Web-Based vs. Classroom Instruction of Statistics

Dissertation

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Abstract

This study compares the performance and experiences in an introductory statistics course across two modalities: web-based and classroom-based instruction. The research was conducted in classrooms from each learning environment for two teachers at a large midwestern community college. The results from the Pre-Test, Post-Test, and departmental final exam indicated that students in web-based statistics courses can have levels of average achievement comparable to that of their classroom-instructed counterparts. Yet, the facts that distance learners entered the course with stronger levels of mathematical preparedness, and had greater proportions of students at the extremes of the performance indicators, jointly challenge the notion of web-based instruction being "as good as traditional." The faculty interviews, student questionnaires, and both virtual and physical instructional observations informed the researcher that the successful teaching strategies in the classroom can have an online comparative. Independent of modality, students desire teacher immediacy. It is also confirmed that the asynchronous nature of online learning that allows students to learn at their own pace will continue to drive student interest in spite of any potential barriers. The researcher recommends that future studies control for relevant student characteristics and any instructor effect to measure overall learning gains over longer periods of time. Hybrid courses were discussed as being the next modality on the horizon that would merit further research.

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Field of Study

Major Field: Education

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Nomenclature

Web-Based Instruction (WBI): Instruction that occurs between teacher and student that is facilitated strictly by use of the World Wide Web. The teacher is able to post curriculum, notes, etc. on a particular platform for student review. The student is in no way required to come to campus. Common synonyms include online learning and virtual learning. Online learning is used interchangeably with web-based instruction in this document.

Hybrid Courses: Courses that are primarily rooted in WBI, but have a regular mandated time set aside for some form of classroom instruction. Hybrid courses are commonly referred to as "blended" courses.

Classroom-based Instruction (CBI): The more traditional form of education between student and teacher. Common synonyms include "traditional" and "face-to-face" instruction.

Platform: the mechanism that stores data for web-based courses and provides a general structure for them (also referred to as a 'course management system').

Chapter 1: Introduction

Rationale

Web-based instruction (WBI) in statistics is here to stay. With the education industry's increasingly scarce resources, WBI has been considered cost-effective (Kirby, 1998) and is therefore of great appeal to school administrators. Evidence of similar levels of achievement as peers who receive classroom-based instruction (CBI) (Wisenbaker, 2002; Gunnarson, 2004) and the prospect for utilizing current and emergent technologies to create new opportunities for active learning (Garfield, 2004; Malone & Bilder, 2001) jointly evoke teachers' interest. Furthermore, students consider WBI to be of great appeal due to the flexibility and the new opportunities for virtual collaborations with classmates that it affords them (Frey & Alman, 2003). More students are using the World Wide Web (www) in other courses as well; hence, its usage in statistics does not seem far-fetched. With the interest of the three critical stakeholders piqued, WBI has delved into one of the more timeless areas within the academy—the mathematical sciences.

The Sloan-Consortium developed the Making the Grade: Online Education in the United States annual report (2006), which indicated that in the fall of 2005, over 3 million students were taking at least one course online. The Midwest alone had 460,000 students enrolled in more than 500 institutions doing so, and across the country, 4,491 institutions were offering online courses. In fact, 98% of large, public institutions had at least one online offering. Conversations as to which modality is “better” (WBI or CBI) continued with 62% of Chief Academic Officers from the schools in the study believing that online learning can have at least the same quality of instruction as in-class instruction and even 13% believing WBI is better than the traditional classroom. Blasphemy perhaps? With an astounding 62.8% of all Midwestern undergraduate students enrolled at an associate degree-granting institution taking online courses, it is indeed time to incorporate associate degree-granting institutions into the WBI vs. CBI discussion.

In mathematics, the exploration into the field of online learning has been quite cautious, but it is now gaining in momentum. This excursion has begun with statistics—the discipline that lends itself well to WBI—by virtue of the propensity for active-learning strategies and the incorporation of technology (Garfield, 2004). Further probing of this field with a proven history of strong academic performance identified a student population that would be most desirous of flexibility with course offerings. Hence, graduate students enrolled in survey-oriented statistics courses (Dereshiwsky, 1998) have become a viable target of WBI.

As the rest of students’ lives reflect more of the 21st-century technological advances, the delivery of their mathematics and statistics courses follow suit. Today’s ubiquity of wireless internet access and pop-up banners encouraging online learning programs have thrust a new arena of learning upon us. The question for those within the mathematical sciences now centers on whether this new arena is more appropriate for those in the arts as opposed to those in the sciences. Specifically beginning with the discipline that is already being explored, can students of WBI in statistics have comparable levels of performance as their peers receiving classroom-based instruction (CBI)? Moreover, what does WBI entail? This study will address these questions in the context of the instructional institution most amenable to embracing WBI, the community college.

As one exemplar, the mathematics offerings using WBI increased at the institution where this study resided from 201 students in two courses in 2002 to 842 students in four mathematics courses in 2008. For the same period, the introductory statistics course enrollment grew from 136 in 2002 to 507 in 2008. The 270+% growth for one particular course was more than double the rate of the other mathematics offerings. With this course equally satisfying degree requirements for hundreds of students (just at this institution alone), student performance and mastery are of critical importance. The time to investigate this phenomenon has indeed come.

Purpose

This research study investigates student performance and mastery in the web-based instruction of an introductory statistics course and compares it to the classroom-based instructional course. Performances on common assessments between the two groups were compared. The pedagogy, interactivity, and types of students that typify the web-based course will also be uncovered. Because this study involves undergraduates and independent learning is a critical element of effective distance education (Frey & Alman; 2003), adult learning theory will be quite relevant (Knowles, 1975). However, social interaction among students and between student and instructor is becoming increasingly important to distance education (Stacy, 1999). Hence, Vygotskian theories on social learning will also be employed in the design of qualitative instrumentation and in conducting virtual observations of web-based instruction. To further underpin the research, various pedagogies associated with statistics-reform related “traditional” classroom-based statistics courses will also be included (e.g., emphasis on the graphing calculator, group work, etc.) (Rouncefield, 1993).

Then various pieces of literature will be discussed. Research on web-based instruction is becoming more widespread, but it is only slowly reaching research specific to mathematics and/or statistics. Findings from studies in the wider arena and discussion, in greater detail, of the findings more directly related to statistics courses are both provided in the second chapter of this document.

The methodology section describes the details employed in executing the study. The six instruments (four quantitative and two qualitative) are described within the methodology chapter and analyzed in the following chapter. The study closes with some discussion of the analyses, reflects on the questions initially posed, and identifies areas of future research.

Conceptual Framework

The conceptual framework for this study is a hybrid of the learning theories that support both Distance Learning and Statistics Education and can be visually represented by the organizational chart in Figure 1.1.

Conceptual Framework Underpinning the:

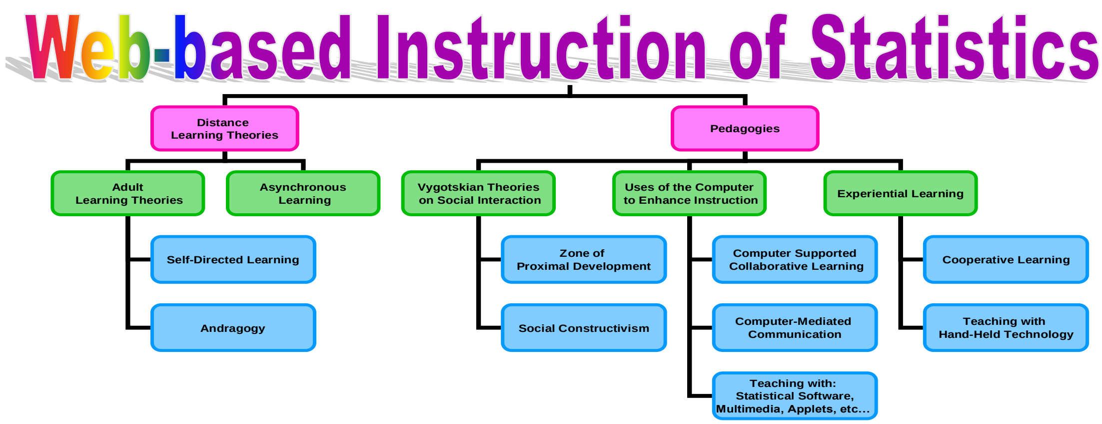

Fig. 1.1. Conceptual Framework

Adult Learning Theories

Self-directed learning has been described as the process whereby individuals take the initiative, with or without the help of others, to diagnose their learning needs, formulate and implement learning strategies, and evaluate learning outcomes (Knowles, 1975). The field of adult learning was pioneered by Malcolm Knowles, and the majority of adult learning is self-directed learning (Cross, 1981). Many self-directed learners aspire to gain new skills and knowledge for professional benefit, or they participate in activities for recreational reasons. Practically any of the "Do-It-Yourself" home improvement activities are prime examples of self-directed learning.

As defined by Malcolm Knowles in 1980, andragogy, "the art and science of helping adults learn" (p. 61), is the most renowned of the adult learning theories. Andragogy refers to the desire for learners to have control, flexibility, and feedback. This can be manifested in how adult learners view their roles: they are learners secondary to other life roles, such as parents, caretakers, and employees.

Another aspect of adult learning theory is motivation. At least six factors serve as sources of motivation for adult learning: desire for social relationships, compliance with someone else's expectations, desire to better humanity, personal advancement, relief from daily routine, and cognitive interest. The best way to motivate adult learners is to *enhance* their reasons for enrolling in a course or program and *decrease* any significant barriers. Distance Learning, and specifically web-based instruction, accomplishes both aims.

The Need for Social Interaction Among Adult Learners in the Online Classroom

Since adults are self-directed learners, it has become obvious that they would be the primary market for web-based instruction. They would continue to learn independently and have even less synchronicity, or learning at a specified time in a specified location. However, Frey & Alman (2003) mentioned that even in the virtual classroom, adults have expressed a need for interaction, which is consistent with one of their motivating factors for partaking in the learning process.

These learning theories have their place in the context of online education. However, according to Wegerif (1998), students in his study strongly valued online interaction with their instructors and classmates as they moved “from outsiders to insiders” (p.48). Hence, he speculates that the interaction between students and instructor, the interaction among students, and active learning are all vital to successful adult learning experiences.

To attend to this demand, many universities have incorporated on-campus experiences, which generally consist of two or three face-to-face class sessions during the semester, in addition to their distance education courses. The on-campus aspect of instruction has been shown to have a positive impact on learning, retention, and learner satisfaction, (Brown, 2001). This need for on-campus experiences refers explicitly to the need for social interaction among learners. Theoretical support of social interaction is further supported by Lev Vygotsky’s Sociocultural Theory and Zones of Proximal Development.

Vygotskian Theories Regarding Social Interaction

The major theme of Vygotsky's (1978) theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky’s sociocultural theory of learning emphasizes that human intelligence originates in our society or culture and individual cognitive gain occurs first interpersonally (interaction with social environment) and then intrapersonally (internalization of knowledge). This can exist via scaffolding by the teacher or classroom discussion.

Another aspect of Vygotsky's (1978) theory is that the potential for cognitive development is limited to a certain time span that he calls the zone of proximal development (ZPD). Vygotsky defined ZPD as a group of activities that individuals can navigate with the help of more capable peers, adults, or artifacts.

Instructional strategies informed by Vygotsky’s (1978) ZPD are cooperative learning and cognitive apprenticeship (a term for the instructional process in which teachers provide and support students with scaffolds as the students develop cognitive strategies). Vygotsky's sociocultural approach of learning and ZPD can be successfully employed in the study of online learning and can help fulfill the adult learners’ need for social interaction even within self-directed situations.

In the web-based learning environment, learners can maximize their zones of proximal development through interaction with their professor, a classmate, or even a text-supported tutor. The construct of social presence pertains to members of the web-based environment providing personal characteristics to present themselves as “real people” (Pelz, 2004). This allows for some of the dynamics and culture which typify classroom instruction, and thereby provide the learner with a learning environment that increases comfort and reduces anxiety, to be replicated in the web-based environment. Students may use Discussion Boards, e–mail, and other devices to communicate with one another and address problems and concerns. The essential question is to what extent these human resources are being utilized. This study investigated the social interaction that occurred within two web-based statistics courses.

Asynchronous Learning Networks

In all ages, there have been people of great motivation that have studied by themselves. Even with technological advances, off-campus learners have worked mainly in isolation, with only occasional contact with instructors and peers. Most of today's distance education techniques can be grouped into two categories: self-study techniques, with little or no human interaction, and techniques with limited human interaction. Both approaches limit learners in their ability to interact with others.

Low-cost communications and computer technologies, however, enable learning in Asynchronous Learning Networks (ALNs) to flourish. These ALNs overcome barriers of isolation, distance, and imposed time constraints (Mayadas, 1997). Asynchronous Learning Networks are a relatively new kind of distance education. They combine elements of self-study techniques and asynchronous interactivity.

The appeal of ALNs lies in their ability to enable anytime, any place education with high human interactivity for geographically-distributed cohorts (networks). Today, this type of learning system occurs more with World Wide Web-based learning and online reading materials than via telephone conference calls, as correspondence courses have been formatted (Bourne, McMaster, Rieger, & Campbell, J., 1997).

Building on the Internet opportunities, online courses and degrees are developed using the concepts and principles of asynchronous learning networks. They have fundamentally altered the face of higher education in the United States, specifically in the area of distance education and lifelong learning. In just a few short years, ALNs have become the predominant distance education medium, quickly outpacing and replacing all other delivery modes (Oakley II, 2004).

Computer-Mediated Communication

Over 400 years ago, the printing press revolutionized our communication with one another. Today, a similar statement could be made about the Internet and the World Wide Web. These innovations have implications for our classrooms—especially the adult-laden online classroom. Combining the flexibility of the Internet with the tenets of asynchronous learning, computer-mediated communication (CMC) was born.

In computer-mediated communication, the computer serves as a mediator rather than the typical role of an information processor. This creates a favorable environment for asynchronous learning networks. CMC usage in instruction occurs in three ways: conferencing (e.g., e–mail, Discussion Boards), informatics (storage facilities of information for public access), and computer-assisted instruction (CAI) (Santoro, 1995). In addition, CMC facilitates student-to-student and student-to-teacher interaction, even potentially across the world. Independent learning is promoted, and a paradigmatic shift in teaching and learning from distance education to Distance Learning can occur.

A preliminary observation from the research is that variations in underlying educational perspectives based on the faculty member’s own experiences significantly affect the extent to which a teacher promotes CMC (Annand & Haughey, 1997). As such, I would expect that the extent to which CMC is used in the virtual classroom will only increase over time as faculty familiarity and comfort increase.

CMC instructors perform a number of functions, such as assisting students in understanding and taking control of their learning processes, providing them with emotional support, and carrying out administrative and organizational duties. Even still, for learning to occur, a strong element of a teacher presence is required and needs to be improved (Brown, 2001). A teacher presence allows the learner to experience meaningful outcomes brought on by the instructor's guidance of mental and social processes. Pelz (2004) identified the asynchronous instructor's role of dialogue facilitator or deliverer of content as actions that reflect teaching presence.

Computer-Supported Collaborative Learning

Computer-supported collaborative learning (CSCL) has grown out of wider research into computer-supported collaborative work (CSCW) and collaborative learning (Santoro, 1995). CSCW refers to the emphasis on the communication techniques, and CSCL focuses on what is being communicated. Both are based on the promise that computer-supported systems can enhance and facilitate group process. Theories involving social interaction and asynchronous learning have led to the emergence of CSCL and are based on the same underlying assumptions—that individuals are constructing knowledge within a meaningful social context.

Active and Experiential Learning

While there are many different theories of learning, research generally indicates that optimal adult learning occurs when the training participant is actively engaged in the learning process (Eastern Kentucky University, 2004). Rogers (1969) distinguished two types of learning: cognitive (academic knowledge) and experiential (applied knowledge). Experiential learning theory connects with adult learning theories with statistics reform initiatives. The transfer of knowledge occurs when learners are participants in problems of personal relevance and they are allowed to reflect on their learning. The tenets of this theory are evidenced by the cone of learning (Dale, 1969), whereby one learns more from direct purposeful learning than from mere verbal symbols.

Active learning strategies suggest that all learning activities involve some kind of experience (hence synonymously referred to as experiential learning) or some kind of dialogue. In "dialogue with self," (Fink, 2004) the learners reflect on a topic in terms of their own metacognition, or the learners reflect on how their own learning occurs. The learners consider why they chose to take certain steps and not others. In "dialogue with others," the teacher creates ways for the students to communicate among themselves or with prospective experts outside of the class (Fink).

The experiences, both observing and doing, may occur directly or indirectly. Direct observation occurs when the learner observes the real action, e.g., actually attends a high school statistics class session. Indirect observation refers to observing a simulation of the event, e.g., reading a journal article on the activities that occur within a high school statistics class. And in similar ways, the experience of doing occurs directly and indirectly.

The learning by doing and cooperative pedagogies have emerged as popular byproducts of the active learning theory (Garfield, 1993; Rouncefield, 1993). Both products are of paramount importance in Statistics Education. Garfield and other statistics reformists subscribe to instruction that consists of concrete experiences versus mundane formulaic computations.

The Teaching and Learning of Introductory Statistics Courses

Requiring more professionals to possess statistical literacy naturally results in more learners of statistics, and hence, more teachers thereof (Garfield, et. al., 2002). These forces have led to a need for more than the adequate teaching of statistics and for research on the best way to teach statistics to various groups of students. Faculty and administrators have had to rethink how to offer statistics to enhance affect (Filebrown, 1994). To this end, new teaching philosophies have emerged. The preexisting major philosophy is one with a de-emphasis on traditional formula-based computations to bring about a focus on statistical ideas that are present in everyday life and practice through experiential learning (Smith, 1998). Today's topics in statistics education cover a spectrum of areas including curricular reform in statistics, the use of cooperative learning and projects, innovative methods of instruction, assessment, research (including case studies) on students' understanding of probability and statistics, research on the teaching of statistics, attitudes and beliefs about statistics, the use of computers and other media in teaching, statistical literacy, and distance education.

Statistics is more of a physical science than a traditional mathematics course, and researchers in statistics education believe that these courses should be taught with active learning strategies (Gnanadesikan, et. al., 1997). Activity-based learning deepens the understanding of probability, data collection, and distributions of random phenomena. In fact, it was once boldly stated, “A statistics course at a university should have as many laboratory hours as physics or chemistry” (p. 4). The more successful probability activities challenge students' intuitions and attempt to increase understanding of variation and chance (Keeler, 2001). These types of active learning strategies enhance learning and improve the students’ attention, motivation, and comprehension.

In 1998, Gary Smith incorporated a semester-long sequence of projects, including written and oral reports, into his statistics teaching. Smith used projects to help students learn by doing, communicate, and use relevant examples from various disciplines. He adds, "Instead of asking students to work on 'old' data, even though real, is it not better to have them find or generate their own data?” (p. 2) The semester that projects were used, Smith noticed that midterm examination grades were over 10% higher and half as variable. In his learning-by-doing approach, he helps students develop their statistical reasoning to supplement “what they have heard and read about statistics by actually doing statistics -- designing studies, collecting data, analyzing their results, and giving oral presentations.” (p. 2)

In 1994, Filebrown indicated that students should collect data via surveys, experiments, or observational studies and that curriculum is “honed” and knowledge is best constructed when students conduct personalized research. Many other instructors consider student-conducted projects in statistics courses to be an authentic assessment that provide information about students’ understanding in realistic contexts (Albert, 2000). A student project gauges the students’ understanding of the entire statistical process, judges the students’ ability to interpret statistical arguments and computer output, assesses the students’ ability to work with others and communicate results, and increases student interest in statistics. These are all consistent with the reform efforts that now exist in statistics education.

Others suggest that the use of active strategies, including David Pugalee (2002), who says that classroom discourse can be promoted through spoken and written language, graphic representation and the active mode of performing, demonstrating, and physical involvement. Pugalee mentioned that conveying mathematical concepts in both written and oral forms prepares students for the requisite reasoning skills necessary for the successful use of mathematics in the real world. Practical work is not just relegated to projects, but they can take place on a regular basis. Rouncefield (1993) proposes the frame of having a practical activity, collecting real data, discussing it, and then developing a model.

Researchers have reported success from cooperative practices in statistics as well. Joan Garfield’s (1993) meta-analysis on the use of cooperative learning (CL) activities in teaching and learning statistics looked at different ways of using CL, rationale for learning activities, and identifiers of success. She also describes how usage of CL can improve attitudes and increase achievement.

Courtesy of the Guidelines for Assessment and Instruction for Statistics Education, an immediate goal for the introductory statistics course has been to emphasize conceptual understanding and attainment of statistical literacy and thinking and to de-emphasize teaching a set of procedures (GAISE, 2004). A carpentry analog was cited, intimating that students should be taught how to “build a table” instead of learning “characteristics of different types of wood.” Building the table is the active process of learning statistics. These six recommendations are rooted in active learning:

1. Emphasize statistical literacy (terminology) and develop statistical thinking (processes);
2. Use real data;
3. Stress conceptual understanding rather than mere knowledge of procedures;
4. Foster active learning in the classroom;
5. Use technology for developing conceptual understanding and analyzing data;
6. Use assessments to improve and evaluate student learning.

Real data adds an element of authenticity to data analysis whereby students’ thinking is broadened through concept discovery and not just uncovering methods. Active learning allows students to construct and understand important statistical ideas. Activities are often enjoyable and engaging. Technology should be used in ways that truly leverage the increased functionality it now affords learners. For example, using Minitab just for data entry was not an implicit recommendation. Instead, technology should be used for developing concepts and analyzing data, such as using simulations to estimate p-values based upon graphical displays. And assessments must be in concert with instructional methods. The recommendations have laid the foundation for the new era in statistics education and specifically for the epistemology that is to underscore teaching the introductory statistics course.

If the traditional classroom-instructed statistics course is experiencing a change in the instruction of probability theory, an increase in active learning strategies, and a substantial amount of cooperative learning, is it safe to assume that the web-based courses are experiencing similar changes? This study investigates this notion and others. Reform efforts are also informing us of greater amounts of cooperative teaching among faculty. In this environment, teachers share ideas and work together toward a common greater quality of teaching (Rumsey, 1998). The instructors maintain vitality within their own classrooms by exchanging ideas and success stories with each other.

The Role of Technology in Statistics Education

Research on how statistics is taught and learned is still relatively new. Hence, any research on the usage of technology, let alone web-based course offering research, is only in its rudimentary stages.

Statistics is a discipline that has evolved with technology. Advancements with the computer have also helped propel statistics. The computer here is more than the mediator, as with CMC. In statistics, computing should be taught to promote a digital hands-on environment. In 1995, Romero and his colleagues revamped their introductory statistics courses in engineering and computer science schools for the benefit of approximately 90 students per class, totaling over 800 (Romero et. al., 1995). Teachers work with students to motivate the teaching of new concepts, collect relevant data, and use

STATGRAPHICS to create graphical displays of the data; then the students have an opportunity to perform similar analyses. As a result, the attendance rates increased from 65% to more than 90% with an 85% pass rate. Romero and his colleagues believed that this type of instruction reduces or even eliminates the time devoted to boring and often practically impossible calculations done by hand. Students can then focus on questions relevant to the problem at hand and on the interpretation and analysis of the results.

Multimedia devices provide more graphics, create a more enjoyable course, and can augment conceptual understanding for students (Robinson, 1993). In the 1990s, introductory Statistics students primarily used graphing calculators which, in many cases, have similar capabilities as basic statistical computing software. Current technology, used by these students, includes a variety of well-known statistics software packages used in industry—from Excel to SAS. For example, “sliders” and applets allow the user to interactively manipulate the effects of changing the mean and standard deviation of a distribution.

Advantages of a multimedia approach include increased logistic flexibility, greater interactivity, timely and universal feedback on students’ state of knowledge, uniformity of lecture content, self-paced learning, and more class time available for activities and student presentations (Ferris & Hardaway, 1994). Ferris and Hardaway believe that the classroom of the future will shift from same time same place (STSP) to a more asynchronous environment. The role of the professor in this scenario would be to serve as the statistics coach and facilitator. This vision lays the foundation for the possibilities of web-based delivery of the introductory statistics course.

The newest and most popular technology is the World Wide Web. Statistics courses with a web presence often use course home pages to provide information to students, such as assignments and announcements. The web-enhanced course utilizes web technology and services to provide course materials and resources (Malone & Bilder, 2001). The web-centric course uses the Web to manage class materials and support communication between members of the web community. JAVA applets, similar to the slider, can be included to graphically display how changes in a parameter's value may affect a function. Videos can further enhance the presentation of content on the web. College students are using the web in other courses, and it is becoming more integrated in their daily lives, so usage in a statistics course will become even more natural for future students. As our students' lives reflect more of the 21st century, their statistics course should also reflect less of the 20th century.

The usage of computers and the World Wide Web make it easier to consider alternatives to traditional methods and formats used in education (Garfield, et. al., 2002). Nevertheless, when considering web-based instruction, it must be mentioned that there has been some resistance from faculty. It must be clear that software is used only to assist the teacher, not to replace him or her (Robinson 1993). Computers, and consequently web-based courses, are not panaceas, and they do require effective teaching to facilitate student learning. Pagnucci (1998) asserts

New educational technologies can challenge even our most fundamental ideas about what it means to teach and learn and I saw, in the ensuing discussion, that it was these conceptual shifts that made it so difficult to discuss my proposed course." (p. 48)

This makes web innovators timid for fear of standing out, and they usually encounter difficulty in getting others to adjust their own educational philosophies. Using the Web, statistical software, and even new pedagogies pose challenges, mainly because they are different from the medium faculty used when they learned statistics as students. However, as mentioned earlier with ALNs, CMC, CSCL and knowing we have self-directed learners as our students, I believe that it will be faculty themselves who will have to modify their own perspective on how learning should occur within the 21st century statistics classroom. Adequate knowledge of these components together can inform us on how to best teach statistics in an online context.

Web-based instruction of statistics relies upon the concepts and theories presented in this section. At the heart of this mode of instruction is that the adult learner will be self-directed and self-motivated enough to allocate the requisite time to master the material. Yet, even though the adult is learning, at essentially his own pace, Vygotsky would assert that his understanding of the material can be maximized by assistance from another person. Hence, there is a need for CMC or ALNs to exist. Also, the content being delivered is replete with various uses of technology and experiential learning pedagogies that can better promote higher conceptual understanding than if rote formulaic strategies were used. The novelty of this within the statistics community is now leading to an emerging dialogue among professionals. The research conducted in this study will help solidify any formal positions taken by these organizations.

Problem Statement

Colleges throughout the country continue to deliver more courses via the Internet (Oakley, 2004). Oakley indicated that the consortia of Illinois colleges (forming the Illinois Virtual Campus) enrolled over 50,000 students in over 3,700 online courses during the fall of 2003 alone. The quandary lies in whether the nature of learning statistics is consistent with the strictly web-based comparative. Hence, the researcher developed a few questions about the teaching and learning that occurs within strictly web-based statistics courses. The first question is if students in web-based statistics courses have comparable levels of achievement as those who receive classroom instruction. Second, what types of learning, pedagogy, and interactive experiences describe the web-based learning environment as compared to classroom-based instruction? I synthesized these two issues into one problem. My research compares the experiences and performance of students in a web-based statistics course at a local community college with those of students in face-to-face classroom-based courses. Through research, I intend to answer these questions and will extend existing research on whether Distance Learning of statistics is a viable (or even preferred) alternative to traditional face-to-face offerings. Findings of this study will be particularly useful to faculty and administrators of higher education institutions who may desire to expand the number of undergraduate web-based statistics and mathematics courses and to any K-16 educators who are considering ways to best serve their non-traditional students.

Research Questions

1. Do students in web-based statistics courses have comparable levels of achievement as those who receive classroom instruction?

2. What types of learning, pedagogy, and interactive experiences describe the web-based learning environment as compared to classroom-based instruction?

Hypotheses

The researcher believes that modality of instruction will not significantly affect student achievement. The literature (Wisenbaker, 2002; Gunnarson 2004) suggests that comparable levels of learning can occur. And assuming good communication between faculty and students, performance on common assessments can be similar.

Social interaction will be necessary for student success. The theoretical comments earlier suggest that students desire communication. And since communication can strengthen social interaction, higher levels of success can be achieved.

Success is a function of one's self-motivation for study of the topic (Knowles, 1980). This is critical, especially for students in web-based courses. The student must be able to motivate himself, because actually seeing a classroom, an instructor, or a classmate may theoretically never occur.

Delimitations

The institution where the study was located has recently begun offering hybrid courses, whereby students attend a 1-hour review section on campus weekly. Yet, I chose to not include this type of instruction in this study to focus primarily on instructional settings that have been taught for at least 2 academic years. Also, I valued researching web-based instruction because of its extreme contrast to classroom instruction and its increasing popularity. I believe that if web-based instruction could yield comparable levels of achievement as classroom-based instruction, then students enrolled in hybrid courses should perform at least as well. Therefore, I foresee researching the effectiveness of hybrid learners as a study that will be attempted after this one.

Limitations

A natural limitation of static group comparisons and nonequivalent control group designs, in general, is that subjects are not randomly assigned to the treatment nor to the control group. For this study, I was unable to randomly assign subjects to the web-course and others to the classroom course. Students self-selected their modality of instruction based upon preference and section availability.

Chapter 2: Literature Review

Overview

With the dawning of the 21st century has come a new avenue for distance education. Electronic mail and the World Wide Web have made it possible for learners separate from their institutions of instruction to bypass usage of postal carriers and use more direct communication between teacher and student. There are other advantages that web-based learning affords the teacher, student, and institution. However, one main challenge to this mode of delivery has been in establishing a communication among students with all of the players involved.

While research on Distance Learning has emerged over recent years, research within these circles that is specific to mathematics and/or statistics education is still in the formative stage. In this chapter, research on distance education as a whole is discussed, then a few articles that look into the social component of distance education are provided, and finally, the new work in this field as it pertains to teaching statistics is described.

Distance Education and Online Learning

The Sloan-Consortium developed Making the Grade: Online Education in the United States annual report (2006). Then it created more specific supplements for each geographic region. The Midwest section includes a total of 11 states extending from

Nebraska to Ohio. In 2005, the number of students taking at least 1 course online during the fall of 2005 was over 3 million. The Midwest had 460,000 students enrolled at more than 500 institutions. The consortia contacted the Chief Academic Officers (or Presidents) and made two attempts to reach them. In total, of the 4,491 institutions contacted, 2,472 returned responses (a 55% increase). In the Midwest, of the 706 institutions contacted, 573 returned responses (81% response rate). These responses showed that 98% of large, public institutions have at least one online offering and that 62% of the Chief Academic Officers now believe that online learning can have at least the same quality of instruction as in-class instruction. Up to 13% of them believe WBI is better than the traditional classroom. CAOs further determined that students need more self-discipline. Demand for WBI exists, and the employers have not taken issue with the content-knowledge of those enrolled in WBI. An astounding 62.8% of all Midwest undergraduate online students are in an associate-degree granting institution. With the online community college course possessing such a following, it is indeed time to incorporate associate-degree granting institutions into the WBI vs. CBI argument. Distance education does indeed reach a great number of students and is “ideal” for persons who are geographically separated from campus. It is also advantageous for students whose professional obligations make regular travel to campus problematic. In 2000, Hyland proposed that web-based learning has a “Win-Win-Win” effect that accompanies it. In a summary of findings from several studies conducted by the Epic Group, SunTAN, and the Royal Bank of Scotland, Hyland states that the trainees benefit by better access to content that can be completed at one’s own pace and management benefits because of the ease with which both individual progress and success of the training method can be evaluated. The final win is in the fact that, after the initial development and start-up costs, the online infrastructure can lead to significant reductions in personnel and utility costs, among others.

