Effects of Guided Project-Based Learning Activities on Students’ Attitudes Toward Statistics in an Introductory Statistics Course

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EFFECTS OF GUIDED PROJECT-BASED LEARNING ACTIVITIES ON STUDENTS’ ATTITUDES TOWARD STATISTICS IN AN INTRODUCTORY STATISTICS COURSE

by

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B.S. August 2003, Virginia Polytechnic Institute and State University
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A Dissertation Submitted to the Faculty of Old Dominion University in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

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This research sought to determine if the use of a guided project-based learning instructional approach improved students’ attitudes and academic performance in a college-level introductory statistics course at a community college. It also sought to determine if the guided project-based approach improved attitudes and academic performance more than a traditional lecture-based instructional approach. The research used a quasi-experimental Pre-test, Post-test approach. The independent variable was either the use of a guided project-based learning instructional approach or the use of a traditional lecture-based instructional approach. The dependent variables were student attitudes and final course grades. Students’ attitudes were measured using the six components of the Survey of Attitudes Toward Statistics (SATS-36). The statistical analysis was conducted using a Multivariate Analysis of Variance (MANOVA) followed by an Analysis of Variance (ANOVA). Significant differences were found in each analysis. Guided project-based learning was shown to improve the components of affect and value in students’ attitude toward statistics and academic performance. Students in the guided project-based instructional group \((N = 83)\) performed better academically than students in the traditional lecture-based group \((N = 58)\).
DEDICATION

This dissertation is dedicated to my wife and best friend, Sarah. You have encouraged me from the beginning. Through the years you have always been the support I needed at the time I needed it. Thank you for everything you have done for us and for patiently enduring time apart so that I could complete this work. Your loving support was an essential component of completing this entire process. Without you I would not have been able to do it. Thank you for all you have done. I am forever grateful.

To my children Grace, Joshua, and Jacob, thank you for being who you are. Thank you for being wonderful reminders of how much I have that I do not deserve. My hope is for you all to dream big, consider thoughtfully, feel deeply, work hard, and apprehend all that God has planned for you.
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Many people helped me to complete this dissertation. Dr. John Ritz, you have done far more for me than I could ever repay. The completion of this dissertation is a testament of your dedication to those you mentor. You have revised my work too many times to count. You have worked with me over the years helping me become a better researcher and a better professional educator. Thank you for all you have done to help me. To my committee members, Dr. Petros Katsioloudis and Dr. Mary Enderson, thank you for the guidance, revision, and recommendations. Thank you for serving on my dissertation committee. Thank you for being a part of this process.

To my fellow students who helped me along the way, thank you.
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CHAPTER I
INTRODUCTION

Statistics is increasingly being recognized as a necessary component of many college and university programs (Bond, Perkins, & Ramirez, 2012). Statistics requires the ability to apply mathematics and the ability to use mathematics and has long been recognized as essential to bettering one’s economic prospects, gaining employment, keeping employment, and obtaining better employment (National Mathematics Panel, 2006; Sum & National Commission on Adult Literacy, 2007). Improving employment prospects is important, so as nations and employers gain access to larger and larger caches of data, students will increasingly need to become familiar with statistical techniques such as organizing and analyzing data (American Statistical Association 2012). Currently, data collection, analysis, and interpretation are necessary components of many fields and occupations and it is likely the number of occupations will continue increasing. Data based decision making is being transformed from an atypical practice to an essential one. This rapidly increasing use of data necessitates students acquire the training and skills necessary to collect, organize, analyze, and interpret data. In an introductory statistics course students are given the opportunity to gain the statistical knowledge and skills needed to make these data based decisions (Gal, 2002; Utts, 2003).

A consensus has long existed among statistics educators that an introductory statistics course should be required for all college students regardless of program, degree, or certificate (Bartz, 1981; Cobb, 1992; Galli, Chiesi, & Primi, 2011; Hogg, 1991; Manalo & Leader, 2007; Shin, 1975). Even though an introductory statistics course has been seen as a necessary component for future career success in many fields, students have come to perceive statistics negatively. Instead of seeing statistics as a useful tool, many see it as an obstacle. Students taking these courses often report apprehension and anxiety (Bui & Alfaro, 2011; Fitzgerald, Jurs, &
Hudson, 1996; Onwuegbuzie, Leech, Murtonen, & Tähtinen, 2010; Onwuegbuzie & Wilson, 2003; Sciutto, 1995; Zanakis & Valenzi, 1997; Zeidner, 1991), negative attitudes, a lack of motivation, or a lack of interest in studying statistics (Capshew, 2005; Dempster & McCorry, 2009; Nolan, Beran, & Hecker, 2012), and lack of understanding regarding the practical use of statistics (Acee & Weinstein, 2010; Bartsch, 2006). Students’ feelings of apprehension, anxiety, negative beliefs, lack of interest, and their lack of perceived value of statistics eventually translate into poor attitudes toward the study and use of data analysis and statistics. These poor attitudes toward statistics can affect student academic performance and conceptual understandings (Schau & Emmioglu, 2012).

Academic performance and conceptual understanding are important elements related to student success and it has been shown that statistics anxiety may influence both performance and conceptual understanding (DeVaney, 2010). Research has also shown student attitudes toward statistics to be generally negative (Mills, 2004). Further, Finney and Schraw (2003) found a statistically significant relationship between statistics anxiety and a negative attitude toward statistics. Statistics anxiety and poor attitudes can negatively affect students’ academic performance in statistics courses (DeVaney, 2010), while a positive attitude can affect academic performance positively (Schau & Emmioglu, 2012). In addition to the evidence suggesting academic performance is linked to students’ attitudes, students need to have good attitudes toward statistics because it is likely students will make statistical decisions in the future (Gal & Ginsburg, 1994). If students have poor attitudes they will not only be affected in the present but also in the future. Because attitudes toward statistics affect present perceptions, course performance outcomes, and the way students may perceive statistics when they encounter it
within future contexts, improving students’ attitudes towards statistics must be one of the
objectives of instruction in an introductory statistics course (Schau & Emmioglu, 2012).

One suggestion for improving students’ attitude toward statistics is through the use of
innovative instructional approaches (American Statistical Association, 2012; Carnell 2008;
Loveland, 2014; Mills, 2004). Traditional teaching approaches have been criticized for being too
abstract and unappealing to students (Hogg, 1991; Willett & Singer, 1992). In contrast to this,
active learning approaches, such as project-based learning, have been focused on increasing
students’ interest in studying mathematics and statistics (DeCorte, Greer, & Verschaffel, 1996).
However, active learning approaches have been criticized for offering minimal guidance to
students and producing at best mixed results (Pfaff & Weinberg, 2009; Weltman & Whiteside,
2010), while the use of a guided instructional approach has been shown to increase students’
academic performance in statistics courses (Bude, Wiel, Imbos, & Berger, 2012; Kuiper &
Collins, 2009). Thus as a solution to the problem of unappealing instruction and minimal
guidance, a guided active learning approach can be both effective and appealing to students. One
possible guided active learning intervention which may improve students’ attitudes toward
statistics is the use of a guided project-based learning approach.

**Purpose of the Research**

The purpose of this study was to determine if the implementation of a guided project-
based learning instructional approach improved students’ attitudes toward statistics and overall
course performance measured by final grade. The results will inform statistics educators about
the successful development and implementation of more appealing project-based instructional
approaches that can be used to enhance statistics courses.
Hypotheses

This research project was designed to confirm the following hypotheses:

H1: The use of a guided project-based learning approach will improve students’ attitudes towards statistics as measured by the Survey of Attitudes Toward Statistics (SATS-36).

H2: Students enrolled in the guided project-based learning courses will have better attitudes toward statistics than students who enrolled in traditional lecture-based courses as measured by the Survey of Attitudes Toward Statistics (SATS-36).

H3: The use of a guided project-based learning approach will improve students’ course performance measured by final course grades compared to students who are taught in traditional lecture-based courses.

Background and Significance

Societies of developed nations increasingly use data in policy matters and decision making. Indeed, the growing emphasis on using data to make decisions has led many college and university programs to call for an introductory statistics course as a core education requirement (Bond, Perkins, & Ramirez, 2012). In these introductory courses, mathematics and statistics educators have a responsibility to develop students’ quantitative reasoning skills, increase students’ statistical literacy, and improve students’ attitude toward statistics (Gal, Ginsburg, & Schau, 1997; Gal, 2002; Utts, 2003). The instructional method used in these courses can have a major bearing on the development of positive attitudes and statistical skills. A growing body of evidence suggests traditional instructional methods have not been effective enough. Among other recommendations has been the inclusion of more active learning in the classroom (American Statistical Association, 2012). This lack of effectiveness, using traditional instruction in conjunction with poor academic performance, anxiety, and negative student attitudes, has led
to greater emphasis being placed on reforming statistics education in introductory statistics courses (Garfield, Hogg, Schau, & Whittinghill, 2002; Onwuegbuzie & Wilson, 2003). Research suggests reforming instructional practice in undergraduate mathematics and statistics courses can improve student learning (Ellis & Berry, 2005; Laws & Hastings, 2002; Steffe & Wiegel, 1992), and students perform better in college mathematics and statistics courses using student-centered active learning activities (Kwon, Rasmussen, & Allen, 2005; Rasmussen, Kwon, Allen, Morrongelle, & Burtch, 2006).

Project-based learning as an instructional approach has been shown to be beneficial to students. Students who have engaged in project-based learning have performed better academically (Ayaz & Soylemez, 2015; Karacalli & Korur, 2014), improved their perceptions and attitudes (Chu, Tse, Loh, & Chow, 2011; Frank, Lavy, & Elata, 2003), improved their attitudes toward STEM education (Alexander, Knezek, Christensen, Tyler-wood, & Bull, 2014), increased their levels of statistical literacy (Koparan & Guven, 2015), and improved their self-directed learning skills (Bagheri, Wan Ali, Binti Abdullah, & Daud, 2013). Even though project-based learning has been shown to be beneficial to students, it has not yet been implemented or researched to a large extent in introductory statistics courses, although other forms of active learning have been researched (Bates-Prins, 2009; Bude, Imbos, Wiel, Broers, & Berger, 2009; Carlson, & Winquist, 2011; Knypstra, 2009; Pfaff & Weinberg, 2009; Steinhorst & Keeler, 1995; Strangfeld, 2013). In addition to the lack of research on project-based learning in introductory statistics courses, relatively few studies have used active learning techniques throughout an entire course or compared active learning techniques to traditional teaching techniques (Loveland, 2014).
One outcome which has been shown to be indicative of a reduction in students’ feelings of anxiety, and a change from negative feelings towards statistics, was having a positive attitude toward statistics (Onwuegbuzie, 2000; Ramirez, Schau, & Emmioglu, 2012; Schutz, Drogosz, White, & Distefano, 1998; Sgoutas-Emch, & Johnson, 1998). Having a positive attitude toward statistics has also been linked with better academic performance. Several studies have shown positive attitudes toward statistics were positively correlated with student performance in statistics courses (Cashin & Elmore, 2005; Dempster & McCorry, 2009; Harlow, Burkholder, & Morrow, 2002; Lalonde & Gardner, 1993; Nasser, 2004; Sorge & Schau, 2002; Tremblay, Gardner, & Heipel, 2000; Wisenbaker et al., 2000). Given the need to improve instructional interventions through the use of active learning, the need to reduce students’ anxiety and negative feelings toward statistics, and the need to improve students’ academic performance, it is time to conduct research involving project-based learning in introductory statistics courses. The need to determine if such an instructional method can be used to foster these improvements is long overdue.

One study has considered the effect of a single student designed project on students’ attitudes toward statistics. Carnell (2008) concluded that there was no significant evidence to suggest a student-designed data collection project improved students’ attitudes toward statistics. However, it is essential to consider two limitations of Carnell’s study. First, only one project was undertaken throughout the entire course and it took only a small portion of the course time to complete it. Second, the project was unguided by the instructor. By Carnell’s own admission her study raised many questions and provided few answers regarding the positive effects of projects on attitudes. She suggested further evidence was needed on the effect of project-based learning on students’ attitudes toward statistics and proposed changing the structure of the project. One
change that may improve students’ attitudes toward statistics is using guidance during the implementation of a project-based approach.

One of the drawbacks of project-based or open-ended inquiry-based methods is the unguided nature of the instruction. Learning in statistics is both highly structured and abstract (Bude et al., 2009). In domains such as mathematics, statistics, and computer science, research has shown that guided instruction has a greater effect on learning than unguided instruction (Carroll 1994; Debowski, Wood, & Bandura, 2001; Fay & Mayer, 1994; Kirchner, Sweller, & Clark, 2006; Lee & Thompson, 1997; Paas, 1992; Sweller, 1999; Sweller & Cooper, 1985; Tuovinen & Sweller 1999). In 2011, Bude, van de Wiel, Imbos, and Berger reported that students, who were enrolled in a problem-based learning statistics course, had a better conceptual understanding of statistics when they were in a guided tutoring group. Concerning the level of directedness in instruction in disciplines with highly structured, interconnected concepts such as statistics, Bude et al. determined that further research was needed on both the level of directness in instruction and the most effective teaching methods.

At this time no research has been conducted regarding how the use of guided project-based learning as an instructional intervention will affect students’ attitude toward statistics when used for an entire course. Also no research has been conducted comparing project-based learning to traditional instruction in an effort to determine if project-based learning improves students’ attitudes toward statistics or performance over a traditional instructional approach.

**Limitations**

The limitations of this study were as follows:

1. This research was conducted using students who were already enrolled in an introductory statistics course at a two-year college.
2. This study lacked randomization in choosing the treatment and control groups. An optimum procedure would have included random assignment to either group. Because classes are already formed students could not be randomly selected for participation in the guided project-based intervention or the traditional lecture-based approach.

3. Ideally the study would have been conducted in one semester but due to possible interaction effect and the lack of large sample sizes it was necessary to conduct the study over two semesters.

Assumptions

The assumptions of this study were:

1. Students at the community college take a mathematics placement test upon being admitted to the college. Students who need to complete remedial work in mathematics are placed into modules to complete this work. Students who enroll in the introductory statistics course have completed the necessary pre-requisite course work or tested out of the course work.

2. The students who participated in this study were enrolled in an introductory statistics course. Therefore, students had little or very limited previous experience in the formal study of statistics in a college environment.

3. Students in both the control and intervention groups experienced the same lecture, notes, and activities, but the project-based group also completed guided projects throughout the course. The projects consisted of simulated research scenarios that required students to develop research questions and hypotheses, design data collection methods, analyze
simulated data, and based on the statistical analysis present conclusions and recommendations. After completing the projects students gave formal presentations.

4. Project-based learning has traditionally been used with groups. All students in the guided project-based instructional intervention condition completed the projects in groups of four to six individuals.

**Procedures**

Data for this study were collected from students enrolled in introductory statistics courses at a two-year college. Students initially enrolled into the statistics course without knowing about the research project. Based upon the semester they enrolled, students were put into one of two groups. One group functioned as the control group which received only the traditional approach to instruction. The other group functioned as the treatment group which received the guided project-based instructional intervention. The same learning objectives were designed to be achieved by both groups. Students’ responses to the Survey of Attitudes Toward Statistics (SATS-36) were collected on the first and last days of the class for both groups. The survey measured to see if there was a within group change in attitudes toward statistics across any of the six instrument subscales. The statistical analysis was done using a multivariate analysis of variance (MANOVA) at the .05 level of significance to determine if there was difference in attitude for the guided project-based instructional group for the six component scores on the SATS-36 over time (pre-survey vs. post survey). Univariate analysis was conducted through the use of a separate Analysis of Variance (ANOVA) for each of the dependent variable component scores. A second MANOVA was conducted at the .05 level of significance to determine if there was a difference in attitude between the guided project-based instructional group and the traditional instructional group on the post SATS component scores and the final course grades.
Again a separate ANOVA was conducted at the .05 level of significance for each dependent variable. These analyses were done to determine if there was a difference in any of the subscales between the guided project-based instructional group and the traditional lecture-based instructional group after the course was completed as well as a difference between the average final course grades for the two groups. The between groups factor was instructional group. Participants were in the guided project-based instructional group or traditional lecture-based instructional group. The within groups factor was time identified as pre SATS and post SATS.

**Definition of Terms**

The following terms were used in this research study:

Active learning: Teaching and learning techniques in which doing is a primary part of the learning process. This can be accomplished through the use of projects, experiments, demonstrations, and/or activities that require direct student participation (Kvam, 2000; Strangfeld, 2013).

Affect: A component of attitude measuring how students felt about statistics (Schau, 1995).

Attitude Toward Statistics: Construct measured with the SATS-36 using six subscales. The subscales were affect, cognitive competence, difficulty, value, interest, and effort (Schau, 1995; 2003).

Cognitive competence: A component of attitude measuring students’ perception of their understanding of statistics (Schau, 1995).

Constructivism: A student centered approach to instruction in which students actively construct knowledge by connecting previous knowledge and skills to skills and concepts currently being learned (Draper, 2002; Matthews, 2003).
Difficulty: A component of attitude measuring students’ perceptions of the difficulty of statistics (Schau, 1995).

Effort: A component of attitude measuring students’ perceptions about the amount of effort required to learn statistics (Schau, 2003).

