was to make more time for statistics learning. The primary challenge for adult learners was the shortage of time. Comments from the students indicated that if they had more time for statistics, they would find more success and enjoyment in statistics. Time constraints could increase anxiety while decreasing interest, success, and satisfaction. The students reported that much of the anxiety they experienced was not related to statistics subject matter but rather to not having enough time to prepare for classes and exams. The interviewees expressed that with more time to study and practice statistics, they would enjoy the subject more. This finding is consistent with the previous finding that adult learners usually had a lot to juggle, like family, friends, work, and the need for quality, personal time. The shortage of time was a major constraint for adult learners, which was often the cause for statistics anxiety (Pappas, 2013).

The third action, suggested by all students, was to focus on fewer materials at a time to increase learning. This activity supports the suggestion from Alfred North Whitehead (1916) that teachers should focus on teaching only a few essential ideas as "thoroughly" as possible. Attempting to cover too many ideas leads to one's becoming an expert in none of them, and everyone should "possess…expert knowledge in some special direction…" (Whitehead, 1916). In applying this idea to statistics education for graduate students, instructors might consider breaking down the statistics subject matter into smaller, more manageable lessons so that students have time to learn the material more deeply, especially for this introductory statistics course. The finding is also consistent with the recommendation from Garfield and Everson (2009) that stress the necessity of conceptual understanding, rather than a mere knowledge of procedures. Moreover, this third finding is also supported by research from Pappas (2013) that aging affects learning, and although adult learners tended to be slower in learning, yet they comprehended more integrative knowledge. While adults tended to learn less rapidly with age, their depth of learning tended to increase over time, as they learned to navigate knowledge and skills to unprecedented personal levels.

The fourth action was to relate statistics to students' research areas. Comments from the students indicated that using topics from students' research areas might inspire their interests and connect their statistics learning to practical studies. These comments are in accordance with the learning assumptions of Knowles (1984), who asserted that adult learners were problem centered and had a perspective for immediate application of knowledge. The finding also supports the recommendation from Garfield and Everson (2009) that relating statistics learning to students' research areas, using real data.

Lastly, involve the simulation instruction for demonstrating the abstract statistics topics. This finding is supported by the recommendation from Garfield and Everson (2009) that use technology to develop conceptual understanding and data analyzation of data. Such simulations could inspire students to raise questions and explore answers, which in turn promoted statistical thinking.

These findings became essential for institutions, higher education instructors, and social sciences statistics learners to consider, even though statistics anxiety was severe among students (Perney and Ravid, 1991, p. 2). This was common among most students before entering the area of statistics. However, the unique traits of adult learners played a supportive role for them in a challenging statistics course. Moreover, the instructors of the introductory statistics course could also consider these steps to guarantee students' foundation in this course, and thereby releasing students' anxiety.

However, the population of this study, combined with social sciences and adult learners, resulted in many different traits compared to their counterparts. The researcher recommends that future research be conducted on undergraduate students. The researcher also suggests that future research be performed on two or more different teaching methods to provide supportive evidence for this conclusion, with one teaching method following the steps from this study. Students' anxiety related attitudes before and after the introductory statistics course are then collected and compared.

Conclusion Eight

The comments from the fifteen students suggested that the online learning style was presently inappropriate for the introductory statistics course for adult learners from social sciences.

The conclusion is based on interview data from the fifteen students. Most of the students have the online course experience. In response to the preferred statistics learning style, fourteen out of the fifteen participants responded with a firm, consensual preference for the in-class course, with one exception, who displayed a good background in mathematics and statistics, and also dealt with full-time work and family issues.

Three major factors led to students' preference for the in-class learning style. These three major factors presented a barrier for the online learning style, yet were enablers for the in-class learning style, showing statistics to be a math natured subject. The barrier then, for an online learning style, reflected the students' resistance to technology. This particular population was birthed before the global burst of information and technological development. The daily lives of these adult students were not as familiar with present-day technologies that were so commonplace with the youth of today, a view that is also consistent with the previous research that adult learners were less open-minded, and therefore more resistant to change (Pappas, 2013). Moreover, the areas of interest for this specific population were not technology related. As a result, this target population demonstrated resistance to an online learning style use of technology.