Web-based learning is also preferred because of its ability to provide supportive instructional discourse. More learners can provide remarks that are of greater substance and enrich course dialogue (learners see the exact postings of other classmates and deliberate over their own responses). With the advantages of the “Win-Win-Win” and the potential for supportive discourse, many colleges have seized the opportunity to offer distance courses and even full-fledged distance programs.

The construct of “presence” (social, cognitive, and teaching) is critical to Distance Learning courses (Pelz, 2004) and transcends conversations that refer to discourse alone. Social presence allows students to project their non-academic interests and provides a collegial basis among the students. Cognitive presence allows for reflective thought on content presented on the learning outcomes. Teaching presence coordinates the social and cognitive presences into avenues for personal meaning and learning.

Pelz, a 2003 Sloan-C award winner for Excellence in Online Teaching, advocates three principles for effective online pedagogy. First, let the students do (most of) the work. This includes finding additional web resources for the course and helping each other learn by answering each other’s questions regarding content. Second, interactivity should be at the heart and soul of effective asynchronous learning. This allows students to work together on collaborative research papers and proposals. Third, instructors should strive for presence. Teachers should use their skills to facilitate the other two types of presence—through direct instruction or facilitation of discussions.

Codifying these principles provides a published exemplar for many online courses to follow. The prevalence of these principles provides structural ways for the web-based environment to replicate the classroom in qualitative ways. In cases where Distance Learning is not 100% possible, institutions have incorporated on-campus instruction.
In 1999, Stacey determined that Distance Learning should be dynamic, collaborative, and group-oriented. By placing her MBA students who were situated far from the institution in groups and by making computer-mediated-instruction a course assessment, students were able to learn collaboratively in several ways. Students learned collaboratively by sharing their own diverse perspectives, clarifying others' ideas, and using the group to test out new theories before sharing them with the entire class. Moreover, learning was no longer relegated to business hours since students were able to communicate around the clock. Once, the instructor was stunned by the numbers of students communicating at 1:30 a.m. "Talking" was done electronically, and data analysis was based on transcriptions of the dialogue and student interviews. The students were fundamentally invested in the educational process (their own and their fellow group members), and the teacher as served as the facilitator. Many of the participants mentioned that being forced to participate "increased their confidence in expressing ideas to a group of unknown peers" (p. 5). Another finding from this qualitative study included a reduction in student sense of isolation because of their increased sense of connectedness to the class. Initial studies on web-based courses did not pay much attention to establishing social

connections for students. But Stacey, and now others, are now informing us that students need conversation, electronically or in person, to help facilitate learning.

Teacher presence can impact student success and satisfaction with the online course (Richardson, 2003). Richardson studied 97 of the 369 students in a particular course, and those with high perceptions of social presence also had high levels of perceived learning and instructor satisfaction. This association was stronger than that of some of the traditional demographics (age, number of college credits earned, etc.). Specific tasks, such as group projects and written assignments, were beneficial to the online students.

Teacher immediacy is also a related measure quantifying the distance placed by a communicator between themselves and the object of their communication. Verbal and nonverbal immediacy in the traditional classroom environment has a history of having high immediacy reflect improvement in student attitudes. The challenge in web-based learning is to provide comparable levels of immediacy with associated results. Richardson's description of the effects of presence on perceived learning and satisfaction with the instructor clearly imply that presence is critical to the online learning environment. Social presence can also have benefits among classmates.

Social interaction among students was also a factor studied by Zachariah (2000). His graduate-level educational administration course consisted of three modules: one completely conducted in a distance format, another in which class attendance could be replaced by e–mailed work, and a third that required attendance and in-class discussion. The students considered his course to offer them greater flexibility with similar levels of collaboration as face-to-face offerings. Because of their positive experiences with this medium, the students were likely to enroll in future online courses.

O'Neal (2009) also investigated to what extent the richness of discussions and themes selected were similar between classroom and web sections for an undergraduate education course. Each section was composed of 22 students. The students had similar course materials and discussion questions. Students in the web-based section used Discussion Boards as their vehicle of communication via the WebCT course management system. Text from these conversations were printed for data analysis, data from the classroom-instructed section was transcribed via tape recorder.

The WBI and CBI students demonstrated positive productive on-topic dialogue. Both groups of students' conversations centered on similar topics including classroom management, assessment, social aspects, and organization. In the web-based environment, students draw meaning from collaboration and an ability to readily reference recorded opinions. The classroom instruction lends itself well to the non-verbal communication that supports the discussion. Nevertheless, O'Neal inferred that content-related questions should structure discussions regardless of modality. The research conducted by O'Neal supports the "just as good as traditional" literature that exists regarding web-based instruction. Bernard, Lou, and Abrimi extended the conversation through their meta-analysis.

Positive experiences with online education are not just limited to education courses. Candler and Blair (1998) researched medical students' experiences with a web-based course component. From surveys and in-class discussions, they surmised that the students faced technical obstacles, such as owning computers that could not facilitate quick downloads. Nevertheless, students commented that the web-based course and digital computer imagery helped them to better understand neuroanatomy concepts that were taught in class.

Tucker (2001) compared Pre-Test scores, Post-Test scores, learning styles, age, homework grades, research paper grades, Final Exam scores, and final course grades of her students in her web-based traditional business communication class with her classroom-based section. She found that the distance students were significantly older and had significantly higher Post-Test and Final Exam scores. These findings supported her claim that Distance Learning was at least "just as good" as learning in traditional classrooms, as long as the method and technologies used are appropriate to the instructional tasks, there is student-to-student interaction, and there is timely teacher-to-student feedback.

With the moral dilemma looming over web-based instruction (i.e., should institutions market an unproven and controversial modality …) in 2002, Bernard and, his colleagues, decided to probe across the body of existing studies comparing WBI and CBI under the correct pretense that, " 'no significant difference' does not 'prove the null (Bernard, 2002, p. 1). '"One hundred and sixty-nine (169) of 712 studies were included based upon explicitness of methodology. "Achievement" referenced performance on specific individual assessments. "Success rates" pertained to metrics associated with course completion. Using effect sizes, WBI emerged as having statistically significant higher levels of achievement (d=.24). Success rates were slightly lower for WBI than for

CBI (d= -.11) – though not statistically significantly lower. Attitudes towards the course were also measured and were deemed to have minimal difference amongst the modalities. A preferred result from this study would have been to see higher achievement with at least comparable levels of success. However, it could be gleaned from this meta-analysis that, “WBI yields higher performance with slightly fewer students.” An assertion that this dichotomy would imply being “as good as,” could be problematic. Similar to the colloquial phrase, “Two wrongs, do not make a right” is the notion that a positive and negative cannot necessarily offset to result in an equivalence relation. Bernard intends to conduct subsequent analyses to better ascertain any conditions under which distance learning is more helpful, or more of harmful, to student learning. Bernard looked at quantitative metrics across scores of studies. However, this still does not inform the avid reader about the type of instruction that occurs in the virtual environment. Kim and Bonk broached this matter in 2006.

Kim & Bonk (2006) hypothesized that the trifecta of pedagogy, technology, and learner needs will intersect for a “perfect storm” that WBI might want to prepare for. The three items are harmonious in that faculty should receive additional training for new technology designed for attending to student needs. Currently, a wide chasm exists between the text-driven nature of many online offerings and the techniques consistent with learner-centered instruction.

Memberships from Multimedia Educational Resource for Learning and Online Teaching (MERLOT), the Western Cooperative for Educational Telecommunications (WCET), and WesterCT, totaling over 10,000 persons, were contacted three times via electronic mail. Ultimately, 562 responded. Kim & Bonk uncovered from the responses that blended offerings could become the new means of conducting Distance Learning. In addition, participants suggested that students need to self-regulate and enter the course better prepared. Kim and Bonk gleaned from the responses that more online certificates can be expected and that blended courses will become the predominant means of Distance Learning. Kim and Bonk's recommendations were timely as millions of students are now taking at least one course online.

Research on web-based courses is of increasing importance to K–12 educators because not all courses will warrant the hiring of a full-time teacher, but only those with the student demand for one (Kirby, 1998). Still, little has been mentioned on web-based mathematics courses, although the need for web-based mathematics courses still persists. Fortunately, many characteristics that describe effective web-based courses are administrative in nature and are not discipline-specific. Hence, the aforementioned studies jointly inform the essential elements for successful Distance Learning. In theory, many principles for good instruction in a face-to-face course, like providing prompt feedback, still apply in a Distance Learning environment (Graham, Cagiltay, Lim, B., Craner, J., and Duffy, 2001). So, web-based mathematics courses should experience comparable success provided that the method and technologies used enhance course curriculum, there is social interaction, and there is supportive instructional discourse.

Distance Education and Mathematics/Statistics Courses

Mathematics education began to emphasize the understanding of problems and concepts, and de-emphasize rigorous procedures in the 1980s. Inquiry-based instruction and cooperative learning, along with constructivist learning theories, highlight classroom techniques that convey mathematical concepts and equip students with the reasoning skills requisite for functioning in today's society (Lubienski, 1999).

Similarly, in the teaching of statistics, activities can be used to enhance student learning and engage them in data sets with personal relevance to them. statistics courses today are taught with some form of technology. Garfield (2004) mentions that tools, like graphing calculators and software packages "are often used to help students 'do' statistics." (p. 10). But technology, in the form of web applets and simulation tools, can also help students "visualize and understand abstract concepts" (p. 10).

In an article comparing the use of computers to calculators in AP Statistics courses, it was expressed that the computer is an essential tool for data analysis (Macnaughton, 1998). But with the web-based course being rooted in computer usage, research needs to be done on whether web-based instructors are providing students with opportunities to use the technology available to them in order to maximize conceptual learning.

The 2005 Conference Board of the Mathematical Sciences Survey of Undergraduate Programs (CBMS) (Lutzer, et. al., 2007) indicated that community colleges enrollments grew by 29% from 2000 to 2005 to account for 44% of all collegiate undergraduate enrollments. It is plausible, given a number of economic conditions that have led to greater numbers of adults returning for greater amounts of education, that in 2010 that community colleges would garner an even larger percentage of collegiate undergraduate enrollments – perhaps up to 50%. Regardless of what the future may hold, community colleges warrant greater attention given their substantial representation amongst the collegiate undergraduate population.

In mathematics specifically, the total growth in enrollment at two-year colleges grew by 27% to 30% from 2000 to 2005 – with the largest growth occurring in PreCollege courses (mathematics courses that are taken in preparation for baccalaureate-transfer courses (Lutzer, et. al., 2007). Elementary Statistics' enrollment increase of 40,000 students was the largest enrollment increase amongst the college-level, transferable mathematics and statistics courses. Not only are two-year college enrollments swelling, but with Elementary Statistics being on the vanguard within the mathematics and statistics curriculum, research on student performance and learning is critical.

Two-year college students are using online resources for instructional support in 10% of statistics courses (double the typical proportion for other courses). In situations where at least half of the students received the majority of instruction using methods where the instructor is not physically present, nine percent of statistics instruction was in this format, which again exceeded the aggregate percentage for mathematics and statistics courses which was five percent.

The 2005 CBMS survey informs us that there is a distinct trend of increased enrollments in Elementary Statistics at two-year colleges. And, within the curriculum, it could be inferred that Elementary Statistics lends itself well to the incorporation of online resources and to distance learning, in general. At variance with these trends is a void in research in WBI of statistics at two-year colleges. The research presented within this document will address the two-year college research void. Research in WBI at four-year colleges and universities in online learning of statistics is in its infancy as well – but there are some pioneers. Their research began with investigation into pedagogy associated with correspondence courses.

In a study that investigated a precursor to web-based instruction, Stephenson (2001) examined student performance and attitudes comparing in-class and tape-delayed video versions of a two-term statistics course offered to General Motors (GM) managers and engineers. The lectures were taped, and the tape was then mailed to various GM plants and played for the distance education students a week later. In looking at outcomes over a 10-semester span from 1994 to 1999, he found no overall differences in terms of student grades or attitudes toward the course. During the 10-year span, 132 students took the course on campus and 280 took the course off-campus. The students receiving instruction at a distance had overall grade-point averages of 3.45, and the students receiving instruction in the classroom had averages of 3.50. Barring the first term, where the students experienced difficulty with the initial development of the course, student overall ratings of the course were not significantly different.

Beth Costner's dissertation entitled, "The Effects on Student Achievement and Attitudes of Incorporating a Computer Algebra System (CAS) into a Remedial College Mathematics Course" (2002), also has relevance to the quantitative methodology the researcher used in this study. Also, Costner's study directly incorporates both constructivist principles and adult learning theories, which are also relevant to this study. In her study, Costner compares performance in a technology-driven delivery method to a classroom-based section and also looks at student attitudes in each section. From her experiences and the others' research, Costner asserts that usage of a CAS can promote comparable levels of achievement and deeper levels of conceptual understanding. These findings are consistent with the mathematics teaching reform movement. Costner tests her claim by collecting data from two sections of a remedial mathematics course over a two-quarter period. Her quantitative study finds that the students who used the CAS systems performed just as well on summative assessments as those who learned without the technology. Incorporation of the CAS has also led to more collaboration among students, while not allowing students to use any graphing utility on summative assessments could undermine the performance of the participants from the treatment group.

Costner's study asked the following research questions:

1) What is the effect of the use of a CAS and graphic utility on remedial mathematics students' achievement?
2) What is the effect of the use of a CAS and graphic utility on remedial college mathematics students' attitudes toward, beliefs about, and confidence in mathematics?

Principles from constructivism, Vygotsky's Zone of Proximal Development, and adult learning theories were key components of the conceptual framework. To answer these questions, Costner (2002) used two-sample t-tests comparing the performance of students in the control group (instructed without graphing technology) with the experimental group (instructed with the TI-92's CAS). She investigated the relationships between some of the student characteristics (preliminary algebra proficiency, gender, and age) and mastery of course material (three exams and a Departmental Final Exam). Costner used likert scales, interviews, questionnaires, and writing assignments as her instruments. On many assessments, the treatment group performed better than the control (e.g., average exam scores differing by two points). Yet, the difference in the performance of the two groups was not statistically significant. Gender seemed to play a significant role in looking at students' confidence. Moreover, students in the control group considered practice with homework exercises as reasons for their success, whereas students in the treatment group attributed it to the fact that the CAS allowed them immediate feedback on their work.

Although Costner's (2002) topic did not involve web-based learning, its structure reflects the studies that compare a technology-based delivery method to the traditional classroom method in two ways. First, its theoretical framework contained constructivist and adult learning principles. Second, the methodology compares performance on common assessments of a control group with an experimental group that utilized technology. A similar structure is used in this study.

Even with mathematics education research referring to peripheral uses of the World Wide Web, Dereshiwsky (1998) reported astounding success in encouraging group work in the web-based section of her introductory statistics course for graduate students. The course curriculum consisted of 10 intuitively-formulated modules of content instead of a textbook. To further respond to potential challenges in teaching the

course, groups were designed based upon relative geographic location (her students were diversely spread across the western state) and she held weekly virtual office hours.
In addition, Dereshiwsky (1998) was specific with deadlines, expressed emotions in e–mails, and developed a weekly newsletter for the students. This created a sense of community for the students and an identity with her as their instructor. One student mentioned, “I feel as though I’m forming a one-to-one partnership with you on my learning needs” (p. 5). Also, the cohort groups gave students “the interactive, face-to-face group environment … with much greater freedom and flexibility than the traditional course” (p. 6) and also encouraged the students to be more accountable to each other, which minimized procrastination.

This large western university, subsequently, developed blended undergraduate courses and other graduate courses based upon Dereshiwsky’s course structure. Dereshiwsky (1998) commented that “I would unconditionally and most enthusiastically recommend it (delivering a quantitative concepts course) to any instructors toying with the notion of road-testing their particular subject area online” (p. 7). Dereshiwsky’s study further supported the notion that social interaction among students can help them deepen their own conceptual understanding as they convey concepts to their peers. This study will extend Dereshiwsky’s study and apply the development of a social network to undergraduates at commuter campuses.

With a new emergent philosophy toward mathematics instruction, web-based courses should not reflect traditional lecture-oriented teaching. A resourceful instructor will use the Internet in creative ways to teach and illustrate mathematical and statistical concepts (Malone & Bilder, 2001). For example, graduate students from a Malaysian university were surveyed about their experiences with a completely online course that used a problem-based approach (Hong et. al, 2003). Hong et al. held an initial icebreaking session with students and 3 on-campus SPSS training sessions. In Hong's 2003 article, they assert that there was an association found between lack of proficiency with technology and dissatisfaction with course. She had difficulty getting students to even participate much in discussions and cooperative learning opportunities because of their own fears, discomfort with the unfamiliar pedagogical technique, and lack of preparation. Despite all this, there was a general level of satisfaction. When the final course grades were compared, the students in the web course achieved as well as traditional classroom-educated students.

Hong et al. mentioned that the web-learning environment requires more structure and strategies to encourage cooperation and effectively incorporate a common face-to-face pedagogy like problem-based learning. Hong et al. support two critical notions of this study as a result of analyzing open-ended interviews and questionnaires at the end of the course via usage of a 5-item Likart scale. First, students enrolled in a web-based mathematics course may perform just as well as those who experience face-to-face instruction. At end of the course, 18 of the 26 students receiving web-based instruction received at least a B–, and 22 of the 25 students receiving classroom-based instruction attained a similar range of marks. Second, further research is necessary on how to better incorporate more current teaching methodologies into the web-based environment.

A recent pedagogy has been to use the Internet in an ancillary way. Wiesenbaker (2002) initially designed his adult education course this way, but it eventually evolved into a formal web-based section. His students were masters and doctoral students enrolled in the College of Education at a large Southeastern university. He wanted to compare the performance of students enrolled in the virtual sections of a class with students enrolled in the face-to-face section taught by the same instructor. Of particular interest were issues of their initial comparability, performance on the Final Examination, and evaluations of the course.

In the fall of 2001, he offered his first online course to doctoral students in adult education, which had minimal interaction with the professor. Then, in his second offering in the spring of 2003, he incorporated a major change with a 1-hour per week mandated online chat session. He also found that the spring term students mostly held full-time jobs and were still full-time students. Students in the fall session were used to taking classes together and had developed a community, whereas the spring term students had little prior contact with each other and markedly less familiarity with online courses.

Table 2.1 below displays the Final Exam performance across the three sections.

Table 2.1 Wisenbaker Final Exam Performance

	Classroom Fall 2000	1st Virtual Fall 2001	2nd Virtual Spring 2003
Final Exam Score M(sd,n)	84.4 (7.5, 22)	72.6 (20.9, 27)	80.3 (13.1, 15)

The data yielded a statistically significant difference in Final Exam performance among the three sections (p=.03). Yet, there was no significant difference between the classroom offering in 2000 and the second virtual course in the spring of 2003. Looking at a breakdown of performance in greater detail, a far greater proportion of the students in the virtual section received failing grades on the final exam, yet a greater percentage received 90 or higher, which in part explains the larger standard deviation for the students from the Fall term. One consequence of web-based instruction is that the students have to set aside the time to prepare for the course and do not have the set schedule associated with classroom sections. As a result, there tends to be greater variability in the time commited to the course and on exam performance.

By acquiring information on Web site hits and by examining the type of discussion in which the students participated, Wisenbaker's (2002) study delved more into the technical data that can be collected from web-based courses than most others in the literature. Nevertheless, the Web site hits data did not significantly correlate with Final Exam performance. Student comments revealed that more directives regarding weekly study plans and related instructional strategies would have better channeled their site navigation and duration of site visits. As well, directing Discussion Board dialogue toward increased cognitive presence and slightly away from attention on social presence (e.g., congratulations on another birthday, inquiry about family members) would have had more direct connection with Final Exam learning outcomes.

Through course evaluations, student satisfaction with the course differed significantly as well. The overall course ratings averaged 4.4 (out of 5) for the classroom-based section, 2.8 for the fall virtual section, and 3.1 for the spring virtual section. Ratings of the quality of the instructor declined following a similar pattern, yet evaluations for the instructor in face-to-face offerings for other sections remained roughly the same.

The end of the quarter feedback showed that the students in the fall virtual course aspired for more on-campus interactions and greater structure and the students in the spring virtual course had more dissimilar findings. Wisenbaker (2002) believes that the recovery in student performance and satisfaction reflects students doing a better job of self-selecting themselves for distance offerings and the instructor's increased amount of course structure and, hence, communication with students.

Gunnarsson's (2001) study has considerable relevance to this study. In 2001, she inquired about the attitudes and achievement of students in web-based courses compared to those from the classroom traditional setting. From her review of literature, she was interested in prior mathematics skills and computer experience as mediating variables for success with WBI. The participants in the study were from her web-based graduate level statistics course for MBA students. Gunnarsson discussed many theories about online course design and structured her own course accordingly with organization and communication venues. To answer her questions, Gunnarsson used qualitative analysis of comments by the students from her web-based class. There were no significant differences in the demographics of the two sections (in terms of age, gender, and race). Students could volunteer to be interviewed and a survey regarding one's beliefs and attitudes was administered. T-tests and ANOVA were used to assess differences in achievement between the online class and the traditional one. Also, a multiple regression model was used to determine the effect of classroom setting, prior math proficiency, prior computer experience, and attitude on achievement.

In investigating attitude, Gunnarsson (2001) used questionnaires and interviews. She used the research-supported notion that both attitude and affect influence success in statistics courses. Gunnarsson found that the vast majority of students liked the flexibility that online learning offered them. There were also a few students who vehemently opposed web-based instruction and vowed to not take another course in this format, and still others who were reluctant toward the online environment. The questions in the qualitative component centered on learning, enjoyment, and effort—a few indicators to which previous studies have pointed. At three different points, students were asked to provide their perspective. The online students had more positive attitude toward the course. However, this could be undermined by the author's insight that "Students who are feeling the least bit anxious or who have lower affect toward the subject matter would be dubious to trying an online environment" (pp. 60-61). Views of online learning, in general, were not impacted by prior computer or math experiences, but more depended on the student's own learning preference.

While investigating achievement, Gunnarson (2001) found that prior math experience was not a strong factor in predicting achievement but that those taking the online course were more computer literate. In looking at performance on three common assessments, there was no significant difference between the two sections of students.

More specifically, the gap between the two groups lessened over time. Some of this may not be generalized to my setting because graduate students were used for this study. Gunnarsson (2001) concludes by saying that her research (although it was based on 13 online students and 42 traditional ones) further supports the notion that online courses can be educationally equivalent to traditional courses. She also mentions that administration should not use this as a means of replacing traditional courses altogether at the risk of forcing students to take a course in a format that may not be consistent with their learning style.

Research in online statistics education is emerging in areas where statistics is taught to populations of students of non-traditional ages or circumstances. Schou (2007) identified that learning outcomes for online students and classroom-educated counterparts were not different for an introductory business statistics class.

Schou purports that the use of technology in statistics classes along with applying the lessons of the reform movement in teaching statistics may have a positive impact on student attitudes. The researcher compared Final Exam performance among the traditional and online students and asserted no difference for the null.

The researcher also found that the online students had an improved attitude toward statistics by the end of the course by usage of the survey of attitudes toward Statistics (SATS) following a Pre-Test/Post-Test design.

Instructional activities were learner-centered with streaming video instruction of statistics topics and statistical software. Students had e–mail, Discussion Boards, chat rooms, white boards and access to tutors. There were 16 traditional course participants and 15 from the online course. The Final Exam performances were not significantly different (p=.15), largely due to the mean for the traditional students being almost 9.3 points higher with a standard deviation 7.5 points smaller. The SATS information was significant with p=.016, implying a positive improvement in student attitudes toward statistics by the end of the course in the online offering. Subscales of affect, cognitive competence, and value showed strongest gains. Perceived difficulty was the only subscale to not show significant improvement.

Schou's work adds to an existing body of research that there is little difference in mean performance and substantial difference in variation. But again, there is a need to extend this type of work to the larger introductory statistics course.

Evans et. al (2007) found that in a Harvard Biostatistics course that there were no dissimilarities with respect to overall course grade averages or course evaluations. Biostatistics is a course not taught in many institutions. Hence, offering it in a distance format could meet the needs of current full-time students, as well as learners who are current professionals in medical and public health fields. This study was also different in that it compared the traditional offering the year the Distance Learning alternatives were offered to the previous year that preceded it to measure how the composition of the traditional course is impacted by a Distance Learning offering.

Enrollment during the 2005 term, which offered Distance Learning alternatives, increased 100% over 2004. 79% of the increase in 2005 was due to hybrid option with 11% due to WBI, and traditional enrollment experienced no significant change. There were no significant differences with respect to age, gender, race, prior statistics course, and major. There was also no significant difference between traditional and non-traditional sections with respect to overall course average, final, exam average, homework, or project average. More interesting was the fact that the overall grades for traditional students were lower in 2005 than in 2004. This leads to a possible inference that some of the stronger students might have chosen the web option in 2005. Overall course average was not significantly different, and homework and project averages were not significant either. Qualitatively, instructors noticed a heavy increase in e–mail communication and facsimiles. Evans identifies “the ability to watch the video as many times as desired” (p.63) as one distinct benefit that Distance Learning provides the student and cost-effectiveness as an administrative benefit. Loss of non-verbal communication was seen as a pedagogical disadvantage.

Evans mentioned that the “distance effect is not solely the Distance Learning effect, but it is actually a combination of this effect and the differences between traditional and non-traditional students” (p.74). This implies that the modality and the types of students that select the modality are both factors that merit consideration in analysis. In 2004, the exam average for traditional students was 91. In 2005, the exam average for traditional students was 82 and the Distance Learning average was 78. There could be a Distance Learning effect that the stronger students elected the Distance Learning option. There was also no difference in Hybrid students; their average exam score was 83. The research on the effects of Hybrid sections is beyond the scope of this study. However, Evans’ work is in the Biostatistics course reminds us that this type of work with undergraduate introductory statistics courses is warranted.

Zhang (2002) shared his experiences with teaching statistics online and also commented that videotaped lectures allowed students to review material as much as possible. He highlighted the importance of the role played by the institution's distance education department in structuring one's course. Self-motivation is critical to success, as students do not have the important face-to-face contact with their instructor. One key advantage for both students and instructors is the convenience that Distance Learning affords. A web course relies heavily on self-discipline and self-motivation since the students do not have an instructor urging them forward. Technology via digital pictures, videotaped lectures, and vocal instruction enables students to overcome some of the barriers inherent to Distance Learning. Organization, communication, and videotaped lectures are keys to academic success according to Zhang. Zhang predicts that "with the advance of technology, I foresee that distance education via the Web will be more wide spread and more accepted by future students" (p.4). This hypothesis seems to follow the direction of future education, as research more closely related to Distance Learning in the undergraduate introductory statistics course expands. The findings of Zhang regarding the instructional technology that leads to successful learning are becoming mainstays within the modality.

Utts, Sommer, Acredolo, Maher, & Matthews (2003) delved into web-based instruction research by comparing a traditional introductory statistics course with a hybrid. The traditional course did not have a lab, but the hybrid course, "StatsV," met weekly for 80 minutes and used the online textbook CyberStats. Utts, et al. desired to compare the two courses in four key areas: initial comparability (GPA, class standing, gender, computer skills test), performance measures (using a 12-item Pre-Test and 30-item Final Exam which included the 12 items from the Pre-Test), student behaviors and satisfaction (student evaluations, surveys of students' primary sources of learning), and weekly amount of time invested by the Utts who taught both sections.

Students in both sections had comparable levels of performance on the Pre-Test (means of 4.7 for traditional and 4.8 for hybrid, respectively), had similar amounts of computer competence (3.95 and 4.08, respectively) and similar composition in terms of class standing and GPA. It was found that the students in the hybrid section tended to enroll in that course to improve their computer skills and because it fit their schedule. Although self-selection typically has the potential to further problematize assessing the effect of a treatment, this concern was not an issue for Utts' study. In terms of performance, the effect sizes comparing the overall gain scores were 1.72 and 1.69, respectively.

In comparing behaviors and satisfaction, the traditional students believed the text was more important whereas the students in the hybrid course believed that the text and the data analysis software CyberStats were most important. Students in the hybrid class felt that it was more work. Evaluation ratings were higher for the traditional course than the hybrid.

The instructor invested about the same amount of time in each course. Utts noted that she invested about 18.5 hours for the semester in interacting with students outside of the traditional course and 16 hours for those in her hybrid section. More time (in hours) was spent in preparing for lectures for the traditional class (34.5 vs. 20), but the hybrid course required more time to evaluate student performance (34.5 vs. 24). The total time invested only differed by 3 hours for the entire term (99.5 v. 102.5).

The weekly meetings were most effective as question-and-answer sessions. Other student feedback included that computer software should be used to help students visualize and explore data, CyberStats helped by providing consistent feedback, and a weekly lecture and quiz encouraged the students in the hybrid course to keep up with the syllabus. Utts, et al. (2003) concluded by saying that offering partially online courses may be beneficial.

Everson and Garfield (2008) share the efforts by which they implemented guidelines for assessment and instruction in Statistics education (GAISE) recommendations in designing collaborative online discussions. Both courses selected were targeted toward non-majors (undergraduate and graduate) with minimal mathematics preparation. Course enrollments were limited to 30 students who were formed into five or six groups for the first half of the course, then reassigned for the second half of the course. Students then completed small group discussion assignments within the course management system.

The discussions upon which the assignments were based forced students to think and reason about their postings. Students grappled with conjectures about real data, used interactive technology, and iteratively instructors revised instruction based upon student comments. Students had an interim deadline to post initial thoughts on each assignment within a few days of being informed about the assignment. Yet, what was most unique about this approach was that students posted their assignments where only their classmates and the instructor were able to view them, and then an elected leader posted a summary on behalf of the group with the instructor summarizing each group's work. This multi-stage approach allowed students to focus more closely on a few postings as opposed to the more common practice of scanning postings from the entire class. Instructors intervene accordingly with either praise or some redirection.