Guided project-based learning: The term project-based learning has been used to describe various instructional interventions. For use in this study project-based learning was a student-centered inquiry-based instructional approach which facilitates learning through the use of projects. Projects were both challenging and complex. The projects used in this study were based on guided questions posed to students. The guiding questions were designed to lead students through the process of completing the projects (Leppink, Broers, Imbos, Vleuten, & Berger, 2014; Markham; 2003; Thomas, 2000).

Inquiry-based learning: A teaching and learning method in which students learn content in a discipline specific manner through the use of investigations (Hmelo-Silver, Duncan, & Chin, 2007).

Interest: A component of attitude measuring students’ interest in statistics.

Traditional lecture: A teaching and learning method that primarily involves listening to the instructor lecture and taking notes from the lecture (Kvam, 2000).

Value: A component of attitude measuring students’ perceptions of the usefulness of statistics (Schau, 1995).

**Summary**

This research study investigates how the use of a guided project-based learning approach affects both student attitudes toward statistics and student academic performance in an introductory statistics course. A general lack of conceptual understanding and poor attitudes
toward statistics have statistics educators calling for improvements in instructional delivery such as active learning methods. Previous research involving project-based learning has shown it to be beneficial in decreasing students’ anxiety and improving student academic performance. In this study a guided project-based learning approach was compared to a traditional lecture approach to determine if students in the project-based course perform better academically than students in the traditional course. Students’ attitudes in both courses were measured to determine if the guided project-based approach improves students’ attitudes over the traditional lecture format.

A further discussion of statistics education, project-based learning, and student attitude toward statistics will be provided in Chapter II, the Review of the Literature. In Chapter III, the methods that were used to collect the survey data and academic performance data as well as analyze the data will be provided. The results of the analysis will be provided in Chapter IV. Finally, the Summary, Conclusions, and Recommendations will be presented in Chapter V.
CHAPTER II

REVIEW OF THE LITERATURE

The use of guided project-based learning to teach statistical concepts is a relatively new instructional approach. This chapter will provide details about the development of statistics education and the use of project-based learning.

Statistics Education

Statistics education is of practical importance across all educational levels. The use of quantitative information and statistical arguments to add credibility to claims, arguments, or products is widespread (Wilks, 2006). To evaluate statistical claims students need to be educated in the use of statistics. As a methodological STEM discipline, statistics exists to be used within other disciplines (Moore & Cobb, 1997). It is the context of the problem that provides meaning not the statistical processes themselves (Moore & Cobb, 1997). To develop statistical understanding requires students to understand and apply complex concepts (Garfield & Ben-Zvi, 2007). These are just a few factors which need to be considered when developing effective statistics instruction.

While statistical instruction has been increasing at all levels since the 1990s (Moore, 2012; Scheaffer & Stasney, 2004), it has not always garnered the attention it deserved. The development of statistics education can be attributed to the disciplines of statistics and mathematics education (Garfield & Ben-Zvi, 2008). Statistics has historically been a challenging subject both for teachers and learners. However, improving the teaching and learning of statistics is a relatively new construct (Garfield & Ben-Zvi, 2007). The first sections on training statisticians were developed by the International Statistical Institute in 1948 (Vere-Jones, 1995).
and the American Statistical Association in 1944 (Mason & McKenzie, 2015). However, instructional pedagogy related to statistics education did not develop until sometime around the late 1960s and early 1970s (Becker, 1996). At this point statistics education was seen as mathematics education, so initially the development of instructional pedagogy occurred within the mathematics education field because teachers were interested in teaching basic data analysis (Garfield & Ben-Zvi, 2008). In 1967 the American Statistical Association and the National Council of Teachers of Mathematics formed a committee to develop curriculum materials to teach probability and statistics in grades K-12 (NCTM, 1980). Educational materials continued to be developed throughout the 1970s in an attempt to interest and engage learners, but it was not until the 1980s and 1990s that statistics education began to grow and take the form that we recognize today.

The 1980s saw steady growth in the offering of statistics courses in colleges and universities (Scheaffer & Stasney, 2004). Starting with the publishing of the journal *Teaching Statistics* in 1979, the 1980s also saw an increased number of publications related to statistics education (Garfield & Ben-Zvi, 2008). This increase in publications indicates statistics education was finally becoming a discipline in its own right. In 1982 a taskforce within the International Statistics Institute published a report on teaching statistics (Barnett, 1982). Titled *Teaching Statistics in Schools Throughout the World*, the report provided an overview of the locations where statistics was being taught, the ways it was being taught, and discussed possible teaching improvements. Beginning with the convening of the first *International Conference on Teaching Statistics* in 1982 a growing effort was made to incorporate statistics courses in secondary schools and improve statistics education at the postsecondary level (Garfield & Ben-Zvi, 2007). One example of this effort was the Quantitative Literacy Project (QLP). The American Statistical
Association (ASA) and the National Council of Teachers of Mathematics (NCTM) worked together on the Quantitative Literacy Project for most of the 1980s (Scheaffer, 1990). The aim of the QLP was the development of high quality curriculum materials to be used by secondary students learning about probability and statistics (Scheaffer, 1990). In 1986 the QLP began producing materials (Landwehr & Watkins, 1986) and continued to produce materials into the 1990s (Scheaffer, 1990; Scheaffer, Watkins, Witmer, & Gnanadesikan, 2004). The activities, while designed for students in grades 6-12, were used extensively in college statistics courses and eventually gave rise to the Activity Based Statistics project (Scheaffer, Watkins, Witmer, & Gnanadesikan, 2004). All of this activity was evidence of the rise of statistics as a branch of learning increasingly separate from mathematics.

In the same way statistics was founded in mathematics but grew to be its own discipline, the standards associated with statistics developed from the standards for mathematics. Having specific standards associated with the teaching of statistics began when the NCTM introduced a statistics strand in the 1989 NCTM standards (NCTM, 1989; Scheaffer, 1990). This reference to statistics in the 1989 NCTM standards was the first time statistics education was addressed in national standards for mathematics (Scheaffer, 1990). Statistics education continued to develop and grow as a field in both K-12 and college. Eventually giving rise to the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report in 2005 which was produced by the American Statistical Association (ASA). The report was produced in two different versions. One version was aimed at K-12 education and the other was aimed at college level statistics courses. One of the suggestions that came out of the GAISE report was the need for more inquiry-based active learning in statistics courses. These two reports represent the present and future directions of statistics education.
Inquiry-Based Learning

Inquiry-based learning is rooted in the constructivist approach to learning (Hmelo-Silver, Duncan, & Chin, 2007; Kirschner, Sweller, & Clark, 2006). A constructivist approach to learning is based on the idea that learners actively construct knowledge using an intellectual schematic based on prior knowledge and personal experience (Lehman, 2011; Spector, 2012). Constructivism is a student-centered instructional approach within which students essentially create their own knowledge through social interaction which is organized by some narrative (Matthews, 2003). In a constructivist learning environment, learners work together to solve problems through a social collaborative process (Mvududu, 2003; Neo & Neo, 2002). Within mathematics and science education constructivist learning theories have been adopted because constructivism is seen as an effective method of learning complex material (Draper, 2002; Duit, Fraser, & Treagust, 1996; Fraser & Walberg, 1995; Phillips, 2000). Constructivism was founded in the active learning approaches promoted by Jean Piaget, Lev Vygotsky, and John Dewey (Lehman, 2011; Matthews, 2003; Mvududu, 2003; Spector, 2001).

Lev Vygotsky was a psychologist who viewed becoming a participant within a community of practice as a necessary pre-requisite for learning (Spector, 2001). Vygotsky’s main contribution to constructivism was his consideration of the social environment within which learning occurred (Spector, 2001). He proposed an approach to understanding how children learn called the zone of proximal development (Vygotsky, 1978). According to Vygotsky, children’s learning was always somewhere between their actual level of development and their potential level of development. This zone was defined by problems a child could solve autonomously and problems a child could only solve given assistance from an adult. This understanding of the internal development and learning in children, furnished by the theory of
the zone of proximal development, provides a foundation for the idea that children actively construct knowledge.

Jean Piaget was a Swiss psychologist who studied children’s developmental levels. Piaget (1967) theorized that children develop through states of cognitive disequilibrium in which children do not comprehend a particular phenomenon because it is contrary to their understanding. Through guidance children explore possible explanations and eventually they find a suitable justification which leads to a new level of cognitive disequilibrium. One of Piaget’s contributions to constructivism was an understanding about the ways a specific type of instructional approach affected a child’s development. Children advanced through levels of cognitive disequilibrium while being actively engaged. Piaget (1973) suggested instructional approaches needed to be adapted to the specific needs of the child according to his or her developmental stage. This adaption of instruction or tailoring of instruction to the student’s needs represents a student-centered instructional approach.

John Dewey was a science teacher and educational philosopher. According to Dewey (1907; 1938), learning requires active participation experienced within a social context or within an authentic setting. Dewey (1907) referred to this learning by doing as experienced learning. Active involvement and personal understanding on the part of students instead of passive listening became necessary components of instruction (Dewey, 1938). While traditional instruction has the teacher at the center of the learning process, in a constructivist approach the student’s learning becomes the focus of instruction with the teacher as guide or facilitator (Matthews, 2003). Dewey (1938) developed his ideas into what he called a theory of inquiry.
When Dewey (1910) initially proposed inquiry in the K-12 science curriculum, he did so in part because of the over emphasis on facts without the inclusion of thinking (Barrow, 2006). Inquiry-based learning originated within the practice of scientific inquiry. Inquiry involves questioning, collecting data, analyzing data, making conclusions, and presenting arguments which are all part of the process of scientific inquiry. Dewey made significant use of these processes in the development of his model (Barrow, 2006; Kuhn, Black, Keselman, & Kaplan, 2000). Initially Dewey’s ideas applied specifically to science education, however over time his idea of inquiry transformed into a method of teaching and learning a broad scope of topics (Mvududu, 2003).

Inquiry-based learning has been defined in many ways in the literature but for this literature review the definition put forward by Hmelo-Silver, Duncan, and Chinn (2007) will be used. Using inquiry-based learning allows students to “learn content as well as discipline-specific reasoning skills and practices (often in scientific disciplines) by collaboratively engaging in investigations” (p. 100). Added emphasis will be placed on “collaborative learning and activity” while “students are actively engaged in sense making, developing evidence-based explanations, and communicating their ideas” (p. 100). While, inquiry-based learning can take various forms, one of the most common characteristics of inquiry methods is being different from traditional instruction. Traditional instruction has students memorizing information presented by teachers in a very structured manner usually through some form of lecture. Inquiry-based instruction may involve the use of this type of instruction just-in-time as it is relevant to student learning but also includes complex ill-structured learning situations (Edelson, 2001; Hmelo-Silver et al., 2007). The use of scaffolding provides students with direction in a way similar to the teacher in traditional teaching environments (Hmelo-Silver et al., 2007).
Although inquiry-based learning can be used in teaching and learning many topics, the majority of references to it occur in publications about science education (Anderson 2002; Edelson, Gordin, & Pea, 1999). For example, Barrow (2006) provides an excellent summary and historical overview of inquiry but does so within the context of science education. Another example is provided in the meta-analysis completed by Furtak, Seidel, Iverson, and Briggs (2012). Since statistics is used extensively within the context of science, using inquiry-based methods in statistics courses is a logical choice.

Inquiry-based instructional methods can be difficult for both teachers and students. Teachers are required to change the classroom structure and students are required to actively engage the material. Inquiry also requires students to work collaboratively, apply scientific reasoning skills, think critically, and regulate behavior and learning (Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, & Tal, 2004). While inquiry methods can be difficult to implement, using them does have benefits for many learners. Indeed inquiry methods have been shown to be helpful to some students and not harmful to others (Kogan & Laursen, 2014).

Today, inquiry-based instruction allows students to have learning experiences rooted in their interests (Aulls & Shore, 2008). Researchers and practitioners have various definitions of what might be classified as inquiry-based methods. Examples include discovery learning, design-based learning, problem-based learning, and project-based learning (Hmelo-Silver, Duncan, & Chin, 2007; Kirschner, Sweller, & Clark, 2006). Inquiry-based methods differ from traditional methods. Traditional methods have the teacher at the center of the instruction transmitting knowledge while students passively receive the information conveyed to them. The appealing nature of inquiry-based instructional design is beneficial to students (Capshew, 2005).
Project-Based Learning and Problem-Based Learning

Project-based learning and problem-based learning are both types of inquiry-based learning (Hmelo-Silver, Duncan, & Chinn, 2007). Both types of teaching and learning share many common characteristics such as using authentic problems, collaboration among students, with students proposing ideas and solutions. In fact, many times in the literature authors refer to project-based learning and problem-based learning without making a distinction between the two approaches, e.g., Thomas (2000) and Frank, Lavy, and Elata (2003).

The main difference between project-based learning and problem-based learning is the creation of a project. Problem-based learning focuses on solving the problem but not necessarily on the creation of a product or performance. Because problem-based learning and project-based learning share many commonalities, in this literature review some research related to problem-based learning has been presented as evidence for the use of project-based learning.

Project-Based Learning

Project-based learning is a type of student-centered inquiry-based learning that requires learners to use discipline specific concepts and tools, experience, and technology to solve authentic problems (Lee, Blackwell, Drake, & Moran, 2014; Krajcik & Blumenfeld, 2006; Markham, Larmer, & Ravitz, 2003). Within a project-based learning environment, students engage in investigations and pursue solutions through asking questions, discussing ideas, making predictions, designing experiments, implementing experiments, communicating results, and designing and/or creating products (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). Markham, Larmer, and Ravitz (2003) defined project-based learning “as a systematic teaching method that engages students in learning knowledge and skills through an extended
inquiry process structured around complex, authentic questions and carefully designed products and tasks” (p. 4).

According to Markham et al. (2003) effective projects:

- are student centered so that students desire to learn and students’ learning potential is demonstrated,
- force students to engage in the central concepts of a discipline,
- encourage students to engage in in-depth investigations of topics,
- require students to use a range of necessary tools and skills,
- produce projects that present information or solve problems,
- have frequent feedback and experiential learning,
- have performance-based assessments that are rigorous and communicate high expectations, and
- lead students towards student centered collaborating in small groups or as an entire class.

Project-based learning begins with a driving question and concludes with students designing or producing a product or giving a presentation. The driving question provides the context, gives students a purpose for learning, and challenges them to find their own answers (Larmer & Mergendoller, 2010). The question should assist students with organization and guide their activities (Alozie, Eklund, Rogat, & Krajcik, 2010). The driving question may be initiated through an entry event that generates the question or simply provided to students at the beginning of instruction (Larmer & Mergendoller, 2010). Regardless of how the driving question is presented, project-based learning should always be designed with the end product or presentation in mind (Markham et al., 2003). Once the driving question has been provided,
students begin working on the project with assistance from group members, instructors, and experts. During the learning process as students focus on answering the driving question they are engaged in a sequence of complex tasks leaving them in control of their own learning while the teacher acts as a facilitator and guide (Barron, Schwartz, Vye, Moore, Petrosino, Zech, & Bransford, 1998; Mergendoller, 2006). Various models of project-based learning exist with various implementation strategies, e.g., Barron et al. (1998), Markham et al. (2003), and Mergendoller (2006). For this research project the researcher will be using the form put forward by Markham et al. (2003).

**Challenges of Project-Based Learning**

Prior research has shown reformed instructional practice can have an effect on students’ performance in statistics courses but can be difficult to implement. For example, Derry, Levin, Osana, Jones, and Peterson (2000) concluded innovative reform-oriented instructional methods were successful but were difficult to implement and students required supportive resources. Most of the research on challenges associated with the implementation of PBL has been conducted in K-12 settings (Lee et al., 2014). Implementation problems included classroom management, technology use, and assessment of learning (Marx et al., 1997). Other problems included the challenge of providing an authentic learning experience, student engagement, and the use of unfamiliar alternate assessment models (Brinkerhoff & Glazewski, 2004; Lee et al., 2014). Further challenges included providing enough time for students to complete projects, balancing instructional time between completing projects and providing direct instruction, effectively making use of technology, and students gaining a deeper understanding of a more limited amount of content but failing to sufficiently learn a wider breath of content (Krajcik,
Because project-based learning relies so heavily on active involvement from students to complete the projects, it presents many problems for teachers. This transfer of responsibility from teacher to student does not happen naturally (Brush & Saye, 2008). Because of their lack of experience with control over their own learning, students may be confused or become frustrated (Ertmer & Simons, 2006). Teachers also face significant challenges as they transition from a knowledge provider to a facilitator (Ertmer & Simons, 2006).

**Benefits of Project-Based Learning**

Given the many challenges associated with implementing a project-based learning approach, it is necessary to weigh the challenges against the benefits of such an approach. Such benefits might include appealing instruction, students who acquire a wide-ranging, flexible, knowledge base, effective collaboration amongst students, the development of problem solving skills, and greater self-directedness towards learning (Barrows, 1986; Loyens, Magda, & Rikers, 2008; Norman & Schmidt, 1992). Research has shown both project-based learning and problem-based learning to be effective instructional approaches. If project-based learning can be shown to be as effective as traditional methods, its use should be considered. One reason this is true is because when compared to a traditional lecture approach, Albanese and Dast (2014) reported students and faculty had greater satisfaction with a problem-based approach and lower attrition rates. In another study conducted by Frank, Ilana, and Elata (2003) researchers found using project-based learning in an introductory engineering course improved students’ attitudes,
increased their motivation to study, and empowered students so that they felt like collaborators in the learning process.