Enablers that guide the in-class learning style included (1) the availability to ask questions in a real class, (2) the importance of attending a real class, and (3) the presence of a human being. All participants held the viewpoints that asking questions in class was very important, especially for the statistics course, attending class was a must, and the presence of a human being as a teacher made them feel connected and comfortable. Further, asking questions in class could clear confusions immediately, providing a benefit to the students who were not comfortable with asking questions in class, and also enabling students to understand better when explaining problems to others. This is consistent with the previous research noting that student-student interactions, as well as student-instructor interactions, were significant contributors to student achievement (Diaz-Cortes, 2017). Moreover, Zhang (2002) stated that the online course was not appropriate for the introductory statistics course, due to the evidence of the three aspects: (1) the lack of face-to-face interactions, (2) the inability to identify students needing help immediately, and (3) the need for students to have certain technical skills, is not usually met.

Finally, the comments from the participants indicated that statistics or mathematics natured courses were not appropriate for an online learning style for the social sciences graduate learners presently. This conclusion supports the finding from Speed and Hardin (2001) that an inability to communicate mathematics in “real-time” existed with problems that present mathematics formulas on the internet. Furthermore, Thirunarayanan, Bayo, and Slater (2014) supported that there was a relationship between the content areas and students’ preferred learning style for taking the courses. An overwhelming majority of more than 80% of the students preferred the face to face setting to take statistics (n=93, 82.3%), calculus (n=99, 87.6%), physics (n=92, 81.4%), and trigonometry (n=93, 82.3%) courses.

This finding is consistent with the previous finding that online courses were not always up to their expectations, and both traditional learners and online learners perceive online learning as convenient, but not necessarily conducive to their learning (Burns, 2013). Moreover, more mature students enrolled in traditional full-time degree programs were more likely to be successful (Dutton & Dutton, 2005).

These findings became essential for institutions and higher education statistics instructors to consider. Even though the online course was almost indispensable to people’s lives presently, due to the digital revolution, most higher education institutions offer online courses. However, the online learning style didn’t fit all types of courses, especially the statistics or mathematics natured course, presented to the social sciences adult learners for this study. Moreover, this introductory statistics course not only provided students with the knowledge and skills required for research, but also should prepare students to take higher level statistics courses (Gal & Ginsburg, 1994). Therefore, students' preferences, experiences, and performances for this course were quite substantial.

However, the population for this study, combined with social sciences adult learners, displayed many unique traits, including being less open-minded and therefore, more resistant to change (Pappas, 2013). The researcher recommends that future research be conducted for other groups of population, such as undergraduate students. In addition, this study focused on only one statistical topics, within only one class, even though there are some improvements, most of the hypothesis are not significant, the future research could cover more statistical concepts, and lasts a longer time period, such as one semester.

REFERENCES

Abrahamson, D., Janusz, R. M., & Wilensky, U. (2006). *There once was a 9-block ...- A middle-school design for probability and statistics*. *Journal of Statistics Education*, *14*(1).

Bakker, A. (2004). Reasoning about shape as a pattern in variability. *Statistics Education Research Journal, 3*(2), 64–83.

Benson, J. (1989), "Structural Components of Statistical Test Anxiety in Adults: An Exploratory Model," *Journal of Experimental Education*, 57, 247-261.

Ben-Zvi, D., & Arcavi, A. (2001). Junior high school students' construction of global views of data and data representations. *Educational Studies in Mathematics, 45*(1), 35-65.

Ben-Zvi, D. (2004). Reasoning about variability in comparing distributions. *Statistics Education Research Journal, 3*(2),42–63.