Everson and Garfield cited the instructor's ability to see what every student was thinking as a distinct advantage to online discussions in statistics. Requiring each student to post transcends classroom-based practices where there is rarely time for the entire class to participate. The additional demand of articulating responses is often outweighed by the flexibility students have in formulating a response. Again, in the classroom, the question is posed and usually within several seconds someone has either begun a discussion or the next topic is up for discussion. In the online environment, students have a larger window to ponder on and formulate a response. In each course, an effort was made to create an online community where students could learn from a variety of sources and where support and encouragement from the instructor were evident to students. Everson and Garfield represent the next echelon that statistics education must pursue with online learning—moving from achievement comparisons toward the pedagogy that underscores achievement. The research study conducted within this dissertation addresses a similar question by describing the structure of WBI.

The work done by Schou (2007), Zhang (2002), Evans (2007), Hong, et al. (2003), Dereshiwsky (1998), Gunnarson (2001), Utts et al. (2003), and Everson & Garfield (2008) have been extensions of the distance education literature in statistics education. I will continue to build on their efforts by investigating the experiences and performance of students in web-delivered statistics courses in comparison to the traditional CBI. But my research will differ more from my predecessors as I will conduct my research at a community college, the type of higher education institution that has most readily embraced online courses.

Chapter 3: Methods and Procedures

Perspectives on Methodology

A mixed-methodological design was used in this study to assist in the ultimate goal of inquiry into whether there was a significant difference in students' learning in web-based statistics courses when compared to their in-class counterparts. The quantitative component was appropriate as the researcher looked at differences in student performance on the CAOS (Comprehensive Assessment of Outcomes) in a first Statistics course. The CAOS test was administered in the first week of the course and again the final week of instruction (Appendix A). This allowed for a Pre-Test/Post-Test control group design. Each of the instruments appears at the end of this document. In addition, the departmental exam (Appendix B) was administered to all students at the end of the quarter. The Researcher evaluated all the exams.

In addition to the quantitative instruments, the researcher saw a direct need to conduct inquiry on the nuances and climate of the educational settings. Qualitative data analyses were used in this regard, as the construct measured was important but not necessarily a learning outcome of the course, and therefore not deemed appropriate for evaluation with merely the CAOS test. Each student completed a background questionnaire to provide demographic information on some potential predictors of success (Gunnarson, 2001), including students' attitudes toward mathematics and proficiency with hand-held technology. This instrument can be found in Appendix C.

In answering the second research question, what types of learning experiences are students in web-based statistics courses encountering, the researcher used qualitative data analysis. To best ascertain the "how behind the what," qualitative analyses provided the thicker description (Denzin & Lincoln, 2000) of the events, activities, and experiences observed by those who represent the emic perspective. For this study, two faculty members who have taught the web-based statistics course for at least two years were interviewed (Appendix D). Students discussed the extent of the presence in their courses via a questionnaire that probed their experiences and attitudes toward their statistics course (Appendix E). The researcher also observed each instructor's teaching of descriptive statistics and hypothesis testing as those are topics that, from my experience in teaching statistics, tend to be most problematic for many students. For the web-based sections, the researcher accessed the week that each course covered the aforementioned concepts.

Setting

This study was conducted at a community college in a large Midwestern city. The community college services over 20,000 students and is situated in an urban environment. The average student age is 27.8 with approximately 57.9% women, 30% minorities (21% of African descent), and 65.7% part-time. Students may either pursue technical or arts and science degrees. Transfer and articulation agreements exist, whereby courses taken at this college can be considered equivalent to offerings held by other institutions.

The demographics of the general statistics course tend to differ slightly from the college by having more women and part-time students, and fewer minorities. The average ages of the students (mean=25.48) in traditional sections of my pilot study was slightly lower than the college average (mean=27.1) and average from the web-based sections (mean=27.38). The slight shift in demographics reflects the fact that many of the students in the course aspire to work in the allied health fields, for which this course is a requirement. The statistics course covers descriptive statistics, Elementary Probability Theory, Discrete Random Variables, Continuous Random Variables, Confidence Intervals, Hypothesis Testing, and Regression Analysis. Classrooms are designed to accommodate 30 learners, and seats are traditionally aligned in a 5-row, 6-column format. There is also a weekly one-hour lab associated with the course whereby students use the statistical software package Minitab to further investigate concepts covered in class.

Sample Selection and Participants

Faculty

Web-based learning in statistics is a relatively new area. The researcher selected those sections of students taught by instructors who had at least two years experience teaching in this environment. It was the researcher's belief that after two years of teaching a course, many of the key revisions to web-based instruction would have been made previous to the study and that the courses would run considerably smoother after such adjustments. Yet for comparison purposes, I chose participating faculty who also teach classroom sections of the same course. Hence, the sample selection of faculty participants was purposeful. These faculty members were Caucasian females, each with over 10 years of teaching experience. Neither teacher had formally taken a web-based statistics course, but they had taught statistics via the Web for more than 3 years. Beverly had a career in industry before teaching K–12 for about 5 years and had been at her current position for 13 years. Ann taught for 10 years in a suburban high school and had been at the community college for 10 years. Ann is also the original designer of the web-based statistics course at the college.

Both Beverly and Ann teach their classes from a technology-centered paradigm. The participating faculty members strongly encourage usage of the hand-held calculator to perform many of the statistical computations to enable more time to be spent discussing the output with their students. They both affirm, supported by the research of Romero et al. (1995) and Robinson (1993) among others, that the increased class time allocated to discussions about technology outputs can provide the learner with a richer understanding of the material.

The college uses the teaching platform “Blackboard” for all of its web-based courses. Beverly and Ann posted notes online for student perusal and review. They also encouraged collaboration among their students, but recognized that it mostly occurs when it is required (e.g., with graded assessments or classroom-based activities).

Students

The researcher believed that more than 150 students (over 25 per section) would begin the study. If 80% of the classroom-instructed students typically completed courses, then it can be anticipated that about 120 students will complete the course. Similarly, if at least 60% of the students in the web-based sections tended to complete their courses, then it can be anticipated that about 35 of them will ultimately complete the course. The students enrolled in this course have at least completed Beginning Algebra II (covering topics through factoring trinomials) with at least a C. And, as evidenced from preliminary questioning, the students tended to be comfortable with hand-held technology, be in their late 20s, have multiple responsibilities outside of the classroom, and have had at least 3 years of high school mathematics. The students in web-based courses differed slightly from the students in the classroom sections in that they tended to be slightly older, have more non-academic responsibilities, and be more likely to be learning independently.

Participants

Class rosters were monitored weekly. New registrants were recruited within one day of review of the updated roster. Only four of the classroom-instructed students replied prior to the first day of the classes. At the first class session, many of the students were familiar with the project and submitted consent forms at that time. This minimal intrusion on their lives outside of their statistics class was of great appeal and resulted in consent from 21 of the 26 students enrolled in Ann’s class and 11 of Beverly’s 15 students. The demographics and class size differed in the two sections: Ann’s class was taught from 10:00 a.m. to 11:50 a.m. on Monday, Wednesday, and Friday, and Beverly's class was from 8:00 p.m. to 10:15 p.m. on Monday and Wednesday. By virtue of the time offerings, Ann's students were younger and reflected the more traditional age of a college student. Beverly's students tended to have greater non-academic responsibilities.

The students receiving web-based instruction had considerably greater amounts of enrollment turn-over; only 54 of the 108 students enrolled at the time of the initial recruitment letters' mailing were actually on the first day class rosters. The weekly checks of rosters were instrumental in recruiting the distance learners. One interesting nuance was that five days prior to the start of the quarter, students at this institution are dropped for non-payment of fees. Table 3.1 shows that more students were dropped at the fee payment deadline than the total number that dropped prior to it.

Table 3.1 Non-Payment De-registration Activity

Dates	Number of Web Students Dropped
Prior to Non-payment Deadline	25
Fee Payment Deadline	29

Only nine classroom registrants were dropped at the fee payment deadline. The Distance Learning sections would increase their enrollments by 22 students by the end of the first week of classes to a total of 101. The classroom sections ended the first week with 41 students enrolled, which is a six student increase from enrollment prior to the fee payment deadline. While 21 of Beverly's distance learners expressed some interest in the project, only 9 completed consent forms and the pre-test. Likewise, 24 and 13 respectively for Ann's students. In total, 22 of the 101 distance learners consented to participate in the research project. There were minimal additions to classes after the first week of the quarter. Students who completed all of the instruments required of their instructional modality received $5 gift cards to a nationally-known department store.

Data Collection

For this study, data was collected using a quasi-experimental design (non-equivalent control group design). The researcher studied Beverly and Ann's web-based courses, as well as their two traditional statistics sections. As alluded to previously in this chapter, five key instruments were used for data collection: the CAOS test (administered as both a Pre-Test and a Post-Test), the departmental Final Exam, the Background Questionnaire completed by participants in both learning environments, the survey completed by participants in the online classroom, and the interview protocol used with the two faculty members. The researcher also conducted observations on both the classroom and virtual environments for both instructors.

The CAOS exam is multiple choice, and student raw scores were determined within 48 hours of test completion. CAOS was administered during the first week of the course and again during the last week. This test-retest format better identifies knowledge gains as a result of a term of instruction on statistics (among other factors). The CAOS test has been used with thousands of students, has been reviewed by some of the leading researchers in statistics education, and has a Chronbach's alpha of .82. The test consists of 40 multiple choice items covering an array of concepts typically taught in an introductory statistics class (descriptive statistics, graphical displays, confidence intervals, etc.) and probes students' abilities to reason statistically. Hence, there was a distinct emphasis on interpretations instead of computation. Each of the participants' scores were recorded in Minitab, and student confidentiality was protected.

The Final Examination is cumulative and was administered only once. Graphing calculators were permitted and formulas were provided. Both instructors used a custom version of the 3rd edition of Larson & Farber's *Elementary Statistics: Picturing the World*. The custom version had keystrokes and screen captures for the Texas Instruments 84 graphing utility.

The quick survey of background information completed by students from both types of learning environments was based upon Candace Schau's Survey of Attitudes Towards Statistics survey (Gunnarson, 2001). The survey inquired about several predictors of success in statistics courses, including mathematics background, graphing calculator proficiency, confidence, and attitude. It also includes indicators of success in online learning environments, such as strength of computer skills, possession of appropriate computing hardware and software, and learning style. The first eight questions pertained to demographic information and were either quantitative or dichotomous. The four remaining questions were qualitative in nature, but they were coded on a scale from 1 (weakest) to 4 (strongest). The researcher communicated with faculty and students to maximize completion of the surveys by all student participants. The Schau instrument had a Chronbach's Alpha of .83.

The survey for the student in the web-based setting delves deeper into the investigation of the nature and types of learning that occurs in the web-based learning environment. Inquiry was conducted on the quality of learning, the type of learning, the level of interactions with classmates and instructors, and general pros and cons of the web-based learning experience as it relates to mathematics (Appendix E). Students were given two weeks to complete the survey.

The two faculty participants were subjected to a 20-item interview schedule (Appendix D). They were asked about the types of learning that occurred in their classes, their usage of technology to develop conceptual understanding, and both the type of interaction they had with their students and the nature of the interaction students had with each other. The researcher also attempted to ascertain any characteristics of successful students and estimations of students' mastery of specific concepts from the faculty perspective.

The interviews were conducted two weeks prior to the beginning of the course by Leigh Slauson. Leigh is a Doctoral Candidate in Mathematics Education and holds a Master's Degree in Statistics. Leigh was selected per her education, experience as a former instructor at the institution, and as a means of reciprocity toward the investigator who conducted interviews for one of her research projects. The researcher transcribed the tape within weeks of the interviews. The interviews were conducted in the faculty's offices.

Researcher as Instrument

I would also like to discuss my own positionality in the context of this study. I am supportive of web-based statistics courses and have taught statistics for over 10 years, 2 years as a teaching assistant and ten years as a professor at the same college as Ann and Beverly. The only time that I taught a completely web-based statistics course was in the fall of 2004. After that term, I used my experiences and research on the need for social interaction among students in web-based courses to advocate for a "blended" course offering. I received administrative approval and taught the "blended" section from the spring of 2005 through the spring of 2006. The "blended" course is now considered "hybrid."

I would venture to say that my technology-centered paradigm is slightly stronger than that held by the faculty in this study. After over 12 months of witnessing students apply tenets of asynchronous learning theory in my Hybrid sections, I became more of a believer in the usage of the Internet to encourage the students to aggressively seek the information and for me as the instructor to facilitate their learning.

I also consider myself to have a cautiously optimistic view toward the future of distance education. My coursework enlightened me to the societal influence of steadily increasing dependence on technology; at times, to the point of excess (Postman, 1993). I feel that, just as with many technological advances, there will be a learning curve that everyone involved must endure, then, given the proper demand, there will be a shift toward incorporating the technology more within our culture. With the demands for web-based education being as high as they are, I think it is here permanently and that educators have to find out how to maximize the learning potential it can provide. This being said, I must state that I did aspire for neutrality with the development of my instruments and will continue to be aware of my disposition as I conduct my analyses.

Instrumentation

CAOS

The researcher proctored the administration of the CAOS examinations during the second hour of the first day of class (Pre-Test) for both instructors and again the last Wednesday of the quarter (Post-Test). Students had 45 minutes to complete the exam. CAOS aims to assess students' ability to reason statistically and focuses more on understanding than computation. The exam contains 40 items and covers the four most important learning outcomes from an introductory statistics course. The students' grades on each of the assessments had no bearing on their course grade.

On both occasions, the researcher made arrangements with the institution's testing center for the CAOS exams to be administered there. The exams were available for 10 days early in the quarter for the Pre-Test and again late in the quarter for the Post-Test. The testing center provided a secured proctored location for academic and placement examinations. An estimated number of students was provided to the testing center for proper administration. The Background Survey was administered with the Pre-Test for all students. Distance learners had the option of taking the Post-Test immediately before the Final Exam.

Departmental Final Exam

The researcher graded each of the departmental Final Exams. Each subject's point value on each item was recorded and used for analyses. The students in the classroom sections took their exams during their scheduled class times. The students in the web-based sections took their exams in the college's proctored testing center with the above availability. The Final Exam is created by a representative of the full-time faculty with input from a variety of instructors from the previous quarter's exam.

Background Questionnaire

The quick survey of background information that was completed by students from both types of learning environments was based upon Schau's survey (Gunnarson, 2001). The survey inquired about several predictors of success in statistics courses: mathematics background, graphing calculator proficiency, confidence, and attitude, as well as indicators of success in online learning environments: strength of computer skills, possession of appropriate computing hardware and software, and learning style. The first eight questions pertained to demographic information and were either quantitative or dichotomous. The four remaining questions were qualitative in nature, but were coded on a scale from 1 (weakest) to 4 (strongest). This instrument was administered with the CAOS test in both the classroom and web-based sections. Students needed roughly 15 minutes to complete the questionnaire.

The researcher was allowed access to student academic information via the institution's data-management software. The data that are not publicly available were used to obtain student academic records and to review transcripts. This information was particularly useful in ascertaining student prior coursework in the mathematical sciences as preparedness continues to underscore performance.

The Background Questionnaire investigates demographic information regarding each of the participants. Variables pertain to demographic information, student attitudes toward mathematics, and learning practices. The Background Questionnaire was administered with the Pre-Test for classroom and web-educated students.

Obtaining over 80% of the classroom learners' participation was not as alarming as receiving the participation of only 20% of the distance learners. Comparisons between random samples of two groups—participating web-based students and non-participating ones—were taken. The researcher considered several variables, including (with abbreviations parenthetically included) Distance Learning hours (WEB) attempted, Distance Learning hours completed, hours of mathematics courses completed, hours of mathematics courses which resulted in grades of D or E (math hours <C), grade point averages in mathematics courses, highest mathematics course, whether the student had taken Math 135, whether the students took their most recent mathematics course at the current institution, grade point average, hours attempted and completed at the institution, hours completed elsewhere, and previous coursework in English as a Second Language.

Surveys for Students in the Web-Based Statistics Sections

Inquiry was conducted on the quality of learning, the type of learning, the level of interactions with their classmates, and general impressions of statistics web-based instruction. Each teacher afforded the students 14 days (weeks seven and eight of the quarter) to successfully complete their surveys and responses were returned via e–mail. Additional time was allocated to give these students ample time to log-on to the class and to complete it with deeper descriptions of their experiences. This instrument may be found in Appendix E

Interviews with Faculty Members

The two faculty participants were subjected to a 20-item interview schedule. They were asked about the structure of their courses, the learning strategies used, and their assessment of the type of community that exists in each of their classes. The interviewer also asked them about characteristics of successful students and their estimations of students' mastery of specific concepts, usually in the context of contrasting them with the traditional class section. The faculty were given a window of available dates prior to the start of the quarter to be coordinated with Leigh Slauson who had worked previously with Beverly and Ann.

Observational Notes

Observational notes were made in two key ways. The researcher conducted classroom observations on each teacher within the first and last months of the course with the intent of examining constructs, such as depth of emphasis on statistical reasoning skills and classroom discourse, with descriptive statistics and hypothesis testing. The second observation will also be contrasted with the first as a means of ascertaining any temporal changes in the classroom environment.

The researcher obtained temporary guest access to each instructor's web course to view how the selected topic is presented in the web course and to what extent student understanding of that material occurred.

Member Checks/Triangulation

The interview protocol used with faculty participants, Background Questionnaire, and survey for students in the web-based statistics sections are all based on earlier versions of the same instrument that were used in my pilot study. The instruments were revised based on input from my dissertation committee, pilot, and participants. This second iteration of these instruments are inherently of greater validity than the initial versions.

As a way to further build upon the reliability and validity of the qualitative data that was collected, the two faculty members were allowed to review the data gathered from their interviews. This process only reaffirmed common themes that were mentioned and ensured that the researcher's interpretations of such comments were accurate (Denzin, 2000). The instructors reviewed drafts of transcription notes. Participants were encouraged to keep their own notes to better develop an audit trail that will provide a means by which others can detect consistency in the findings over time.

The results from the survey for the students in the web sections will also be shared with peers and committee members to glean their perspectives on the summaries. The students will retain copies of their electronic submissions. The code-recode strategy will be used for data analysis as well.

The departmental Final Exam is peer-reviewed by a committee of instructors from the college and is largely based on committee feedback from the previous quarter's exam. The lead instructor synthesizes all feedback and then sends out a draft of the final approximately one month prior to finals' week. The Lead Instructor then sends the final draft one week prior to the date the exam is to be administered. Students also receive a Final Exam review sheet that broadly covers the curriculum. Revisions to the review sheet follow an iterative process similar to that used with the development of the Final Exam.

Using multiple sources of data and a multiplicity of techniques should best detect emergent and consistent themes from the data (Vithal, 1997). These noteworthy themes would be constructs that are directly related to the theoretical framework. Information gathered from the researched that supported: self-directed learning, levels of social interaction, experiential learning, and the usage of the computer to promote conceptual understanding, surfaced in the combination of faculty interviews, student responses to Background Surveys, and performance on particular items.

Confidentiality of Data

Quantitative and qualitative methodology were elicited for data analysis. Anonymous identification numbers were issued to each participant. For the qualitative data, anonymity will be protected through pseudonyms. Accurate records, which recorded the provenience associated with each piece of data, were kept.

Information from academic records, including grade point average, performance in previous mathematics courses, and performance at other academic institutions, were handled via a coding system. The student's name and/or student ID were used to retrieve the information. After the information was retrieved, a three-digit numeric code was assigned as the student's R.I.D. (Research ID). The first digit in the code denoted the instructor and began with either a 1 or a 2. The final 2 digits corresponded to the modality of instruction. Numbers 00–59 were assigned to students in WEB sections, and 60–99 were assigned to students receiving classroom instruction. A maximum class size for Distance Learning sections is 54 (27 for classroom sections).

The documentation verifying student name and/or student ID with R.I.D. were locked within the researcher's office. This de-identification of the data protected subjects' privacy (Glesne, 1993). The information will be destroyed at the conclusion of the study. Any subsequent reports on this study will only refer to subjects by either their pseudonym or R.I.D.

Analyses of Quantitative Instruments

Student Achievement on Common Exams

In the 2005-2006 school year, CAOS was class tested by over 1000 students across 33 institutions of higher education. Eighteen expert raters unanimously agreed that CAOS had four of the most important learning outcomes, and it received a 94% agreement that it measured important learning outcomes. Based on a sample of 10,287 students, an internal consistency of the exam produced a Cronbach's alpha of .77 Minitab that was used for statistical analyses.

Constructs from Quick Survey

Constructs, which may affect achievement (e.g., computer proficiency, previous GPA, attitude, and self-motivation), were measured via a correlation analysis. Associations among students in each modality were compared to each other as well as the aggregated data. Two sample t-tests were often used. Categorical data analysis were done to detect associations between modality and several qualitative variables. These analyses were also done by each teacher.

However, data for each modality were subdivided by teacher, since classroom environment may vary with each teacher. Then, normality assumptions were checked. When there were significant departures from normality (p-value < .02), non-parametric analyses were used.

Analyses of Qualitative Instruments

Survey Administered to Students in the Web-Based Courses

Transcripts from faculty surveys and comments from students about the online learning experience were analyzed via traditional qualitative coding strategies. Phrases regarding motivation, attitude, interactions with classmates, effort devoted to the course and other affective comments regarding their online learning experiences were particularly interesting based upon the research and, subsequently, were particularly important in detecting any emerging themes (Ary, 2002).

Faculty Interviews

Faculty interviews were transcribed and a side-by-side comparison of their responses was conducted. Phrases associated with research-related predictors of success, along with teacher attitude, were particularly important. Faculty experiences with technology (specifically Distance Learning), perceptions of student learning, views of predictors that contribute to student success (specifically, motivation, attitude, and background) (GAISE, 2004), and advantages and disadvantages to online learning were also investigated (O'Neal, 2009; Zachariah 2000).

Procedures

The research adhered to the following schedule to answer the proposed research questions:

1. Interviewed faculty participants.

2. Administered Background Questionnaire by middle of first week of classes.

Background Questionnaire was available in the Testing Center for distance learners for 10 days early in the term.

3. Administered Pre-Test by middle of first week of classes and Post-Test by the middle of the last week of classes. Pre-Test and Post-Test were available in the testing center for distance learners at each respective window of time.

4. Conducted classroom and virtual observations during third and seventh weeks of the quarter.

5. Administered a survey to students in the 2 web-based sections.

6. Administered departmental Final Exam in classroom sections.

Final Exam was available in the testing center for distance learners.

Impact of Preliminary Explorations of Data

Preliminary explorations of the data and consequences therein helped in two key ways: technical and organizational. From a technical standpoint, I was able to realize that certain procedures would require more attention to details than others. For instance, I realized that I should be very explicit in giving any details to teachers that should be then passed on to students; otherwise I would leave what could be a critical component up to the interpretation of a participant as optional.

I also realized that I needed to be careful in not only asking the same types of questions, but structuring them in such a way that a detailed description is provided for each item. One faculty member tended to provide larger amounts of dialogue than the other. Perhaps I could have asked her to elaborate on certain ideas. Similar conclusions were reached about the items that were posed on instruments that were to be given to students.

Timeline

All of the data collection for this research occurred during the summer of 2007 term at a large Midwestern community college according to the scheduled outlined in Table. 3.2.

Table 3.2 Research Study Timeline

Activity	Approximate Window of Time
Informed prospective faculty of data collection plans	Two months prior to term
Received instructor consent	Seven weeks prior to term
Interviewed instructors	Three weeks prior to term
Informed students of project	Six weeks prior to term
Administered CAOS (Pre-Test)	By end of first week
Administered Background Questionnaire	By end of first week
Observed instruction on material covered in the first half of the quarter (Web sections also)	By end of fourth week
Administered survey to web participants	Middle of term
Observed instruction on material covered in the second half of the quarter (Web sections also)	Middle of term
Deadline for all outstanding documents	End of seventh week
Administered CAOS (Post-Test)	By end of last week of term
Administered departmental final exam	End of finals week
Conducted quantitative analyses	Winter 2008
Conducted qualitative analyses	Winter 2008
Produced a draft of chapter 4	Fall 2008

Communication between researcher and advisor occurred regularly during the summer of 2007 and as necessary thereafter. Limitations and delimitations will be discussed further in chapter 5. The results from the data collection are described in the next chapter.

Chapter 4: Results

Overview

The key findings from the participants' involvement in this research study are presented in this chapter. The quantitative instruments have indicated that students in web-based statistics courses can have comparable levels of achievement as their classroom-instructed counterparts. Analysis from the departmental Final Exam, CAOS (Comprehensive Assessment of Outcomes for a first course in Statistics) exam administered as both Pre-Test and Post-Test, and Background Questionnaire have specific results that support this statement and identify other factors that impact performance. The qualitative instruments contextualize the quantitative results with comments from the faculty interviews, online survey administered to students, and virtual and classroom observations that provided the researcher with insight into the pedagogy that accompanies Distance Learning and its perceived effectiveness. This chapter consists of graphical displays and quotations that amplify these two points.

Interviews with Faculty Members

Evolution of Web-based Teaching and Learning

Ann has 21 years of teaching experience (the majority at the current college and some in secondary school). She had taught at least one section of the web-based introductory statistics sections quarterly for the last six years. Beverly began her career as an elementary school teacher, then returned to graduate school and became an actuarial analyst. She later re-entered the teaching profession as an adjunct professor. Beverly realized, “I enjoyed working with people more than programming computers all day long.” She cited her experience with statistics as an actuary to be beneficial to her hiring in the collegiate setting.

Both instructors have academic training in programming languages. It is the researcher’s opinion that this innate interest in technology made them comfortable with teaching and learning statistics and its software packages.

This was the only web course Ann had experienced either as a student or as an instructor. But she eagerly volunteered to develop the initial web course in 2001. Beverly was taking web-based courses in Metaphysics. She found that these courses broaden her view of necessary components for developing community and content. Beverly noticed that “I wanted to start giving my (web) students what I REALLY wanted as a student. And it’s hard to think of it that way, unless you’re really in it.” Beverly began teaching web-based statistics in 2003.

Ann is the original developer of the web-based course, yet she was reluctant to create it because she fundamentally believed that statistics was “better learned in the classroom.” Ann eventually changed her mind and now believes that she had a major role in improving the “ways it should be learned and be able to cater to them (the students).” Beverly’s experiences as a student in her own web courses led her to make her Discussion Boards more interactive venues and to administer more assessments online to provide students with immediate feedback. Ann and Beverly are using a few applets that they found from other Web sites. Applets surrounding probability or features of data sets enable students to adjust parameters and visually see how the probability distributions are affected. These instructors also incorporated items from professional development opportunities.

Ann had transcended the function of her Discussion Boards. Initially, students just used them to pose questions. During the study, however, she had implemented a recursive process by which students responded to her scenario, posted their own scenario, and the next person responded to that posting. Ann consciously chose the more difficult topics to afford students a greater opportunity to engage in the same concepts.

And even more progressively, Ann created "Flash Cards," which were online learning tools that presented situations to students, required student responses, and verified answers. This differed from a quiz as the Web pages for the Flash Cards were designed to mirror they type of instructional flash cards commonly associated with primary grades. Calculator keystrokes were posted, and some homework exercises had step-by-step descriptions included. Ann constructed her web class so that everything her students needed online was at their fingertips. The Flash Cards and Discussion Boards were rarely used in classroom-based learning.

Topics More Easily Understood in the Classroom

Descriptive statistics might be learned at least as well via the web as in the classroom. The only exceptions would be those web students that possess apprehension regarding the graphing calculator. The classroom setting allowed such students opportunities to interact directly with the instructor and classmates on how to correctly produce the desired output. The keystrokes provided online tend to have just one set of directions. In addition, textbooks often presented the formulaic processes before the technological ones, and students tended to just stay with those. Beverly mentioned that "some of my older students, who really might not trust the calculator yet… and have learned better with the algorithms and tables prefer algorithms so they don't intimidate them. So, it's more of a comfort level or a trust issue." Some distance learners were able to overcome this deficiency because of their overall technical prowess.

Probability also might have been better learned in the classroom. In Beverly's 20 years of experience with the statistics course, she was able to identify patterns even though "the exercises are not as obvious as, let's say Algebra and Calculus. So, for a beginning student, there's a lot of critical thinking that needs to go in those instances… In a traditional classroom, you can practice, point things out, use key words, key phrases, you lose all of that in the Web." In the classroom setting, this was often offset by additional instructional resources. Use of ancillary resources was an emerging trend in the web-based environment. The instructors found a few "games" to help students in web class experience learning probability concepts, but these were not a true replication of what occurred in the classroom.

Initially, it seemed that instruction on discrete random variables was better taught and learned in the classroom than via the web. But, when looking specifically at the binomial distribution, Beverly mentioned, "And again, I don't know if they (web-based learners) pay more attention to the details. And in the traditional class, my students don't pay as much attention to the details as my Web students do." Indirectly, Beverly was referring to the anecdotal notion that committed distance learners are deeply vested in their learning and thereby have to grapple with concepts as they internalize them. Students receiving classroom instruction may have the occasional tendency to become more dependent on the instructor for information. Citation of the binomial distribution here was relevant as instruction usually occurred after the first examination as the students' learning habits began to establish themselves.

Both instructors contended that the learning of concepts associated with continuous random variables was about the same in both environments and that confidence intervals were better taught in the classroom. Ann mentioned that "my web students eventually get it. But, right off the bat, they don't see that they're predicting a population value. They see it as they're predicting data… or something.… Whereas in my traditional class, I can demonstrate to them its importance."

Beverly mentioned hypothesis testing as being better learned in the classroom. She then mentioned regression analysis as being better learned by web students, citing the "attention to detail" as being a critical attribute of students in the web courses. Another caveat would be that due to the perceived higher attrition rates in web-based courses, with regression analysis being the final topic in the course, the stronger students have persisted to the end of the course. Again, there could be a propensity to skew the data, but this was not able to be confirmed in this study.

Ann makes all of her web content available to her students receiving classroom instruction; hence, any significant differences in the two are minimal. Students in the classroom sections are missing the Discussion Boards, but they have access to actual discussion with classmates.

In sum, the faculty seemed to contend that descriptive statistics are learned better via the Web. There was some evidence for better performance in regression analysis being better learned via the Web, but this was also confounded by the higher attrition rates. Students electing to participate in this study had slightly higher GPAs than a random sample of non-participants (3.291 vs. 2.793), and the completion rates for participants across modalities differed by less than 2%. Perhaps the completion rate for the general population of students receiving web-based instruction would be markedly different than their classroom counterparts, but this was not experienced within this study.