One of the most important research studies conducted on the use of project-based learning was done by Boaler (1998). Boaler conducted a three year longitudinal study in which she compared two teaching approaches in secondary mathematics courses at two different schools. In one school she described the use of a traditional instructional approach which was employed by all of the teachers. In the other school she observed what she described as an open-ended project-based approach. In the open-ended project-based group, students were taught in a relaxed atmosphere where they worked on projects in heterogeneous groups. Each of the projects was completed in two to three weeks. At the conclusion of a project, students had to give written descriptions to their teachers. Students in both groups were said to be similar in background and ability. Both schools had average standardized test scores which fell below the national average. Through multiple measures including observations, questionnaires, interviews, and assessments she concluded students in the project-based group had better attitudes toward mathematics, increased confidence and competence when transferring mathematics to authentic situations, and passed the national examination in higher percentages and with higher scores than students who were taught using the traditional methods. She concluded that students taught using the traditional approach lacked the ability to apply the mathematics, while students taught using the project-based approach developed mathematical understandings which were more flexible and useful.

In another research study conducted by Ayaz and Soylemez (2015), researchers found project-based learning to be more effective than traditional approaches. Ayaz and Soylemez conducted a meta-analysis on project-based learning in Turkey. In their analysis they found
project-based learning approaches to be more effective than traditional teaching approaches on academic achievement in science classes. The study analyzed 42 experimental studies conducted between 2002 and 2013 in Turkey and found that 39 of the 42 had positive effect size values (Ayaz & Soylemez, 2015). Of the 39 that had positive effect sizes 20 had strong effect sizes, 11 had moderate effect sizes, 5 had modest effect sizes, and 3 had poor effect sizes. These researchers found project-based learning to be effective at all educational levels. They found largest effect at the high school level and they found the smallest effect at the university level. These researchers determined that the use of project-based learning was most effective in Physics courses and least effective in Chemistry courses. They concluded, for Turkish students, project-based learning was more effective than the traditional approach.

**Guided Project-Based Learning**

One component of effective instruction is the use of guidance. Guided instruction has been shown to be better than unguided instruction especially when working with novice learners (Kirchner, Sweller, & Clark, 2006; Mayer, 2004). When comparing inquiry methods, guided inquiry methods have been shown to be more effective than unguided inquiry methods (Mayer, 2004). In fact the use of guided discovery methods has been shown to be less effective than expository teaching methods. The use of guided inquiry learning has been on the rise in recent years. However, currently no research studies have specifically considered the use of guided project-based learning. The closet research to guided project-based learning was conducted using guided labs in advanced statistics courses (Kuiper & Collins, 2009). Researchers found that using of guided labs assisted students by improving the quality of their work, improving their analysis skills, increasing their enthusiasm, helping them gain an appreciation of the uses of statistics, and allowing them to improve their ability to communicate using statistics.
Several studies have found promising results using guided problem-based learning. Because of the similarities between problem-based and project-based learning these results should either extend into or at least be useful for project-based learning. In one of these studies, Bude, Imbos Wiel, Broers, and Berger (2009) found the use of guidance to be beneficial. In the study students were randomly assigned into one of two tutoring groups. One group was guided through instructional activities while the other group was not. Students in the guided group perceived the course, the tutor, and the tutorial group discussions more positively than the students in the unguided group. Researchers also found that students who experienced the condition of guidance through a directive tutor performed better on end of course exams than students who did not have directive tutor guidance. Bude et al. also found students valued the course more when in the guided tutoring condition than they did in the unguided tutoring condition. In another study researchers found that students, who were enrolled in a problem-based learning statistics course, had a better conceptual understanding of statistics when they were in a guided tutoring group (Bude, van de Wiel, Imbos, & Berger, 2011).

In another study involving a introductory statistics course, researchers studied the use of guided questions (Bude, van de Wiel, Imbos, & Berger, 2012). The questions were designed only to guide students as they reasoned through problems but not provide them with correct answers. Students were required to advance towards the correct answers themselves and state them in their own words. This approach is well suited to a project-based or problem-based approach. In both instructional approaches students are required to formulate their own best answers but are not provided with the correct solutions. The researchers concluded that directive guidance did lead to students having a better understanding of statistics and suggested a need for further research determining the effect of guided questions on problem-based learning.
A study conducted by Leppink, Broers, Imbos, vander Vleuten, and Berger (2014) considered the effect of guided problem based learning on students conceptual understanding of statistics. Once students had obtained sufficient prior knowledge of the subject, guided problem-based learning improved students’ conceptual comprehension of statistics but unguided problem-based learning did not. Leppink et al. also found that students in the guided problem-based learning group had an increased understanding of the value and effectiveness of the learning activity. Value is one of the construct components of attitude toward statistics so the use of guidance could lead to improved attitudes towards statistics.

**Measuring Attitudes Toward Statistics**

Bendig and Hughes (1954) developed the first instrument to measure attitudes toward statistics but the instrument was lost because it was never published and there are no records of it having been used by others. After that initial instrument was developed and used there is no literature referring to measuring attitudes toward statistics until the early 1980s. Measuring attitudes toward statistics has been a focus of research in statistics education since at least 1980. The next instrument to attempt to measure attitudes toward statistics was modeled after a survey designed to measure attitude toward mathematics (Scott, 2001). Developed by Roberts and Bilderback (1980), the Statistics Attitude Survey (SAS) was designed to measure students’ perceptions about the usefulness of statistical analysis (Roberts & Saxe, 1982). The survey contained 33 items with no subscales (Roberts & Bilderback, 1980).

Partially in response to problems with the SAS, Wise (1985) developed the Attitude Toward Statistics (ATS) Survey. According to Wise, the nature of students who are just beginning to study statistics, such as having no experience with statistics, precluded them from
understanding statistical concepts and asserted the SAS failed to take this into account. As was noted by Gal and Ginsburg (1994) years later, students may not even know what is meant by the term “statistics”. Wise also saw the construct of attitude toward statistics as a multidimensional construct. As a result, Wise divided the ATS into two subscales: Attitude Toward Course and Attitude Toward Field.

After Wise developed his survey, instruments to measure attitudes toward statistics were developed with increasing complexity. Several surveys designed to measure attitudes toward statistics were developed using a multidimensional approach. Some examples of these instruments follow. A three dimensional 20 item approach was used by McCall, Belli, and Madjidi (1990). The Multifactorial Scale of Attitude Toward Statistics (MSAS) developed by Auzmendi (1991) had five subscales. The Students’ Attitudes Toward Statistics (STATS) developed by Sutarso (1992) had six subscales. While the complexity of the instruments was increasing many were not consistent with the research being conducted in the field of statistics education (Scott, 2001). Schau, Dauphinee, Del Vecchio, and Stevens (1992) cited a number of shortcomings in the instruments available to measure attitude toward statistics and developed their own instrument and began the process of validating it (Schau, Dauphinee, & Dauphinee, 1995).

In 1995, Schau, Stevens, Dauphinee, and Del Vecchhio completed a rigorous validation of the Survey of Attitudes Toward Statistics (SATS). The Survey of Attitudes Toward Statistics (SATS-36) includes 36-items designed to measure undergraduate students’ attitudes toward statistics (Schau, 2003b). The survey consists of two versions: a pre-course version to be administered to students prior to the course and a post-course version to be administered upon completion of the course. The SATS contains six subscales. These subscales are Affect,
Cognitive Competence, Value, Difficulty, Interest, and Effort. This instrument was used in the majority of research studies measuring student attitudes toward statistics after it was created (e.g., Ashaari, Judi, Mohamed, & Wook, 2011; Bond, Perkins, & Ramirez, 2012; Carlson & Winquist, 2011; Carnell, 2008; Chiesi & Primi, 2010; Coetzee & Van der Merwe, 2010; Dempster & McCorry, 2009; DeVaney, 2010; Hannigan, Gill, & Leavy, 2013; Hannigan, Hegarty, & McGrath, 2014; Liau, Kiat, & Nie, 2015; Mahmud & Zainol, 2008; Mathew, & Aktan, 2014; Posner, 2011; Zhang, Shang, Wang, Zhao, Li, Xu, & Su, 2012; Zimprich, 2012.

Relevance of Attitudes Toward Statistics

The fundamental goal of introductory statistics courses is to introduce and teach students basic statistical concepts and skills. Ultimately statistics educators desire students who perform well academically in statistics courses and also use statistical methods and reasoning appropriately beyond the classroom. Many statistics educators and those engaged in research in statistics education also believe attitudes toward statistics are important both as a construct individually and as attitudes relate to academic performance in statistics courses. In addition to providing students with the necessary skills associated with statistical learning, introductory statistics courses should help students develop strong positive attitudes toward statistics (Garfield, Hogg, Schau, & Whittinghill, 2002). Statistics students should not have apprehension or negative feelings toward learning future statistics after completing a statistics course (Gal & Ginsburg, 1994). Students should have increased appreciation, interest, and confidence in statistical abilities, and they should be willing to think statistically upon completion of a statistics course. Many also believe that having a positive attitude and performing well academically in statistics courses to be related (Ramirez, Schau, & Emmioglu, 2012). For example, having a positive attitude can lead to active study behavior both in current and future courses (Peterson,
Maier, & Seligman, 1993; Pintrich & Schunk, 1996) which can then improve academic performance and the likelihood that students will interpret statistical concepts and use statistical methods appropriately beyond the classroom.

The results of research exploring the relationship between attitudes and academic performance have not been fully conclusive. Much of the literature has reported correlations between having positive attitudes toward statistics and successful academic performance in statistics courses (Cashin & Elmore, 2005; Dempster & McCorry, 2009; Harlow et al., 2002; Lalonde & Gardner, 1993; Nasser, 2004; Sorge & Schau, 2002; Tremblay, Gardner, & Heipel, 2000; Wisenbaker et al., 2000). While some studies have reported no relationship or a relatively weak relationship between attitudes and academic performance, the bulk of the evidence supports attitudes toward statistics and achievement being related (Emmioglu & Capa-aydin, 2012). A clear relationship between statistics anxiety and poor performance in statistics courses has been reported. Studies considering statistical anxiety have reported higher statistical anxiety leads to lower performance in statistics courses (Fitzgerald, Jurs, & Hudson, 1996; Onwuegbuzie & Seaman, 1995; Zanakis & Valenzi, 1997).

In a seminal study, Cashin and Elmore (2005) found that attitudes toward statistics were predictive of student achievement in introductory statistics courses. They used three different instruments and had 342 students who participated in the study. Each of the attitude measuring components on the SATS instrument showed a positive correlation with course achievement. Researchers found the relationship between the SATS components and course achievement was stronger after the course than they were before. However they did not find an overall improvement in students’ attitude toward statistics. Two out of seven attitude measures did show a difference but the effect sizes were small. In a large meta-analysis of 17 studies considering the
relationship between attitude and achievement, Emmioglu and Capa-aydin (2012) concluded that attitudes toward statistics and achievement were related. They also found studies done with students in the United States reported markedly higher effect sizes, in some cases double, for the correlation coefficients in those studies. In a study conducted by Dempster and McCorry (2009) researchers found a relationship between students’ attitudes toward statistics and academic performance. Based on their findings they suggested that further research needed to be conducted to determine which interventions would be likely to improve students’ attitudes. While many research studies have found a relationship between positive attitudes and academic performance in statistics courses at least two studies did not.

Hannigan, Gill, and Leavy (2013) found that pre-service mathematics teachers’ attitudes towards statistics did not strongly correlate with performance on the Comprehensive Assessment of Outcomes in Statistics (CAOS). There were several limitations to this study. The biggest limitation was that while the teachers were tested on statistical knowledge they were not offered any type of statistics instruction prior to being tested. Indeed because the study was conducted on first-year students through postgraduate students it was clear that the first-year students had not even taken a single statistics course. Testing anyone without instruction is likely to yield poor performance. The results of the study bear this out. The second-year students in the study scored higher than all of the other students on the CAOS which was the year students were required to take an introductory statistics module. Given this limitation alone the conclusions regarding the correlation between academic performance and attitude toward statistics made by Hannigan, Gill, and Leavy can be dismissed.

In a study conducted that compared traditional, flipped, and fully online courses Gundlach et al. (2015) found that traditional students scored better on course examinations and
had improved attitudes towards statistics over the other two groups. Researchers suggested that this result may have been due to “traditional” not descriptive of the traditional lecture courses. While the students were taught using traditional lecture, these classes also “included active learning and problem-solving with peers and their teaching assistant” (p. 25). Researchers suggested this lack of clarity about the nature of traditional instruction may have been the reason for the traditional sections outperforming the other two sections.

**Project-Based Learning and Attitudes Toward Statistics**

While many studies have been done considering the effect of active learning approaches on students’ attitude toward statistics, only one study has been done on the effect of project-based learning on students’ attitude toward statistics. For example, when using an active learning approach in a semester long introductory statistics course, Carlson and Winquist (2011) found that an activity based curriculum did have a positive effect on students’ attitudes toward statistics. They also found a positive correlation with students’ GPA and final exam performance. In another study Hagan, Awosoga, Kellett, and Dei (2013) concluded nursing students in statistics courses preferred real life, hands on, cooperative learning and that effective use of these aspects within the course significantly reduced students’ fear and anxiety. Other examples exist of active learning approaches reducing students’ fear or improving students’ attitudes toward statistics as well as their academic performance but the one study that considered using project-based learning did not share this finding.

In a quasi-experimental research study conducted by Carnell (2008) on the effect of project-based learning on student attitude toward statistics, Carnell reported no change in student attitudes toward statistics after students completed a project. The study was conducted in an
introductory statistics course. Students self-selected themselves into one of two sections. One section had students complete a project and the other did not. Students were initially unaware of which group they were in. No significant difference was detected between the attitudes of the two groups on any of the subscales. One important aspect to note was that students in this study were required to design and implement their own projects in a minimally guided instructional environment. The students picked the topic they wished to study, decided if they wished to be grouped or not (up to four students per group), decided how to collect the data, decided how to analyze the data, and decided how to report on the data. Using minimal guidance to instruct students in this way has been shown to be highly ineffective (Kirchner, Sweller, & Clark, 2006; Mayer, 2004). So it is likely the lack of an improvement in attitude can be at least partially attributed to the unguided nature of the instruction.

Carnell (2008) concluded that there was no significant evidence to suggest student-designed data collection projects improved students’ attitude toward statistics. However, in further discussion she suggested that many questions about project-based learning remained unanswered regarding the positive effects of projects on attitudes. She also suggested further evidence was needed on the effect of project-based learning on students’ attitude toward statistics. She proposed changing the structure of the projects but did not give any clear indications about how changing the structure looked. From this study this researcher can conclude that further research is needed regarding the effect of project-based learning approaches on students’ attitude toward statistics and the effect of project-based learning approaches on students’ academic performance in introductory statistics courses.
Summary

In Chapter II the details regarding the development of the discipline of statistics education were provided. A discussion was also provided regarding inquiry-based learning with special emphasis placed on project-based learning. Finally the relevance of measuring students’ attitudes toward statistics was discussed with a focus on the relationship between positive student attitudes towards statistics and successful academic performance. Chapter III will present the methods and procedures used to perform the experiment and gather the data to confirm or refute the research hypotheses.
CHAPTER III

METHODS AND PROCEDURES

This chapter describes the methods and procedures used in this study. A discussion of the population, research variables, research design, instrument design, methods of data collection, and statistical analysis are provided within this chapter.

The purpose of this study was to determine if using a guided project-based approach to instruction improved introductory statistics students’ attitudes toward statistics and their academic performance over traditional students. This research was conducted using a quasi-experimental design. The study used both a control group and treatment group but lacked random selection to either group. The study employed a pre-test, post-test design to measure students’ attitudes toward statistics. Data analysis was conducted using a Multivariate Analysis of Variance (MANOVA). The univariate analysis was conducted using an Analysis of Variance (ANOVA) on each of the dependent variables.

Population

The population of this study consisted of students enrolled in introductory statistics courses at a two-year college in Virginia. A sample of students was taken during the Fall 2015 and Spring 2016 semesters to participate in this study. Students self-enrolled themselves into the courses during each semester and were asked to participate on the first day of classes. Because students may elect to take the introductory statistics course at different points within their programs of study, this population contained both first-year college students and second-year college students. Other students who needed a refresher course in statistics to pursue graduate degrees or professional licensure were also enrolled in the course.
Content in the introductory statistics course included the following topics: descriptive statistics, displaying data, linear regression, probability, random variables, probability distributions, one sample statistical inference, and two sample statistical inference. The course was taken by students who needed it to meet a core mathematics requirement of their major, as a transferable elective, or to prepare for other pursuits. The course was taught for 3 hours per week over 16 weeks with the final week reserved for the final examination.