Ben-Zvi, D., & Amir, Y. (2005). How do primary school students begin to reason 、 about distributions? In Reasoning about distribution: A collection of current research studies. Proceedings of the Fourth International Research Forum on Statistical Reasoning, Thinking, and Literacy (SRTL-4), Ed. K. Makar, University of Auckland, New Zealand, 2–7 July, 2005. Brisbane: University of Queensland.

Burns, B. (2013). Students' Perceptions of Online Courses in a Graduate Adolescence Education Program. *MERLOT Journal of Online Learning and Teaching*, *9*(1), 13–26. Retrieved from http://jolt.merlot.org/vol9no1/burns_0313.htm

Bush, S., & Menzies, G. (2009). An Array of Online Teaching Tools. *Teaching Statistics*, *31*(1), 17–21.

Carleton, R. N., Norton, M. A., & Asmundson, G. J. (2007). Fearing the unknown: A short version of the Intolerance of Uncertainty Scale. *Journal of Anxiety Disorders, 21*(1), 105-117.

Ceci, S.J., Ginther, D.K., Kahn, S., and Williams, W.M. (2014). Women in Academic Science: A Changing Landscape. Psychological Science in the Public Interest, 15(3): 75–141.

Cecil R. Reynolds, Ronald B. Livingston, & Victor Willson. (2011). Measurement and Assessment in Education. New Delhi-110001: PHL Learning Private Limited.

Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. *Statistics Education Research Journal, 9*(1), 6–26.

Cobb, P., McClain, K., & Gravemeijer, K. (2003). Learning About Statistical Covariation. *Cognition and Instruction*, *21*(1), 1–78. http://doi.org/10.1207/S1532690XCI2101_1

Creswell J. W., & Plano Clark V. L. (2007). Designing and Conducting Mixed Methods Research. Sage Public Press, Thou- sand Oaks, CA.

Cunningham, B. C., & Hoyer, K. M. (2015). STATS IN BRIEF Science, Technology, Interest, Credits Earned, and NAEP Performance. *Statistics in Brief*, (February).

Dambolena, I. G. (1986). Using simulation in statistics courses. Collegiate Microcomputer, 4, 339–344.

Dee, T. (2007), "Teachers and the Gender Gaps in Student Achievement," *Journal of Human Resources*, 42, 528 - 554.

delMas, Robert, C., Garfield, J., & Chance, B. L. (1999). A model of classroom research in action: Developing simulation activities to improve students' statistical reasoning. *Journal of Statistics Education*, *7*, 1–18.

Delmas, R., & Liu, Y. (2005). Exploring Students' Conceptions of the Standard Deviation. *Statistics Education Research Journal*, *4*(1), 55–82.

Dempster, M., & McCorry, N. K. (2009). The role of previous experience and attitudes toward statistics in statistics assessment outcomes among undergraduate psychology students. *Journal of Statistics Education*, *17*(2), 1–7. Retrieved from http://www.amstat.org/publications/jse/v17n2/dempster.pdf

Diaz-Cortes, D. (2017). The Influence of Three Types of Interaction: Students-Instructor, Students-Students, Student Content, and Selected Demographic Characteristics on the Cognitive Achievement of Online Graduate Students.

Doane, D. P. (2004). Using simulation to teach distributions. *Journal of Statistics Education, 12*(1), 1–21.

Dutton, J. and Dutton, M. (2005), "Characteristics and Performance of Students in an Online Section of Business Statistics," Journal of Statistics Education [online], 9,3. Available at http://www.amstat.org/publications/jse/v13n3/dutton.html.

Earley, M.A. (2001). Improving statistics education through simulations: the case of the sampling distribution. Paper presented at the Annual Meeting of the Mid-Western Educational Research Association. Chicago, Illinois, October 24–27.

E.E. Cureton, "Rank-Biserial Correlation," *Psychometrika* 21 (1956): 287-290, and "Rank-Biserial Correlation-When Ties Are Present," *Educational and Psychonolocal Meaurement* 28 (1968): 77-79.