Teaching and Learning Advantages/Disadvantages

One primary advantage of web-based instruction is the flexibility it affords instructors and students. Both instructors in this study have families, and teaching these courses has afforded them flexibility in attending to their personal responsibilities. They are still expected to teach a minimum of 16 hours weekly, have office hours proportionate to the extent of their web-based offerings, and complete a variety of work deemed beneficial by the institution. The time commitment is the same as teaching classroom sections. However, asynchronous instruction requires them to span their availability across a wider spectrum of time. Faculty informed the researcher that as they became accustomed to this new modality of instruction, their learning curves flattened considerably and a lot of work came in the way of course maintenance. This holds true in the classroom setting, with formal periods of instruction. A major difference is that the content (notes, applets, etc.) can be copied from quarter to quarter, but classroom instruction does not have a comparative. The inherent flexibility associated with web-based instruction makes it comport well with institutions that service non-traditional students. This student population is primarily community college students and returning graduate students, but may also include students from four-year institutions with a variety of non-academic responsibilities.

The primary disadvantage though was loss of personal contact with the student. Ann summarized by saying, “The really motivated web students will interact with you. But for the most part, you don’t meet a web student ever.” The intangibles like instilling confidence, peering out to a crowd and seeing who is paying attention, and other non-verbal cues are unaccounted for with web-based instruction. “They can’t hear the voice inflection, see the body language. They can’t fill in the gaps. You can’t elicit questions.” Beverly continues, “I’m still trying to work with this concept of chat rooms and Discussion Boards to make my classroom more of a virtual classroom, … I’m hoping that with more training on my part that even in a virtual sense there can be some real-time connection.” She even mentioned video-taping classes and including them with her web-based course. Hopefully, this can be pursued by administration as well. “I think the steep curve we’re all going through as students and instructors is how do we work in this medium? How we work in this environment is one of those things that are on the back burner. And with technology (and video) streaming getting better and better, that will probably take care of itself."

Hopefully the advances in technology will alleviate the communication barriers that might be erected. As a learner in the web-based environment, these instructors believe that students have to generate their own motivation. Many students look to the Internet for additional resources. These instructors also consider the graphing calculator as a resource critical to student success regardless of instructional modality.

Hand-held technology

The graphing calculator's role in minimizing computation and focusing on interpretations have led these instructors and their colleagues to require the calculator for all their students. Ann says, "I want them to worry not about how I get the number, but what does this number mean when you get it." Beverly is predisposed that "with an experienced instructor, you can teach them as richly and deeply with the technology as with the algorithm." She has even coined the term "technological anxiety" to describe some of her students' anxiety with the graphing calculator. To help with this anxiety, Ann reminds students of the two critical keystones involved in obtaining the solution to provide them with a point of origin in case their technological anxiety levels paralyze them.

The technological anxiety is addressed at the lowest level through a proactive posting of step-by-step keystroke guides. The next step for students requiring additional help is to e–mail the instructor, and some faculty have made themselves available via telephone. Both instructors encourage their web-based learners to occasionally attend their classroom sections. Usually early in the quarter (up through descriptive statistics), there is significant time on acculturating students to the graphing calculator. The current textbook is customized with keystrokes imbedded within the content and provides instructional videos on the graphing calculator for another level of assistance. Over time, students become familiar and successfully navigate the course.

Attributes for Success

Technical requirements are important as quizzes are made available online during small windows of time. Inopportune down Internet periods could adversely affect a student's ability to complete these quizzes. Even with the potential for a negative consequence, Beverly comments that quizzes are necessary: "One, to give them immediate feedback in the key concepts they need to be getting and, two, to get them to stay on schedule. A long-standing issue is that Minitab requires an IBM machine, not a Macintosh. The students find a way to work with this issue also by using local computer labs. Students need Minitab to be successful in the course and faculty have found that those who are less self-sufficient in accessing Minitab are the ones who are not as technologically savvy."

The instructors also commented that students who do not access content the first week of the course or who tend to have regular technical questions are particularly at risk. The extent of this disparity in performance was not commented on.

For the most part, the same assessments are provided to both web-based and classroom learners. This is definitely true for mid-terms and final exams. Beverly's classroom-educated students have end-of-chapter group activities that they are awarded points for, and the group project at the end of the course is also slightly different.
The higher-stakes assessments are the same: the midterms and departmental final. Beverly's classroom learners benefit from formative assessment practices, which are more difficult to replicate via the Web.

In terms of achievement, Beverly mentions that "either they blow it out of the water or they fail it miserably. There's very little middle ground on that." But toward the end of the quarter, with the second exam and the final in particular, the web students outperform the classroom learners. There is strong suspicion that by the second exam, the poorer students have weeded themselves out. Ann confirms this: "as the web students filter themselves out then by the end of the quarter, the web students are better because there are fewer of them staying." As a point of information, the Post-Test performances administered within this study did not confirm these remarks.

Ann attributes the improved retention to higher expectations and accountability for web students. Weekly quizzes, Discussion Board postings, and labs have improved the amount of time-on-task. Ann mentioned that "initially I thought, 'these people are so busy that I don't want to overload them with all of this work.' But if you don't, then they don't get into the content they don't get online." Ann also uses a learning styles inventory and advises the students accordingly. "I say that these are your learning style preference kinesthetic and oral…. You don't want to be taking this online because you really need the interaction with people."

There have been recent improvements in success. Ann attributes this in part to her strategy of alerting students of the expectations for this course in her "Welcome Letter" that the students read when they first access the course. The letter pointedly encourages students with minimal time to invest in the course or sub-par technology skills to enroll in a classroom section. It also makes a strong case that the time demanded of the course exceeds that of the classroom section. Ann also mentions, "… they enroll in a web course because they don't have time for a traditional class, which is contradictory to the Web class, because you need even more time." Student comments from previous quarters are also included. Beverly has a similar letter for her students.

Both instructors consider this type of introduction to the course important because the prerequisites for the web-based sections and classroom sections are the same, although the delivery of content differs significantly.

Motivation is considered a key factor that underpins success, as it leads to heightened participation and persistence first. Ann succinctly stated, "If they are intrinsically motivated, they do well in a web class." Attitude interacts with motivation as those who believe they can do it will ask the questions they need to get the desired answers. Both instructors believe that the students in their web sections are more motivated than those in their classroom sections. "There's that determination, that if they want to succeed, to do whatever it takes. And that's what gets them through." Students receiving classroom instruction have less to navigate through to interact with the instructor, and the instructor directly helps them to learn the material. Without the Web, many students would find ways to complete courses. However, there are some who may not have enrolled at all. Ann comments, “It (web-based instruction) is handy for those students who do succeed. If you are motivated and you can squeeze it in after the kids go to bed and figure that out, then that’s great.”

Attitude can be more influenced by the instructor’s attitude. When students are frustrated, the key is to obtain help from the instructor as soon as possible. Beverly describes the interaction between two of the constructs in the following way: “If they’re open to being socially interactive and vulnerable to their instructor or to another student, they can get some help with their attitude. I think attitude, if it’s going to inhibit your social interaction, could be a detriment.”

Negative attitudes toward the course can lead to poor attendance and/or participation in either modality. It is more difficult to identify issues with attitude toward a course with distance learners as the non-responsiveness is more difficult to interpret.

Computer expertise is deemed important for success via the Web. In the traditional class, you can rely more on the instructor. Those that are less computer-savvy can readily reach out to others for immediate help. In some cases, faculty and students may offer help as they notice that someone is having difficulties. Computer expertise is critical as the content is accessed through the Internet. An unreliable Internet connection is a barrier to web-based instruction and can affect student learning.

Social interaction is important, but not critical, for web-based instruction. With class projects, those who are more reclusive may withdraw more from participation and, consequently, receive lower grades. Classroom instruction may have more emphasis on social interaction, as they are co-learning (in many cases) with their peers. However, distance learning is rooted in independent learning. Ann believes, “I don’t think peer interaction has as much to do with it (student decision to enroll in web-based statistic course).”

These instructors believe that motivation and attitude are critical in determining success in web-based courses. A strong knowledge of the computer will make the academic journey more pleasant for the student, with peer availability for occasional consultation as an added bonus.

The instructors believe that students can learn via the Web. In fact, they believe that a “special type of student” might be better suited to it. Beverly states that “I’ve had some of my best students take it on the Web. Some of my best projects, exams, open-ended responses I’ve ever seen have been from my online students.”

More often distance learners are not getting their first degree, so academia experience gives them increased levels of academic maturity and organizational skills. Beverly states: “The type of student that is most successful tends to be the student who already has a degree and need a stats course to go on to get a Master’s degree.” Ann indicates that successful students are “older people that do well with schedules (not procrastinators), the ones that have jobs and probably families and they probably have to keep a schedule. Just with that accomplishment alone, they have more experience with the expectations associated with the college setting. Beverly also mentions that “I’ve also seen some of my worst. They should be in a traditional class (and take it a few times).”

Ann notices that more of her classroom learners complete statistics than her distance learners. For the 2005-06 academic year, the median withdrawal rate for students in the statistics web course was 45% and the overall withdrawal rate for the course was 20% (this includes the web courses). Ann's data for the same period was comparable to the general trend with classroom learners and slightly larger (median withdrawal rate of 56%) for web-based instruction. This statement alone seems to indicate that because the instruction is largely independent, stronger students should enroll in web-based statistics courses. The prospective web-based learner would be wise to take an inventory of his or her experiences with mathematics, current situation in life, and then conduct his or her own cost-benefit analysis.

Both instructors enjoy teaching via the Web. Ann's experience was enhanced by her most recent students' performances. Web instruction allows Ann flexibility and places the responsibility of the learning more on the student. Both instructors have adjusted to the numbers of e–mails and the occasional strongly emotional e–mails that accompany web-based instruction. In the beginning of the quarter, there is a flurry of communications with students, but it eventually drops. Beverly mentions that "my 'more capable students' enjoy the web class more than traditional because it's more efficient for them." In agreement, Ann states that "I end up in the web class with the people who are top-notched at the end of the quarter; it's awesome.' Classroom-instructed students tend to hold on even against greater odds of failing the course. However, this was not widely the case according to the spring of 2006 data. Of the students who did not withdraw from the classroom section, 20% received an A and 13% received an E. For the four web sections, the median percentage of an A was 21 and the median percentage of an E was 32.5, with the median percentage being the median of the listing of proportions of As and Es from the four sections. Beverly mentions, “I’d say that my students who struggle really should not take the web class. There’s way too much pain and suffering. And I wonder why they don’t sign up for a traditional class.” In cases where a student has taken this class via the web multiple times, she e–mails them to encourage them to change sections or at least occasionally attend a classroom section. Perhaps these actions could reduce the percentage of Es.

Ann mentions that some of her classroom learners often claim that they cannot imagine taking the web-based introductory statistics course. In fact, it is rare to hear of a student being encouraged to take a class online when they begin in the classroom, nor is this suggested by the student.

There is a population of students taking both web-based and classroom-based sections. Hence, some distance learners in statistics consider it a minimal inconvenience to attend an office hour because they are already on campus. Beverly thinks, “Now, why they’d choose to take statistics online, I do not know. I would think that that would be one they’d do traditionally if you’re coming to campus anyway.”

Strong motivation has been a key component for success in web courses.

Summary of Faculty Interviews

Both instructors respond to voicemails, and Ann encourages such when she receives confusing e–mails or matters involving the calculator. This is a good adaptation for the problems associated with communicating mathematics notation via the computer. An added bonus from a teaching perspective has been Ann's Tablet PC. "With my notebook, I can save it, write out my response, and save it as a PDF and send it to them as an attachment." Ann also uses the software to aid with graphing calculator instruction. These technology tools help in replicating classroom instructional practices.

Projects, problem sets, and Discussion Boards are all used. Chat rooms have not been used widely, because it is both a new modality of instruction and it can be challenging to find a common time for a set of students who enrolled in a modality rooted in asynchronicity. Ann uses Discussion Boards for students to virtually teach each other in a more content-oriented sense. Beverly allows for more general dialogue.

The course grade is determined with 80% of the assessment coming from the three midterms and the departmental final, 10% coming from the Minitab labs, and 10% coming from the alternative assessments. Ann incorporates lab questions into the quizzes and considers that addition to be staying within departmental guidelines. Classroom learners have weekly labs, quizzes, and a project.

Despite backgrounds in computer programming, web-based instruction is forcing the instructors to teach in a setting that they have minimally experienced as students. With increased opportunity to teach in this new modality, they are beginning to expand their instructional repertoires. Ann uses Flash Cards and Beverly, Power Point; both have found applets helpful. The students are becoming more "self-sufficient" as the typical student today is more comfortable with technology than the students the instructors encountered in their earlier experiences with web-based instruction. As well, student conceptual understanding is perceived to be improving. Beverly summarizes a fundamental difference in web instruction as, "Anytime you teach yourself something and you hang in there and master it. You probably know it better than just relying on what the instructor told you… their learning is probably deeper than in a traditional classroom simply because they have to construct the information for themselves as opposed to borrowing my construct of it." Ann affirms this as she has asked more concept-related questions through Discussion Board postings and her students have responded favorably. Both use Minitab labs and have noticed marked improvement in student performance.

The faculty interviews provide initial windows into the milieu that contextualizes the potential answers to the research questions posed in this study. Faculty have mentioned that students can learn via web-based instruction. Specifically, they identify that even with greater attrition than traditional students, the "strong students" can be successful.

Still, something is missing. Both instructors indicated that their web sections are still environments where the strong (mathematically, in maturation, degree completion, motivation) survive. They purport that hypothesis testing and confidence intervals are better learned in the classroom. (This is discussed later in the item analysis of the CAOS exam.) Some of the needs with learning the graphing calculator keystrokes are being addressed; yet, web-based learners are still unable to visually witness a step-by-step progression through exercises with the calculator. And yes, the instruction is largely text-driven.

Overall, the entire community is becoming more familiar with web-based instruction. Students have fewer questions with trouble-shooting, faculty are more experienced, and infrastructure has strengthened. Beverly articulates, “I think they, the younger students, just know how to use the computer. Web instruction will just be something that’s out there that’s known by students.” Self-admittedly, Beverly identifies that because she has not grown up with the computer, it may not be her preferred way to teach. Hence, there is greater comfort to try new ideas in her more familiar educational setting of the classroom.

There is a common conviction among the two faculty members that the numbers of web sections will only increase. Beverly believes that technology may even transcend our views of how learning is conducted—not by gathering in classrooms, but instead by meeting in virtual groups. The demand may force issues with communication to be remedied faster. Ann is more pragmatic in thinking that the financial benefit to the institution for Distance Learning (students more likely to attempt a course multiple times) will perpetuate growth. The joint perspective on the hybrid offerings—where, in addition to replicating the web course, these students are expected to attend in-class sessions usually not totaling above half the total instructional hours—will stabilize and witness a slowing in demand. Historically, the enrollment pattern has reflected a preference for the Web over the hybrid. Beverly’s hybrid students can complete group work during their in-class sections. Often, attendance wanes by the end and some of these students do not attend at all. The permanence of the hybrid courses will be discussions for the next few years to come.

There is growing interest for a possible conference or day-long session where faculty can meet with colleagues who also teach this course online. Usually, web dialogue centers on classroom pedagogy. There is now coming a time for discussions surrounding “web pedagogy.” Beverly mentions, “As opposed to re-inventing my own wheel, I’d just use someone else’s.”

Ann and Beverly believe web-based instruction will remain a formidable part of the community college fabric. Beverly asserts that the very essence of teaching will be redefined by Distance Learning with more “virtual work groups.” Ann recognizes that the convenience factor will make it popular among students and accepted by faculty. There is shared optimism that nuances that are currently unique to classroom instruction will be replicated in the virtual one as well.

The faculty interviews provided great insight into the issues, trends, and challenges with web-based instruction from a longitudinal perspective into the rationale behind why instructors emphasize certain instructional practices based on their own experiences. Now that there is a window into the minds of the instructors, it is time to ascertain greater information about the students that were a part of this study. Demographic information about the students and other pieces of information regarding student attributes will be explored in the next section.

Demographics

Efforts to recruit participants included multiple attempts at phone calls and electronic mail messages. Table 4.1 shows the classifications of each person enrolled as of one week in advance of the first day of the quarter.

Table 4.1 Prospective Participants by Confirmation Status and Section

		Yes	Undetermined	No	New	Total
Ann	Web	17	32	4	1	54
	Classroom	9	16	0	2	27
Beverly	Web	17	29	4	3	53
	Classroom	5	10	0	0	15
	Total	48	87	8	6	149

Students in the "Undetermined" category had neither responded in the affirmative nor had they declined participation in the research project. "New" students had yet to have been formally contacted. Table 4.2 shows the final categorization of Participants.

Table 4.2 Participants and Non-Participants by Section

		Participants	Non-Participants	Total	Participation Rate
Ann	Web	13	41	54	24.1%
	Classroom	21	5	26	80.7%
Beverly	Web	9	42	51	17.6%
	Classroom	11	4	15	73.3%
	Total	54	92	146	37.0%

A 37% participation rate evenly distributed would have been preferred to what resulted. But, having the distance students come to campus two additional times for the CAOS Exam seemed to pose a barrier to their participation. With 78% of students participating, the classroom-instructed students were almost thrice more likely to participate in this project over their web-instructed counterparts, who had 21% participate. Beverly seems to have lower participation rates in-part due to strong participation rates and size of Ann’s classroom section.

This phenomenon forced the researcher to investigate whether the participants were dissimilar to non-participants as it pertained to the distance learners. In each case, the researcher compared the data collected from the participants to a random sample of statistics web students who chose not to participate.

The two variables that yielded statistically significant differences were “Overall GPA” (cumulative grade point average) and “Math hrs. <C” (number of hours in mathematics resulting in a grade below a C). For notational purposes, from here forward, standard deviation will be referred to as “s.d.” and sample size as “n.”

Table 4.3 GPA Combined by Instructor and by Participant Status

	Instructor	Participants M, (SD, n)	Non-participants M, (SD, n)
GPA	(combined)	3.291 (.429, 12)	2.783 (.607, 22)
GPA	Ann	3.354 (.517, 7)	2.861 (.620, 11)
	Beverly	3.204 (.299, 5)	2.704 (.613, 11)

Twelve students had GPAs from the local institution (the 10 transfer students did not have GPAs). Table 4.4 provides some initial confirmation that the students interested in responding to and participating in the research study had above average GPAs (combined p-value <.01). There was a negligible difference in overall GPA by instructor, when comparing participants to non-participants of those randomly sampled. There was minimal evidence that one instructor was naturally enrolling students with stronger GPAs.

On an aggregate level, Ann's 18 students had an average GPA of 3.053 with an s.d. of .618. Beverly's students had an average of 2.860 with a s.d. of .576. (p-value = .355). Ann's students had slightly higher GPAs, but for all practical purposes, the results were comparable. Knowing that the stronger-than-average students participated in the research project coupled with the 20% participation rate in the web course informs that performance might be slightly inflated relative to the larger web-student population. Other variables included: “Math hours below a grade of C,” “Distance Learning (WEB) not completed” (hours in Distance Learning not completed), “WEB completed, (hours of web courses completed)” “Math Completed (hours of mathematics courses completed),” “Math GPA (GPA in mathematics courses),” “(CSCC) Completed (hours completed at the participating institution),” “CSCC Attempted (hours attempted at the participating institution),” and “Completed Elsewhere (hours completed at other institutions).” The random sample of participants on average had fewer hours below a C, completed more courses, higher math GPAs, completed a higher percentage of courses, and completed fewer hours elsewhere. In sum, these results were consistent with the notion that the respondents were in all likelihood better prepared for the course than the non-respondents. Individually, they were not significant at the .05 levels of significance, but the average scores tended to lean in that general direction.

Are the students in the web-based sections repeating introductory statistics?

For the 11 non-participants with a previous grade in the course, 4 of them had taken the course multiple times. One person failed 3 times, another withdrew 4 times, and the other two had withdrawn once and received either a W or an E for the other attempt. Assigning a metric of -1 for withdrawal, -1.5 for D and W, and -3 for multiple unsuccessful attempts with no credit yields an average of -1.2 for the participants and -1.73 for the non-participants. At this particular institution, only the grade from the most recent attempt at the course is included in the grade point average. The other attempts still appear on the transcript and have an “R” designation next to them, indicating that that grade was replaced. Nevertheless, the participants tended to have fewer negative previous experiences with this course.

It is also noteworthy that of the 16 total web students (participants and non-participants) who were previously enrolled in the introductory statistics course, 12 had taken it at least once via the web. A 95% confidence interval for the proportion of web students who had previously attempted the course via the Web would be (47.6%, 92.74%). Almost a majority of web students who are repeating the course had taken it previously via the Web. There is some indication that a lack of success in the previous attempt for distance learners was due to taking the course on the Web.

Another factor is that many students are not native students to the institution where the study was conducted. It is inconclusive as to whether these students had previously taken the introductory statistics course. Since courses taken receiving failing or withdrawal marks are not transferred, there is some concern about performance. It is now appropriate to investigate whether participants are as likely to have had their pre-requisite mathematics coursework from the institution as those from the set of non-participants.

Native

For simplicity, “native” students are defined as students for whom either their most recent or penultimate mathematics course was taken at the institution where the research in this document was conducted. This is particularly relevant as summer quarter courses tend to cater to transient students from other institutions. The high proportions of students that had significantly exceeded the pre-requisite led to the thought that many of the students may not have been previously from the institution, and instead were transient students from other institutions. There was no statistically significant difference among the participants and non-participants (p-value = .204). Thirteen of the 19 participants and 13 of the 26 that were randomly sampled had taken their highest math at another institution. This is relevant as students from four-year institutions may have stronger academic preparation as their home institution may have admissions requirement, but the community colleges do not. According to the data, the participants were 18% more likely to have taken their most recent mathematics course at another institution.

Table 4.4 Math GPA, Hours Attempted at the Institution and Completed by Participant Status

	Participants Median (IQR, n)	Non-participants Median (IQR, n)
Math GPA	3.25 (2.31, 6)	2.882 (1.516, 13)
Hours Completed	32 (51.8, 12)	50.50 (60.5, 22)
Hours Attempted	33.5 (55.5, 12)	68 (77, 23)

Given that many of the students were transient, the point-valueless K (denoting credit from another institution) or KD (acknowledgement of a D from another institution) were the only indicators of successful course completion. The differences in math GPA were not statistically significant, but the participants did seem to have higher GPAs, as evidenced in Table 4.4. The Median and Inter-quartile range (IQR) were reported due to the skewness in the data.

Focusing on the students with credit hours at the institution, both groups had similar behavior in terms of the number of hours completed (grade C or better). The more intriguing matter was in the number of hours attempted. Performance of the Mann-Whitney Nonparametric test yielded of .0497; supporting that participants were more likely complete the courses attempted. Hence, they were less likely to withdraw and fail.

Hours Not Completed Successfully and the Rate of such an Occurrence

The N.C.R. = “(hours attempted – hours completed) / hours attempted.” The average N.C.R. for participants was 17.63% with a s.d. of 15.57%. The N.C.R. for the random sample was almost twice as high at 32% with a standard deviation of 24.75%.

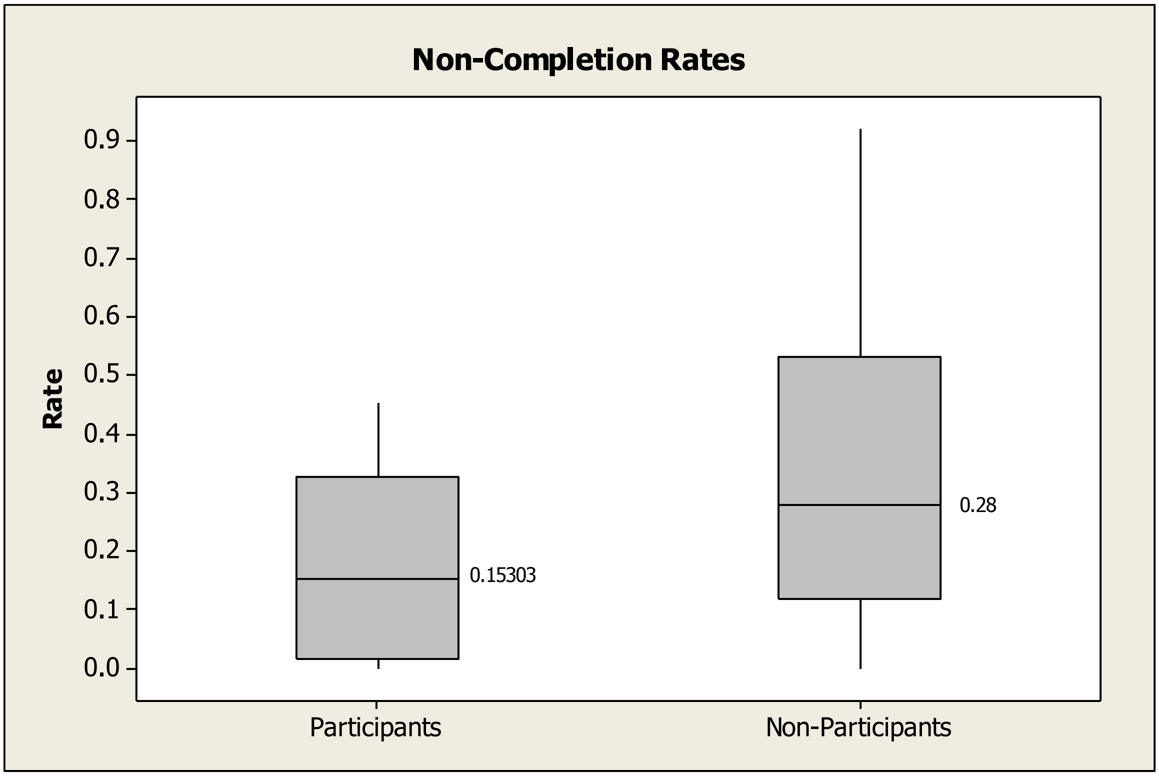

Figure 4.1 Non-Completion Rates by Participation Status

The median NCRs are labeled in Figure 4.1. The Mann-Whitney Test yielded a p-value of .097 implying there is some support of a difference, but not statistically significant at the .05 level.

GPA

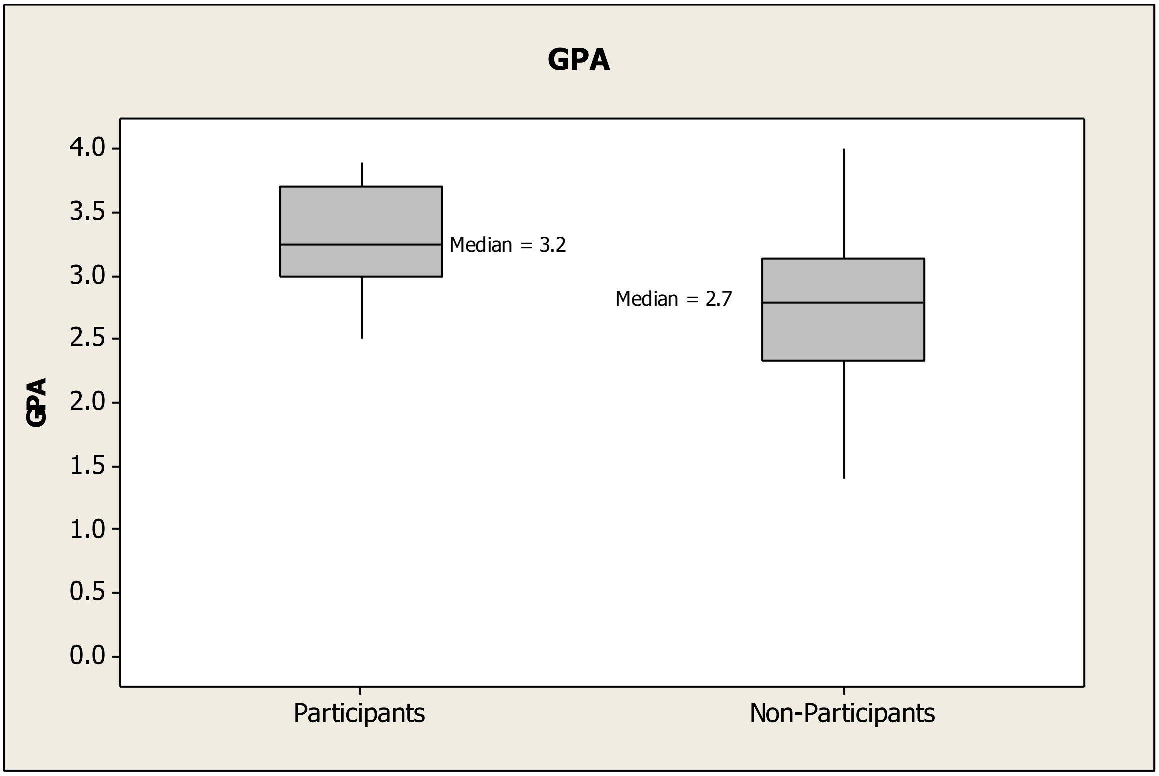

Figure 4.2 GPA by Participation Status

The median GPAs are labeled in Figure 4.2 with averages of 3.291 for participants and 2.783 for non-participants (p-value = .008). A comparison of the random sample of participants to those enrolled in the two web courses revealed that the participants might be of stronger preparedness, as evidenced by higher GPA, lower NCRs, and other related variables. This limitation is discussed further in the next chapter.

Now that there is knowledge that the participating web students have some differences from the larger population, it is more important to compare their performance to their classroom-educated counterparts beginning with highest math course completed.