**Research Variables**

The independent variable in this study was the instructional approach. The independent variable had two levels. Students in the treatment group experienced the guided project-based learning instructional approach and students in the control group experienced the traditional lecture-based instructional approach. These students took notes from lectures provided by the instructor. The dependent variables were students’ attitude toward statistics measured by the Survey of Attitudes Toward Statistics 36 (SATS-36) and students’ academic performance measured by final course grades. The SATS-36 was administered twice, once at the beginning of the course and once at the end of the course. See Appendix A for the Pre SATS-36. See Appendix B for the Post SATS-36. The SATS measured attitude using six components including affect, cognitive competence, value, difficulty, interest, and effort. The final course grade for each student was determined through a weighted average calculated according to the percentages provided in Table 1.

**Research Design**

Students who elected to participate in the research study were placed in one of two groups based on the semester they agreed to participate. Students were placed in the treatment group if they were enrolled in the introductory statistics course during the Spring 2016
Table 1

*Percentage of Students’ Grade for Each Type of Assignment*

<table>
<thead>
<tr>
<th></th>
<th>Homework</th>
<th>Quizzes</th>
<th>Tests</th>
<th>Projects</th>
<th>Activities</th>
<th>Final Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-Based Learning</td>
<td>5%</td>
<td>20%</td>
<td>40%</td>
<td>15%</td>
<td>-</td>
<td>20%</td>
</tr>
<tr>
<td>Traditional Lecture</td>
<td>5%</td>
<td>20%</td>
<td>40%</td>
<td>-</td>
<td>15%</td>
<td>20%</td>
</tr>
</tbody>
</table>

semester. The treatment in this research study consisted of guided projects participants were required to complete. The projects were explained to participants in the first week of classes and continued for the duration of the course. Students in the treatment group designed and carried out mock research projects based on scenarios provided by the instructor (Table 2). An Example of Table 2

*Project Titles, Concepts, and Grade Percentages*

<table>
<thead>
<tr>
<th>Title</th>
<th>Concepts</th>
<th>Percent of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1  Can Honey Soothe Coughing?</td>
<td>Research Design and Measuring Variables</td>
<td>2.5%</td>
</tr>
<tr>
<td>Project 2  Is the Tannery Polluting the River?</td>
<td>Linear Regression</td>
<td>5%</td>
</tr>
<tr>
<td>Project 3  How Much Time Does it Take a Rock to Fall 2 Meters?</td>
<td>Confidence Intervals and Measurement Error</td>
<td>5%</td>
</tr>
<tr>
<td>Project 4  Can Honey Reduce Coughing?</td>
<td>Hypothesis Testing</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

project 1 and project 4 combined can be found in Appendix C. Once they completed a research project, students were required to report their findings by giving a presentation which could be
attended by individuals who were not enrolled in the course. To provide students in GPBI instructional group with enough time to complete the projects they were provided with videos of the lectures for some of the notes to replace classroom lecture. Participants in the control group also had access to these video lectures. Participants were placed in the control group if they enrolled in the introductory statistics course during the Fall 2015 semester. They experienced the same lecture, tests, and activities of the treatment group. However the treatment group did not receive a grade for the activities. The control group was completely excluded from being informed about the projects. A total of two classes participated during the Fall 2015 semester and a total of three classes participated during the Spring 2016 semester. The different number of classes participating accounts for the variation in sample size for the two groups.

To measure participants’ attitudes toward statistics they were given the Survey of Attitudes Toward Statistics (SATS-36) developed by Schau (2003). During the first week of classes both groups were given the Pre SATS-36 to establish a baseline attitude for each group. On the last day of classes both groups were again given the Post SATS-36 to determine if a change in attitude had occurred. A comparison was also made between the final attitudes toward statistics for each group measured by the Post SATS-36. Lastly, final grades of the treatment group and the control group were collected and compared to determine if the project group showed greater academic performance.

Instrument Used

The Survey of Attitudes Toward Statistics is commonly used to measure attitudes within statistics education (Nolan, Beran, & Hecker, 2012). This instrument was designed to assess students’ attitudes toward statistics in introductory statistics courses (Schau, 1995). The psychometric properties of the survey have been well established (Chiesi, 2009; Emmioglu &
Capa-aydin, 2012; Schau & Emmioglu, 2012; Schau, Millar, & Petocz, 2012; Schau, Stevens, Dauphinee, & Vecchio, 1995; Vanhoof, Kuppens, Sotos, Verschaffel, & Onghena, 2011), and the internal reliability of the SATS instrument, measured by Cronbach’s alpha, has been remarkably consistent ranging from .64 to .94 (Cashin & Elmore, 2005; Nolan et al., 2012; Schau et al., 1995). Initially the SATS-28 was tested by Schau et al. (1995) and had Cronbach’s alpha values from .81 to .85 for Affect, .77-.83 for Cognitive Competence, .80-.85 for Value, and .64-.77 for Difficulty. However, Schau et al. did not distinguish between Cronbach’s alpha values for the pre-course administration and post-course administration of the survey. Cashin and Elmore (2005) measured the internal consistency reliability of the subcomponents of the SATS-28 with Cronbach’s alpha and the scores for the coefficients ranged from .74 to .92 for the pre-course survey and .79-.94 for the post course survey. In both administrations of the survey, the Difficulty sub-scale had the lowest Cronbach’s alpha value. Nolan et al. (2012) analyzed the published peer reviewed articles containing score validity for the SATS-28 and the SATS-36. They analyzed several surveys measuring attitude toward statistics and concluded that the SATS-28 and SATS-36 are most likely to have the most convincing content and substantive validity. In addition to this finding, they found seven studies using the SATS-28 all confirmed that the SATS-28 did measure the dimensions of Affect, Cognitive Competence, Difficulty, and Value (Nolan et al., 2012). Four studies using the SATS-36 all confirmed that the SATS-36 did measure the dimensions of Affect, Cognitive Competence, Difficulty, Value, Interest, and Effort (Nolan et al., 2012).

The SATS-36 uses a multidimensional component approach to measuring students’ attitudes toward statistics. The survey includes 36-items designed to measure undergraduate students’ attitudes toward statistics (Schau, 2003). The survey consists of two versions: a pre-
course version to be administered to students prior to the course and a post-course version to be administered upon completion of the course. In addition to the 36-items measuring attitude, the pre SATS-36 contains 17-questions assessing group demographics. The post SATS-36 has an additional nine questions assessing demographics. Each of the first 36-items on the survey measuring attitude toward statistics is a closed-form item using a 7-point Likert scale. Responses range from 1 which indicates the person responding strongly disagrees to 7 which indicates the person responding strongly agrees. The survey contains six subscales. The Affect subscale contains six-items measuring how students feel about statistics. The Cognitive Competence subscale has six-items measuring students’ perception of their statistics comprehension. The Value subscale has nine-items measuring students’ perceptions regarding the usefulness and further application of statistics. The Difficulty subscale has seven-items which measures students’ perceptions about the relative ease or difficulty of the statistics course. The Interest subscale has four-items which measure the level of interest students have in statistics. The Effort subscale has four-items which measure students’ perception of the work required in the statistics course.

**Methods of Data Collection**

Students were initially solicited for voluntary participation in the research study during the first week of classes. If students indicated they wanted to participate, they were given the pre SATS-36 with a cover letter (Appendix D). On the last day of class prior to the final exam students were given the post SATS-36. Students were instructed not to put any identifying information on the survey because only the group results would be considered, not individual results. Once students returned the surveys to the researcher, the surveys were then placed into an envelope and placed in a secure location. After the surveys had been collected by the
researcher, access was then limited to the researcher alone. Participants’ final course grades were collected by the researcher at the conclusion of each semester. Final course grades were collected in the aggregate and stored without individual identifying markers.

**Statistical Analysis**

The scores from the SATS-36 were used to analyze the differences in attitudes toward statistics and the final course grades were used to analyze the differences in academic performance. Once the results of the pre SATS-36 and post SATS-36 were collected, the pre SATS-36 scores were compared to the post SATS-36 scores for each component to measure the change in students’ attitude toward statistics. First the treatment group was measured for a change in attitude toward statistics. To measure this change required a comparison between each of the sub-components for the treatment group. A multiple analysis of variance (MANOVA) was needed to test the research hypotheses. Initially to test for the equality of covariance matrices for each MANOVA, Box’s Test of Equality of Covariance Matrices was conducted at the .005 level of significance. This was done to provide evidence for the assumption that the covariance matrices were equal. The assumption is met if the significance value is greater than the level of significance. Following Box’s Test of Equality of Covariance Matrices, a MANOVA was used to compare the guided project-based instructional (GPBI) groups’ pre and post survey responses. Subsequently, a second MANOVA was used to compare the GPBI group’s post responses to the traditional lecture-based instructional (TLBI) group’s post responses, and the final grades at the .05 level of significance. Given the large number of dependent variables in this study, this type of analysis was conducted to determine if any results were statistically significant while reducing the probability of a Type I error. The multivariate result Wilk’s Lambda was used to determine if a statistically significant difference existed within the GPBI group pre SATS and post SATS or
between the GPBI group and the TLBI group post SATS. Separate ANOVA’s were used for each dependent variable to test for group differences between the pre and post component scores on the SATS-36 for the guided project-based instructional group. Separate ANOVA’s were also used for each dependent variable to compare the post SATS guided project-based instructional group component scores to the post SATS traditional instructional group component scores. Finally, an ANOVA was also used to determine if a statistically significant difference existed in student academic performance measured by students’ final course grades.

**Summary**

This chapter provided details regarding the methods and procedures used to complete this research study. The population of interest was students enrolled in introductory statistics courses at a two-year college in Virginia. Findings will be presented in Chapter IV. This study employed a quasi-experimental pre-test, post-test design to determine the effects of guided project-based learning on students’ attitude toward statistics and students’ academic performance. The research hypotheses were tested using a MANOVA at the .05 level of significance followed by separate ANOVA’s for each dependent variable.
CHAPTER IV
FINDINGS

The purpose of this research study was to determine if the implementation of a guided project-based learning instructional approach improved students’ attitudes toward statistics and overall course performance measured by final grade. In this chapter the findings are presented.

This project was conducted using the following hypotheses:

$H_1$: The use of a guided project-based learning approach will improve students’ attitudes towards statistics as measured by the Survey of Attitudes Toward Statistics (SATS-36).

$H_2$: Students enrolled in the guided project-based learning courses will have better attitudes toward statistics than students who enrolled in traditional lecture-based courses as measured by the Survey of Attitudes Toward Statistics (SATS-36).

$H_3$: The use of a guided project-based learning approach will improve students’ course performance measured by final course grades compared to students who are taught in traditional lecture-based courses.

Data used to test the hypotheses were obtained from two sources: the analysis of the 36 question Survey of Attitudes Toward Statistics (SATS) completed on the first day and last day of an introductory statistics course, and an analysis of students’ final grades in an introductory statistics course. This chapter begins by presenting the demographic information for the study. The chapter concludes by presenting the findings from each of the components of the survey Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort and the results of the final grade comparison.

Survey of Attitudes Toward Statistics

The Survey of Attitudes Toward Statistics 36 (SATS-36) was administered to students enrolled in an introductory statistics course at a Virginia Community College. The total number
of students who were initially enrolled was 156. Based upon the semester they were enrolled, students received instruction using either a traditional lecture-based instructional (TLBI) approach \((N = 64)\) or a guided project-based instructional (GPBI) approach \((N = 92)\). The students in the TLBI group and GPBI group completed the SATS-36 survey on the first and final days of class. Students were given the opportunity to opt out of completing the survey but none did so.

**Demographic Information**

A total of 156 students completed the pre SATS survey and a total of 141 students completed the post SATS survey. The change in the number of participants can be attributed to students withdrawing or failing to complete the course. All students who failed to complete the final examination were excluded from the study before completing the post SATS survey and were also excluded from the final grade analysis. Table 3 presents the demographics of participants from all groups categorized by time, gender, and age.

Table 3

*Demographics (all groups) Time by Gender and Age*

<table>
<thead>
<tr>
<th>Time</th>
<th>Males</th>
<th>Females</th>
<th>18-26</th>
<th>&gt;26</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre SATS</td>
<td>64</td>
<td>92</td>
<td>137</td>
<td>19</td>
<td>156</td>
</tr>
<tr>
<td>Post SATS</td>
<td>56</td>
<td>85</td>
<td>124</td>
<td>17</td>
<td>141</td>
</tr>
</tbody>
</table>

**Gender**

There were a total of 156 initial participants, 64 (41.0%) of which were males and 92 (59.0%) of which were females. Out of the 141 final participants 56 (39.7%) were males and 85 (60.3%) were females. There were 64 initial participants in the TLBI group including 25 (39.1%) males and 39 (60.9%) females. The GPBI group had 92 initial participants including 39 (42.4%)
males and 53 (57.6%) females. Both groups saw a decrease in the number of participants as the course progressed. Only 58 of the initial 64 students in the TLBI group and 83 of the initial 92 participants in the GPBI group completed the course. In the TLBI group 25 (39.1%) males initially participated and 20 (34.5%) males were participating at the completion of the course. Initially there were 39 (60.9%) females participating and 38 (65.5%) in the TLBI group at the completion of the course. In the GPBI group 39 (42.4%) males were initially participating and 36 (43.4%) completed the course. Out of the 53 (57.6%) initial female participants 47 (56.6%) completed the course. In Table 4 the demographics of the TLBI group and the demographics of the GPBI group are presented separately.

Table 4

Demographics Gender and Age by Group and Time

<table>
<thead>
<tr>
<th>Group/Time</th>
<th>Males</th>
<th>Females</th>
<th>18-26</th>
<th>&gt;26</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Pre SATS</td>
<td>25</td>
<td>39</td>
<td>57</td>
<td>7</td>
<td>64</td>
</tr>
<tr>
<td>Traditional Post SATS</td>
<td>20</td>
<td>38</td>
<td>51</td>
<td>7</td>
<td>58</td>
</tr>
<tr>
<td>Guided Project Pre SATS</td>
<td>39</td>
<td>53</td>
<td>80</td>
<td>12</td>
<td>92</td>
</tr>
<tr>
<td>Guided Project Post SATS</td>
<td>36</td>
<td>47</td>
<td>73</td>
<td>10</td>
<td>83</td>
</tr>
</tbody>
</table>

Age

A large majority of the initial participants 137 (87.8%) ranged in age from 18-26 with only 19 (12.2%) ranging above 26 years of age. Of the 141 participants who completed the research, 124 (87.9%) participants ranging in age from 18-26 completed the course and 17 (12.1%) participants above the age of 26 completed the course. Table 4 shows 57 (89.1%) of the
initial 64 participants in the TLBI group ranged in age from 18-26 and 7 (10.9%) of the initial participants ranged in age above 26. Out of the 64 original participants 58 (90.6%) continued participating until the end of the research. Out of the 58 participants 51 (87.9%) participants ranging in age from 18-26 completed the course and 7 (12.1%) above the age of 26 completed the course. In the GPBI group 80 (87%) of the initial 92 participants ranged in age from 18-26 and 12 (13%) ranged in age above 26. Out of the 92 original students only 83 (90.2%) students participated until the completion of the research. Out of the 83 participants, 73 (88%) ranged in age from 18-26 completed the course and 10 (12%) above age 26 completed the course. Table 4 shows the demographics gender and age by group and time.

Degree

The majority of the participants, 111 out of 156 (71.2%), were seeking an Associate’s degree. A total of 26 (16.7%) were seeking a Bachelor’s degree. A total of 10 (6.4%) were seeking a Master’s and a total of 5 (3.2%) were seeking a Doctorate. A single participant was pursuing a post-bachelor’s non-graduate degree and 3 (2%) participants were not seeking a degree listed on the survey. In the TLBI group 43 (67.2%) were seeking an Associate’s degree, 12 (18.8%) were seeking a Bachelor’s degree, 3 (4.7%) were seeking a Master’s degree, 3 (4.7%) were seeking a Doctorate degree, 1 (1.6%) was seeking Post-Bachelor’s Licensure, and 2 (3.2%) were not seeking a degree listed on the survey. In the GPBI group 68 (73.9%) were seeking an Associate’s degree, 14 (15.2%) were seeking a Bachelor’s degree, 7 (7.6%) were seeking a Master’s degree, 2 (2.2%) were seeking a Doctorate degree, and 1 (1.1%) was not seeking a degree listed on the survey. The various degrees sought by students who participated in the research are displayed in Table 5.
Table 5

*Demographics Current Degree Type by Group*

<table>
<thead>
<tr>
<th>Degree Type</th>
<th>Traditional</th>
<th>Guided Project-Based</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associate’s</td>
<td>43</td>
<td>68</td>
<td>111</td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>12</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>Master’s</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Doctorate</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Post-bachelor’s</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>92</td>
<td>156</td>
</tr>
</tbody>
</table>

**Program of Study**

Participants were spread across various degree programs. The largest number of participants placed themselves in the other group but of the participants who had declared majors, the largest number of them were enrolled in the Medicine/Pre-Medicine group followed by Psychology. Combined there were 8 (5.1%) participants enrolled in an Arts or Humanities program, 7 (4.5%) enrolled in a Biology program, 12 (7.7%) enrolled in a Business program, 1 (0.6%) enrolled in an Economics program, 12 (7.7%) enrolled in an Education program, 3 (1.9%) enrolled in an Engineering program, 1 (0.6%) enrolled in a Mathematics program, 32 (20.5%) enrolled in a Medical or Pre-Medical program, 29 (18.6%) enrolled in a Psychology program, 10 (18.6%) enrolled in a Sociology or Social Work program, 1 (0.6%) enrolled in a Statistics program, and 40 (25.6%) who were not enrolled in a program or who were enrolled in
a program that was not listed. In the TLBI group 3 (4.69%) participants were enrolled in an Arts or Humanities program, 2 (3.1%) enrolled in a Biology program, 8 (12.5%) enrolled in a Business program, 1 (1.6%) enrolled in an Economics program, 6 (9.4%) enrolled in an Education program, 2 (3.1%) enrolled in an Engineering program, 1 (1.6%) enrolled in a Mathematics program, 14 (21.9%) enrolled in a Medical or Pre-Medical program, 10 (15.6%) enrolled in a Psychology program, 5 (7.8%) enrolled in a Sociology or Social Work program, 1 (1.6%) enrolled in a Statistics program, and 11 (17.2%) who were not enrolled in a program or were enrolled in a program that was not listed. In the GPBI group 5 (5.4%) participants were enrolled in an Arts or Humanities program, 5 (5.4%) enrolled in a Biology program, 4 (4.4%) enrolled in a Business program, 6 (6.5%) enrolled in an Education program, 1 (1.1%) enrolled in an Engineering program, 18 (19.6%) enrolled in a Medical or Pre-Medical program, 19 (20.7%) enrolled in a Psychology program, 5 (5.4%) enrolled in a Sociology or Social Work program, and 29 (31.5%) who were not enrolled in a program or who were enrolled in a program that was not listed. The degree program results can be found in Table 6.