Eggen, P. and Kauchak, D. (2001). Educational Psychology: Windows on Classrooms (5th edn). Upper Saddle River, NJ: Prentice Hall.

Emmioğlu, E., & Capa-Aydin, Y. (2012). Attitudes and achievement in statistics: A meta-analysis study. *Statistics Education Research Journal*, *11*(2), 95–102.

Ennis, R. H., & Millman, J. (1985). Cornell critical thinking test—Level Z. Pacific Grove, CA: Midwest.

Freeman, C. (2004), *Trends in Educational Equity of Girls and Women: 2004*. NCES 2005-016, U.S. Department of Education, National Center for Education Statistics. Washington DC, U.S. Government Printing Office.

Gal, I., & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: Towards an assessment framework. *Journal of Statistics Education*, *2*(2), 1–15.

Garfield, J. (1995). How Students Learn Statistics. *International Statistical Review*, 63, 25–34.

Garfield, J. & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: implications for research. *Journal for Research in Mathematics Education, 19*(1), 44–63.

Garfield, J., & Everson, M. (2009). Preparing Teachers of Statistics: A Graduate Course for Future Teachers. *Journal of Statistics Education*, *17*(2), 223–237.

Ghulami, H. R., Ab Hamid, M. R., & Zakaria, R. (2015). Comparative analysis of positive and negative attitudes toward statistics, *2014*(1), 212–218. http://doi.org/10.1063/1.4907447

Gigerenzer, G. (1996). On narrow norms and vague heuristics: A reply to Kahneman and Tversky. *Psychological Review*, *103*(3), 592–596. http://doi.org/10.1037/0033-295X.103.3.592

Glencross, M. J. (1988). A practical approach to the central limit theorem. Paper presented at the Second International Conference on Teaching Statistics, Voorburg, The Netherlands.

Gluck, K. A., Shute, V. J., Anderson, J. R., & Lovett, M. C. (1998). Deconstructing a computer-based tutor: Striving for better learning efficiency in Stat Lady. In B. P. Goettl, H. M. Halff, C. L. Redfield, & V. J. Shute (Eds.), Proceedings of the 4th International Conference on Intelligent Tutoring Systems (pp. 66–75). New York, NY: Springer-Verlag.

Greenland, S., Senn, S. J., Rothman, K. J., Carlin, J. B., Poole, C., Goodman, S. N., & Altman, D. G. (2016). Statistical tests, P value, confidence intervals, and power: a guide to misinterpretations. *European Journal of Epidemiology*, *31*(4), 337–350. http://doi.org/10.1007/s10654-016-0149-3

Groeneboom, P., de Jong, P., Tischenko, D. B., & van Zomeren, B. C. (1996). Computer-Assisted Statistics Education at Delft University of Technology. *Journal of Computational and Graphical Statistics*, *5*(4), 386–399. http://doi.org/10.1080/10618600.1996.10474719

Gonzalez, R. (2003). Applied Multivariate Statistics for the Social Sciences. *The American Statistician*, *57*(1), 68–69. http://doi.org/10.1198/tas.2003.s213

Gordon, S. P., & Gordon, F. S. (2009). Visualizing and Understanding Probability and Statistics: Graphical Simulations Using Excel. *PRIMUS*, *19*(4), 346–369. http://doi.org/10.1080/10511970701882891

Gould, R. (2010). Statistics and the modern student. *International Statistical Review*, *78*(2), 297–315. http://doi.org/10.1111/j.1751-5823.2010.00117.

Hagtvedt, R., Jones, G. T., & Jones, K. (2007). Pedagogical Simulation of Sampling Distributions and the Central Limit Theorem. *Teaching Statistics, 29*(3), 94-97.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. F. (2010). Multivariate Date Analysis (7th ed.). New Jursey: Pearson Education, Inc.

Hammerman, J. K., & Rubin, A. (2004). Strategies for Managing Statistical Complexity With New Software Tools 3. *Statistics Education Research Journal*, *3*(2), 17–41.