Highest Math Course Completed Prior to Statistics Enrollment

Table 4.5 Highest Course Legend

Code	Descriptor
Beginning	Beginning Algebra
Calculus	Calculus
College	College Algebra
Intermediate	Intermediate Algebra, Technical Mathematics, or Mathematics for the Liberal Arts
Placement	Students whose placement was determined by placing into a course above the pre-requisite or whose placement was determined by an advisor and transcripts were still under processing.
Pre-Calculus	Pre-Calculus, Business Calculus I, or Business Calculus II

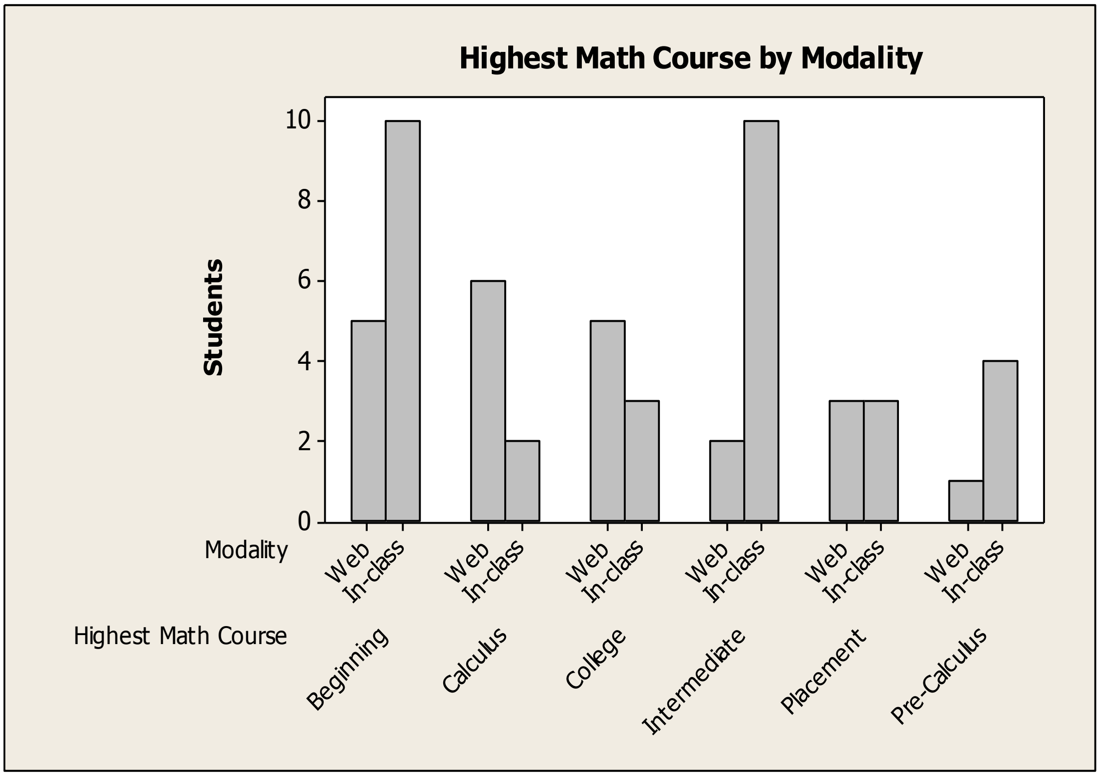

Figure 4.3 Cluster Bar Graph of Course by Modality

Classifying the students by prior mathematics preparation, there was a statistically significant association between preparedness and modality. Figure 4.3 displays this for the categories described in Table 4.6. Analyses revealed that students in the web section were more likely to have preparedness at least at the College Algebra level (p-value= .014). The hours of mathematics courses completed among the two modalities were comparable. The fact that there were four students who did not have previous coursework in mathematics reflects those students able to enroll in the course due to a placement exam or with transcripts under review.

Table 4.6 Coursework Information by Modality

	Web Median, (IQR, n)	Classroom Median, (IQR, n)
Math GPA	3.25 (2.31, 6)	2.00 (1.643, 27)
Overall GPA	3.241 (.708, 12)	2.732 (.728, 29)
Hours Completed at Institution	32 (51.8, 12)	57 (33, 29)
Hours Attempted at Institution	33.5 (55.5, 12)	79 (61.5, 29)
Credit hours Completed Elsewhere	52.5 (78.8, 18)	37.5 (44.3, 16)

There were a total of 22 students enrolled in the web sections and 32 in the classroom sections. Their coursework, in terms of credit hours, is described in Table 4.6 and, again, due to skewness, the Mann-Whitney test will be implored. Many students had transfer credit from other institutions. The math GPA for web students was higher even though the small sample size for web inflated the p-value (.142). The cumulative GPAs were significantly different (p-value = .009). Students in the traditional classroom environment tended to enroll in more credit hours at the institution (p-value = .0497). This same trend continued for credit hours attempted (p-value = .167). One of the aims of Distance Learning is to reach a broader student base through asynchronous learning, and the evidence in this study does not contest this goal.

The math GPA for students in the web course tended to be higher than for the classroom students. But, could it be that the students receiving classroom instruction are taking more courses in mathematics and having difficulty matriculating through them?

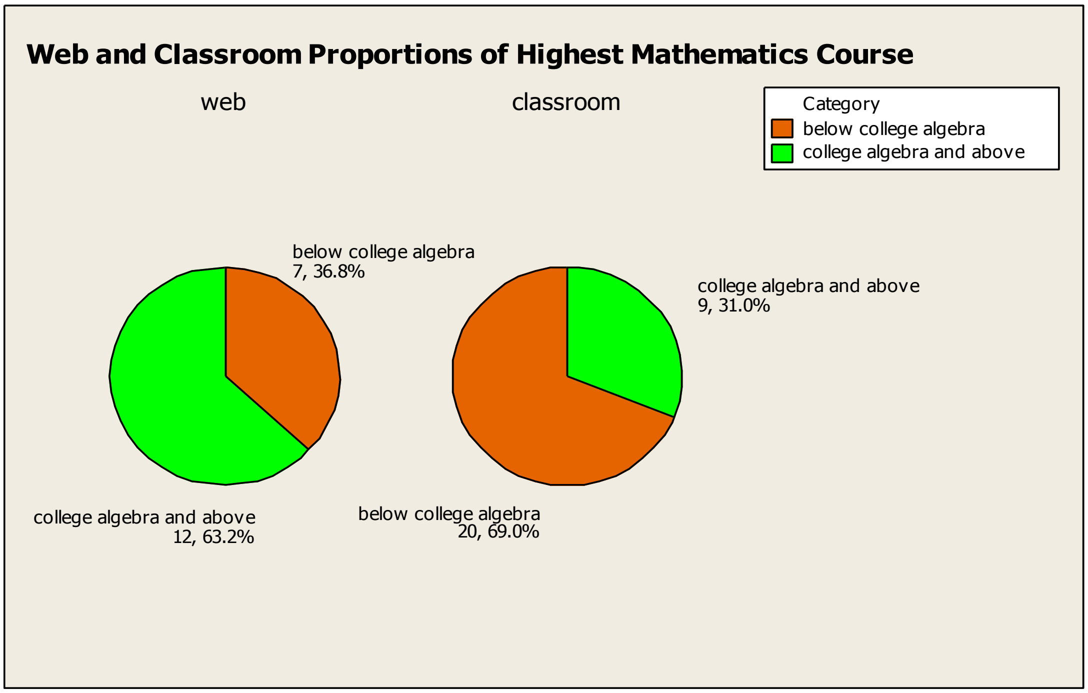

Figure 4.4 Pie Charts of Modality by College Algebra Classification

Figure 4.4 aggregates the courses from Table 4.5 into two broader categories—either being below College Algebra or at least at the level of College Algebra—to more succinctly summarize the data. This is important as College Algebra is the lowest widely recognized course that is not considered remedial. The College Algebra course in this study is the final pre-requisite to Pre-Calculus, and it covers inverses and exponential and logarithmic functions. This level of information was not available for 6 students (3 from each modality). Thereby, the number of web students is reduced from 22 to 19 and from 32 to 29 for those receiving classroom instruction.

For seven of 19 (36.8%) students in the web section, their highest math course was "below College Algebra," whereas 20 of 29 students (68.9%) receiving classroom instruction have the same distinction (p-value = .022 reflects removal of students who enrolled in the course via placement examination). Students taking the course in the classroom are almost twice as likely to have minimal preparation for statistics. The classroom instructed students seem to have worse performance in lower courses.

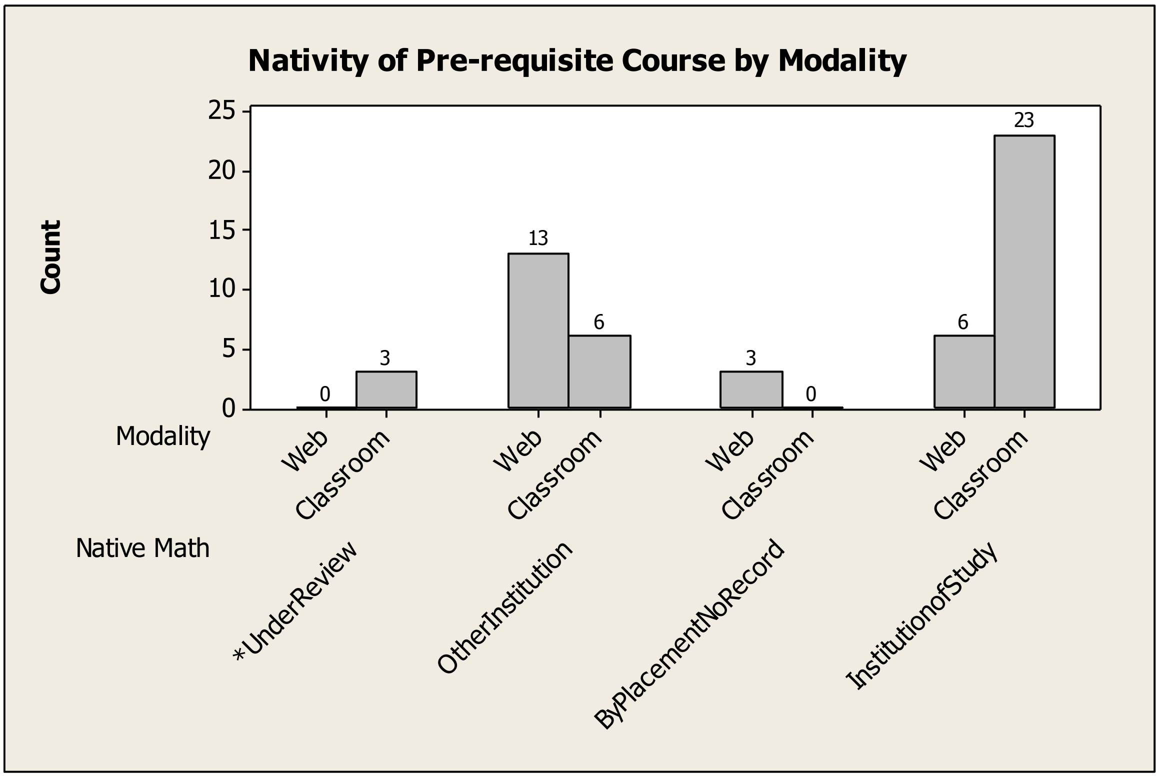

Figure 4.5 Cluster Bar Chart of Native Mathematics by Modality

Figure 4.5 displays where students of both modalities had taken their prior mathematics coursework. This will provide additional information about the milieu of the preparatory coursework. In only about 11% (3 for distance learners, 3 for classroom learners) of the cases, the student enrolled in the statistics course without formal academic record of the pre-requisite. Largely in these cases, this was attributed to a review of an unofficial transcript by a college staff member, or by the college placement exam. Only 6 of 19 (31.6%) web-based learners had taken their highest mathematics course at the institution. The same statistics were 23 of 29 (79.3%) for the classroom (p-value = .000). Distance learners were more likely to have hailed from other institutions. The modal institution for non-natives was the LLU (large local university) claiming 9 of the 20 non-natives.

Table 4.7 Statistics Repeat Attempters by Instructor and Modality

		Repeat Attempters	No Previous Statistics Course	Unconfirmed	Total
Ann	Web	4	7	2	13
	Classroom	7	12	2	21
Beverly	Web	1	7*	1	9
	Classroom	5	5	1	11
	Total	17	31	6	54

*- Six of these students had taken mathematics courses at other institutions (none below college algebra).

Table 4.7 probes further information about repeat attempters of statistics. A substantial proportion of students were enrolling in the course for at least a second time (26.3% for web-based sections and 41.4% for classroom sections). This disparity revealed that the distance learners were coming in with stronger backgrounds in mathematics and with less formal experience with this statistics course. Classroom-educated students seemed to be retaking the course at higher rates: (50% for Beverly, 36.8% for Ann).

Of Ann's 11 distance learners with confirmed mathematics coursework, 5 had confirmed a highest math course below college algebra. Of Beverly's 8 students with this designation, 2 had such a distinction. With these smaller sample sizes, participants from Ann's class were more than twice as likely to have minimal mathematics proficiency for this course. For those receiving classroom instruction, 13 of Ann's 20 students with confirmed mathematics histories were below College Algebra, and 7 of 10 for Beverly. Overall, 69% of participants that enrolled in classroom sections had mathematics preparedness below College Algebra. Conversely, the majority of distance learners had preparation above College Algebra. This disparity in preparation could play a critical role in course success.

Correlation Analyses

The following pairs of variables had strong correlations. GPA was a common variable impacting the significance of the correlation. Table 4.8 investigates a variety of independent variables.

Table 4.8 Correlation Analyses

Pair	Correlation	P-value	Implication
Modality and Pre-Test	-.549	.000	Classroom-educated students performed lower on Pre-Test.
Modality and Post-Test	-.421	.011	Classroom-educated students performed lower on Post-Test.
Modality and GPA	-.395	.011	Classroom students had lower GPAs.
GPA and Pre-Test	.317	.044	Students with higher GPAs performed well on the Pre-Test.
GPA and Post-Test	.563	.000	Students with higher GPAs performed well on Post-Test.
GPA and Math GPA	.789	.000	Math success impacts overall success.
Web completed and Pre-Test	.574	.002	Students with more web hours performed better on the Pre-Test.

continued

Non-completion Rate and GPA	-.371	.017	Higher non-completion rates translate into lower overall GPAs.
Post-Test and Instructor	.608	.000	Beverly's students had higher Post-Test scores.
GPA and WEB not completed	-.403	.041	The higher the GPA, the fewer unsuccessful completion of WEB courses
WEB not Completed and Instructor	-.459	.018	Beverly's students had fewer incidences of unsuccessful WEB attempts.
Final and GPA	.405	.044	Students with higher GPAs had stronger Final Exam scores.
Total Elsewhere and Math Completed	.426	.014	Students from other institutions tended to have more hours in mathematics.

Items pertaining to instrumentation used in the research study (Pre-Test, Post-Test, final) will be addressed in greater detail in subsequent parts of this chapter. A common theme from the above chart is that successful course completion (especially with more mathematics courses) can lead to success in statistics.

Non-completion rates did not differ by factor-level combinations of modality and instructor. For Ann and Beverly's web students, respectively, they scored 18.22% and 16.81%.

A brief investigation of the entering characteristics have revealed that preparedness as measured by highest math course completed and GPA are critical to success in introductory statistics courses. The participants in the web sections are better prepared than those receiving classroom education. GPA is a common covariate associated with strong correlation. It was the case that students in the web-based sections were better prepared, from other institutions, and tended to have stronger GPAs than their classroom counterparts. The implications of this are that the students receiving web-based instruction tended to be stronger students who were better-situated for some of the challenges (independent learning and self-regulation) asynchronous learning presents. Other demographic variables will be investigated in analyzing the following survey that was administered within the first week of the course.

Background Questionnaire

Students completed the Background Questionnaire prior to the Pre-Test. A general summary of the results indicates that students have over 55 hours weekly committed to other responsibilities, they are comfortable with a computer, over 90% have high-speed Internet service, they have taken three college mathematics courses, they are

27 years old, and they have relatively high levels of self-efficacy towards mathematics. The number of responses did not equal 54 since some did not answer every item.

Non-Academic Responsibilities

Table 4.9 Non-Academic Responsibilities by Instructor and Modality

	Web Median, (IQR, n)	Classroom Median, (IQR, n)
Non-Academic Responsibilities	52.5 (40, 22)	40 (38.5, 30)
Ann	45 (35, 13)	32.5 (28.75, 20)
Beverly	75 (52.5, 9)	60.5 (18.75, 10)

The asynchronicity of web-based instructions allows for great flexibility to accommodate a variety of non-academic responsibilities. A presumption is that web-based learners have higher involvement in such activities than students receiving classroom instruction. Table 4.8 reveals that there are exceptions to this presumption. First, the students in web-based learning did not have significantly more non-academic responsibilities (p-value=.11, Mann-Whitney due to skewness). Since the study covered a summer course, perhaps more transient traditional-aged students enrolled in web courses. Second, Beverly's classroom section was an evening section. Ironically, Beverly's students had more responsibilities than Ann's at the .05 level of significance. This could in large part be due to Beverly's class being offered at night.

Age

Table 4.10 Age by Instructor and Modality

	Web Median, (IQR, n)	Classroom Median, (IQR, n)
Aggregate	24 (7.25, 22)	24 (10.25, 32)
Ann	24 (12, 13)	23 (8, 21)
Beverly	24 (7.5, 9)	28 (21, 11)

The mean age was 27.02 overall. Table 4.10 displays the median ages for each section involved in the research study. Beverly's web students seemed uncharacteristically younger ($p = .056$) than her classroom-instructed students. However, this could be largely due to summer quarter's ability to attract other transient students and that her classroom was conducted in the late evenings.

Table 4.11 Learning Style and Computer Proficiency by Modality

	Web Mean (sd, n)	Classroom Mean (sd, n)
Learning Style (1=Individual, 2= With others)	1.306 (.458, 18)	1.833 (.379, 30)
PC Expertise	7.857 (1.59, 21)	7.109 (2.047, 32)

Learning Style, Internet Service, PC Expertise

The overwhelming majority of web-based learners indicated a preference toward individual learning (p-value=.000). Table 4.11 reflects that students chose learning modalities consistent with their preferred means of learning. Computer proficiency consistently averaged between 7–9 as students self-assessed on a Likart scale from 1–10 (10 being extremely proficient). Many students consider themselves computer savvy, but because of their own sliding scales of self-appraisal, students seemed reluctant to refer to themselves as experts. Students in web courses had higher (7.857 vs. 7.109) averages, but this was not statistically significant. Similarly, it was also found that roughly 29 of the 32 (90%) students in the classroom section had high-speed Internet. The analog was 21 of the 22 (95%) students in the web-based sections. This seems quite plausible given that their learning will take place largely through the Internet. According to these data, the ubiquity of the Internet makes it a valuable source for all students.

College GPA, Graphing Calculator, College Math & Confidence

Table 4.12 GPA and Graphing Calculator Efficacy by Modality

	Web Mean, (sd, n)	Classroom Mean, (sd, n)
GPA	3.299 (.554, 21)	3.002 (.559, 32)
Graphing	2.682 (.646, 22)	2.629 (.836, 31)

Table 4.13 Counts of College Math Courses, Confidence, and Attitude by Modality

	Modality	Under 3 (%)	3 (%)	4 (%)
College Math	Web	3 (13.6)	13 (59.1)	6 (27.3)
	Classroom	8 (21.9)	22 (68.8)	2 (6.3)
Confidence	Web	4 (19.1)	10 (47.6)	7 (33.3)
	Classroom	7 (22.6)	15 (48.4)	9 (29.0)
Attitude	Web	1 (4.6)	16 (72.7)	5 (22.7)
	Classroom	5 (16.1)	20 (64.5)	6 (19.4)

Students also had the opportunity to list their college GPA. The data referred to in this document was obtained through the institution's data management system. However, the 39 cases for which there was both institutional data and self-reported student data, the correlation was .654 (p-value=.000). Even though there were some inconsistencies, those of any substantial nature were in the minority. As seen in Table 4.12, GPA differed significantly by modality (p-value =.000). It was also determined that Ann's students self-reported lower GPAs than Beverly's (p-value=.003). Ann's students reported an average of 2.966 and Beverly's, 3.373. Again, Beverly's students were either enrolled in an evening section or enrolled in the web section. Even still, the student self-reported GPA correlated strongly with their comfort with the graphing calculator (r=.325, p-value = .017). Self-efficacy with the graphing calculator was self-reported on a scale of 1–4 and was not an obvious strength for participants as confirmed in Table 4.13. This may pose difficulty for both faculty and students, given the extent to which the calculator is emphasized within the course.

A Likart scale from 1–4 (with four being the largest) was used for performance in collegiate mathematics, frequency of computer usage, graphing calculator proficiency, and confidence in prospective mastery of statistics content. There was dependence between opinion of performance in college math course and comfort with graphing calculator. Students with higher self-efficacy were also quite comfortable with the graphing calculator (p-value < .01). There seems to be less evidence that confidence plays a role in modality choice (p-value =.927). Many of the students (almost a majority and regardless of modality) self-identified their confidence level as a 3 out of a highest score of 4. Distance learners self-identified as having higher rates of excellence with mathematics.

Student perception of their own confidence did not impact modality selection (p-value = .278). Confidence does have an impact on GPA, but in a less conventional sense.

The students with the middle level rating had the lowest average GPA. Persons who self-rated at 2 had mean GPAs of 3.40 (n=11), 3.2281 (n=24) for levels of 4 (n=16). Correlation matrices revealed college math courses as being a strong factor that correlated with GPA (p-value = .023), confidence (.092), attitude (.001), and motivation (.013) (all p-values <.10). Attitude and confidence also correlated (.012). Eleven considered their attitude at the highest level of four. There is some evidence that collegiate math performance influences attitude. The fact that so many students self-identified at these levels made modality uncorrelated with attitude. All of Ann and Beverly's web students identified their motivation as at least positive. The high views of motivation also led to both modalities having high student motivation.

Table 4.14 Correlation Analyses (Background Questionnaire)

Pair	Correlation	P-value	Implication
High School Math and Age	-.384	.004	Younger students tended to have more mathematics courses in high school
PC Confidence and Post-Test	.366	.031	Students with higher PC confidence levels had better Post-Test results
Age and Graphing Ability	-.395	.003	Older students tended to have lower self-efficacy toward their ability to use the graphing calculator
Age and Attitude	-.297	.031	Older students tended to have negative attitudes towards mathematics.
College Math and GPA	.311	.023	Students with more college mathematics courses had higher overall GPAs.

continued

continued

College Math and Attitude	.454	.001	Students with more college mathematics courses had better attitudes towards mathematics.
PC Confidence and Graphing Ability	.45	.001	Students with greater computer proficiency also had greater confidence in using the graphing calculator.
High School Math and Confidence	.375	.006	Students with more high school mathematics coursework had greater confidence in their mathematics ability.
High School Math and Attitude	.272	.048	Students with more high school mathematics courses had better attitudes towards mathematics.

continued

continued

Motivation and College Math	.339	.013	More college mathematics courses tended to produce greater amounts of motivation.
Graphing and Confidence	.401	.003	Proficiency with the graphing calculator underscored overall confidence in mathematics.
Motivation and Attitude	.409	.002	Students with greater levels of motivation tended to have more positive attitudes about mathematics.
Motivation and Confidence	.345	.012	Students with greater levels of motivation tended to have more confidence.

The same relationships from the background survey are captured in Table 4.14. Many of the students had substantial numbers of non-academic responsibilities (regardless of modality). It was not widely confirmed that web-based learners were older students. Computer proficiency was consistent across modalities. Approximately 90% of students have high-speed Internet access. Graphing calculator usage was similar. The more expected outcome was that independent learners enrolled in the Distance Learning course.

There were interesting associations. Graphing ability, college math coursework and mathematics GPA correlated strongly with many of the affective variables like confidence and attitude. GPA was one of the variables that correlated strongly with the quantitative instruments. However, confidence, attitude, and motivation were not significantly correlated with the three major quantitative instruments of the Post-Test, Pre-Test, and Final Exam. This lack of correlation implies the direct existence of limitations regarding affective factors and quantitative instruments. Understanding that more intrinsic variables, such as confidence and attitude, have greater association with performance on quantitative instruments than external factors, such as modality and high-speed Internet access, inform the researcher that cognitive factors can have immunity to perceived externally constructed barriers and can underscore any gains in Pre-Test, Post-Test and final.

Comprehensive Assessment of Outcomes for a First Course in Statistics

The Comprehensive Assessment of Outcomes for a First Course in Statistics (CAOS) exam was administered as a Pre-Test and then again as a Post-Test the week of the Final Exam for each instructor's web-based and classroom-based sections.

The three response variables were scores on the Pre-Test, the Post-Test, and the Departmental Final Exam. The Pre-Test and Post-Test were positively correlated at .647 with a p-value of .000. The final and Pre-Test had poor correlation .095 (p-value .571).

The final and Post-Test had stronger correlations (.289), but they still not significant at .05 (p-value = .289). Of course, because the Pre-Test and Post-Test are the same instrument, they would prove to be most valid in measuring student learning.

The categorical variables were modality and instructor. The quantitative variables correlated with the qualitative ones in the following way:

Table 4.15 Correlations of Quantitative Instruments with Key Factors

	Modality (p-value)	Instructor (p-value)
Pre-Test	-.549 (.000)	.154 (.265)
Post-Test	-.421 (.011)	.608 (.000)
Final	.037 (.826)	.168 (.314)

The analysis from Table 4.15 was based on the existing coding scheme of 1=Web, 2=Classroom for Modality and 1=Ann, 2=Beverly for Instructor. The table indicates first that the Pre-Test does not correlate significantly with instructor. Hence, neither instructor began at any advantage or disadvantage with respect to statistics knowledge. Students enrolled in the classroom sections performed worse on the Pre-Test. Classroom-educated students continued to perform lower on the Post-Test. Beverly's students showed significant gains in performance and will be discussed later. Final Exam performance did not differ significantly by either Modality or Instructor. A linear regression analysis produced the following model: Pretest = 23.9 – 4.52*Modality (Modality t= -4.74, p = .000). This begins to suggest that students in web-based sections performed an average of 4.5 points higher on the Pre-Test than the classroom-educated counterparts based upon regression (R-sq = 30.1, adj. 28.6). An equation modeling the linear relationship between Pre-Test and Post-Test would be Post-Test = 5.77 + 0.7881*Pre-Test. Essentially, on average adding 6 to ¾ of one's Pre-Test would yield the Post-Test score. Figure 4.6 shows the performance disparity by modality.

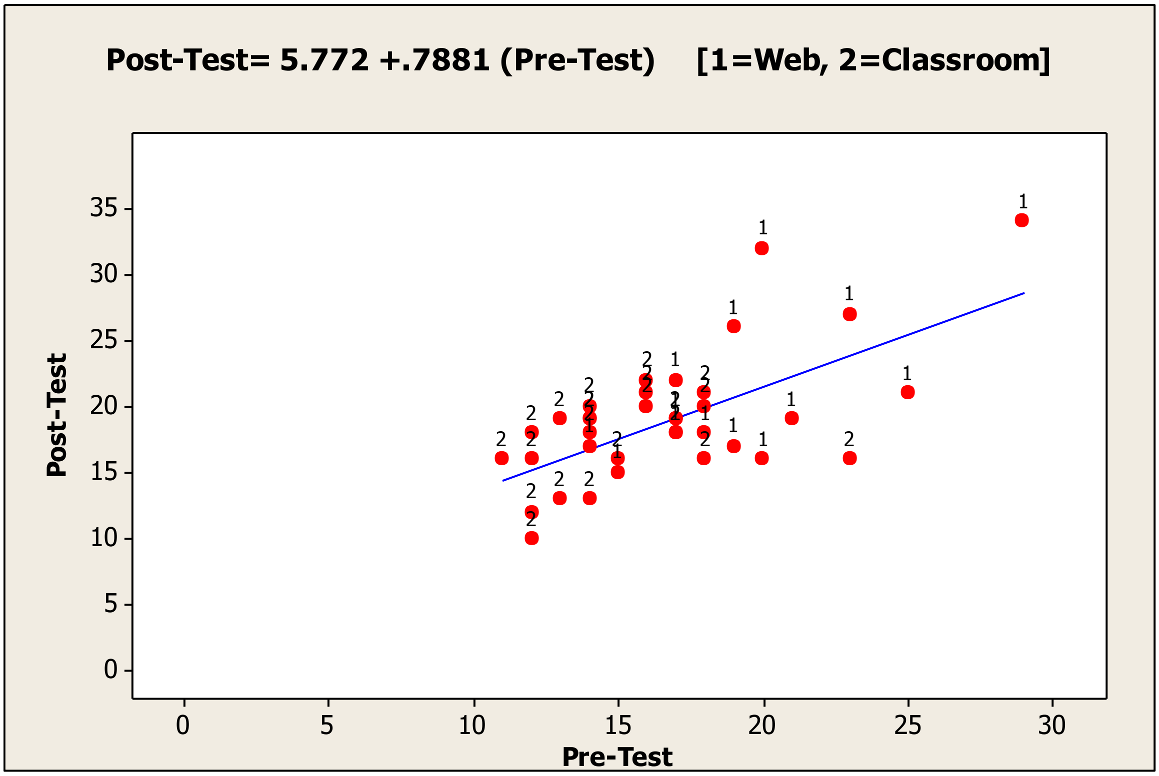

Figure 4.6 Pre-Test/Post-Test Scatterplot

The values are distributed on both sides of the linear regression equation with the ordered pair (17, 17) serving as a point to divide the majority of points between the two modalities. The increased variability in Figure 4.6 amongst WBI must also be noted. This difference in distribution undermines any initial assertions of equivalence in performance between WBI and CBI.

In beginning to ascertain the important factors that impact student performance on Pre-Test and Post-Test, the researcher considered background data (from the Background Questionnaire and from the institution), as well as, instructional methodology (instructor and modality). Essentially, the researcher believed that the type of student entering the course and the type of instruction received were essential to making inferences on student learning. Where appropriate, GPA used in General Linear Models within this paper, refers to the self-reported student GPA.

In general, weak associations between the instruments and the data gathered from the students led to their exclusion from the more substantive models. The above average proportion of students enrolling summer quarter with transfer credit made certain information (exact grade point average, for example) less available. Incompleteness of data and subjectivity of self-reported data proved partially problematic.

With less expansive General Linear Models, Instructor continued to exert itself as a critical factor in impacting Post-Test performance. Using self-reported GPA as a covariate, variables involving the CAOS Exam typically began with these two variables.

Pre-Test

There was some attrition during the study. Of the 54 students who took the Pre-Test, 36 of them took both Pre-Test and Post-Test. Of the 22 distance learners, 14 took both and 22 of 32 from the classroom sections. There was minimal difference among completion rates by modality or instructor, as reflected in Table 4.16.

Table 4.16 Study Completion Rates by Modality and Instructor

Instructor	Modality	Completion Rate
Ann	Web	8/13=61.5%
	Classroom	15/21 = 71.4%
Beverly	Web	6/9 = 66.67%
	Classroom	7/11 = 63.6%

Table 4.17 Enrollments at Key Points During the Quarter

		First Day	14^{th} Day (Census)	End of Course	Completion Rate
Ann	Web	54	51	31	57.4%
	Classroom	26	23	17	65.4%
Beverly	Web	51	41	33	64.7%
	Classroom	15	12	9	60%

The completion rates listed in Table 4.17 were quite similar to the exact rates based upon all persons who were enrolled and persisted in these classes. Also, although this is true, there was still the limitation that for WBI, the participation rates were quite low. An explicit comparison of completion rates between those who completed the study and those who did not would be quite difficult given that a non-completer of the study, does not naturally equate to not completing the course.

For this study, Beverly's completion rates were more similar between web and classroom. Participants from Ann's classroom had slightly higher persistence rates than students from her web sections, but it was not statistically significant. The differences between instructors are negligible (67.65% Ann vs. 65% Beverly). The differences between modalities were not statistically significant (63.6% Web vs. 68.75% Classroom). Of students who took the Pre-Test, 66.67% took the Post-Test. There was no significant difference in attrition based on instructor (p-value = .842).

To investigate whether the absence of the non-completing students differed greatly from the participants, the researcher compiled some additional information:

Table 4.18 Summary Statistics Regarding Pre-Test Scores by Project Completion Status

	Take Both	n	Mean (sd)	Median
Pre-Test	0	18	16.56 (4.38)	16.5
	1	36	16.75 (3.99)	16.5

The 18 non-completers (denoted by 0 above in Table 4.18) had an average Pre-Test score of 16.56 which was only .26 lower than the 36 completers. (p-value = .875). This led the researcher to conclude that the non-completers did not enter with significantly less knowledge than those who completed the course. This should undermine any beliefs that the Post-Test scores were inflated due to attrition.