**Participants Who Were Required to Complete Course**

The majority of the 156 participants initially enrolled in the introductory statistics course were required to complete the course either as a prerequisite or a program requirement. Table 7 shows the combined total number of participants from both groups was 131 (84%) of which there were 52 (81.3%) in the TLBI group and 79 (85.9%) in the GPBI group.

**Expected Grade**

Participants expected to obtain a higher final grade at the beginning of the course than they did at the end of the course. The combined groups had 64 (41%) participants expecting a final grade of “A” in the course initially, though only 29 (20.6%) participants expected to make
Table 6

Demographics Instructional Group by Degree Program

<table>
<thead>
<tr>
<th>Degree Program</th>
<th>Traditional</th>
<th>Guided Project-Based</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts/Humanities</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Biology</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Business</td>
<td>8</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Economics</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Education</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Engineering</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Medicine/Pre-Medicine</td>
<td>14</td>
<td>18</td>
<td>32</td>
</tr>
<tr>
<td>Psychology</td>
<td>10</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>Sociology/Social Work</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Statistics</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>29</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>92</td>
<td>156</td>
</tr>
</tbody>
</table>
Table 7

<table>
<thead>
<tr>
<th>Response</th>
<th>Traditional</th>
<th>Guided Project-Based</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>52</td>
<td>79</td>
<td>131</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Unsure</td>
<td>10</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>92</td>
<td>156</td>
</tr>
</tbody>
</table>

an “A” at the end of the course. Initially 76 (48.7%) participants expected a final grade of “B” compared to 50 (35.5%) at the end of the course. The expected number of “C” grades increased considerably with 16 (10.3%) initially expecting a final grade of “C” to 45 (31.9%) at the completion of the course. No one initially expected to receive a grade of “D” or “F”, but combined 17 (12.1%) expected to get a “D” or “F” by the completion of the course.

In the TLBI group initially 60 (93.8%) of the 64 participants expected to have a final grade of “A” or “B”, but only 36 (62.1%) expected an “A” or “B” by the completion of the course. In the GPBI group initially 80 (87.0%) of the 92 participants expected to have a final grade of “A” or “B”, but only 43 (51.8%) expected an “A” or “B” by the completion of the course. The expected grade trends correspond to the participants’ confidence about mastering the material. Expected grade results can be found in Table 8 and Table 9.

Confidence About Mastering Course Material

Question 40 on the pre SATS survey and Question 39 on the post SATS survey asked participants about their mastery of course material. Participants could answer using 1-7, an
Table 8

*Pre SATS Expected Grade*

<table>
<thead>
<tr>
<th>Expected Grade</th>
<th>Traditional</th>
<th>Guided Project-Based</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+, A, A-</td>
<td>26</td>
<td>38</td>
<td>64</td>
</tr>
<tr>
<td>B+, B, B-</td>
<td>34</td>
<td>42</td>
<td>76</td>
</tr>
<tr>
<td>C+, C, C-</td>
<td>4</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>92</td>
<td>156</td>
</tr>
</tbody>
</table>

Table 9

*Post SATS Expected Grade*

<table>
<thead>
<tr>
<th>Expected Grade</th>
<th>Traditional</th>
<th>Guided Project-Based</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+, A, A-</td>
<td>12</td>
<td>17</td>
<td>29</td>
</tr>
<tr>
<td>B+, B, B-</td>
<td>24</td>
<td>26</td>
<td>50</td>
</tr>
<tr>
<td>C+, C, C-</td>
<td>13</td>
<td>32</td>
<td>45</td>
</tr>
<tr>
<td>D+, D, D-</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>83</td>
<td>141</td>
</tr>
</tbody>
</table>

answer of 7 meaning very confident and an answer of 1 meaning not at all confident. Initially students were more confident although not very confident concerning their perceived academic performance in the course with a mean of 4.813 for the traditional group, a mean of 4.978 for the guided project-based group, and a combined mean of 4.910. When participants completed the
post survey their confidence had decreased noticeably with a mean of 4.138 for the TLBI group, a mean of 3.976 for the GPBI group, and a mean of 4.043 for the combined groups. These results imply that initially students were more than neutrally confident that they could master the material but regressed to a neutral response by the completion of the course. Table 10 shows the mean, standard deviation, and sample size for this question on the pre and post surveys for both groups.

Table 10

<table>
<thead>
<tr>
<th>SATS Course Mastery Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group by Time</td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Traditional Pre SATS</td>
</tr>
<tr>
<td>Traditional Post SATS</td>
</tr>
<tr>
<td>Guided Project Pre SATS</td>
</tr>
<tr>
<td>Guided Project Post SATS</td>
</tr>
<tr>
<td>Combined Pre SATS</td>
</tr>
<tr>
<td>Combined Post SATS</td>
</tr>
</tbody>
</table>

Likelihood of Enrolling in Statistics Courses

Question 42 on the pre SATS survey and Question 41 on the post SATS survey asked participants about the likelihood of enrolling in statistics courses with an answer of 1 being not at all likely and an answer of 7 being very likely. The pre SATS asked students about the likelihood of enrolling in any statistics course. The post SATS asked students to report how likely it was they enrolled in another statistics course. The mean response for the TLBI group on the pre SATS was 3.375 with a standard deviation of 1.907. The mean response for the GPBI group on
the pre SATS was 3.000 with a standard deviation of 1.863. The post SATS mean for the TLBI group was 3.276 with a standard deviation of 2.059 and the post SATS mean for the GPBI group was 3.157 with a standard deviation of 1.825. These responses indicate students would not have enrolled in the current course and were not likely to enroll in a statistics course in the future. The mean, standard deviation, and sample size for each group are shown in Table 11.

Table 11

Likelihood of Enrolling in Statistics Course

<table>
<thead>
<tr>
<th>Group by Time</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Pre SATS</td>
<td>3.375</td>
<td>1.907</td>
<td>64</td>
</tr>
<tr>
<td>Traditional Post SATS</td>
<td>3.276</td>
<td>2.059</td>
<td>58</td>
</tr>
<tr>
<td>Guided Project Pre SATS</td>
<td>3.000</td>
<td>1.863</td>
<td>92</td>
</tr>
<tr>
<td>Guided Project Post SATS</td>
<td>3.157</td>
<td>1.825</td>
<td>83</td>
</tr>
<tr>
<td>Combined Pre SATS</td>
<td>3.154</td>
<td>1.884</td>
<td>156</td>
</tr>
<tr>
<td>Combined Post SATS</td>
<td>3.206</td>
<td>1.918</td>
<td>141</td>
</tr>
</tbody>
</table>

Statistical Analysis

A multivariate analysis of variance (MANOVA) was used to determine the effect of the instructional method within each instructional group and across the two instructional methods. The between groups factor instructional group had two levels, guided project-based instruction (GPBI) and traditional lecture-based instruction (TLBI). The within groups factor time also had two levels, pre SATS and post SATS.
Component Means of the SATS-36

The analysis of the Survey of Attitudes towards Statistics (SATS-36) required a computation and analysis of the means for each of the six subcomponents: affect, cognitive competence, value, difficulty, interest, and effort. Table 12 provides the means, standard deviations, and sample sizes for each component on the pre SATS-36 and post SATS-36 for both instructional groups.

Testing the Hypotheses

Hypothesis 1, 2, and 3 were tested using a MANOVA. Each dependent variable was then analyzed using an analysis of variance (ANOVA) at the .05 level of significance. Due to the large number of comparisons between dependent variables required to test the hypotheses, the probability of committing a type I error was increased. However, using a MANOVA to conduct several tests at one time decreased the probability of committing a Type I error (Leech, Barrett, & Morgan, 2011). The MANOVA was used to compare the pre SATS means and post SATS means of the six components for the GPBI group. A MANOVA was also used to compare the post SATS means between the GPBI group and the TLBI group for the components of the SATS and the final grades of each instructional group.

Hypothesis 1

The null hypothesis for the first hypothesis is that there is no difference between the students’ attitudes towards statistics after they complete an introductory statistics course using a guided project-based instructional approach. The alternative hypothesis is that students’ attitudes towards statistics will improve after having completed an introductory statistics course using a guided project-based instructional approach.
Table 12

*SATS Components Means, Standard Deviations, and Sample Size by Group and Time*

<table>
<thead>
<tr>
<th>Component</th>
<th>Instruction</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affect</td>
<td>GPB Post SATS</td>
<td>4.305</td>
<td>1.13780</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>GPB Pre SATS</td>
<td>3.888</td>
<td>1.02654</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>TLB Post SATS</td>
<td>4.273</td>
<td>1.46921</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>TLB Pre SATS</td>
<td>3.813</td>
<td>.83913</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>4.063</td>
<td>1.13858</td>
<td>297</td>
</tr>
<tr>
<td>Cognitive Competence</td>
<td>GPB Post SATS</td>
<td>4.711</td>
<td>1.10679</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>GPB Pre SATS</td>
<td>4.500</td>
<td>.81275</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>TLB Post SATS</td>
<td>4.707</td>
<td>1.24812</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>TLB Pre SATS</td>
<td>4.555</td>
<td>.89583</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>4.611</td>
<td>1.01111</td>
<td>297</td>
</tr>
<tr>
<td>Value</td>
<td>GPB Post SATS</td>
<td>4.963</td>
<td>1.06874</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>GPB Pre SATS</td>
<td>4.577</td>
<td>.95925</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>TLB Post SATS</td>
<td>4.512</td>
<td>1.38276</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>TLB Pre SATS</td>
<td>4.780</td>
<td>1.06122</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>4.716</td>
<td>1.11323</td>
<td>297</td>
</tr>
<tr>
<td>Difficulty</td>
<td>GPB Post SATS</td>
<td>3.210</td>
<td>.85985</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>GPB Pre SATS</td>
<td>3.309</td>
<td>.65389</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>TLB Post SATS</td>
<td>3.355</td>
<td>.93897</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>TLB Pre SATS</td>
<td>3.429</td>
<td>.60502</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>3.316</td>
<td>.76822</td>
<td>297</td>
</tr>
<tr>
<td>Interest</td>
<td>GPB Post SATS</td>
<td>4.660</td>
<td>1.35733</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>GPB Pre SATS</td>
<td>4.595</td>
<td>1.45908</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>TLB Post SATS</td>
<td>4.082</td>
<td>1.70229</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>TLB Pre SATS</td>
<td>4.578</td>
<td>1.47322</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>4.509</td>
<td>1.49341</td>
<td>297</td>
</tr>
<tr>
<td>Effort</td>
<td>GPB Post SATS</td>
<td>5.913</td>
<td>1.07808</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>GPB Pre SATS</td>
<td>6.438</td>
<td>.91509</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>TLB Post SATS</td>
<td>5.875</td>
<td>1.01226</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>TLB Pre SATS</td>
<td>6.539</td>
<td>.58625</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>6.203</td>
<td>.96753</td>
<td>297</td>
</tr>
</tbody>
</table>
To test the first hypothesis a MANOVA was conducted comparing the pre SATS and post SATS component scores for the GPBI group. Box’s test of equality of covariance matrices was used to decide if the observed covariance matrices were equal across groups at the .005 level of significance. Table 13 shows the null hypothesis for Box’s test of covariance matrices was not statistically significant given \( p = .016 \) which indicates the dependent variables’ observed covariance matrices were equal across groups, thus the MANOVA assumption of equal covariance matrices was satisfied.

Table 13  

*Box's Test of Equality of Covariance Matrices*

<table>
<thead>
<tr>
<th>Box's M</th>
<th>38.540</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1.767</td>
</tr>
<tr>
<td>df1</td>
<td>21</td>
</tr>
<tr>
<td>df2</td>
<td>107634.699</td>
</tr>
<tr>
<td>Sig.</td>
<td>.016</td>
</tr>
</tbody>
</table>

For the first hypothesis the null hypothesis was rejected. The results of the comparison between the pre SATS and post SATS components scores for the GPBI group were Wilk’s \( \Lambda = .807 \), \( F(6, 168) = 6.698 \), \( p = .000 \), partial \( \eta^2 = .193 \). The MANOVA results for the first hypothesis are reported in Table 14.

Table 14  

*Guided Project-Based Instructional Group MANOVA Analysis*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Test Statistic</th>
<th>Hypoth. Value</th>
<th>F</th>
<th>df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Lambda</td>
<td>.807</td>
<td>6.698</td>
<td>6</td>
<td>168</td>
<td>.000</td>
<td>.193</td>
</tr>
</tbody>
</table>

For each dependent variable a separate ANOVA was conducted at the .05 level of significance to determine if a significant difference existed in the pre SATS and post SATS
component scores for the GPBI group. The results of the univariate analysis for the affect component were $F(1, 173) = 6.513, p = .012$, partial $\eta^2 = .036$. The results for the cognitive competence component were $F(1, 173) = 2.090, p = .150$, partial $\eta^2 = .012$. The results for the value component were $F(1, 173) = 6.315, p = .013$, partial $\eta^2 = .035$. The results for the difficulty component were $F(1, 173) = 0.744, p = .390$, partial $\eta^2 = .004$. The results for the interest component were $F(1, 173) = 0.091, p = .763$, partial $\eta^2 = .001$. The results for the effort component were $F(1, 173) = 12.124, p = .001$, partial $\eta^2 = .065$. The ANOVA results for the first hypothesis are reported in Table 15.

Table 15

*Guided Project-Based Instructional Group ANOVA Analysis*

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>df</th>
<th>Mean Square</th>
<th>$F$</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Affect</td>
<td>1</td>
<td>7.607</td>
<td>6.513</td>
<td>.012</td>
<td>.036</td>
</tr>
<tr>
<td></td>
<td>Cognitive C.</td>
<td>1</td>
<td>1.940</td>
<td>2.090</td>
<td>.150</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>1</td>
<td>6.475</td>
<td>6.315</td>
<td>.013</td>
<td>.035</td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>1</td>
<td>0.428</td>
<td>0.744</td>
<td>.390</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>Interest</td>
<td>1</td>
<td>0.182</td>
<td>0.091</td>
<td>.763</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>Effort</td>
<td>1</td>
<td>12.020</td>
<td>12.124</td>
<td>.001</td>
<td>.065</td>
</tr>
<tr>
<td>Error</td>
<td>Affect</td>
<td>173</td>
<td>1.168</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cognitive C.</td>
<td>173</td>
<td>0.928</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>173</td>
<td>1.025</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>173</td>
<td>0.575</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest</td>
<td>173</td>
<td>1.993</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effort</td>
<td>173</td>
<td>0.991</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hypothesis 2**

The null hypothesis for the second hypothesis is that there is no difference in the attitudes toward statistics between students enrolled in a guided project-based course and students enrolled in a traditional lecture-based course. The alternative hypothesis for the second
hypothesis is that students enrolled in guided project-based statistics courses will have better attitudes than those enrolled in a traditional lecture-based course.

To test the second hypothesis a MANOVA was conducted comparing the post SATS component scores for the GPBI group to the post SATS component scores for the TLBI group. Box’s test of equality of covariance matrices was used to decide if the observed covariance matrices were equal across groups at the .005 level of significance. The null hypothesis for Box’s test of covariance matrices was not statistically significant given \( p = .091 \) which indicates the dependent variables’ observed covariance matrices were equal across groups thus the MANOVA assumption of equal covariance matrices was satisfied. The results of Box’s Test of Equality of Covariance Matrices are shown in Table 16.

Table 16

<table>
<thead>
<tr>
<th>Box's Test of Equality of Covariance Matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box's M</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>df1</td>
</tr>
<tr>
<td>df2</td>
</tr>
<tr>
<td>Sig.</td>
</tr>
</tbody>
</table>

For the second hypothesis the null hypothesis was rejected. The results of the comparison between post SATS component scores and final grades for the GPBI group when compared to the post SATS components scores and final grades for the TLBI group were Wilk’s \( \Lambda = .896 \), \( F(7, 133) = 2.214, p = .037, \) partial \( \eta^2 = .104 \) reported in Table 17.