Harvey, A. L., Plake, B. S., and Wise, S. L. (1985), "The Validity of Six Beliefs About Factors Related to Statistics Achievement," paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Hodgson, T., & Burke, M. (2000). On Simulation and the Teaching of Statistics. *Teaching Statistics*, *22*(3).

Jones, G. A., Langrall, C. W., Mooney, E. S., & Thornton, C. A. (2004). Models of Development in Statistical Reasoning. In D. Ben-Zvi & J. Garfield (Eds.), *The Challenge of Developing Statistical Literacy, Reasoning and Thinking* (pp. 97–117). Dordrecht: Springer Netherlands. http://doi.org/10.1007/1-4020-2278-6_5

Kadijevich, D., Kokol-Voljc, V., & Lavicza, Z. (2008) Towards a suitable designed instruction on statistical reasoning: understanding sampling distribution with technology. Paper presented at the ICMI Study 18 Conference and IASE 2008 Round Table Conference (eds C. Batanero, G. Burrill, C. Reading & Rossman A.), [CD-ROM]. ITESM, Monterrey, México (on CD).

Keeley, J., Zayac, R., & Correia, C. (2008). Curvilinear relationships between statistics anxiety and performance among undergraduate students: Evidence for optimal anxiety. *Statistics Education Research Journal*, *7*(1), 4–15. http://doi.org/DOI _ TO LOCATE

Kröpfl, B., Peschek, W., & Schneider, E. (2000). Stochastik in der Schule: Globale Ideen, lokale Bedeutungen, zentrale Tätigkeiten. [Stochastics in school: Global ideas, local significances, central activities]. *Mathematica Didactica, 23* (2), 25–57.

Lane, D. M., & Tang, Z. (2000). Effectiveness of simulation training on transfer of statistical concepts. *Journal of Educational Computing Research, 22*(4), 383–396.

Lin, Y. C. (2008). Development and application of a two-tier diagnostic test for identifying students' correlation misconceptions. Paper presented at the 6th Annual Hawaii International Conference on Education, 922–926. Honolulu, Hawaii.

Lin, Y. C., & Tsia C. C. (2009). Identifying misconceptions about statistical correlation and their possible causes among high school students: an exploratory study using concept mapping with interviews. *International Journal of Science & Mathematics Education,* 7, 791– 820.

Lin, Y. C., & Kinshuk. (2010). The application of Simulation-Assisted Learning Statistics (SALS) for correcting misconceptions and improving understanding of correlation. *Journal of Computer Assisted Learning*, *26*(2), 143–158.

Love, B., Hodge, A., Corritore, C., & Ernst, D. C. (2015). Inquiry-Based Learning and the Flipped Classroom Model. *PRIMUS*, *25*(8), 745–762. http://doi.org/10.1080/10511970.2015.1046005

Lundberg, C. A. (2003). The Influence of Time-Limitations, Faculty, and Peer Relationships on Adult Student Learning: A Causal Model. *The Journal of Higher Education*, *74*(6), 665–688. http://doi.org/10.1080/00221546.2003.11780863

McLaren, C. H. (2004), "A Comparison of Student Persistence and Performance in Online and Classroom Business Statistics Experiences," Decisions Sciences Journal of Innovative Education, 2, 1-10.

McGee, M., Stokes, L., & Nadolsky, P. (2016). Just-in-Time Teaching in Statistics Classrooms. *Journal of Statistics Education*, *24*(1), 16–26. http://doi.org/10.1080/10691898.2016.1158023

Mills, D. J. (2002). Using Computer Simulation Methods to Teach Statistics: A Review of the Literature. *Journal of Statistics Education*, *10*(1), 1–22.

Mills, J. D. (2003). A Theoretical Framework for Teaching Statistics. *Teaching Statistics*, *25*(2).

Mills, J. D. (2004). Learning Abstract Statistics Concepts Using Simulation. *Educational Research Quarterly*, *28*(4), 18–33.