The researcher also investigated whether the students lost by attrition differed in performance from course completers. The analysis is in Table 4.19.

Table 4.19 Pre-Test Score by Project Completion Status, Instructor, and Modality

Instructor	Completion Status	Mean (standard deviation, n)	P-Value
Ann	Non-Completer	16.18 (4.75, 11)	p=.982
	Completer	16.22 (3.68, 23)	
Beverly	Non-Completer	17.14 (4.02, 7)	p=.784
	Completer	17.69 (4.48, 13)	
Web Students			
Ann	Non-Completer	19.8 (2.77, 5)	p=.639
	Completer	19.00 (3.07, 8)	
Beverly	Non-Completer	17.67 (2.52, 3)	p=.341
	Completer	20.33 (5.2, 6)	
Classroom Students			
Ann	Non-Completer	13.17 (3.87, 6)	p=.408
	Completer	14.73 (3.13, 15)	
Beverly	Non-Completer	16.75 (5.25, 4)	p=.664
	Completer	15.429 (2.149, 7)	

Beverly’s non-completers received a slightly lower score on their Pre-Test. Ann’s students experienced an even smaller decrease. There was greater variety in Ann’s non-completers. In fact, in Beverly’s case, the completers had the lower class average. Students in web-based sections typically entered the course and correctly answered about 19 out of 40. Those who persisted showed more variability on the Pre-Test. The non-completers for the classroom-educated were lower for Ann and slightly higher for Beverly. In general, students enrolled in classroom sections tended to achieve scores near 14 on the Pre-Test.

A Multiple Factor Analysis of Variance (MANOVA) model including GPA (p-value= .241), coursework above College Algebra (p=.371), Instructor (p= .161) and Modality (p=.005) was first used and indicated that Modality was a statistically significant in its association with Pre-Test.

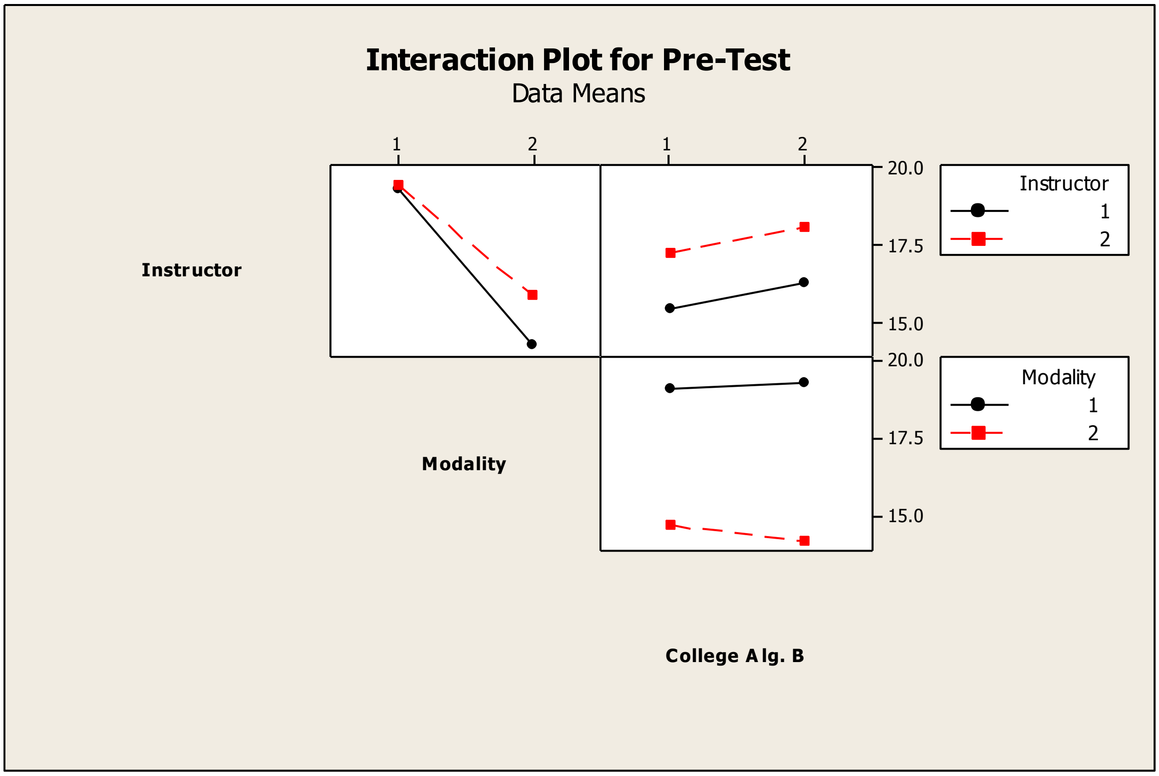

Figure 4.7 Profile Plots of Pre-Test Scores for Modality, College Algebra Coursework, and Instructor

Figure 4.7 supports the notion that there are small amounts of interaction amongst the three pairings of variables and that there is a sizable main effect due to Modality. When all 54 students' grades were included, the students in the web-based learning sections had a significantly higher performance on the Pre-Test. The 22 web-based learners averaged 19.36 with a standard deviation of 3.53. The 32 enrolled in classroom sections had an average of 14.84 on the Pre-Test with a standard deviation of 3.39. Students in web-based sections are indeed entering with a greater understanding of content (p-value = .000). Figure 4.8 is a pictorial representation of the differential.

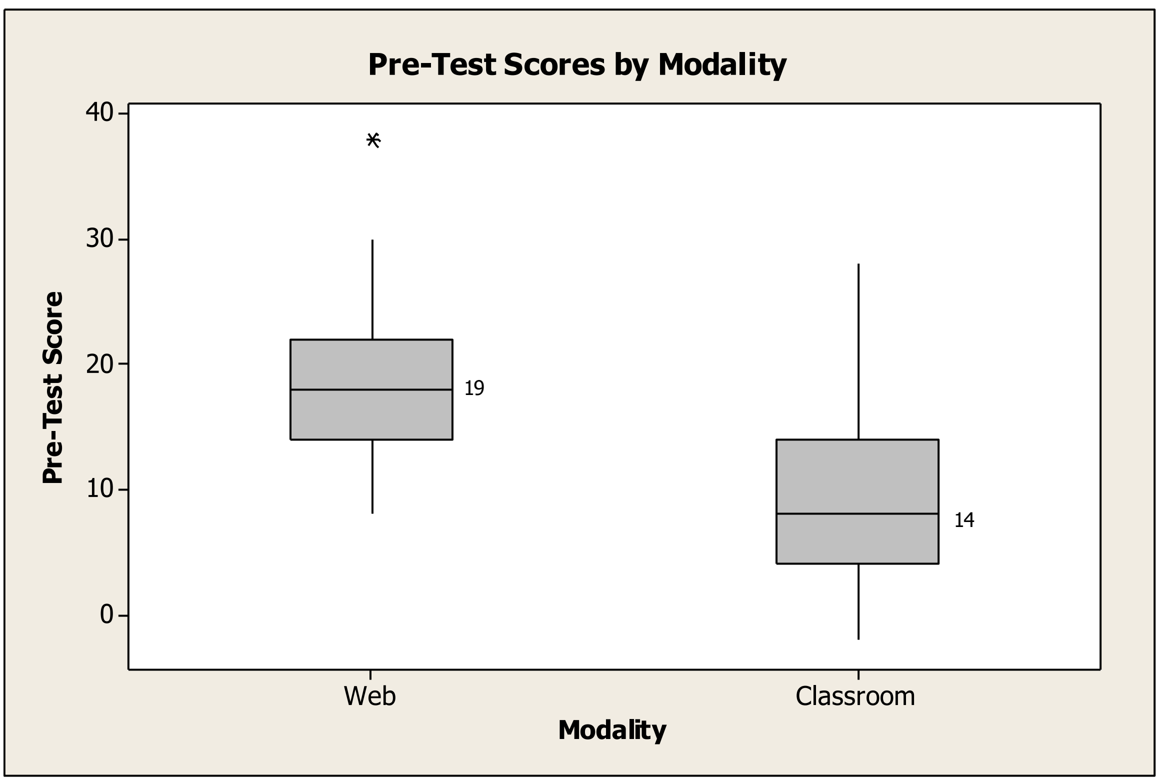

Figure 4.8 Pre-Test Scores by Modality

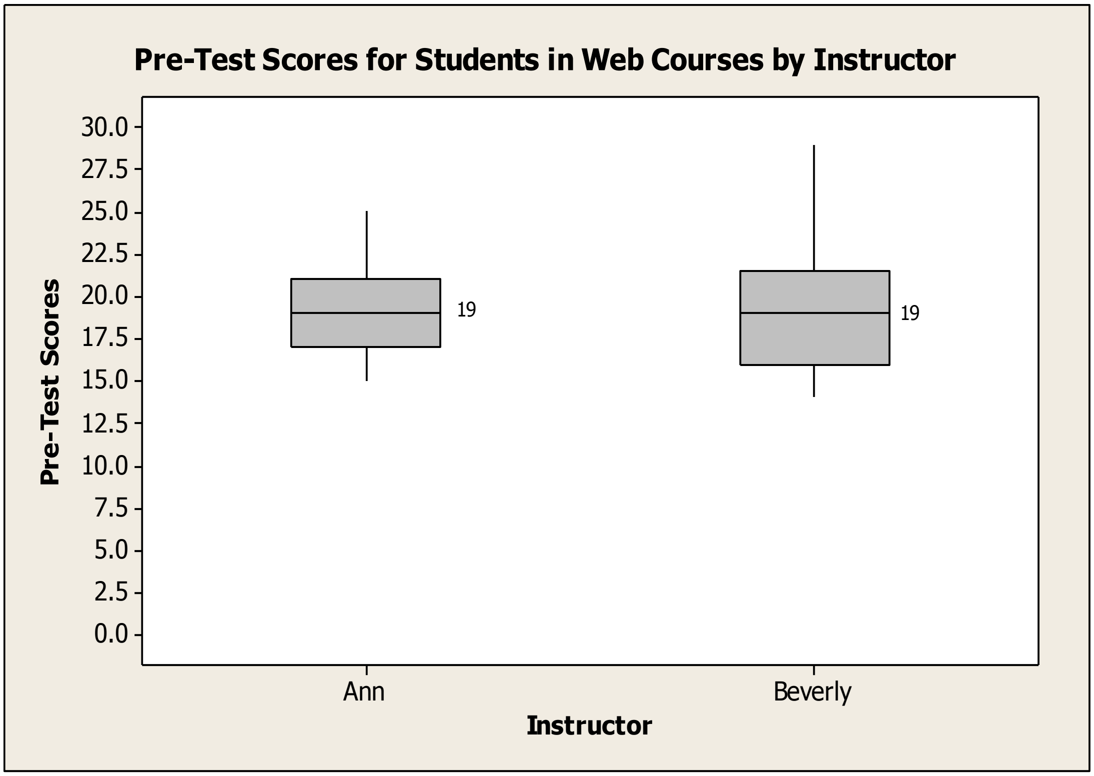

Figure 4.9 Pre-Test Scores for Distance Learners by Instructor

Overall, the average exam scores for Ann were 16.206 and 17.5 for Beverly (p-value = .274). This again confirms that neither instructor was particularly advantaged. Figure 4.9 shows the similarities in mean Pre-Test performance among web students for each instructor. In fact, Ann's students averaged 19.308 and Beverly's, 19.44. In the classroom, it was 14.286 and 15.91 respectively. Ann had almost twice as many students, which may have impacted the differences. Medians were within two points of each other. The researcher investigated as to whether preparedness influenced Pre-Test scores. Beverly's students with mathematics preparedness at the level of at least College Algebra had an average CAOS Pre-Test score of 19, and Ann's student's average was 15.90 (p-value = .206). The higher rates of students with mathematics coursework in at least the level of College Algebra leads the overall Pre-Test scores for Distance Learners who finished the project to differ significantly from those who were enrolled in the classroom sections. The mean for those in the web-based section was 18.90 (standard deviation 4.36, n=10), and the classroom average was 14.71 (standard deviation 2.36, n = 7). This is a p-value =.023. With the better prepared students, the stronger ones choose to take the course via the web. This serves as evidence that distance learners are entering the Elementary Statistics course with stronger initial understandings of statistics. This could be explained by them also entering better prepared. This same type of analysis could not be performed for the lesser-prepared students since there was only one student whose highest mathematics course was below College Algebra that was enrolled in either web section and completed the study. As a precursor to the "as good as traditional" argument, please be aware that in this study the web-based learners have already been given a colloquial "head start" towards the goal.

Post-Test

Beginning with a MANOVA including GPA as a covariate with Modality, Instructor, and College Algebra course history the model yielded p-values of .211, .260, .002, and .913, respectively for each of the variables. A General Linear Model could be Post-Test = 22.806 -1.521GPA - .0733 College Algebra +1.07 Modality – 2.732

Instructor. Removing GPA as a covariate, increased the insignificance of College Algebra. Figure 4.10 shows the relationship amongst the categorical variables.

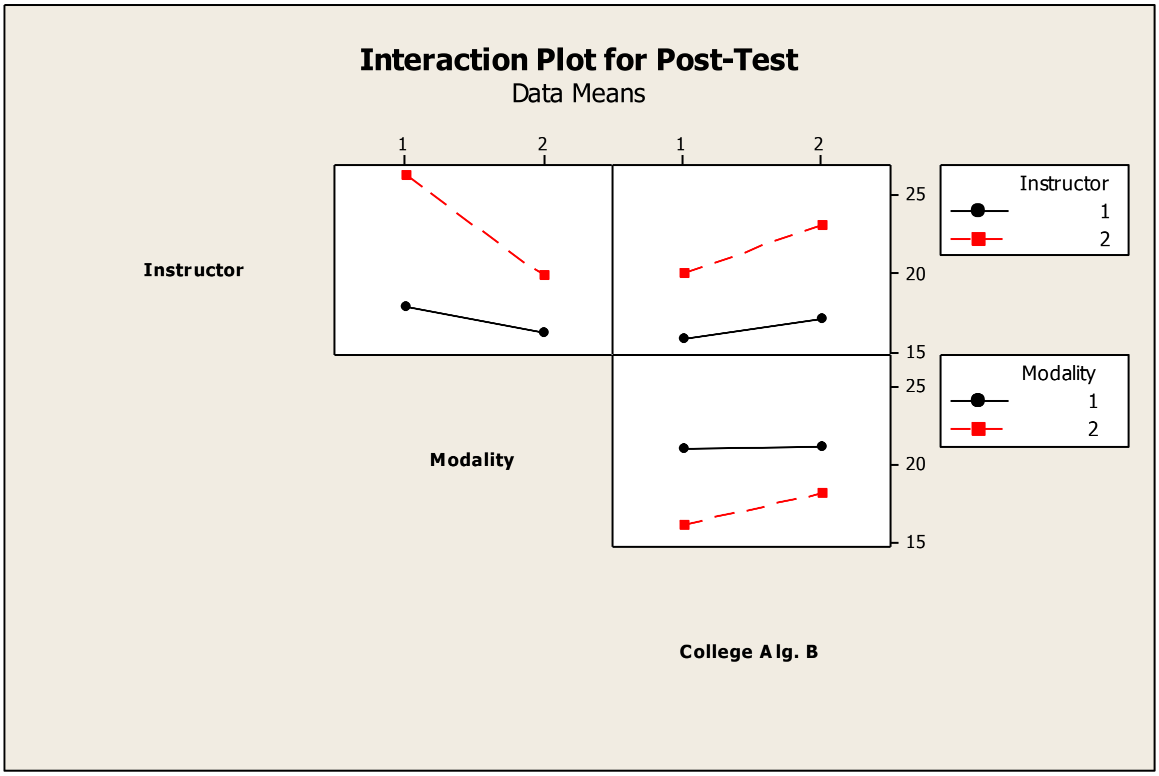

Figure 4.10 Profile Plots of Pre-Test Scores for Modality, College Algebra Coursework and Instructor

A more restrictive model of Modality and Instructor yielded p-values of .007 and .000, respectively. The associated model was Post-Test = 20.1490 + 1.7555 Modality – 2.8321 Instructor. With Modality being coded as 1=Web, 2=Classroom and Instructor as 1=Ann, 2=Beverly, Beverly's Web students yielded the highest predicted values at 24.7366 and Ann's classroom instructed students as having predictions at 15.5614. Although this model is more simplistic, as seen with the earlier Post-Test model mathematical preparedness and GPA explain much more of the variability in Modality than in Instructor.

Beverly's web students were the highest achieving and Ann's classroom section, the lowest. Students enrolled in web sections performed better on the Post-Test as evidenced by Table 4.20.

Table 4.20 Analysis of Post-Test by Modality

Modality	Mean (sd, n)	P-value
1 (Web)	21.50 (6.00, 14)	.029
2 (Classroom)	17.36 (3.17, 22)	

Further probing revealed a large difference in Post-Test performance by instructor as shown in Table 4.21. Ann's Post-Test average hovered near 16.78 with a standard deviation of 2.83. Likewise, it was 22.85 and 5.35 for Beverly. Beverly's students performed significantly better (p-value = .002). Post-Test performance was higher for Beverly's students across both modalities of instruction. Her students seemed to have a strong mastery of descriptive statistics, as it was reinforced through some group projects and activities and a smaller classroom size. Also, some of the higher performing Pre-Test students overall were enrolled in her web course.

Table 4.21 Post-Test Performance by Modality and Instructor

Section type	M (sd, n)	p-value
Web- Ann	17.88 (1.89,8)	.024
Beverly	26.33 (6.28, 6)	
		.001
Traditional - Ann	16.20 (3.12, 15)	
Beverly	19.86 (1.35, 7)	

In ways similar to the Pre-Test analysis, College Algebra continued to serve as the threshold in determining performance. Students having pre-requisite preparation of a minimum level of College Algebra had an average score of 19.94 on the Post-Test. Those scoring below this had an average of 16.545 (p-value = .044).

The Pre-Test and Post-Tests have individually intimated that factors, such as the instructor, highest mathematics course completed, and modality impact student learning outcomes. A more accurate measure would be to investigate the actual gains in individual student learning.

Gain

A deeper analysis is necessary to probe the extent to which students are acquiring statistical reasoning skills. Administration of the CAOS Test very early in the quarter (Pre-Test) and again the final week of the quarter (Post-Test) provided a consistent benchmark for comparison of content mastery. Student “gains,” for the definition of this study, are the differences between the Post-Test and Pre-Test scores. The mean gain amount was 2.222 with a standard deviation of 3.796. The maximum gain was 12 additional points, while the lowest gain was –7 points. The average Post-Test score was 18.972, and the Pre-Test score was 16.70. This is based on the 36 students who completed the research project. The difference between Post-Test and Pre-Test scores was statistically significant (p-value = .001).

A MANOVA model based upon GPA, College Algebra coursework, Modality, and Instructor was developed with each of the first three variables having p-values > .20. The p-value for Instructor was .048. As evidenced in Figure 4.11, modality of instruction can influence instructor gains.

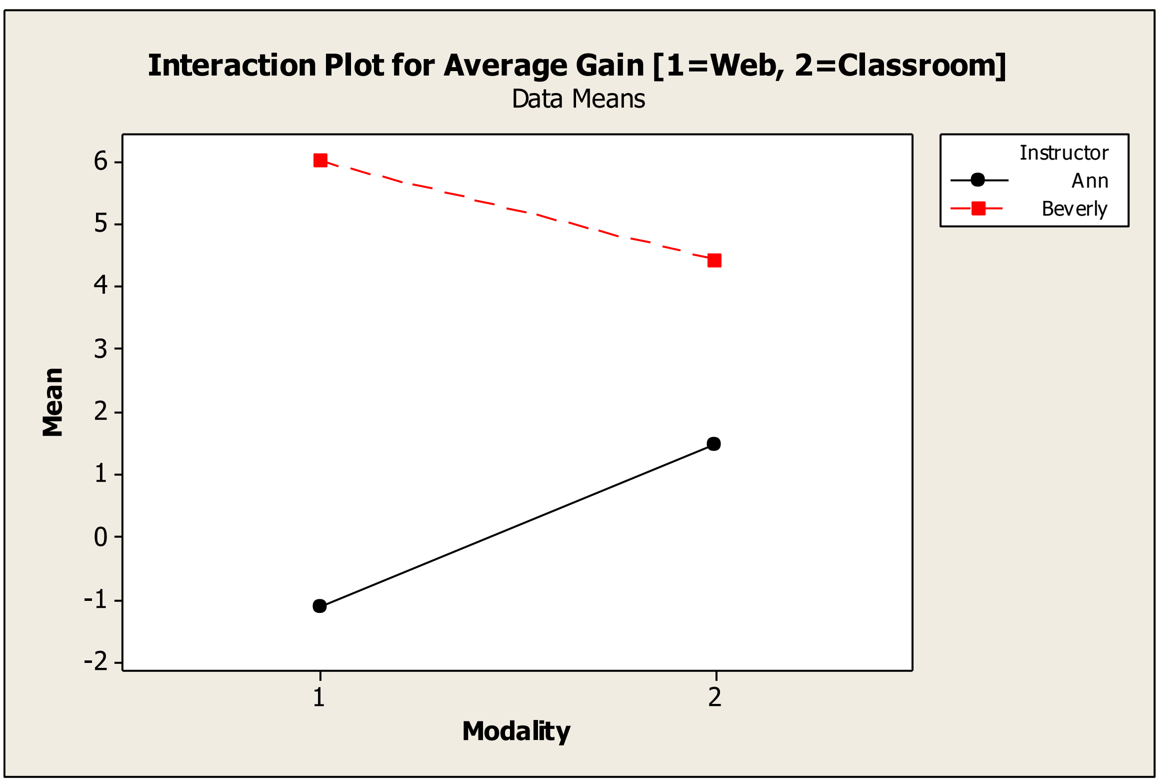

Figure 4.11 Interaction Plot of Average Gain based on Instructor and Modality

Typically students performed 2–3 points better on the Post-Test than the Pre-Test. From Figure 4.11 it can be seen that the averages were adjusted depending on the Instructor-Modality combination.

Table 4.22 Contingency Table of Preparedness by Modality

	Web	Classroom
College Algebra and Above	10	7
Below College Algebra	1	12
Placement	3	3

From Table 4.22, it could be inferred that students with mathematical preparedness below College Algebra are more likely to enroll in classroom-taught sections of Elementary Statistics (p-value = .014; p-value = .004 when Placement row is removed). This is a clear indication that the students with stronger mathematics backgrounds are more confident in their abilities to succeed in a web-based Elementary Statistics course. As alluded to earlier in the Background Information sub-section, the students in the web-based courses who took the CAOS Test both times had stronger mathematics aptitudes. College Algebra played a lesser role when comparing gains among instructors.

Table 4.23 Contingency Table of Preparedness by Instructor for Project Completers

Instructor	College Algebra & Above	Below College Algebra	Placement
Ann	10	9	4
Beverly	7	4	2

There were six students who enrolled in the statistics course by virtue of their COMPASS Placement Exam score being above the course pre-requisite, or, by receiving approval from a college official as their previous coursework from another institution is processed. The other 30 had identifiable mathematics credit. Beverly had a slightly higher rate of students with credit for at least College Algebra (63.6%), but Ann's rate of 52.6% was relatively close. Overall, there was no significant difference in the mathematics preparedness for students by instructor, and Table 4.24 reflects these data. The sample sizes were too small to make comparisons by preparedness within each section.

It could be thought that students with stronger preparation in mathematics could perform better on the CAOS Exam. The 17 with confirmed credit at a minimum level of College Algebra had a mean Pre-Test score of 17.18 with a standard deviation of 4.16. Those with credit below College Algebra had an average score of 15 with a standard deviation of 3.70 (p-value =.142). Likewise for the Post-Test, the students with confirmed credit at least at the level of College Algebra had a mean score of 19.88 with a standard deviation of 5.31. Those with credit below College Algebra had an average of 17.00 with a standard deviation of 3.11(p-value= .074). Mathematics preparation was a strong factor in predicting Post-Test statistics knowledge alone was not statistically significant.

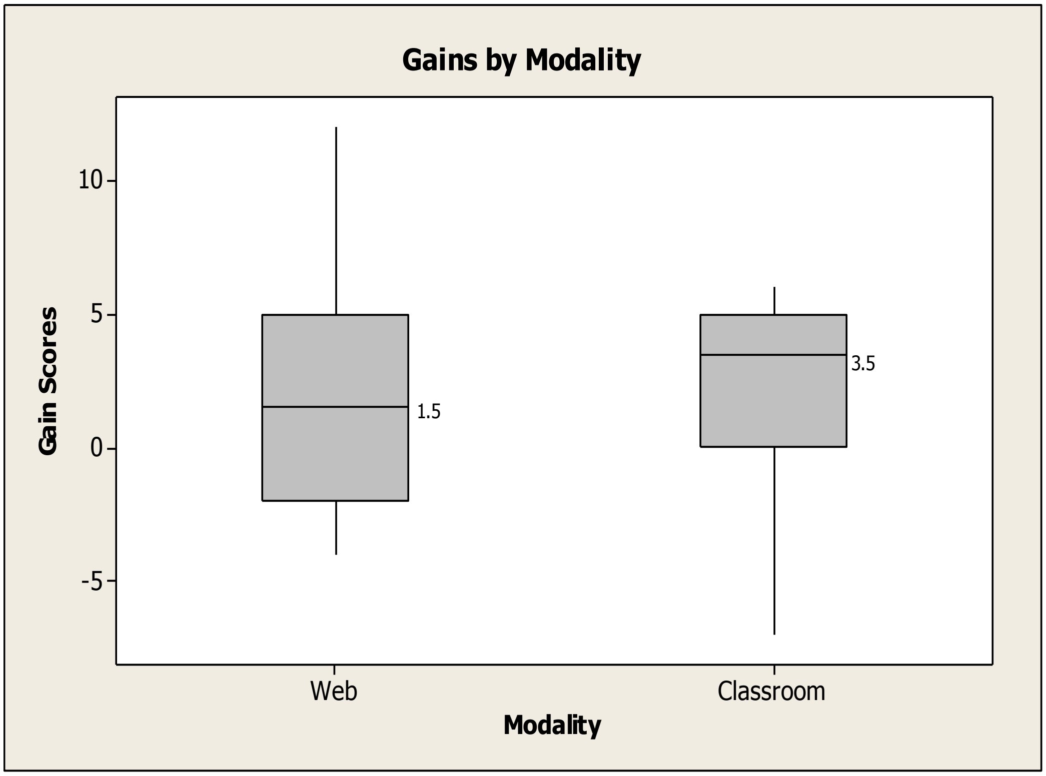

Figure 4.12 Boxplots of Gain by Modality

Initially, modality proved to be a less significant factor in influencing gains. Even though the medians are labeled in Figure 4.12, the mean gain for students in web sections was 1.93 (s.d. of 4.48) and 2.409 (s.d. of 3.39) for students enrolled in classroom sections. The students in web-based sections typically noticed gains in the neighborhood of slightly under two points. Students receiving classroom instruction noticed gains of almost double that. Some web students experienced large gains. Some students receiving classroom instruction noticed significant negative gains. There was no statistically significant difference in gains by modality of delivery (p-value of .734).

The researcher next investigated if the approximate point increase in Post-Test performance was consistent across instructors and modalities. Table 4.24 confirms a differential.

Table 4.24 Contingency Table of Gain by Instructor

	Ann M(sd, n)	Beverly M(sd, n)
Gain	.565 (3.369, 23)	5.154 (2.577, 13)

There was a statistically significant difference in gain according to instructor (p-value = .000). With 95% confidence, it can be determined that the average gain for Ann is 2.54–6.64 points lower than Beverly's. Table 4.25 provides the coding strategy to be used for visually identifying gains by level of preparedness.

Table 4.25 Legend for College Algebra Completion Status

Code	Descriptor
College Algebra and above (Post)	Post-Test scores for students with mathematics credit at least at the College Algebra level
College Algebra and above (Pre)	Pre-Test scores for students with mathematics credit at least at the College Algebra level
Below College Algebra (Post)	Post-Test scores for students with mathematics credit below the College Algebra level
Below College Algebra (Pre)	Pre-Test scores for students with mathematics credit below the College Algebra level

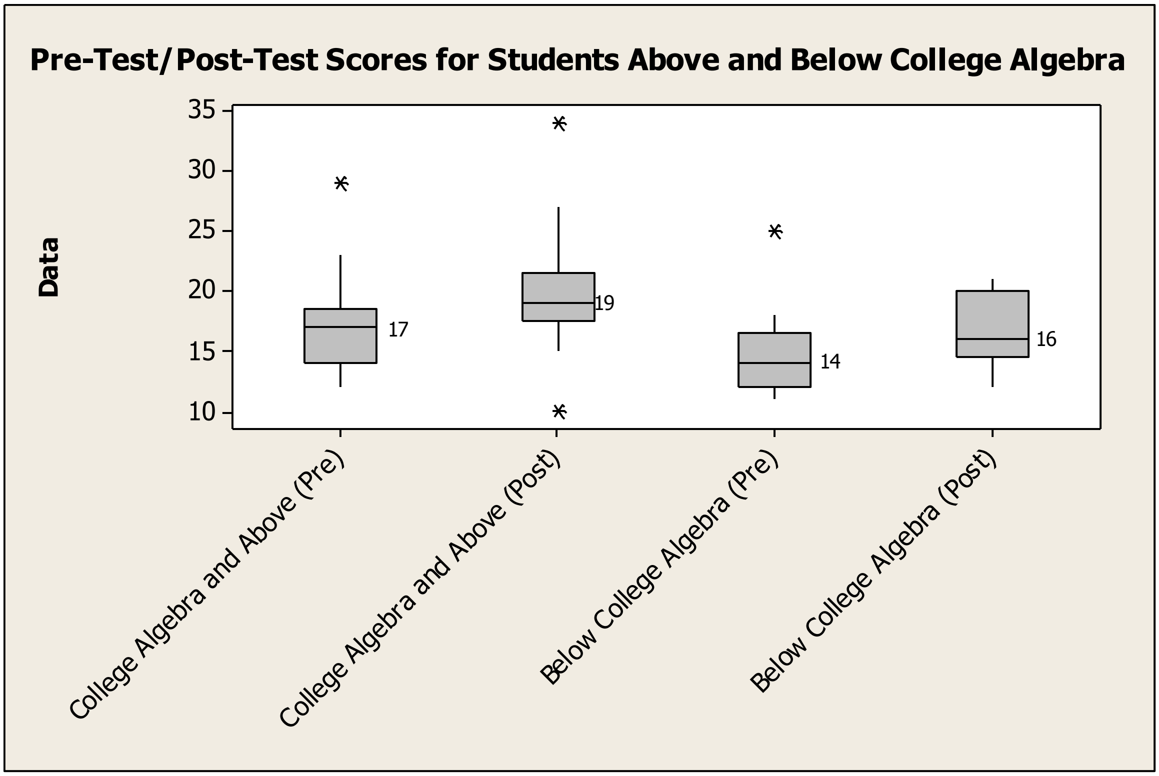

Figure 4.13 Boxplots of Pre-Test and Post-Test Scores by College Algebra Completion Status

The side-by-side box-plot display in Figure 4.13 indicates that those with College Algebra tend to score about 2 points higher and that students generally experience a 2 point gain on the CAOS Exam. Further investigation into modality performance by instructor, yielded some provocative results.