For each dependent variable a separate ANOVA was conducted at the .05 level of significance to determine if the post SATS component scores for the GPBI group were statistically different from the post SATS component scores of the TLBI group. The
Table 17

*Between Groups MANOVA Analysis for Guided Project-Based Instructional Group and Traditional Instructional Group*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Test Statistic</th>
<th>Value</th>
<th>Hypoth. df</th>
<th>Error df</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Wilk’s Lambda</td>
<td>.896</td>
<td>2.214</td>
<td>7</td>
<td>133</td>
<td>.037 .104</td>
</tr>
</tbody>
</table>

results of the univariate analysis for the affect component were $F(1, 139) = .022, p = .884$, partial $\eta^2 = .000$. The results for the cognitive competence component between the two groups were $F(1, 139) = 0.000, p = .984$, partial $\eta^2 = .000$. The results for the value component were $F(1, 139) = 4.764, p = .031$, partial $\eta^2 = .033$. The results for the difficulty component were $F(1, 139) = 0.896, p = .345$, partial $\eta^2 = .006$. The results for the interest component were $F(1, 139) = 5.009, p = .027$, partial $\eta^2 = .035$. The results for the effort component were $F(1, 139) = .044, p = .835$, partial $\eta^2 = .000$. The ANOVA results for the comparison between the GPBI group post SAT components and the TLBI group post SAT components are reported in table 18.

**Hypothesis 3**

The null hypothesis for the third hypothesis was that there would be no difference in students’ final course grades who experienced the guided project-based instructional approach and the students who experienced the traditional instructional approach. The alternative hypothesis was that students’ final course grades in the guided project-based course would be higher than students in the traditional group.
Table 18

Between Groups ANOVA Analysis for Guided Project-Based Instructional Group and Traditional Instructional Group

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Affect</td>
<td>1</td>
<td>0.035</td>
<td>0.022</td>
<td>.884</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Cognitive C. Value</td>
<td>1</td>
<td>0.001</td>
<td>0.000</td>
<td>.984</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>1</td>
<td>6.945</td>
<td>4.764</td>
<td>.031</td>
<td>.033</td>
</tr>
<tr>
<td></td>
<td>Interest</td>
<td>1</td>
<td>0.715</td>
<td>0.896</td>
<td>.345</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>Effort</td>
<td>1</td>
<td>11.396</td>
<td>5.009</td>
<td>.027</td>
<td>.035</td>
</tr>
<tr>
<td></td>
<td>Final Grade</td>
<td>1</td>
<td>0.048</td>
<td>0.044</td>
<td>.835</td>
<td>.000</td>
</tr>
</tbody>
</table>

| Error        | Affect             | 139 | 1.649       |
|              | Cognitive C. Value | 139 | 1.361       |
|              | Value              | 139 | 1.458       |
|              | Difficulty         | 139 | 0.798       |
|              | Interest           | 139 | 2.275       |
|              | Effort             | 139 | 1.106       |
|              | Final Grade        | 139 | 162.448     |

The same MANOVA that was used to compare the GPBI group post SATS components to the TLBI group post SATS components was also used to compare the final grades between the two groups. For the third hypothesis the null hypothesis was rejected. The final grade means, standard deviations, and sample sizes for each group are reported in Table 19. The comparison

Table 19

Final Grade Means, Standard Deviations, and Sample Size by Group

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Grade</td>
<td>Guided Project-Based</td>
<td>78.874</td>
<td>12.06385</td>
</tr>
<tr>
<td></td>
<td>Traditional</td>
<td>74.002</td>
<td>13.66662</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>76.870</td>
<td>12.92582</td>
</tr>
</tbody>
</table>
between the two instructional groups’ final grades yielded the following results $F(1,139) = 4.989, p = .027$, partial $\eta^2 = .035$ shown in Table 18.

**Summary**

This chapter provided the results and analysis of the sample data collected to test the three research hypotheses in the study. The chapter began by presenting the demographic information obtained using the SATS-36 pre and post survey. It then presented the results of the MANOVA for the guided project-based group using the interaction effect of time to compare the component scores from the pre SATS-36 to the component scores of the post SATS-36. The results of the first MANOVA were found to be significant so a separate ANOVA was conducted for each of the dependent variables. The second and third hypotheses were tested using a second MANOVA to compare the post SATS component scores and final grades of the GPBI group to the TLBI group. The results of the second MANOVA were also found to be statistically significant. Separate ANOVA’s were conducted for each of the dependent variables including the final grades. Chapter V will include the summary, conclusions, and recommendations of this research study.
CHAPTER V
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study was undertaken to determine if guided project-based instruction could improve students’ attitudes toward statistics and have a positive effect on academic performance. This chapter contains a summary of the research project, conclusions drawn from the analysis of the data collected in the research, and recommendations for the future based on the study’s conclusions.

Summary

The purpose of this study was to decide if the use of a guided project-based instructional method would improve students’ attitudes toward statistics and final grades in an introductory statistics course. The hypotheses guiding this research project were as follows:

H1: The use of a guided project-based learning approach will improve students’ attitudes towards statistics as measured by the Survey of Attitudes Toward Statistics (SATS-36).

H2: Students enrolled in the guided project-based learning courses will have better attitudes toward statistics than students who enrolled in traditional lecture-based courses as measured by the Survey of Attitudes Toward Statistics (SATS-36).

H3: The use of a guided project-based learning approach will improve students’ course performance measured by final course grades compared to students who are taught in traditional lecture-based courses.

To test the hypotheses students were divided into two instructional groups, a traditional lecture-based (TLBI) group and a guided project-based (GPBI) group which was determined by the semester they enrolled into an introductory statistics course at a two-year college in Virginia. This study was carried out to enhance the current state of instructional practice in introductory
This study set out to determine if the use of a guided project-based instructional approach improved students’ attitudes toward statistics and academic performance over traditional lecture-based instructional methods in an introductory statistics course. In introductory statistics courses students often have a negative perception of statistics shown by reports of apprehension and anxiety, negative attitudes, a lack of motivation, a lack of interest, and a lack of understanding when it comes to the practical importance or value of statistics (Acee & Weinstein, 2010; Bartsch, 2006; Bui & Alfaro, 2011; Capshew, 2005; Dempster & McCorry, 2009; Fitzgerald, Jurs, & Hudson, 1996; Nolan, Beran, Hecker, 2012; Onwuegbuzie, Leech, Murtonen, & Tähtinen, 2010; Onwuegbuzie & Wilson, 2003; Scultto, 1995; Zanakis & Valenzi, 1997; Zeidner, 1991). These poor attitudes over time negatively affect academic performance and conceptual understandings (Schau & Emmioglu, 2012). In contrast to a negative attitude, a positive attitude toward statistics can lead to improvement in active studying behavior and has been linked to academic achievement (Emmioglu & Capa-aydin, 2012; Peterson, Maier, & Seligman, 1993; Pintrich & Schunk, 1996). The American Statistical Association (2012) has recommended including more active learning opportunities for students through innovative instructional approaches in introductory statistics courses. Guided project-based learning is such an approach.

The use of project-based learning offers students the opportunity to acquire a wide-range of flexible problem solving skills through self-directed appealing instruction (Barrows, 1986; Loyens, Magda, & Rikers, 2008; Norman & Schmidt, 1992). However, these opportunities come at the cost of difficult implementation, inefficient use of instructional time, lack of student experience with directedness and control of their own learning, student frustration about which tasks to complete, and the use of unfamiliar assessments (Brinkerhoff & Glazewski, 2004; Brush
The use of guided instruction has been shown to be superior to unguided instruction for novice learners (Kirchner, Sweller, & Clark, 2006; Mayer, 2004). Guided project-based learning allows students to experience the benefits of project-based learning without experiencing the challenges inherent in an unguided instructional approach. Several studies had found encouraging results from the use of guided problem-based learning. Bude et al. (2009) found that students who were randomly assigned to a tutoring group using guided instructional activities had more positive perceptions about the course and group discussions as well as better performance on end of course exams than those assigned to a group without guided instructional activities. Bude et al. (2011) found students enrolled in a problem-based learning statistics course who were placed into a guided tutoring group had a better conceptual understanding of statistics. Bude et al. (2012) concluded the use of guided questions helped students to better understand statistics. Leppink et al. (2014) found that once students had sufficient prior knowledge, the use of guided problem-based learning enhanced conceptual comprehension of statistics and increased students’ understanding of the value of learning statistics. The results of these studies led to the investigation into the effects of guided project-based learning on introductory statistics students’ attitudes toward statistics and academic performance.

The current study took place during the Fall 2015 and Spring 2016 academic semesters at a two-year college in Virginia. Students who were enrolled in the introductory statistics course during the Fall 2015 semester were instructed using a traditional lecture-based instructional method (TLBI). This group (N = 58) functioned as the control group. Students who were enrolled in the introductory statistics course during the Spring 2016 semester were instructed
using a guided project-based instructional (GPBI) method. This group \((N = 83)\) functioned as the experimental group. The treatment entailed the completion of guided projects within a group of four to six individuals. The Survey of Attitudes Toward Statistics (SATS-36) was administered to both groups on the first and last day of class to measure participants’ attitudes toward statistics. Participants’ final grades were used to measure academic success. In the GPBI group a comparison was made between students’ attitudes toward statistics when they began the course and their attitudes when they completed the course. To make these comparisons a MANOVA was conducted at the .05 level of significance. Students in the GPBI group were also compared to students in the TLBI group to determine if there was a significant difference in attitudes and final course grades. To make these comparisons a MANOVA was conducted at the .05 level of significance.

**Conclusions**

This study sought to determine if a significant difference existed in students’ attitudes toward statistics after completing an introductory statistics course using a GPBI approach compared to students’ attitudes when they began the course. This study also sought to compare students in the GPBI group to students in the TLBI group. This comparison was made to determine if a significant difference existed between students’ attitudes toward statistics and final course grades after the course was complete. The SATS-36 was used to measure six components of attitude: affect, cognitive competence, value, difficulty, interest, and effort.

The first null hypothesis stated there would be no difference between students’ attitudes toward statistics after completing an introductory statistics course using a guided project-based approach. The findings, Wilk’s \(\Lambda = .807, F(6, 168) = 6.698, p = .000, \text{partial } \eta^2 = .193\), show there was a significant difference in the pre SATS and post SATS components scores for
the GPBI group. This significant difference led to a univariate analysis for each component of the SATS-36. For each dependent variable a separate ANOVA was conducted at the .05 level of significance to determine if a significant difference existed in the pre SATS and post SATS component scores for the GPBI group. There was a significant difference in the affect component $F(1, 173) = 6.513, p = .012$, partial $\eta^2 = .036$. The post SATS affect component ($M = 4.305$) was higher than the pre SATS affect component ($M = 3.888$). There was not a significant difference in the cognitive competence component $F(1, 173) = 2.090, p = .150$, partial $\eta^2 = .012$. The post SATS cognitive competence component ($M = 4.711$) was numerically higher than the pre SATS cognitive competence component ($M = 4.500$), but the difference was not statistically significant. There was a significant difference in the value component $F(1, 173) = 6.315, p = .013$, partial $\eta^2 = .035$. The post SATS value component ($M = 4.963$) was higher than the pre SATS value component ($M = 4.577$). There was not a significant difference in the difficulty component $F(1, 173) = 0.744, p = .390$, partial $\eta^2 = .004$. The post SATS difficulty component ($M = 3.210$) was lower than the pre SATS difficulty component ($M = 3.309$), but the difference was not statistically significant. There was not a significant difference in the interest component $F(1, 173) = 0.091, p = .763$, partial $\eta^2 = .001$. The post SATS interest component ($M = 4.660$) was higher than the pre SATS interest component ($M = 4.595$), but the difference was not statistically significant. There was a significant difference in the effort component $F(1, 173) = 12.124, p = .001$, partial $\eta^2 = .065$. The post SATS effort component ($M = 5.913$) was lower than the pre SATS effort component ($M = 6.438$).

In the GPBI group statistically significant results were found in affect, value, and effort. Improvement was shown in affect and value, however there was a decline in effort over the
course of the semester. The improvement in affect indicated students had more positive feelings toward statistics after completion of the course. The improvement in value indicates students believed statistics was more useful and important than they did at the beginning of the course. The decline in effort indicates students worked less as the semester progressed. While the GPBI approach did not have significant results in all six components having significant results in two components suggests students’ attitudes did improve. Several studies which used the SATS-28 or SATS-36 to measure students’ attitude toward statistics had results showing no change in attitude or a negative change in attitude (Bond, Perkins, & Ramirez, 2012; Carnell, 2008; Gundlach, Richards, Nelson, & Levesque-Bristol, 2015; Harpe, Phipps, & Alowayesh, 2012; Schau, & Emmioglu, 2012). In contrast to these studies, having two components with positive changes, three components with no change, and one component with a negative change represents a positive result. However out of all the studies that found no change or a negative change only one examined project-based learning. Carnell (2008) studied the effects of student designed projects on students’ attitudes toward statistics. Thus it is reasonable to compare the current study to the Carnell study.

In the Carnell (2008) study, students were required to design and implement projects with minimal guidance from the instructor. The Carnell study found no significant evidence to suggest student-designed data collection projects improved students’ attitude toward statistics. In the analysis of each component, Carnell reported either no change or a negative change in the mean for all the components. The components cognitive competence, value, interest, and effort were all lower after completing the course in the Carnell study. Taken together these findings indicate that students’ attitudes did not change or that their attitudes became worse. In contrast to the Carnell study, the results of this study suggest the addition of guidance to project-based learning
can improve students’ attitudes toward statistics in the affect and value components. In the current study, for the GPBI group, the component mean for effort was lower after the course was completed. The fact that effort was lower in the Carnell study, and in both groups in the current study, suggests some other factor is negatively influencing effort outside of the GPBI approach.

The null hypothesis for the second hypothesis was that there was no difference in the attitudes toward statistics between students enrolled in a guided project-based course and students enrolled in a traditional lecture-based course. The findings, Wilk’s $\Lambda = .896$, $F(7,133) = 2.214, p = .037$, partial $\eta^2 = .104$, show there was a significant difference in the post SATS component means for the GPBI group and the post SATS component means for the TLBI group. This significant difference led to a univariate analysis for each component of the SATS-36. To compare the post SATS component means of the GPBI group to the post SATS component means for the TLBI group, a separate ANOVA was conducted at the .05 level of significance for each of the components. This was done to determine if the post SATS component means for the GPBI group were statistically different from the post SATS component means of the TLBI group. There was not a significant difference in the affect component $F(1,139) = .022, p = .884$, partial $\eta^2 = .000$. The post SATS affect component for the GPBI group ($M = 4.305$) was higher than the post SATS affect component for the TLBI group ($M = 4.273$), but the difference was not statistically significant. There was not a significant difference in the cognitive competence component between the two groups $F(1,139) = 0.000, p = .984$, partial $\eta^2 = .000$. The post SATS cognitive competence component for the GPBI group ($M = 4.711$) was higher than the post SATS cognitive competence component for the TLBI group ($M = 4.707$), but the difference was not statistically significant. There was a significant difference in the value component $F(1,139) = 4.764, p = .031$, partial $\eta^2 = .033$. The post SATS value
component for the GPBI group ($M = 4.963$) was higher than the post SATS value component for the TLBI group ($M = 4.512$). There was not a significant difference in the difficulty component $F(1, 139) = 0.896, p = .345$, partial $\eta^2 = .006$. The post SATS difficulty component for the GPBI group ($M = 3.210$) was lower than the post SATS difficulty component for the TLBI group ($M = 3.355$), but the difference was not statistically significant. There was a significant difference in the interest component $F(1, 139) = 5.009, p = .027$, partial $\eta^2 = .035$. The post SATS interest component for the GPBI group ($M = 4.660$) was higher than the post SATS interest component for the TLBI group ($M = 4.082$). There was not a significant difference in the effort component $F(1, 139) = .044, p = .835$, partial $\eta^2 = .000$. The post SATS effort component for the GPBI group ($M = 5.913$) was higher than the post SATS effort component for the TLBI group ($M = 5.875$), but the difference was not statistically significant.

In the comparison between the GPBI group and the TLBI group, statistically significant results were found in value and interest. In the value comparison, the GPBI group found statistics to be more useful and relevant after completing the course than the TLBI group. The GPBI group also found statistics to be more interesting after completing the course than the TLBI group. Further analysis reveals that the TLBI group had a decline in the interest component over the course of the semester (Pre SATS $M = 4.578$, Post SATS $M = 4.082$), while the interest component for the GPBI group (Pre SATS $M = 4.595$, Post SATS $M = 4.660$) changed very little over the course of the semester. One result that was not statistically significant which should none the less be considered was the finding regarding effort between the two groups. The finding of no difference between the effort component means indicates that although effort declined in the GPBI group, it also declined in the traditional group so it is not likely a result of the guided project-based instruction but a result of some other factor.
The statistically significant results of the second hypothesis provide further support for the guided project-based approach. First, the result for the value component of the second hypothesis support guided project-based students having improved attitude concerning the value of statistics. This result has commonalities with results from previous studies. In the Bude et al. (2009) study, researchers found that students valued the course more when they had access to the guided tutoring. The results of second hypothesis support that finding. In the Leppink et al. (2014) study, researchers found students in the guided problem-based group had an increased understanding of the value of the learning activity. The results of the second hypothesis also support students being taught using the guided project-based approach having more interest in statistics than students being taught using a traditional lecture-based approach. Cultivating and holding students interest in statistics can lead to the use of statistical reasoning and skills beyond the classroom. This is one of the purposes of statistics education. Ultimately students who are interested in statistics are also more likely to use statistics in the future.