Mokros, J., & Russell, S. J. (1995). Children's concepts of average and representativeness. *Journal for Research in Mathematics Education*, *26*(1), 20–39. http://doi.org/10.2307/749226

Moore, D. S. (1990), "Uncertainty," in *On the Shoulders of Giants: New Approaches to Numeracy*, ed. L. A. Steen, Washington, DC: National Academy Press, pp. 95-137.

Morris, E. (2001). The design and evaluation of Link: a computer-based learning system for correlation. *British Journal of Educational* Technology, 32(1), 39–52.

Morris, E. J., Joiner R., & Scanlon E. (2002). The contribution of computer-based activities to understanding statistics. *Journal of Computer Assisted* Learning, 18(2), 114–124.

Mulekar, M. S. (2006). Visualizing the Central Limit Theorem. *Alabama Journal of Mathematics*. http://doi.org/10.1080/10511970.2015.1094684

Newton, H.J. and Harvill, J.L. (1997). StatConcepts: A visual tour of statistical ideas, Duxbury, CA, pp. 102.

Nicolle, P. S. (2005). Technology Adoption Into Teaching And Learning By Mainstream University Faculty: A Mixed Methodology Study Revealing The "How, When, Why, And Why Not."

Novak, J., Kensington-Miller, B., & Evans, T. (2017). Flip or flop? Students' perspectives of a flipped lecture in mathematics. *International Journal of Mathematical Education in Science and Technology*, *48*(5), 647–658. http://doi.org/10.1080/0020739X.2016.1267810

Novak, E. (2014). Effects of simulation-based learning on students' statistical factual, conceptual and application knowledge. *Journal of Computer Assisted Learning*, *30*(2), 148–158. http://doi.org/10.1111/jcal.12027

Oliver, J., Pisano, M. E., Alonso, T., & Roca, P. (2006). The Web as an educational tool for/in learning/teaching bioinformatics statistics. *Informatics for Health and Social Care, 30*(4), 255–266.

OECD (2017), Adult education level (indicator). doi: 10.1787/36bce3fe-en (Accessed on 06 May 2017).

Onwuegbuzie, A. J., & Wilson, V. A. (2003). Statistics anxiety: nature, etiology, antecedents, effects, and treatments – a comprehensive review of the literature. *Teaching in Higher Education, 8*(2), 195–209. doi: 10.1080/1356251032000052447

Onwuegbuzie, A. J. (2004). Academic procrastination and statistics anxiety. *Assessment & Evaluation in Higher Education, 29*(1), 3–19. doi: 10.1080/0260293042000160384

Pan, W., & Tang, M. (2013). Examining the Effectiveness of Innovative Instructional Methods on Reducing Statistics Anxiety for Graduate Students in the Social Sciences. *Journal of Instructional Psychology*, *31*(2), 149.

Pappas, C. (2013). 8 Important Characteristics Of Adult Learners. *E Learning Industry*, 1–7. Retrieved from http://elearningindustry.com/8-important-characteristics-of-adult-learners

Perepiczka, M., Chandler, N., & Becerra, M. (2011). Relationship Between Graduate Students' Statistics Self-Efficacy, Statistics Anxiety, Attitude Toward Statistics, and Social Support. *The Professional Counselor*, *1*(2), 99–108. http://doi.org/10.15241/mpa.1.2.99

Perney, J., and Ravid, R. (1991), "The Relationship Between Attitudes Towards Statistics, Math Self-Concept, Test Anxiety and Graduate Students' Achievement in an Introductory Statistics Course," unpublished manuscript, National College of Education, Evanston, IL.

Pfannkuch, M. (2006). Comparing Box Plot Distributions: A Teacher's Reasoning. *Statistics Education Research Journal*, *5*(2), 27–45.

Pfannkuch, M., & Reading, C. (2006). Reasoning about distribution: A complex process. *Statistics Education Research Journal*, *5*(2), 4–9.