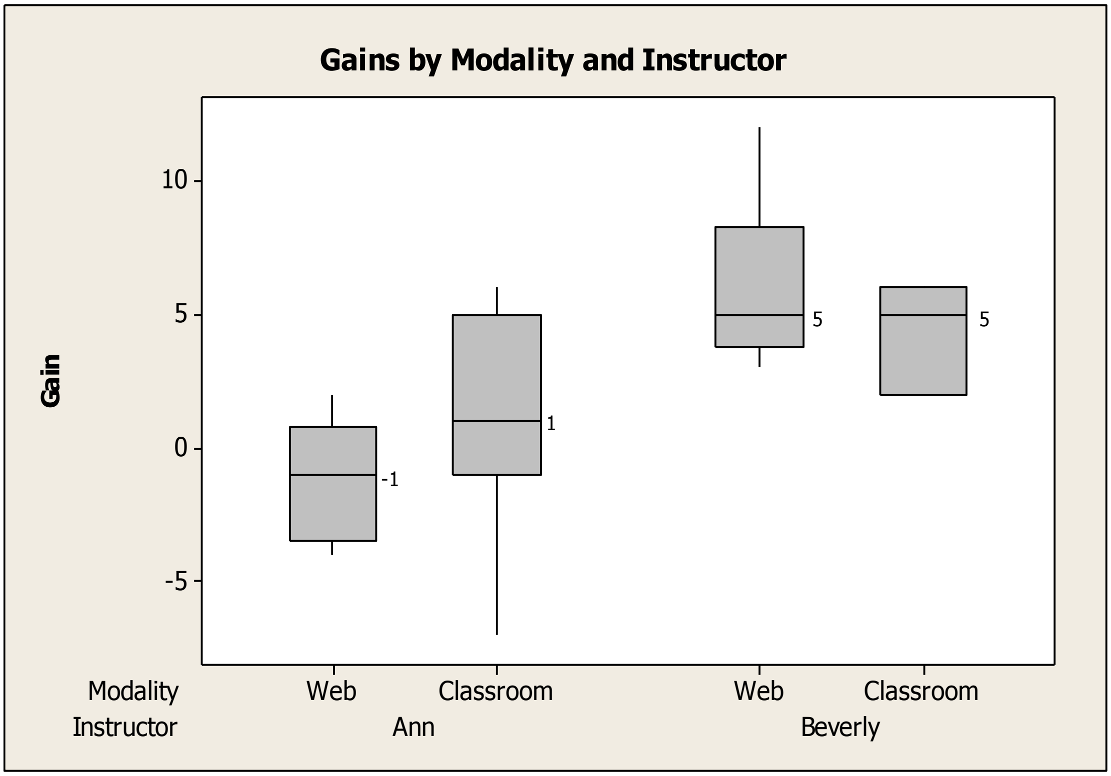

Figure 4.14 Boxplots of Gain by Modality and Instructor

Table 4.26 Table of Gains and Study Completion by Modality and Instructor

Instructor	Modality	Mean (sd)	Completion
Ann	Web	-1.13 (2.23)	8 of 13
	Classroom	1.47 (3.58)	15 of 21
Beverly	Web	6.00 (3.22)	6 of 9
	Classroom	4.429 (1.81)	7 of 11

Figure 4.14 shows that the student with the largest gain (12 points) was in Beverly's web-based section and the student with the largest decrease (7 points) was in Ann's classroom-based section. It could be inferred that in either case the first student had less regard for the Pre-Test and similarly with the Post-Test for the second student. Focusing more on general trends, as evidenced by the medians on the boxplots, Ann's web students typically scored one point lower the second time the CAOS Test was administered. Ann's classroom-educated students had gains of approximately one point. Beverly's students tended to show five point gains regardless of modality. This is confirmed per the means and standard deviations denoted in Table 4.26.

Students in Beverly's web sections had average scores 1.57 units higher than their classroom-instructed counterparts. But this difference was not statistically significant (p-value = .325), largely due to the disparity in standard deviation. Ann's classroom-educated students performed significantly better than her web-based learners. It could be stated with 95% confidence that the average gains for these students was between .06 and 5.13 more correct answers out of 40. The gain differential was noticeable amongst instructors. Students in Ann's web class had an average score of 19 on the Pre-Test and 17.88 on the Post-Test (p-value = .197). The following graph emphasizes this and identifies the hypothesized value of 0 is well within the confidence interval, therefore establishing that there is no significant difference in Pre-Test and Post-Test scores for the students in Ann's web-based class.

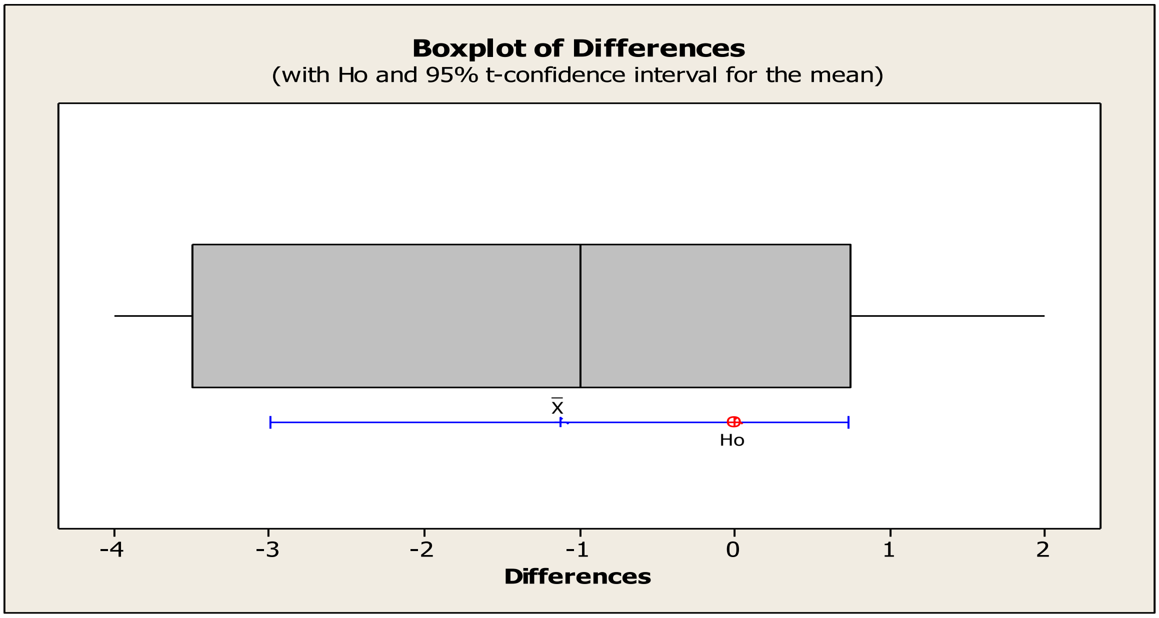

Figure 4.15 Boxplot of Gains for Web Students for Ann

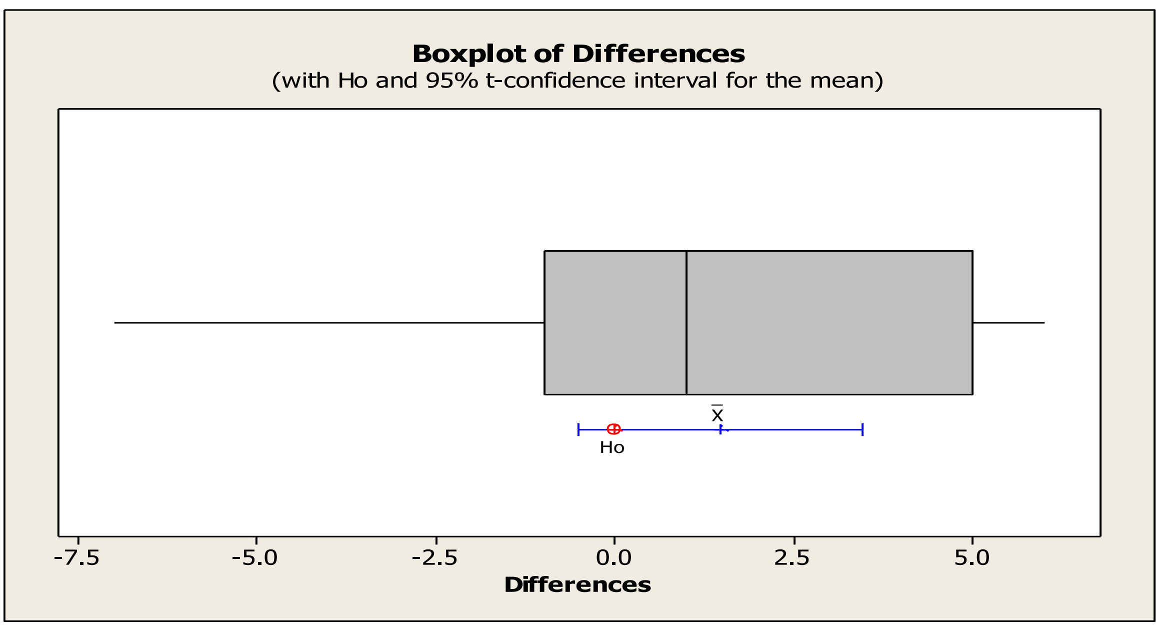

Figure 4.16 Boxplot of Gains for Classroom Students for Ann

Figures 4.15 and 4.16 graphically depict the confidence interval relative to the hypothesized value of zero. Students enrolled in Ann's classroom section had an average score of 16.2 on the Post-Test following a score of 14.733 on the Pre-Test. The improvement was not statistically significant (p-value = .135).

Ann's classroom section reports an average gain of 1.47 additional questions correct on the Post-Test, whereas her web-based section reported an average of 1.12 questions fewer correct. The difference in the gains of the two populations was significant at the .05 level (p-value = .046). Ann's classroom-instructed students (largely with lower levels of preparedness) gained more compared than those enrolled in the web sections (at .05 level). This could provide evidence that students in web-based sections do not exhibit levels of learning comparable to their classroom-instructed counterparts.

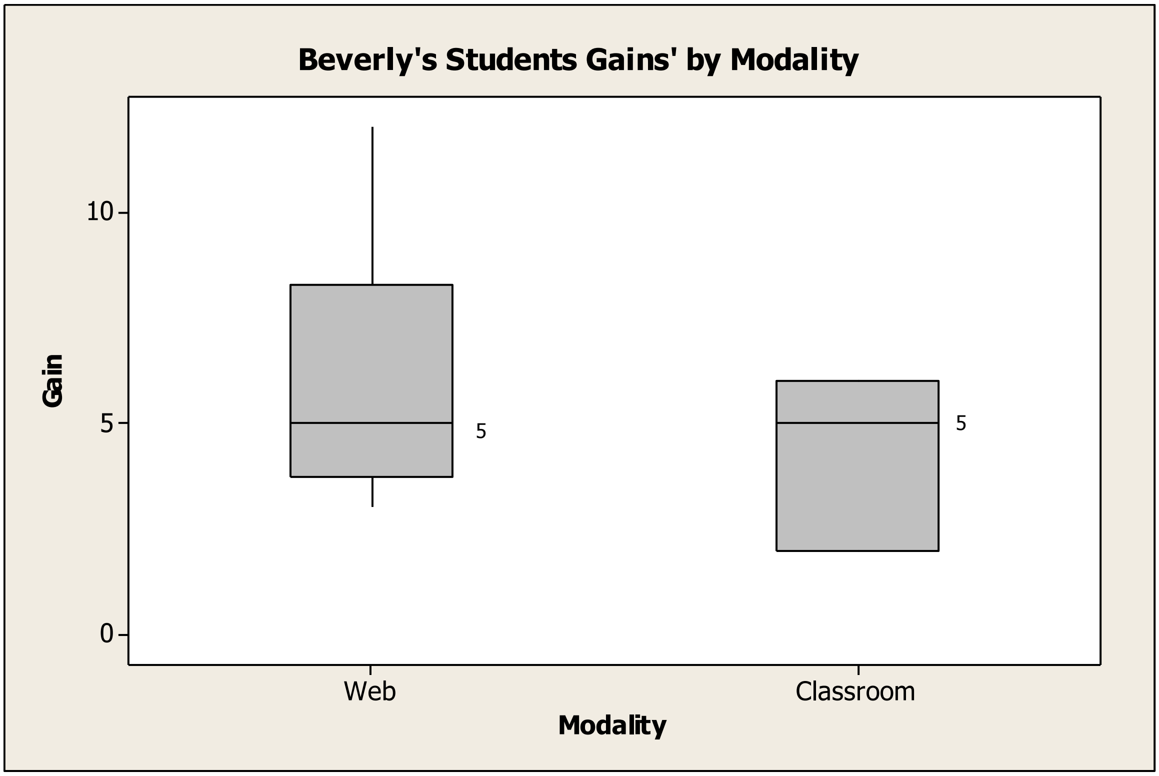

Figure 4.17 Boxplot of Gains for Beverly’s Students by Modality

Just by viewing the pair of boxplots in Figure 4.17, there appears to be little difference in median performance across modalities for this instructor, but variability in the web reflects a greater propensity for high achieving students.

Beverly’s students (aggregately) performed significantly better on the Post-Test than the Pre-Test (p-value = .0006). Figure 4.17 affirms this for her classroom-instructed students. Initially, their mean score was 15.429, and then it improved to 19.857 (p-value = .001). Although Beverly's web-based students had somewhat larger gains, the difference in gains across modalities was not significant at the .05 level (p-value = .325).

Beverly's web-based students gained an average of six points. Ann's students typically performed lower on the Post-Test than the Pre-Test. This resulted in a 7 point difference among instructors (p=.002). The same analysis for classroom-educated students reveals a 3 point difference in the averages among instructors (p-value =.019). In this case, some of Ann's stronger students persisted, but not at a statistically significant rate.

In both modalities, Beverly's students were able to experience comparable levels of knowledge gains as evidenced by the CAOS Test, and this affirms that for these students, web-based learning can have achievement levels comparable with classroom instruction, in terms of central tendency. The question then simply turns to: in which areas did students perform well and what type of teaching occurred to underscore these results.

Statistical Thinking and Reasoning

The CAOS Exam assesses outcomes associated with the introductory statistics course. Items 6, 7, 9, 10, 16, 22, 25, 27, 28, 33, 35, 37, 38 and 39 directly assess statistical thinking and reasoning. Performance on this set of 14 items would be helpful in determining the degree to which learning gains in statistical reasoning are at comparable levels with the more general coverage of topics; and, if stated learning gains are similar across student sub-populations.

Table 4.27 Average Number of Correct Answers on Statistical Reasoning Items

		Pre-Test (n)	Post-Test (n)	Gain
All		3.65 (54)	3.56 (36)	-0.088
Instructor				
	Ann	3.50 (34)	2.91 (23)	-0.59
	Beverly	3.90 (20)	4.69 (13)	0.79
Modality				
	Web			
	Classroom	4.18 (22)	4.21 (14)	0.03
		3.38 (32)	3.14 (22)	-0.24
Instructor -Modality				
Ann	Web	4.00 (13)	2.63 (8)	-1.37
	Classroom	3.19 (21)	3.07(15)	-0.12
Beverly	Web	4.44 (9)	6.33 (6)	1.89
	Classroom	3.45 (11)	3.29 (7)	-0.16

Recalling from Table 4.16 that there was no significant difference in Pre-Test performance amongst participants who completed the study and those who did not and those who did not, it could be inferred that strict usage of the 36 students who took both Pre-Test and Post-Test would yield little difference in the data listed in the third column of Table 4.27.

Nevertheless, Beverly's Web student gains drove the positive gains for web students in general, and for Beverly's classes overall. Beverly's web students' strong gains reflect heightened abilities to think and reason statistically.

Table 4.28 Percentage of Correct Answers on CAOS due to Statistical Reasoning Items

		Pre-Test	Post-Test	Gain
All		21.9%	18.8%	-3.09%
Instructor				
	Ann	21.6%	17.3%	-4.25%
	Beverly	22.3%	20.5%	-1.76%
Modality				
	Web	21.6%	19.6%	-2.01%
	Classroom	22.8%	18.1%	-4.69%
Instructor -Modality				
Ann	Web	20.7%	14.7%	-6.01%
	Classroom	22.3%	19.0%	-3.38%
Beverly	Web	22.8%	24.0%	1.20%
	Classroom	21.7%	16.6%	-5.12%

With the statistical reasoning items comprising 35% of the items on CAOS, Table 4.28 intimates with the lower proportionate composition of correct answers on the Post-Test that student understanding of outcomes in general, accounts for an increased proportion of Post-Test performance. Beverly's web students' proportionate performance increases in statistical reasoning gains further magnified their performance relative to their peers.

Identifying Specific Content Knowledge

Over-arching quantitative summaries of student performance inherently avoid identifying concepts and the degree to which they are mastered. To help with this, the researcher developed the assessment schema described in Table 4.29 to provide performance benchmarks.

Table 4.29 Categories of Student Achievement on CAOS Items

Category	**Desired Achievement Level**
Proficient	85% or higher
Mastery	70% under 85
Aware	50% under 70%
Unfamiliar	under 50%

For example, if 72% of students in a certain population answered an item correctly, then it would be determined those students generally demonstrated a "Mastery" level of understanding of that item. With the "Unfamiliar" category descriptor considered nebulous, the researcher determined that when possible, other relevant information will be provided.

Table 4.30 Unfamiliar Category Descriptors

Coding	Description
Split	2 or more categories within 20% of one another
Reverse	more than 50% for another response

The Split designation in Table 4.30 is useful in identifying situations where students denoted a variety of answers. Reverse was helpful in identifying when students were consistent in having an alternative concept of the appropriate solution. These results better inform instructors to the types of student misconceptions. To attach the items to the statistics course curricula, Table 4.31 was developed.

Table 4.31 Categorization of CAOS Items by Introductory Statistics Course Topic

Topic	CAOS Items	Frequency (%)
Descriptive Statistics	1 – 6, 8-15, 18, 33	16 (40)
Design	7, 38	2 (5)
Sampling	16, 17, 34, 35	4 (10)
Hypothesis Testing	19, 23 – 27, 32, 40	8 (20)
Linear Regression	20 – 22, 39	4 (10)
Confidence Intervals	28 – 31	4 (10)
Probability	36, 37	2 (5)

Table 4.32 CAOS Items' Pre-Test and Post-Test Performance

Item	Pre-Test	Post-Test	Difference
Descriptive Statistics	43.87%	49.13%	5.26%
Design	15.74%	19.44%	3.70%
Sampling	37.04%	45.83%	8.79%
Hypothesis Testing	48.89%	52.45%	3.56%
Linear Regression	37.04%	34.26%	-2.78%
Confidence Intervals	41.20%	61.11%	19.91%
Probability	27.78%	36.11%	8.33%

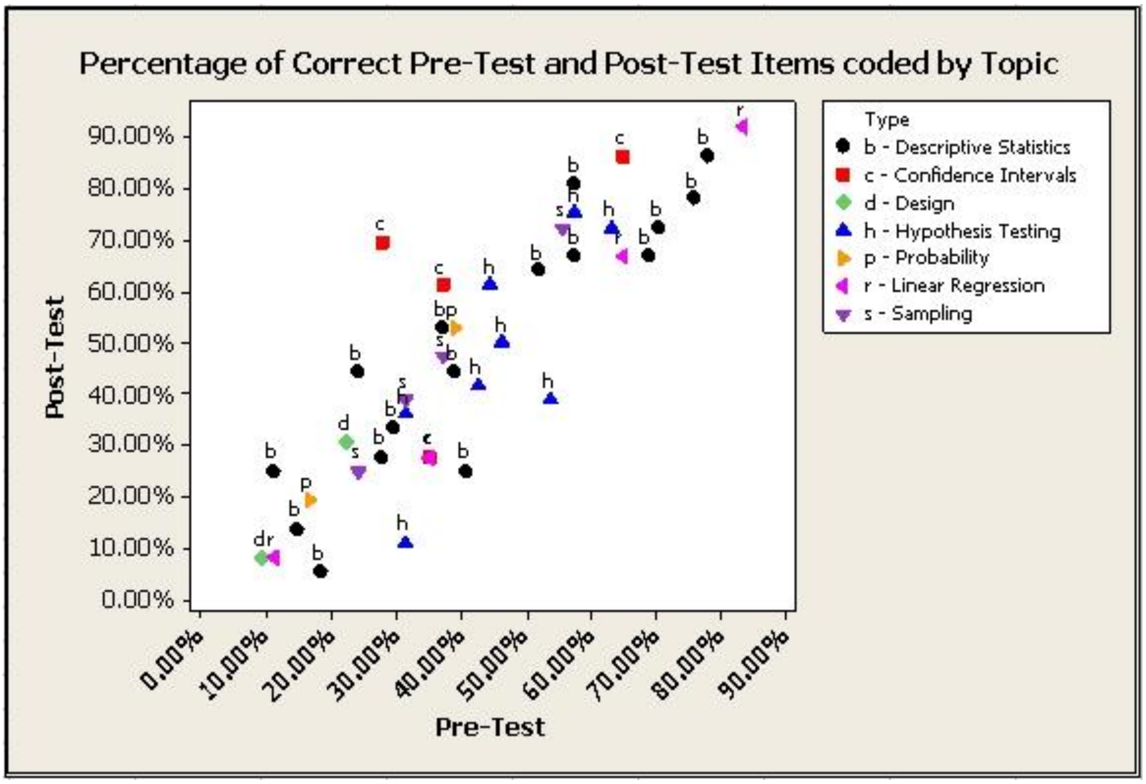

Figure 4.18 Scatterplot of CAOS Pre-Test and Post-Test coded by Topic

Table 4.32 summarizes of the Pre-Test/Post-Test performance by topic indicating that students demonstrated the strongest learning gains in their understanding of confidence intervals. Figure 4.18 confirms that typically strong Pre-Test performance followed with strong Post-Test performance for each item with a consistent understanding of descriptive statistics at both instances.

The Pre-Test was taken by 54 students, and 36 took the Post-Test. The researcher also analyzed these items in terms of gains relative to the amount of learning that could occur using this ratio $\frac{Gain}{Maximum - Pre - test}$. This ratio endeavors to normalize gains for more extreme Pre-Test performances. This is known in Physics Education circles as the individual normalized gain. Then a statistics G_{Ave} could be calculated to find the average Gain for a sample on n students. Richard Hake's work (Hake, 2002) looked at the normalized gain for groups of students who were taught via Interactive Engagement (highly active and engaging instruction) and being compared to traditional physics instruction. Hake's <<g>> is based upon the class averages for the Pre-Test and Post-Tests Then allowing one to discuss the proportion of maximum possible average gain for a class learning that the class experienced, and Cohen's d can easily be calculated when comparing multiple student clusters

Hake's <<g>> confirmed that there was no statistically significant advantage between modalities (web mean = .101, classroom mean = .088, p-value = .855). This is largely to say that students in web-based sections only gained an additional percentage point more on average than those receiving classroom instruction. For the scant numbers of students who were outliers in either direction, this statistic was more relevant. However, it should be noted that achieving a 6-point increase from 19.86 to 26.33 on an instrument that has a maximum score of 40 is noteworthy.

Table 4.33 CAOS Item Topics by Amount of Gain

Topic	Moderate Gains	Minimal Changes	Moderate Losses	Total
Descriptive Statistics	8	6	2	16
Design	1	1	0	2
Sampling	3	1	0	4
Hypothesis Testing	3	3	2	8
Regression	1	2	1	4
Confidence Intervals	3	0	1	4
Probability	1	1	0	2

Table 4.34 Amount of Gain for each Item on CAOS

Moderate Gains	2, 3, 4, 6, 8, 12, 13, 15, 17, 20, 23, 24, 26, 29, 30, 31, 34, 35, 36, 38
Minimal Changes	1, 5, 7, 10, 11, 14, 16, 18, 19, 21, 25, 27, 37, 39
Moderate Losses	9, 22, 28, 32, 33, 40

Table 4.33 defines Moderate Gains as being larger than 5% and Moderate Losses as gains lower than -5%. Minimal Changes are all differences that do not fall in either of those categories. The only noticeable difference is that Hypothesis Testing and Regression tended to yield less improvement. This is largely because, in the current instruction of this course, these topics are some of the last ones to be covered. However, they are also the most recently covered topics relative to the time the Post-Test is taken. Table 4.34 aligns items with the appropriate gain type.

Table 4.35 Summary of Pre-Test and Post-Test Performance by Achievement Category

	Proficient	Mastery	Aware	Unfamiliar	Total
Pre-Test	0	4	10	26	40
Post-Test	3	6	11	20	40

Table 4.36 Summary of Pre-Test and Post-Test Performance by Achievement Category for each Item

	Proficient	Mastery	Aware	Unfamiliar	Total
Pre-Test	N/A	11, 12, 18, 20	1, 2, 8, 13, 21, 23, 24, 31, 34, 40	26 items	40
Post-Test	12, 20, 31	8, 11, 18, 23, 24, 34	1, 2, 3, 4, 13, 21, 26, 27, 29, 30, 35	20 items	40

Table 4.35 summarizes the performance by Achievement Category. Table 4.36 explicitly lists the items that fell within those categories. There was no statistically significant difference between Pre-Test and Post-Test by achievement category (p-value = .238). The researcher suspects there is a steady improvement of performance for each topic. Further analysis is required.

Table 4.37 Summary of Topics and their Achievement Category According to Pre-Test

	Proficient	Mastery	Aware	Unfamiliar	Total
Confidence Intervals	0	0	1	3	4
Descriptive Statistics	0	3	4	9	16
Design	0	0	0	2	2
Hypothesis Testing	0	0	3	5	8
Probability	0	0	0	2	2
Regression	0	1	1	2	4
Sampling Distribution	0	0	1	3	4
Total	0	4	10	26	40

Table 4.38 Summary of Topics and their Achievement Category According to Post-Test

	Proficient	Mastery	Aware	Unfamiliar	Total
Confidence Intervals	1	0	2	1	4
Descriptive Statistics	1	3	5	7	16
Design	0	0	0	2	2
Hypothesis Testing	0	2	2	4	8
Probability	0	0	0	2	2
Regression	1	0	1	2	4
Sampling Distribution	0	1	1	2	4
Total	3	6	11	20	40

Table 4.39 Summary of Pre-Test Performance by Achievement Category for Each Instructor

	Proficient	Mastery	Aware	Unfamiliar	Total
Ann—Pre-Test	0	5	6	29	40
Beverly—Pre-Test	2	5	7	26	40

Table 4.39 shows the consistency in Pre-Test performance between the two instructors (p-value >.50). Table 4.40 compares amounts of Moderate Gains among instructors by topic.

Table 4.40 Summary of Moderate Gains by Topic According to Instructor

	Moderate Gains - Ann	Moderate Gains - Beverly
Confidence Intervals	3	14
Descriptive Statistics	0	1
Design	2	3
Hypothesis Testing	3	4
Probability	1	2
Regression	3	3
Sampling Distribution	1	2
Total	1	3

Both sets of students experienced steady improvements in performance. However, Beverly students' gains in understanding of descriptive statistics proved to be the most distinguishing factor. Table 4.41 compares gains for each item by instructor.

Table 4.41 Percentages of Correct Answers by Topic and Instructor for Pre-Test, Post-Test, and Gain

		Pre-Test (%)	Post-Test(%)	Gain (%)
Confidence Intervals	Ann	43.4	56.5	13.14
	Beverly	37.5	69.2	31.70
Descriptive Statistics	Ann	42.8	40.8	-2.07
	Beverly	45.6	63.9	18.32
Design	Ann	13.2	13.0	-.19
	Beverly	20.0	30.8	10.77
Hypothesis Testing	Ann	43.0	46.2	3.18
	Beverly	51.9	51.9	.05
Probability	Ann	29.4	32.6	3.2
	Beverly	25.0	42.3	17.3
Regression	Ann	49.3	46.7	-2.53
	Beverly	47.5	51.9	4.42
Sampling Distribution	Ann	33.8	39.1	5.31
	Beverly	42.5	57.7	15.19

Ann’s students experienced Moderate Gains for Confidence Intervals and Sampling Distributions and Minimal Changes for all other categories. However, her students tended to show losses with Descriptive statistics. The fact that 40% of the exam was rooted in descriptive statistics impacted their Post-Test scores. Confidence Intervals gains were doubled for Beverly. Beverly’s student experienced moderate gains for 5–7 topics, with minimal changes for hypothesis testing and Regression. With descriptive statistics accounting for 40% of the items on the exam, Beverly’s students were able to experience great gains overall on their Post-Tests.

Table 4.42 Percentages of Correct Answers for Ann's Students by Topic and Modality for Pre-Test, Post-Test, and Gain

		Pre-Test (%)	Post-Test (%)	Gain (%)
Confidence Intervals	Web	51.9	62.5	10.6
	Classroom	38.1	53.3	15.2
Descriptive Statistics	Web	53.4	41.4	-12.0
	Classroom	36.3	40.4	4.1
Design	Web	7.7	6.3	-1.4
	Classroom	16.7	16.7	0.0
Hypothesis Testing	Web	53.9	56.3	2.4
	Classroom	36.3	40.8	4.5
Probability	Web	23.1	43.8	20.7
	Classroom	33.3	26.7	-6.7
Regression	Web	63.5	50.0	-13.5
	Classroom	40.5	45.0	4.5%
Sampling Distribution	Web	32.7	31.3	- 1.4%
	Classroom	34.5	43.3	8.8%

Table 4.42 indicates that Ann's web students experienced moderate gains for confidence intervals and probability, moderate losses for descriptive statistics and regression, and minimal changes for all other categories. These students also had relatively strong preliminary understandings of Regression. Ann's classroom-educated students experienced moderate gains with Confidence Intervals and Sampling Distributions with some moderate losses with Probability. Design continued to be a topic of deficiency. Ann's web students had fewer "Unfamiliar" topics (achievement being

below 50%). However, the web students also had a large moderate loss in the highest represented topic.