The null hypothesis for the third hypothesis was that in the comparison between final course grades for the GPBI group and students’ final course grades for the TLBI group there would be no difference. The comparison between the two instructional groups’ final grades did yield a statistically significant result $F(1, 139) = 4.989, p = .027$, partial $\eta^2 = .035$. The final grades of the GPBI group ($M = 78.874$) were higher than the TLBI group ($M = 74.002$). This finding indicates that the use of GPBI was beneficial to students’ overall mastery of course material.

The statistically significant results of the third hypothesis parallel results found in previous research studies. The study conducted by Boaler (1998) found that when students were instructed using the project-based approach they had increased competence when transferring
mathematics to authentic situations and passed the national examinations in higher percentages with higher scores. In the current study the grades of students in the GPBI group were higher on average than the grades of students in the TLBI group. In the study by Ayaz and Soylemez (2015) researchers found project-based learning approaches to be more effective than traditional teaching approaches on academic performance in science classes. Similarly, the results of this study support guided project-based learning as a more effective instructional approach than traditional teaching when it comes to academic performance in introductory statistics courses.

The challenges associated with teaching introductory statistics courses have been well documented. As increasing emphasis is placed on collecting, organizing, and analyzing data, the importance of good teaching and learning in statistics has become more and more essential. The fundamental goal of teaching introductory statistics courses is to teach students basic statistical knowledge and skills and also to nurture an appreciation, interest, and desire to think statistically upon completion of the course. Having a positive attitude toward statistics is a necessary component of good teaching and learning in statistics. Based on the results of this research study, one way that statistics teaching and learning can be improved is through the use of guided project-based learning in introductory statistics courses. Guided project-based learning improved attitudes measured by the components affect and value and also positively affected students’ academic performance. Both the guided project-based instructional group and the traditional lecture-based instructional group improved in terms of students’ perception of statistics, but traditional lecture-based student attitudes declined in the components of value and interest. The use of guided project-based learning has been shown to increase the value students placed on the use of statistics. It has also helped students to continue to maintain an interest in statistics as the course progressed compared to those taught using the traditional lecture-based approach. Finally,
it has been shown to positively affect students’ academic performance compared to a traditional lecture-based approach. The results of this study showed guided project-based instruction to be as good or better than traditional lecture-based instruction in terms of students’ attitudes toward statistics and final grades. The analysis of the components of the SATS suggests students found more value in statistics using the guided project-based approach and their level of interest did not decline as the course progressed as it did in the traditional lecture-based approach. All of these findings suggest that using a guided project-based learning approach will be beneficial to students in introductory statistics courses.

**Recommendations**

The results and conclusions of this research study led to the implementation of the two recommendations. The first recommendation is the implementation of guidance when using project-based learning. Project-based learning can be very effective. However various implementation challenges have been cited (Brinkerhoff & Glazewski, 2004; Brush & Saye, 2008; Derry, Levin, Osana, Jones, & Peterson, 2000; Ertmer & Simons, 2006; Krajcik, Blumenfeld, Marx, Bass, Fredricks, & Soloway, 1998; Lee et al., 2014; Marx et al., 1997). One of the drawbacks of using project-based learning instructional methods has been the lack of teacher control over the instruction. Using project-based learning is appealing, but it can have reduced effectiveness due to this lack of guided instruction. The use of guidance in this research study was found to be beneficial to students in introductory statistics courses. The results of this study suggest the use of guidance can increase the effectiveness of project-based learning without limiting its appeal. Statistics instructors can implement guided instruction in conjunction with project-based learning in introductory statistics courses to improve students’ attitudes and academic performance.
The second recommendation is the inclusion of a guided project in all introductory statistics courses. Too often students in introductory statistics courses are required to learn statistics without any concrete examples showing the ways various topics connect together or the ways statistics can be used outside of the classroom. Without comprehending the applied nature of statistics through authentic learning experiences, students tend to value statistics less and lose interest in studying or using it which leads to them to seeing statistics as simply a class they need to pass in order to graduate. Statistics educators need to do all they can to keep this from happening. Part of the solution is to include at least one guided project in the introductory course.

**Recommendations for Further Research**

The effectiveness of project-based learning has been reported in previous studies (Ayaz & Soylemez, 2015; Boaler, 1998). The effectiveness of guidance in conjunction with active learning techniques has also been reported in previous studies (Bude et al. 2009; Kuiper & Collins, 2009; Leppink et al., 2014). This study represents the first time guidance and project-based learning have been used together and shown to be effective to improve students’ attitudes toward statistics and academic performance. In addition to this, the conclusions made in this research project were made using a relatively small sample size. To substantiate the reliability of these results, further research using the GPBI approach is needed in introductory statistics courses.

A second recommendation for further research is the application of a GPBI approach to instruction in other subject areas to improve students’ attitudes and academic performance. One subject area which might benefit from such an approach is mathematics. Mathematics courses have traditionally been mentioned as lacking in appeal. The results of this research suggest that
students may maintain interest and come to value mathematics when studied through a GPBI approach. This leads to the recommendation that a research study be conducted in a college-level general education introductory mathematics course to see if guided project-based learning can improve students’ attitudes and academic performance.

A third and final recommendation for further research is a comparison study between guided project-based learning and another active learning approach. This type of research could also include comparisons to traditional instructional models. In the GAISE report, the ASA (2005) suggested increased use of active learning methods in statistics courses. In this study guided project based learning was shown to be effective at improving students’ attitudes and academic performance. To determine if other active learning methods are going to be effective, these methods need to be the subject of further research.
REFERENCES


DIRECTIONS: The statements below are designed to identify your attitudes about statistics. Each item has 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). If you have no opinion, choose response 4. Please read each statement. Mark the one response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Neither disagree nor agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I plan to complete all of my statistics assignments.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I plan to work hard in my statistics course.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I will like statistics.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I will feel insecure when I have to do statistics problems.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I will have trouble understanding statistics because of how I think.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Statistics formulas are easy to understand.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Statistics is worthless.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Statistics is a complicated subject.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Statistics should be a required part of my professional training.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
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<tr>
<td>10. Statistical skills will make me more employable.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
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<tr>
<td>11. I will have no idea of what's going on in this statistics course.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
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<tr>
<td>12. I am interested in being able to communicate statistical information to others.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
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</tbody>
</table>
13. Statistics is not useful to the typical professional.


15. I will get frustrated going over statistics tests in class.

16. Statistical thinking is not applicable in my life outside my job.

17. I use statistics in my everyday life

18. I will be under stress during statistics class.

19. I will enjoy taking statistics courses.

20. I am interested in using statistics.

21. Statistics conclusions are rarely presented in everyday life.

22. Statistics is a subject quickly learned by most people.

23. I am interested in understanding statistical information.

24. Learning statistics requires a great deal of discipline.

25. I will have no application for statistics in my profession.

26. I will make a lot of math errors in statistics.

27. I plan to attend every statistics class session.

28. I am scared by statistics.

29. I am interested in learning statistics.

30. Statistics involves massive computation

31. I can learn statistics.
32. I will understand statistics equations.  
1 2 3 4 5 6 7

33. Statistics is irrelevant in my life.  
1 2 3 4 5 6 7

34. Statistics is highly technical.  
1 2 3 4 5 6 7

35. I will find it difficult to understand statistical concepts.  
1 2 3 4 5 6 7

36. Most people have to learn a new way of thinking to do statistics.  
1 2 3 4 5 6 7

Please notice that the labels for each scale on the rest of this page change from item to item.

37. How well did you do in mathematics courses you have taken in the past?  
<table>
<thead>
<tr>
<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>Very poorly</td>
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<tr>
<td>Very well</td>
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</table>

38. How good at mathematics are you?  
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<th>Scale</th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td>Very poor</td>
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<tr>
<td>Very good</td>
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</table>

39. In the field in which you hope to be employed when you finish school, how much will you use statistics?  
<table>
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<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td>Not at all</td>
<td></td>
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</tr>
<tr>
<td>Great deal</td>
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</table>

40. How confident are you that you can master introductory statistics material?  
<table>
<thead>
<tr>
<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td>Not at all confident</td>
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<tr>
<td>Very confident</td>
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</table>

41. Are you required to take this statistics course (or one like it) to complete your degree program?  
<table>
<thead>
<tr>
<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

42. If the choice had been yours, how likely is it that you would have chosen to take any course in statistics?  
<table>
<thead>
<tr>
<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all likely</td>
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<td></td>
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<tr>
<td>Very likely</td>
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</tbody>
</table>
DIRECTIONS: For each of the following statements mark the one best response. Notice that the response scale changes on each item.

43. What is your major? If you have a double major, pick the one that best represents your interests.

1. Arts/Humanities
2. Biology
3. Business
4. Chemistry
5. Economics
6. Education
7. Engineering
8. Mathematics
9. Medicine/Pre-Medicine
10. Psychology
11. Sociology/Social Work
12. Statistics
13. Other

44. Current grade point average (please estimate if you don’t know; give only one single numeric response: e.g., 3.52). If you do not yet have a grade point average, please enter 99:

For each of the following three items, give one single numeric response (e.g., 26). Please estimate if you don’t know exactly.

45. Number of credit hours earned toward the degree you are currently seeking (don’t count this semester): 

46. Number of high school mathematics and/or statistics courses completed:

47. Number of college mathematics and/or statistics courses completed (don’t count this semester):

48. Degree you are currently seeking:

1. Associate
2. Bachelors
3. Masters
4. Doctorate
5. Certification
6. Post-bachelor's Licensure
7. Specialist
8. Other
49. What grade do you expect to receive in this course?


In order to describe the characteristics of your class as a whole, we need your responses to the following items.

50. Your sex: 1. Male 2. Female
52. Your age (in years): _____

THANKS FOR YOUR HELP!
APPENDIX B

Survey of Attitudes Toward Statistics 36 Post Survey

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DIRECTIONS: The statements below are designed to identify your attitudes about statistics. Each item has 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). If you have no opinion, choose response 4. Please read each statement. Mark the one response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

1. I tried to complete all of my statistics assignments.  
2. I worked hard in my statistics course.  
3. I like statistics.  
4. I feel insecure when I have to do statistics problems.  
5. I have trouble understanding statistics because of how I think.  
6. Statistics formulas are easy to understand.  
7. Statistics is worthless.  
8. Statistics is a complicated subject.  
9. Statistics should be a required part of my professional training.  
10. Statistical skills will make me more employable.  
11. I have no idea of what's going on in this statistics course.  
12. I am interested in being able to communicate statistical information to others.
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<tr>
<td>13. Statistics is not useful to the typical professional.</td>
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<td>14. I tried to study hard for every statistics test.</td>
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<td>15. I get frustrated going over statistics tests in class.</td>
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<td>16. Statistical thinking is not applicable in my life outside my job.</td>
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<td>17. I use statistics in my everyday life</td>
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<td>18. I am under stress during statistics class.</td>
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<td>19. I enjoy taking statistics courses.</td>
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<td>20. I am interested in using statistics.</td>
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<td>21. Statistics conclusions are rarely presented in everyday life.</td>
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<td>22. Statistics is a subject quickly learned by most people.</td>
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<td>23. I am interested in understanding statistical information.</td>
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<td>24. Learning statistics requires a great deal of discipline.</td>
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<td>25. I will have no application for statistics in my profession.</td>
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<td>26. I make a lot of math errors in statistics.</td>
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<td>27. I tried to attend every statistics class session.</td>
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<td>28. I am scared by statistics.</td>
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<td>29. I am interested in learning statistics.</td>
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<td>30. Statistics involves massive computations.</td>
<td>1</td>
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<td>4</td>
<td>5</td>
<td>6</td>
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31. I can learn statistics. 1 2 3 4 5 6 7
32. I understand statistics equations. 1 2 3 4 5 6 7
33. Statistics is irrelevant in my life. 1 2 3 4 5 6 7
34. Statistics is highly technical. 1 2 3 4 5 6 7
35. I find it difficult to understand statistical concepts. 1 2 3 4 5 6 7
36. Most people have to learn a new way of thinking to do statistics. 1 2 3 4 5 6 7

NOTICE that the labels for the scale on each of the following items differ from those used above.

37. How good at mathematics are you?  
   Very poor 1 2 3 4 5 6 7
   Very good

38. In the field in which you hope to be employed when you finish school, how much will you use statistics?  
   Not at all 1 2 3 4 5 6 7
   Great deal

39. How confident are you that you have mastered introductory statistics material?  
   Not at all confident 1 2 3 4 5 6 7
   Very confident

40. As you complete the remainder of your degree program, how much will you use statistics?  
   Not at all 1 2 3 4 5 6 7
   Great deal

41. If you could, how likely is it that you would choose to take another course in statistics?  
   Not at all likely 1 2 3 4 5 6 7
   Very likely

42. How difficult for you is the material currently being covered in this course?  
   Very easy 1 2 3 4 5 6 7
   Very difficult
DIRECTIONS: For each of the following statements mark the one best response. Notice that the response scale changes on each item.

51. Do you know definitely what grade you will receive in this course?
   1. Yes            2. No

If yes then indicate it here_______


51. What grade do you expect to receive in this course?
(If you know then put the same grade.)


52. In a usual week, how many hours did you spend outside of class studying statistics? Give only one single numeric response that is a whole number _______________

53. In the past week, how would you describe your overall stress level? Very low    Very high

1 2 3 4 5 6 7

THANKS FOR YOUR HELP!
APPENDIX C

Sample Guided Project: Does Honey Soothe Coughing?

Population, Sample, and Experimental Design

Group #
Class meeting time

On this page you will take a guess at the size of your population, guess at a sample size, calculated a sample size based on your population size and probability distribution of x, provide the details about your sampling method, thoroughly explain how you plan to collect your sample, and provide information about your experimental design.

1. (5-7 min) Which age group did you select for your population? What is your specific population of interest for this research study? How large do you think your population is? Provide a best guess for your population size. It does not have to be correct. (a definition of population can be found on pg. 1 of Note Set 1, (NS1 pg. 1)

2. (2 min) Based on your population size how large do you think your sample needs to be? This will not be your final answer it is just a guess.

3. (5 min) What is your experimental unit (NS1 pg. 2)? What is the variable you plan to use to collect data? (NS1, pg. 2) Be very specific. Give an example of one value that your variable can take on with the units.

Now go to the Constructing a Research Question and a Research Hypothesis sheet

4. At this point you should have your research question and hypothesis. Write both below.

5. (10-20 min) It is now time to think through your experimental design. This may take some time and is likely to be an iterative process. Begin by explaining how you plan to recruit people into participating. Talk about your methods of solicitation. Explain why subjects participate. What are some of the obstacles to participation? How will you overcome these? Then think about the experiment itself. You need to provide a thorough explanation of the process you plan to use. You also need to explain how you are going to collect the data and store it. This will need to be explained further in 6, 7, and 8 below.
6. (10 min) Which sampling method do you intend to employ? (NS1, pg. 2) Explain the reason(s) you selected this method. Do you think this method is practically possible? Explain. If it is not practically possible, choose another sampling technique and repeat the process. Explain why you chose your sampling technique.

7. (5 min) Once you have selected a sampling technique you need to begin to think about your sample and the experiment. Specifically look at Experiments, Experimental Design, and Experimental Treatment (NS1 pg. 4) Are you going to divide your sample into groups? How many groups?

8. (30+ min) It is time to provide explicit details about how the experiment will be conducted. Before you start your experiment look at the Criteria for a Well-Designed Experiment (NS1 pgs. 4-5), Experimental Design, Pre-Test/Post-Test (NS1 pg. 5), Reliability of research, General Validity, Validity of an Experiment, Validity in research, and Types of Validity (NS1 pgs. 5-6). There may be other topics in Note Set 1 that you may want to address as well. First provide details about what happens once someone has been selected and agreed to participate. Then provide general details about the experimental process. Make sure to include some random process for deciding who gets selected for the treatment and control groups.

Go to the Collecting Data: Probability Distributions worksheet so before you begin your experiment

9. It is now time to calculate a sample size based on the probability distribution of x that you sketched in question 4 on Collecting Data: Probability Distributions sheet. If your population size is 100,000 or larger then you can use a sample size of 1067. If your population is between 1000 and 10000, you will need to determine your sample size. This can be done through a sample size calculator online or by using formulas from the course. Look on the BB site to find a website to calculate your sample size online. Report it here and take this to your instructor to collect your data.
10. We are now going to construct sampling distributions for the dependent variable. Using the number of people in your control group sketch a picture of your sampling distributions for before placebo is given and after the placebo is given. Construct a sampling distribution of the sample mean using your information. Specifically you need to calculate \( \mu_{\bar{x}} \) and \( \sigma_{\bar{x}} \) for both groups (NS 5 pg. 26). You will construct either one or two sampling distributions.