Pratt, D. (2005). How do teachers foster students' understanding of probability? In *Exploring probability in school: Challenges for teaching and learning* (pp. 171–189). http://doi.org/10.1007/0-387-24530-8_8

Prodromou, T., & Pratt, D. (2006). The Role of Causality in the Co-Ordination of Two Perspectives on Distribution within a Virtual Simulation. *Statistics Education Research Journal*, *5*(2), 69–88.

Ramirez, C., & Bond, M. (2014). COMPARING ATTITUDES TOWARD STATISTICS AMONG STUDENTS ENROLLED IN PROJECT-BASED AND HYBRID STATISTICS COURSES. *ICOTS9 (2014) Invited Paper*, *9*, 1–6.

Ratanaolarn, T. (2016). The Development of a Structural Equation Model of Graduate Students' Statistics Achievement. *International Journal of Behavioral Science, 11*(2), 153–168.

Roberts, D. M., and Bilderback, E. W. (1980), "Reliability and Validity of a Statistics Attitude Survey," *Educational and Psychological Measurement*, 40, 235-238.

Ruggieri, E. (2016). Visualizing the Central Limit Theorem Through Simulation. *PRIMUS*, *26*(3), 229–240. http://doi.org/10.1080/10511970.2015.1094684

Schau, C. (2003). Survey of Attitudes Toward Statistics (SATS-36). [Online: http://evaluationandstatistics.com/]

Schneider, W. R. (2011). The Relationship Between Statistics Self-Efficacy, Statistics Anxiety, and Performance in an Introductory Graduate Statistics Course. *University of South Florida Scholar Commons*, 65. http://doi.org/3450237

Sedlmeier, P. (1999). Improving Statistical Reasoning: Theoretical Models and Practical Implications. Hillsdale, NJ: Erlbaum.

Shaughnessy, M. J. (1992), "Research in Probability and Statistics: Reflections and Directions," in *Handbook of Research on Mathematics Teaching and Learning*, ed. D. A. Grouws, NY: Macmillan, pp. 465-494.

Shaughnessy, J. M. (2007). Research on statistics learning and reasoning. In The Second Handbook of Research on Mathematics, Ed. F.K. Lester, pp. 957–1010. Reston, VA: National Council of Teachers of Mathematics (NCTM).

Shute, V. J., Gawlick-Grendell, L. A., Young, R. K., & Burnham, C. A. (1996). An Experiential System for Learning Probability: Stat Lady Description and Evaluation. *Instructional Science*, *24*, 25–46. http://doi.org/10.1007/BF00156002

Sigal, M. J., & Chalmers, R. P. (2016). Play It Again: Teaching Statistics With Monte Carlo Simulation. *Journal of Statistics Education*, *24*(3), 136–156. http://doi.org/10.1080/10691898.2016.1246953

Škrinjarić, B. (2014). William G. Bowen: Higher Education in the Digital Age. *Croatian Economic Survey*, *16*(1), 171–185. http://doi.org/10.15179/ces.16.1.7

Speed, M.F. and Hardin, J. (2001), "Teaching Statistics Via Distance: Duplicating the Classroom Experience," Communications in Statistics – Simulation and Computation, 30, 391- 402.

Swanson, T., VanderStoep, J., & Tintle, N. (2014). STUDENT ATTITUDES TOWARD STATISTICS FROM A RANDOMIZATION-BASED CURRICULUM. *ICOTS9 (2014) Invited Paper*, *9*, 1–5.

The Journal of Higher Education, Vol. 74, N. 6 (November/December 2003) Copyright ©2003 by The Ohio State Univeristy.

Thirunarayanan, M. O., Bayo, I., & Slater, R. (2014). Students' Content Preferences for Taking Online Courses.

Tintle, N., Chance, B., Cobb, G., Roy, S., Swanson, T., & VanderStoep, J. (2015). Combating Anti-Statistical Thinking Using Simulation-Based Methods Throughout the Undergraduate Curriculum. *The American Statistician*, *69*(4), 362–370. http://doi.org/10.1080/00031305.2015.1081619

Turner, S., & Dabney, A. R. (2014). A Story-based Simulation for Teaching Sampling Distributions. *Teaching Statistics*, *37*(1), 23–25.

Valero-mora, P. M., & Ledesma, R. D. (2011). Using Interactive Graphics to Teach Multivariate Data Analysis to Psychology Students. *Journal of Statistics Education*, *19*(1).

Van Sickle, J. (2015). Adventures in Flipping College Algebra. *PRIMUS*, *25*(8), 600–613. http://doi.org/10.1080/10511970.2015.1031299

Von Glasersfeld, E. (1987). Learning as a constructive activity. In: C. Janvier (ed.), Problems of Representation in the Teaching and Learning of Mathematics, pp. 3–17. Hillsdale, NJ: Lawrence Erlbaum Associates.

Ward, B. (2004), "The Best of Both Worlds: A Hybrid Statistics Course," Journal of Statistics Education [online], 12, 3. Available at http://www.amstat.org/publications/jse/v12n3/ward.html.

Watson, J. M. (1997). Assessing statistical thinking using the media. In I. Gal & J. B. Garfield (Eds.), The assessment challenge in statistics education (pp. 107–121). Amsterdam, The Netherlands: Ios Press.

Watson, J., & Callingham, R. (2003). Statistical literacy: A complex hierarchical construct. *Statistics Education Research Journal, 2*(2), 3–46.

Watson, J. M. & Shaughnessy, J.M. (2004). Proportional reasoning: Lessons from research in data and chance. *Mathematics Teaching Middle School, 10*(2), 104–109.

West, R. W., & Ogden, R. T. (1998). Interactive Demonstrations for Statistics Education on the World Wide Web. *Journal of Statistics Education*, *6*(3), 2–9.

White House Council on Women and Girls. (2011). Women in America: Indicators of Social and Economic Well-Being. Washington, DC: U.S. Department of Commerce, Economics and Statistics Administration and the Executive Office of the President, Office of Management and Budget. Retrieved November 7, 2013, from http://www.whitehouse. gov/sites/default/files/ rss_viewer/Women_in_America. pdf.

Wild, C. J., & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, *67*(3), 223–256. http://doi.org/10.2307/1403699

Yong, D., Levy, R., & Lape, N. (2015). Why No Difference? A Controlled Flipped Classroom Study for an Introductory Differential Equations Course. *PRIMUS*, *25*(9–10), 907–921. http://doi.org/10.1080/10511970.2015.1031307

Yu, C. H., & Behrens, J. T. (1995). Applications of multivariate visualization to behavioral sciences. *Behavior Research Methods, Instruments, & Computers, 27*(2), 264–271.

Zack, L., Fuselier, J., Graham-Squire, A., Lamb, R., & O'Hara, K. (2015). Flipping Freshman Mathematics. *PRIMUS*, *25*(9–10), 803–813. http://doi.org/10.1080/10511970.2015.1031302

Ziegelmeier, L. B., & Topaz, C. M. (2015). Flipped Calculus: A Study of Student Performance and Perceptions. *PRIMUS*, *25*(9–10), 847–860. http://doi.org/10.1080/10511970.2015.1031305

Zhang, J. (2002), "Teaching Statistics On-line: Our Experiences and Thoughts," in Proceedings of the Sixth International Conference on Teaching Statistics, Voorburg, The Netherlands: International Statistical Institute.

VITA

Liuli Huang was born in Wuhan city of Hubei province, People's Republic of China. She received her Bachelor's degree from Huazhong University of Science and Technology in 2011. She also received a Master's degree in applied statistics from Louisiana State University in 2016. She will receive the degree of Doctor of Philosophy at December 2017 commencement.

As a doctoral candidate in program of educational leadership and research, Liuli's area of interest is about statistics education for students from social sciences.