11. (5-10 min) Using the number of people in your treatment group sketch a picture of your sampling distributions before and after the treatment is given. You will construct between one and two sampling distributions of the sample mean using your information. Specifically, you need to calculate \( \mu_{\bar{x}} \) and \( \sigma_{\bar{x}} \) for each sampling distribution (NS 5 pg. 26).

12. (5-10 min) From the picture of your sampling distribution(s), determine the lower and upper values of \( \bar{x} \) that are going to fall within one standard deviation of the mean. Now determine the lower and upper values of \( \bar{x} \) that are going to fall within two standard deviations of the mean and three standard deviations of the mean. Refresh your memory about these values (the empirical rule) from Note Set 2 page 9 if necessary and determine the values of the \( \bar{x} \)'s below.

\[
P(\bar{x}_1 < \bar{x} < \bar{x}_2) = .68, \text{ what are } \bar{x}_1 \text{ and } \bar{x}_2? \\
P(\bar{x}_3 < \bar{x} < \bar{x}_4) = .95, \text{ what are } \bar{x}_3 \text{ and } \bar{x}_4? \\
P(\bar{x}_5 < \bar{x} < \bar{x}_6) = .99, \text{ what are } \bar{x}_5 \text{ and } \bar{x}_6? 
\]
13. (15 min) Now we are going to construct a sampling distribution for $\mu_1 - \mu_2$ (NS8 pg. 50). We are only going to do this for the two groups after the treatment. You need to use your information from questions 10 and 11 above to construct your sampling distribution. Specifically use the $\mu$ and $\sigma$ from question 3 on the Collecting Data and Probability Distributions sheet.

14. At this point you should have a good idea about sampling distributions from a general standpoint. Given the two hypotheses below and the information provided on this sheet should you reject or fail to reject the null hypothesis?

\[
\begin{align*}
\mu_1 - \mu_2 &= 0 \\
\mu_1 - \mu_2 &\neq 0
\end{align*}
\]

Go to the Descriptive Statistics and Data Analysis sheet to begin the project and then use the Hypothesis Testing: Two Populations worksheet to decide if your data provides evidence for honey working to reduce the frequency of coughing to complete the project.
Constructing a Research Question and a Research Hypothesis

Group #
Class meeting time

1. (5-7 minutes) Begin by brainstorming about the question “What does honey soothes coughing actually indicate?” or “How would I know honey worked as a treatment for coughing?”

2. (5-7 minutes) Once you have brainstormed this question start to think about the questions “Why should we measure?”, “What should we measure?”, “How should we measure?”.

3. (10-12 minutes) Now you need to choose an independent variable and a dependent variable to consider in your research study (Note Set 3). Which variables will show honey soothes coughing? Begin to reflect on the process needed for collecting data on these variables. (Keep in mind that your independent variable may not be quantitative.) Select one independent variable and one dependent variable. Be very specific.
   a. Independent variable or explanatory variable (x) =
   b. Dependent variable or response variable (y) =

4. (5 minutes) Why did you choose the variables you chose? Do you think they will show (without a doubt) that honey soothes coughing? This is suggesting that once you conclude an analysis it will be clear that honey does indeed soothe coughing or it does not soothe coughing. If not choose different variables. You may want to think about validity here (NS 1 pg. 6).

5. (10 minutes) Do you think honey works to soothe coughing? Answer this question honestly. If the group does not come to a consensus that is ok. Your study is going to need a question to be answered or a hypothesis that needs to be supported with evidence. You need to construct a research question and a directional hypothesis based on your research variables. The research question will include the independent variable, the dependent variable, and the population of interest for the study. Your hypothesis needs to include a statement about the dependent variable(s). See class examples to guide you in writing your research question and hypothesis.

Once you complete these questions return to the Population, Sample, and Experimental Design question sheet.
Collecting Data: Probability Distributions

Group #
Class meeting time

In this part of the project you will decide which probability distribution your sample data sets are to be sampled from. You will begin by choosing the distribution. Then you will choose a population mean for your probability distribution. You will then calculate the population standard deviation based on your population mean and the lower and upper bounds of the distribution.

1. (7-10 min) Name and provide details of at least 4 probability distributions we have considered in this course. (Note Set 2, 4, and 5; You can find this information in NS2 pg. 8, NS4 pgs. 18-19, NS5, pgs. 23-24) Make sure to sketch pictures of each type of distribution.

2. (7-10 min) Now chose a distribution which you think your sample data set is going to be sampled from. We are specifically considering the measurements associated with the dependent variable. (There is no wrong answer.) Make sure to think about this carefully. Think specifically about what happens before participants are administered the honey. How many times on average do you think a person with an URI might cough in 15 minutes? (There may be two separate distributions associated with your dependent variable.)

3. (5-7 min) Once you have chosen a distribution you need to decide what you think the population mean and population standard deviation are possibly going to be. These are called population parameters (NS5 pg. 25, NS6 pg.27 and 29). This information is going to be used to construct the distribution of x.

4. (5-10 min) Once you have decided the population parameters for your distribution, find the lower and upper bounds of your distribution. Sketch a picture of the population probability distribution (distribution of x). It is necessary for your parameters to “work” for your distribution (e. g. people cannot cough a negative number of times and they are not likely to cough more than 100 times in 15 minutes). If your parameters are impossible you must change one or both of them. Specifically, you may find that you need to change your population standard deviation. You may have two distributions for the control group and two for the treatment group.
5. (5-7 min) Now consider the population z-score formula (NS2 pg. 10). Find the x value associated the z-scores of -2, -1, 0, 1, and 2. It may be helpful to sketch a picture of the standard normal distribution. What are you really finding? Explain. Find the x value that is going to fall 2.5 standard deviations below the mean $\mu$. Now find the value for x that is going to fall 1.5 standard deviations above the mean $\mu$.

6. (3-5 min) Once you have calculated your lower bound, upper bound, and standard deviation begin to think about the sampling distribution of the sample mean (NS5 pg. 26) given the sample size you selected on question 2 from the Population, Sample, and Experimental Design sheet. Report your sample size(s) here.

7. (5 min) Now you need to construct a sampling distribution of the sample mean using your information. Specifically you need to calculate $\mu_\bar{x}$ and $\sigma_\bar{x}$ (NS 5 pg. 26).

8. (10 min) Once you calculate the two sampling distribution parameters you need to draw a picture of your sampling distribution(s) with an interval at the bottom that matches your $\mu_\bar{x}$ and $\sigma_\bar{x}$.

9. (5-10 min) From the picture of your sampling distribution, determine the lower and upper values of $\bar{x}$ that are going to fall within one standard deviation of the mean. Now determine the lower and upper values of $\bar{x}$ that are going to fall within two standard deviations of the mean and three standard deviations of the mean. Refresh your memory about these values (the empirical rule) from Note Set 2 page 9 if necessary and determine the values of the $\bar{x}$’s below.

$$P(\bar{x}_1 < \bar{x} < \bar{x}_2) = .68$$, what are $\bar{x}_1$ and $\bar{x}_2$?

$$P(\bar{x}_3 < \bar{x} < \bar{x}_4) = .95$$, what are $\bar{x}_3$ and $\bar{x}_4$?

$$P(\bar{x}_5 < \bar{x} < \bar{x}_6) = .99$$, what are $\bar{x}_5$ and $\bar{x}_6$?

10. (5-7 min) Now consider the sample z-score formula (NS2, pg. 10). Find the values for $\bar{x}$ associated the z-scores of -2, -1, 0, 1, and 2. What are you really finding? Explain. Find the value for $\bar{x}$ that is going to fall 2.5 standard deviations below $\mu_\bar{x}$. Find the value for $\bar{x}$ that is going to fall 1.5 standard deviations above $\mu_\bar{x}$. Take note that these values are quite different from the ones you found in question 5. This is a demonstration of the difference between $x$ and $\bar{x}$.

Now return to Population, Sample, and Experimental Design sheet. Soon you will collect your data using this sheet.
Descriptive Statistics and Data Analysis

1. Now that you have your data you need to first find some descriptive statistics. Using your data set find the sample mean before and after for both groups; find the sample standard deviation before and after for both groups and also find the sample size for both groups. This can be done in one step in Minitab. Report all of that information here. Interpret each of the measures.

2. Next you need to find the mean difference for your honey group. You will do this in Minitab. First copy and paste your data into Minitab. Next make a blank column called Honey Difference. Next use the calculator to make the column operation of Honey After – Honey Before and store this in the Honey Difference Column. Now find the sample mean $\bar{d}$, sample standard deviation $s_d$, and sample size $n$ for the difference column. Report that information here.

3. Now you will use Minitab to construct a histogram for the After Honey column and the After Control column. To do this you need to click Graph, Histogram, choose simple, and select the columns and ok. You can change the labels on the graph if you need to do so. Now provide some analysis by either comparing/contrasting the two histograms or describing the shape of the histogram. What do you think the histogram indicates about the variable being represented in each histogram?
4. Using the information from question 1 on this sheet. Construct a probability distribution for sampling distribution of the honey group after and the control group after. Is \( \bar{x} \) providing a good estimate for \( \mu \)? Is \( s \) providing a good estimate for \( \sigma \)? Even though we know it is not true, assume \( \bar{x}_1 = \mu_1 \) and \( s_1 = \sigma_1 \) and \( \bar{x}_2 = \mu_2 \) and \( s_2 = \sigma_2 \). Remember \( \mu \) and \( \sigma \) are generally unknown so we would have to use an estimation of these values to do statistical inference. Make at least one interpretive statement about the variability in the sampling distribution for each group.

5. Next you will use Minitab to construct a box plot for each of the columns. To construct the boxplot, you need to click on graphs, boxplot..., Multiple Y’s simple, and choose all the variables at once. Make sure to check to see if you have any outliers.
Hypothesis Testing: Two Populations

At this point you should have your data for both your control group and your treatment group. You should also have the descriptive statistics for each group. For this activity you will need the sample means, sample standard deviations, and sample sizes. You should obtain this information from your Minitab file.

1. (10 min) Begin by considering the after columns for each group from your experiment. You need to make both a general hypothesis (in words) and mathematical statement of hypothesis. Make sure you include both the null and the alternative hypotheses (NS8 pgs. 50, 51, 53).

2. (10 min) Next you need to use the information obtained from your sample to calculate your test statistic. Assume equal variance for this test. First state which type of hypothesis test you are conducting (NS 8 pgs. 47, 50, 51). Then show the appropriate formulas for your test (NS 8 pgs. 50-51, 53). Finally fill in the formulas with the statistics from your experiment and calculate the test statistic. Decide whether you think your statistic is extreme or not.

3. (5-7 min) Once you obtain your test statistic you need to choose your critical value and calculate your p-value, (NS7, pg. 39; NS8 pgs. 51, 53). Make sure you state the level of significance you are using and the type of hypothesis you are using (left tail, right tail, two tails).

4. (7-10 min) Now sketch a picture of your sampling distribution with the critical value(s). Show where your test statistic falls in relation to the sampling distribution. Are you going to reject the null hypothesis or fail to reject the null hypothesis (NS 8, pgs. 52, 54)?

5. (10 min) Now state a conclusion based on what you have done in steps 1-4 (NS 8, pgs. 52, 54). Is this absolutely the truth based on the probability distributions you created on question 8 on Collecting Data: Probability Distributions? Based on the probability distributions you created have you made a type 1 error, a type 2 error, or neither (NS7, pg. 41).

6. (15 min) At this point you need to use Minitab to conduct your hypothesis test and compare the Minitab output to your answers for questions 1 and 2. Put the information you obtain from Minitab below. Include the p-value (NS7, 39). Explain your decision from question 4 based on the p-value.
Now we are only going to consider the treatment group. Specifically, we are going to consider the difference from before the treatment to after the treatment. If you have not already done so, you need to begin by calculating this difference using your data. (You did this on question 2 of the Descriptive Statistics and Data Analysis sheet.) To calculate the difference, you will need to take the after column for the treatment group and subtract the before column for the treatment group. This should be done in Minitab.

7. (5-7 min) Which type of hypothesis test are you conducting this time? (NS8 pgs. 47, 54-55) You need to make both a general hypothesis (in words) and mathematical statement of hypothesis. Make sure you include both the null and the alternative hypotheses.

8. (10 min) Before you can calculate your test statistic, you need to find the mean and standard deviation of the difference column from your treatment group (NS8 pg. 55). Once you have the mean and standard deviation, calculate the test statistic (NS8 pgs. 54, 55). The values you need for your test statistic can be found in question 2 of the Descriptive Statistics and Data Analysis sheet.

9. (5-7 min) Once you obtain your test statistics you need to choose your critical value and calculate your p-value. (NS8, pgs. 55-56) Be sure to state the level of significance you are using the type of hypothesis you are using (left tail, right tail, two tails).

10. (7-10 min) Now sketch a picture of your sampling distribution with the critical value(s). (NS8 pgs. 52,54-56) Show where your test statistic falls in relation to the sampling distribution. Are you going to reject the null hypothesis or fail to reject the null hypothesis?

11. (7-10 min) State a conclusion based on what you have done in steps 1-4. Is this absolutely the truth based on the probability distributions you created on question 8 on Collecting Data: Probability Distributions? Based on the probability distributions you created have you made a type 1 error, a type 2 error, or neither (NS7, pg. 41)?
12. (15 min) At this point you need to use Minitab to conduct your hypothesis test and compare the Minitab output to your answers for questions 7 and 8. Put the information you obtain from Minitab below. Include the p-value (NS7, 39). Explain your decision based on the p-value.

This time we will essentially combine the ideas from the first two hypothesis tests. Specifically, we are going to test to see if there is a difference in the differences between the control group and the treatment group. We already have the difference column from the treatment group. You need to calculate the difference for the control group. If you have not already done so, you need to begin by calculating this difference using your data. To calculate the difference, you will need to take the after column for the control group and subtract the before column for the control group.

13. (5-7 min) Which type of hypothesis test are you conducting this time? (NS8 pgs. 50-52) You need to make both a general hypothesis (in words) and mathematical statement of hypothesis. Make sure you include both the null and the alternative hypotheses.

14. (10 min) Next you need to use the information obtained from your sample to calculate your test statistic. Assume unequal variance for this test. State which type of hypothesis test you will be conducting (NS 8 pgs. 47, 50). Then show the appropriate formulas for your test (NS 8 pgs. 50-53). Finally fill in the formulas with the statistics from your experiment and calculate the test statistic. Decide whether you think your statistic is extreme or not.

15. (5-7 min) Once you obtain your test statistics you need to choose your critical value and calculate your p-value. Make sure you state the level of significance you are using and the type of hypothesis you are using (left tail, right tail, two tails). (NS 8, pgs. 51-53)

16. (7-10 min) Sketch a picture of your sampling distribution with the critical value(s). Show where your test statistic falls in relation to the sampling distribution. Are you going to reject the null hypothesis or fail to reject the null hypothesis? (NS 8, pgs. 51-53)
17. (7-10 min) State a conclusion based on what you have done in steps 1-4. Is this absolutely the truth based on the probability distributions you created on question 8 on Collecting Data: Probability Distributions? Based on the probability distributions you created have you made a type 1 error, a type 2 error, or neither? (NS7, pg. 41)

18. (15 min) At this point you need to use Minitab to conduct your hypothesis test and compare the Minitab output to your answers for questions 1 and 2. Put the information you obtain from Minitab below. Include the p-value. (NS7, 39) Explain your decision based on the p-value.
APPENDIX D

Invitation letter to Participants

You are invited to participate in a study attempting to determine introductory statistics students’ attitudes toward statistics. The research project is titled “Effects of Guided Project-Based Learning Activities on Students’ Attitudes Toward Statistics in an Introductory Statistics Course.” This study is being conducted by Timothy Jonathan Bayer to meet a part of the dissertation requirements of Old Dominion University. This study will be examining the relationship between the instructional approach of guided project-based learning and attitude toward statistics as well as student academic performance. If you do not wish to participate in the research, simply return your SATS-36 survey to the person administering it and inform him or her that you would like to refrain from participation. If after beginning the survey, you wish to stop participating, simply return your SATS-36 survey to the person administering it and inform him or her that you would like to refrain from participation. If at any point during the semester you would like to stop participating in the study, you may inform your course instructor.
VITA

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2013-Present  Associate Professor of Mathematics
Virginia Western Community College
2014-Present  Adjunct Lecturer of Statistics
Roanoke College
2013-2016  Vice President of Faculty Senate
Virginia Western Community College
2012-Present  Adjunct Instructor of Mathematics
Mary Baldwin College
2012-Present  Chair of Distance Learning Peer Review Committee
Virginia Western Community College
2012-2014  Chair of Finance and Facilities Committee
Virginia Western Community College
2010-2013  Assistant Professor of Mathematics
Virginia Western Community College
2009-2015  Consultant for State Testing in Mathematics
Roanoke City Public Schools
2008-2012  Director of Dual Enrollment for Mathematics and Science
Virginia Western Community College
2008-2010  Member of the Board
Blue Ridge Council of Teachers of Mathematics
2007-2010  Instructor of Mathematics
Virginia Western Community College
2003-2007  Teacher of Mathematics
William Fleming High School
Roanoke City Public Schools

Professional Organizations
2007-Present  Virginia Mathematical Association for Two Year Colleges (VMATYC)
2002-Present  National Council of Teachers of Mathematics (NCTM)