Table 4.43 Percentages of Correct Answers for Beverly's Students by Topic and Modality for Pre-Test, Post-Test, and Gain

		Pre-Test (%)	Post-Test (%)	Gain (%)
Confidence Intervals	Web	53.3	70.8	17.5
	Classroom	31.8	67.9	36.0
Descriptive Statistics	Web	40.4	71.9	31.5
	Classroom	38.6	57.1	18.5
Design	Web	16.7	41.7	25.0
	Classroom	22.7	21.4	-1.3
Hypothesis Testing	Web	40.8	62.5	21.7
	Classroom	58.0	42.9	-15.1
Probability	Web	26.7	58.3	31.7
	Classroom	18.2	28.6	10.4
Regression	Web	45.0	54.2	9.2
	Classroom	38.6	50.0	11.4
Sampling Distribution	Web	43.3	70.8	27.5
	Classroom	34.1	46.4	12.3

Table 4.43 indicates that in only one instance did Beverly's students experience a Moderate Loss in Post-Test performance. Descriptive statistics accounted for 16 items of the CAOS Test. Strong improvements in this category facilitated increase in gains more than any other due to its high representation. Beverly's web students exhibited moderate gains in every category. The classroom-educated students showed noticeable improvement with confidence intervals and descriptive statistics, in spite of a moderate

loss in Hypothesis Testing. Although overall achievement for each group is less than ideal, the students in the web-based section outperformed their counterparts in every category.

In general, students are entering with some intuitive knowledge of regression and hypothesis testing. However, by the end of the course, there are not Moderate Gains in either area. Probability receives some gains, and elements of design could be an area of greater focus in the future. The researcher also produced similar charts for each modality by instructor since it was indicated that instructor was a stronger factor than modality. The heavy emphasis on descriptive statistics was a strength of Beverly's students. This is consistent with the MANOVA results.

Interesting Findings

In addition to mathematics preparedness, the researcher considered English nativity as another attribute of consideration due to the propensity for statistics to be more text-driven and inquiry-based than the typical mathematics courses. In this study, none of the students with ESL (English as a Second Language) credit enrolled in either of the web-based sections. In fact, there were only 4 total (3 in Ann's morning class, 1 in Beverly's evening class). Of those 4, only 1 completed the Pre-Test and Post-Test, with 2 taking the Final Exam.

ESL

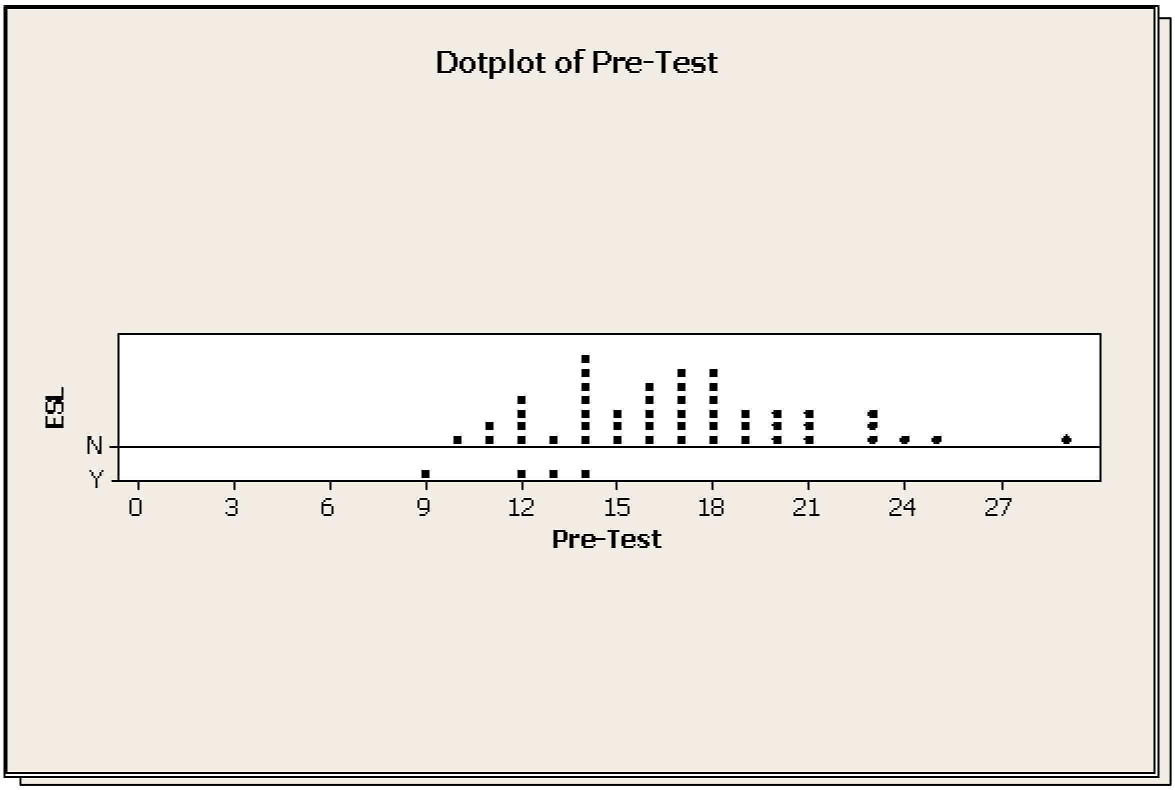

Figure 4.19 Dotplot of Pre-Test by English Nativity

Figure 4.19 indicates a disparity in performance on the Pre-Test with students having English as a Second Language coursework having a consistently lower performance. The average for the four students with ESL credit was 12. The average of the other 50 students on the Pre-Test was 17.06 (p-value=.016). The 2 ESL students who took the Final Exam received scores of 139 and 166 out of a maximum of 200. One student who took both Pre-Test and Post-Test yielded a gain of 0. English nativity could be an area of further exploration**.** At this low level of inquiry and analysis, there seems to be lower performance in statistics by students who have ESL coursework.

Mathematics Preparedness

Mathematics preparedness was a factor worthy of consideration. The researcher reviewed the academic records for the preparedness of each student and compared it to Pre-Test and Post-Test scores.

By classifying students as either being “at or above College Algebra” or “below College Algebra,” more interesting findings were yielded. The average for Pre-Tests of “at or above College Algebra” was 17.05 (std. dev. 4.38, n=21) and 15.81 (std. dev. 3.93, n=27) for “below College Algebra” (p-value = .310). There were no significant differences by Pre-Test.

Neither of Beverly’s web students who entered at “below College Algebra” finished the course. Things faired far better in the classroom with 3 of Beverly’s 7 classroom-instructed students, of similar distinction, finished the course. Preparedness at the level of College Algebra seems to be a determinant of success.

There were only enough students to compare classroom-educated students among instructors when discussing students having coursework “below College Algebra.” Ann had 8 students average a 1.63 pt. gain with a standard deviation of 2.97 and a sample size of 9. Beverly had 4 students with an average of 4.25 and a standard deviation of 1.708.

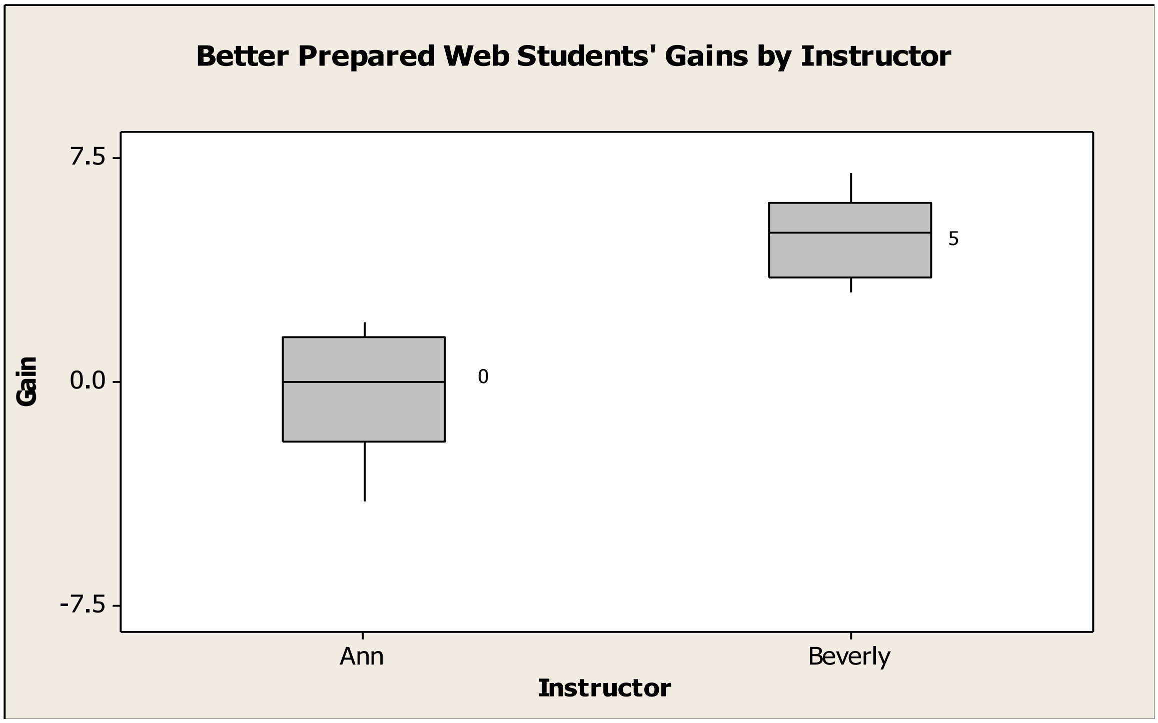

Figure 4.20 Side-by-Side Boxplots of Web Student Performance with Preparation at least at College Algebra by Instructor

For Ann's classroom students, those at least at the level of College Algebra had a mean of 13.833 (2.401, 6). For Beverly's students of similar distinction who enrolled in classroom sections, the mean was 14.33 (3.21, 3). Beverly's web-enrolled students uniformly out-gained each of Ann's students. This is visually confirmed in Figure 4.20.

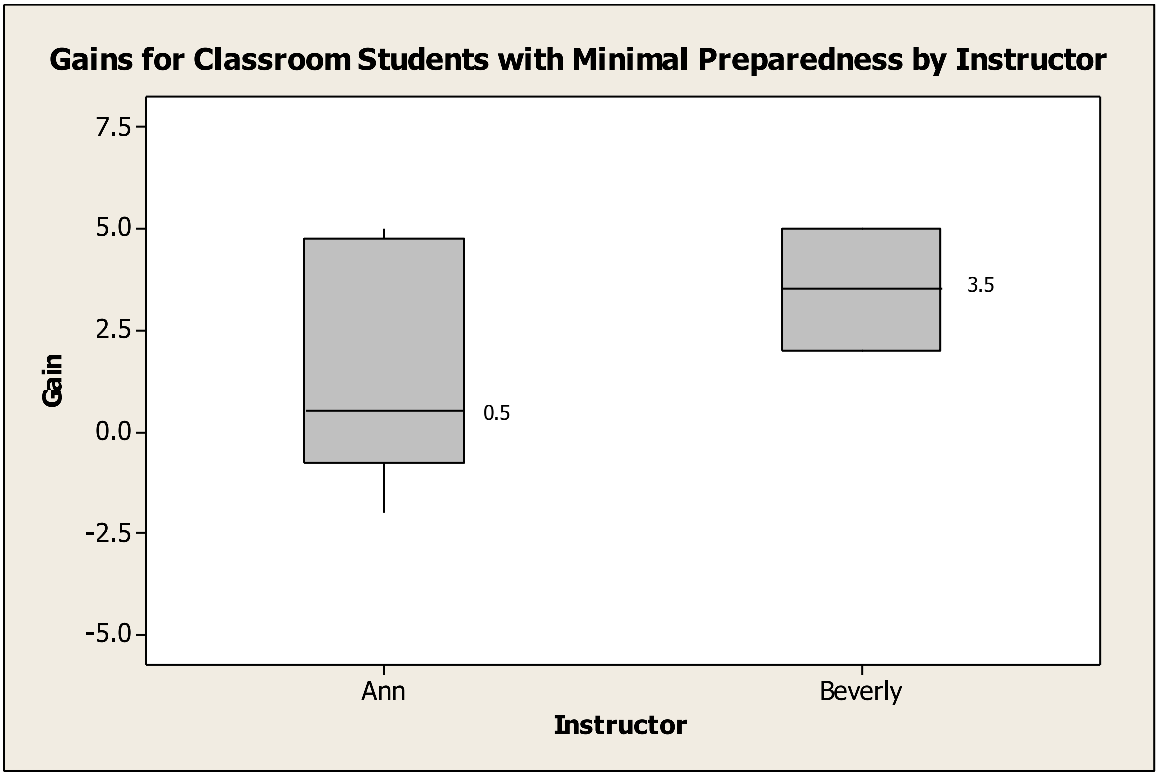

Figure 4.21 Side-by-Side Boxplots of Classroom Student Performance with Preparation below College Algebra by Instructor

Classroom educated students had mean gains of 1.63 and 4.25, for Ann and Beverly respectively (p-value =.085). Figure 4.21 displays the medians for each distribution. The only sizeable subpopulations for comparisons across instructors were the College Algebra and above for web students and students below College Algebra for classroom-educated students.

Nativity

Related to preparedness was whether the student was "native" to the institution, which has been defined as having taken at least their most recent course(s) at the institution. For the 36 students who completed the course, it was determined that 31 could be readily identifiable as either Native or Non-Native (those receiving automatic placement into the course were of the 5 not included). The mean Pre-Test for Native students was 15.2 (std. dev. 3.699, n=30). For Non-Native students, the mean was 18.526 (std. dev. 4.221, n=19). The gains for each group were 2.313 (std. dev. 3.683, n=16) for Native students and 1.867 (std. dev. 3.292, n=15) for Non-Native. In some ways, the Native students experienced greater gains. But there are two caveats. First, for Non-Native students, only 21% (4 of 19) did not persist. However, 46.67% (14 of 30) Native students did not persist. Perhaps the Non-Native students were more purposeful in desiring to accomplish their short-term career goals, as evidenced by course completion. Second, Native students could "gain" relatively more quickly. The relative gain statistic indicates that Native Students gained 9.3% of the available points and Non-Native students gained 8.7% of points available. Relative Gains proved beneficial in this instance.

Summary

Preparedness and instructor were consistently important factors in assessing student performance on the CAOS instruments. Ann's students did not experience large knowledge gains. But, when compared across modalities, classroom-educated students outperformed their web-instructed counterparts. Beverly's students experienced significant knowledge gains, and gains did not differ significantly across modalities.

The reasons for the changes in gains were largely due to performance on descriptive statistics items which accounted for 40% of the instruments. Ann's students performed worse on this critical topic in the Post-Tests. Beverly's students showed strong increases in this area.

In addressing the research question "Do students in web-based statistics courses have comparable levels of achievement as those who receive classroom instruction?", the answer seems to be a cautious 'yes.' in terms of central tendency, with variability still somewhat dissimilar. The achievement question might be simpler to answer by looking at performance in discrete time periods, but should the goal not ultimately be associated more with learning? By the larger variability in gains for some students WBI was highly successful. For others, they entered the course with higher levels of achievement and preparedness than students receiving CBI and finished with lower levels. Given the identification of confounding factors of modality, preparedness, and instructor, a more developed answer to the research question can be formulated after controlling for these variables. These qualifying variables merit full consideration when discussing whether WBI can be "as good as" CBI.

Other areas, such as English Nativity and Nativity (to the institution), were also factors influencing participation in the web-based courses. These factors emerged from the data analysis and merit further exploration.

The CAOS Pre-Tests and Post-Tests were not the only quantitative instruments. The Final Examination was also evaluated in detail.

Departmental Final Exam

The exams for students in the web-based sections were administered in the Testing Center. The researcher proctored each in-class section's Final Exams, graded them, and returned them to the appropriate instructors for them to enter the course grades. Thirty-eight students took the 200-point Final Exam. The average score was 140.92 (70.5%) with a standard deviation of 32.18. Recalling that 36 took the Post-Test, there were two additional students who did not take both the Pre-Test and Post-Test—one from Ann's traditional class who did not take the Post-Test and one from Beverly's web class who did not take the Pre-Test early in the quarter. The Final Exam can be used to address the research question: Can students receiving web-based instruction perform at achievement levels comparable with their in-class counterparts? Yes; if based upon Final Exams alone, the answer could be 'yes' if we also de-emphasize variability. In addition, Pre-Test scores for Web students began higher, hence, one would expect even higher performance on the final. The MANOVA model yielded GPA, College Algebra coursework, Modality, and Instructor as all being insignificant at the .05 level. In fact, Instructor had a p-value of .947.

The 15 students in web courses had an average of 140.5, the 23 students receiving classroom instruction had an average of 141.22 (p-value = .951). The .282 p-value computed in comparing performance by instructors was inflated by the relatively large standard deviations.

Table 4.44 Average (and standard deviations) of Final Exam Performance by Instructor and Modality

Instructor	Modality	Mean (sd)
Ann	Web	130.6 (41.3)
	Classroom	139.19 (23.29)
Beverly	Web	151.7 (42.2)

As indicated in Table 4.44, there was a sizeable difference in standard deviations. Students enrolled in web-based sections had a standard deviation of 41.7, and classroom-instructed students had an average of 25.2. The resulting p-value was .035. Hence, one definition of comparable performance would need to be investigated. Students receiving web-based instruction were more likely to be widely distributed, which resulted in more As, but also more Es. Students receiving classroom instruction had lower proportions of students at the extremes.

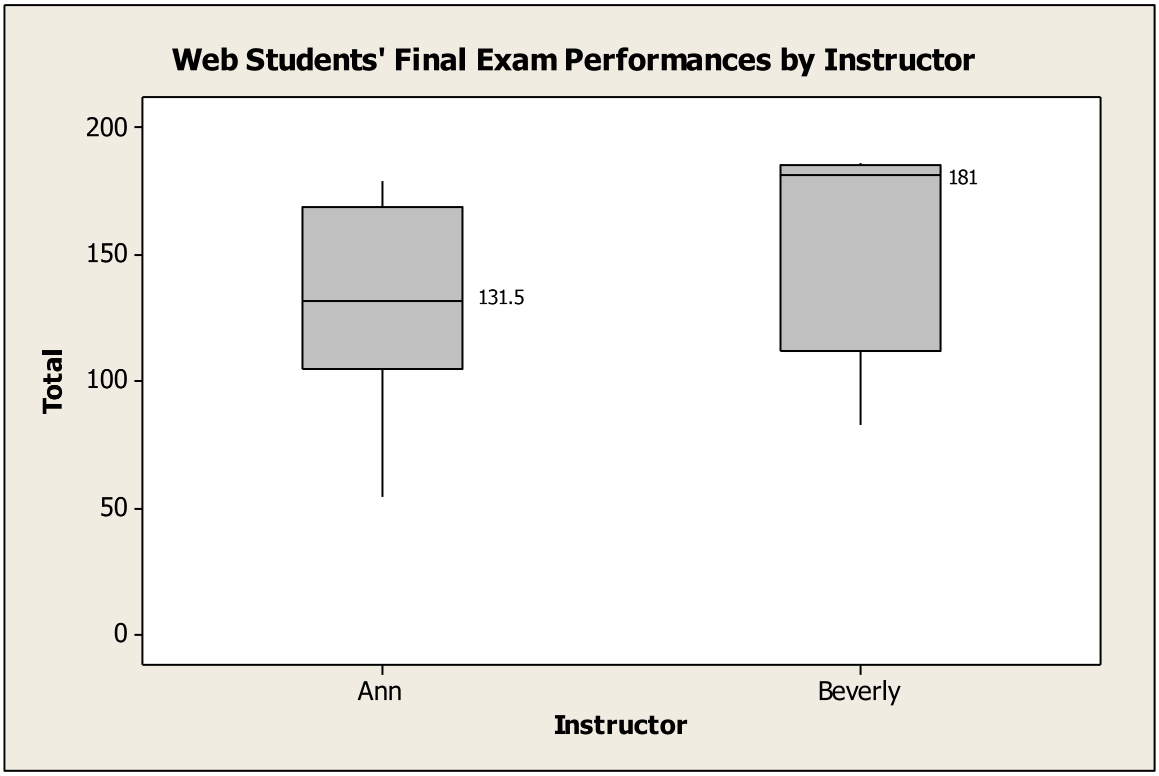

Figure 4.22 Side-by-Side Boxplots of Web Students' Final Exam Performance by Instructor

When investigating the performances of the students receiving Distance Learning (by instructor), the results yielded Ann's students had a median performance of 131.5 (IQR=64.3, n=8) and Beverly's students having a median of 181 (IQR=73, n=7). Figure 4.22 visually displays the distributions for each instructor. Both of these subpopulations had comparable standard deviations—albeit relatively large—with Beverly's student scoring 10% higher. However, the difference in the medias was not statistically significant according to the Mann-Whitney Test at the .05 level (p-value = .224). Likewise, there is no significant difference in Final Exam performance by classroom-educated students among the instructors.

Ann's variability in Final Exam scores for her web section differed from her classroom section with a p-value of .06. Four of Beverly's students received at least a 180 on the Final Exam, which skewed the data to not follow a Normal Distribution at the .10 level of significance.

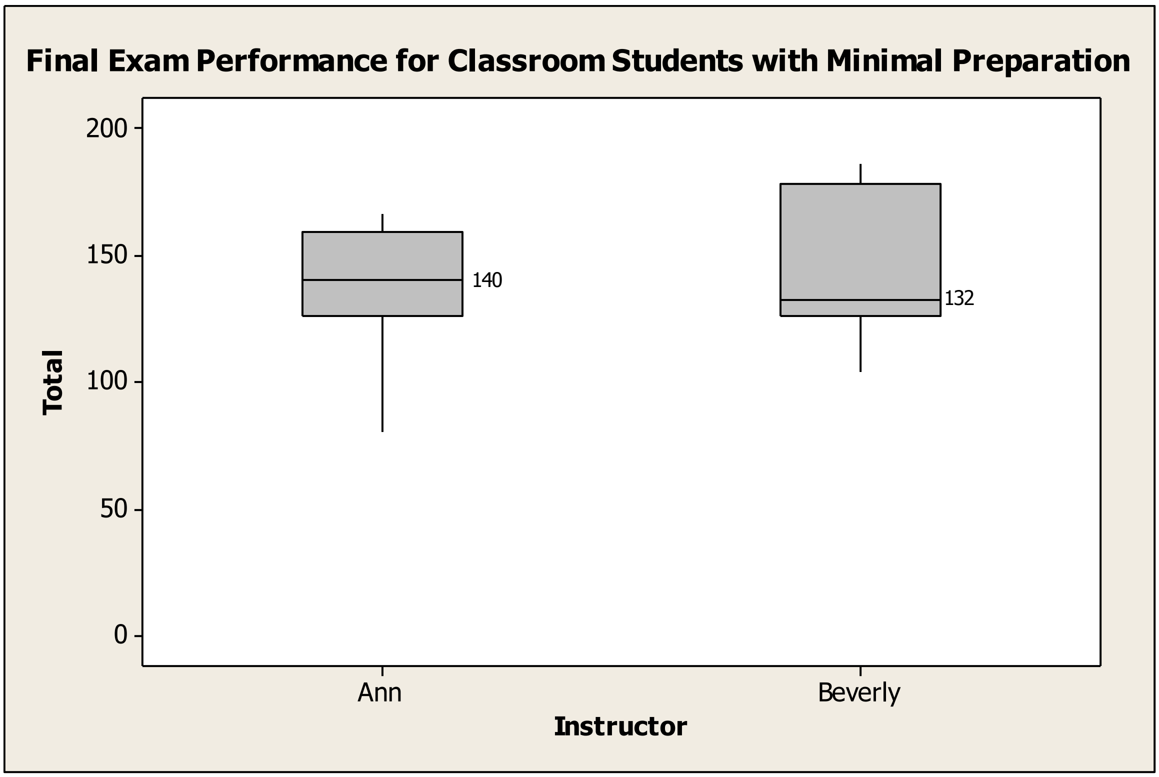

Figure 4.23 Boxplots of Final Exam Scores for Classroom Students with Highest Courses Below College Algebra by Instructor

Final Exam performance did not differ significantly for the two largest populations of preparedness/modality combinations, as reflected in Figure 4.23. The 13 students with prior preparation below College Algebra who were enrolled in classroom sections had roughly similar scores. The nine in Ann's class (Instructor 1) had an average of 136.6, and the four in Beverly's class had an average of 136.8 (p-value = .991). The five students in Ann's classroom section that were at the level of College Algebra had an average of 138.4. Beverly's students with the same characteristics scored 129 and166.

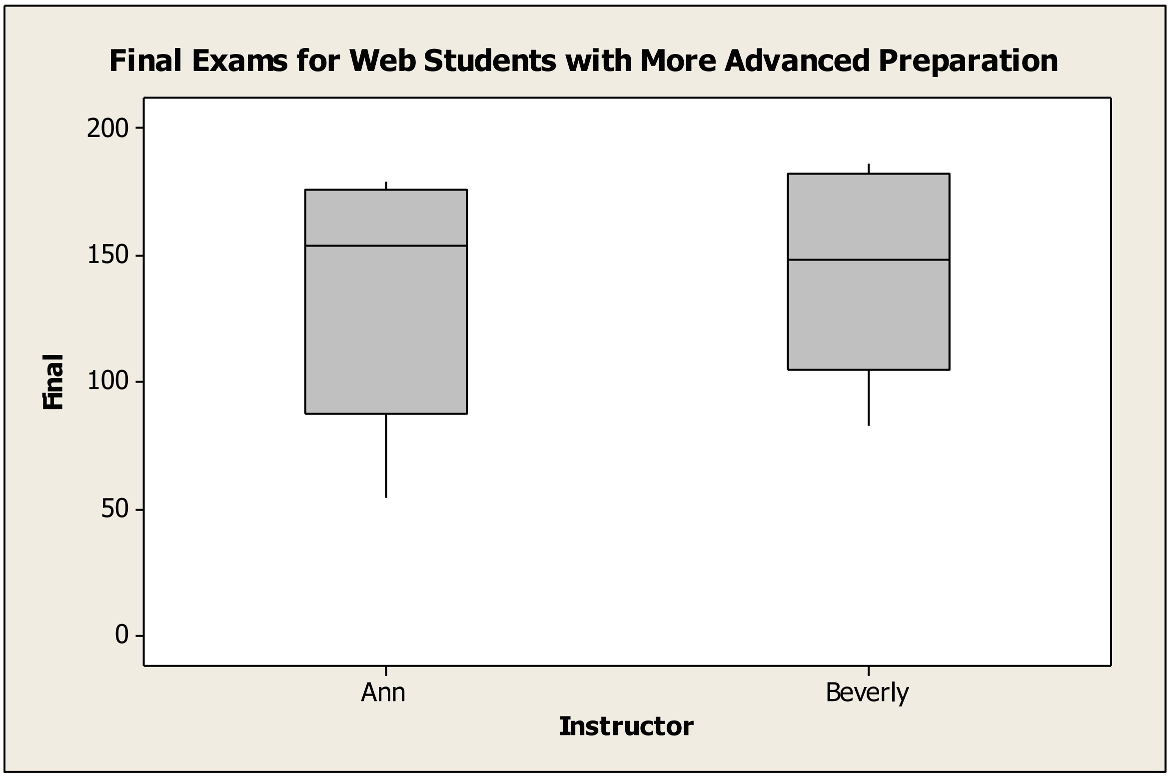

Figure 4.24 Boxplots of Final Exam Scores for Web Students with Highest Courses Above College Algebra by Instructor

The students in the web courses with preparation at least at the level of College Algebra had means of 136.2 and 143. The p-value again was greater than .250 (p-value =.817). There was minimal difference in Final Exam performance for these students, as reflected in Figure 4.24.

Only 1 of the 7 students with preparation below College Algebra completed the web-based course and this student scored 141.

The researcher was intrigued by both the similarities in central tendency among the four sections and the variety of performances in the web-based sections. In addition, it was particularly puzzling that there were stark contrasts between the results of the students' CAOS Exams and their Departmental Final Exams. These unresolved issues led the researcher to analyze student scores on each of the 17 Final Exam questions. A classification denoted with an "I" for "interpretation" to denote items that required responses with substantial discourse. Four exercises were deemed as having the "I" status. Others were deemed as having both an interpretative component and a non-interpretative component. Performance on these items was investigated by modality and instructor in Table 4.45.

Table 4.45 Summary of Final Exam Performance by Achievement Category for each Instructor-Modality

Item (Points)	Instructor	Modality	Mean Points Earned (sd)	Proficiency Status
1 - I (20)	Ann	Web	14.25 (4.23)	Mastery
		Classroom	13.69 (2.33)	Aware
	Beverly	Web	16.86 (2.79)	Mastery
		Classroom	14.87 (2.61)	Mastery
2 (4)	Ann	Web	3.25 (1.49)	Mastery
		Classroom	3.00 (1.27)	Mastery
	Beverly	Web	3.14 (1.57)	Mastery
		Classroom	3.143 (1.07)	Mastery
3 (12)	Ann	Web	8.75 (2.61)	Mastery
		Classroom	7.12 (4.13)	Aware
	Beverly	Web	9.86 (3.18)	Mastery
		Classroom	5.29 (4.86)	Unfamiliar
4 (12)	Ann	Web	10.88 (1.25)	Proficient
		Classroom	9.56 (2.19)	Mastery
	Beverly	Web	11.29 (.76)	Proficient
		Classroom	9.00 (2.50)	Mastery
5 – I (4)	Ann	Web	1.50 (1.60)	Unfamiliar
		Classroom	2.19 (1.28)	Aware
	Beverly	Web	3.86 (.38)	Proficient
		Classroom	2.71 (1.38)	Aware
6 (3)	Ann	Web	2.63 (1.06)	Proficient
		Classroom	2.69 (.79)	Proficient
	Beverly	Web	2.57 (1.13)	Proficient
		Classroom	1.71 (1.60)	Aware
7 (17)	Ann	Web	13.5 (2.78)	Mastery
		Classroom	14.06 (2.62)	Mastery
	Beverly	Web	15.29 (1.25)	Proficient
		Classroom	13.29 (2.56)	Mastery
7 – I (3)	Ann	Web	2.63 (1.06)	Proficient
		Classroom	2.69 (.79)	Proficient
	Beverly	Web	2.57 (1.13)	Proficient
		Classroom	1.71 (1.60)	Aware

continued

continued

8 – I (2)	Ann	Web	1.13 (.99)	Aware
		Classroom	1.19 (.66)	Aware
	Beverly	Web	1.57 (.79)	Mastery
		Classroom	1.86 (.38)	Proficient
9 (16)	Ann	Web	11.75 (4.46)	Mastery
		Classroom	12.75 (4.73)	Mastery
	Beverly	Web	14.00 (3.83)	Proficient
		Classroom	10.86 (4.30)	Mastery
10 (16)	Ann	Web	12.38 (5.34)	Mastery
		Classroom	13.13 (2.73)	Mastery
	Beverly	Web	13.14 (3.24)	Mastery
		Classroom	13.29 (3.95)	Mastery
11 a I (2)	Ann	Web	4.71 (2.81)	Aware
		Classroom	3.94 (3.59)	Unfamiliar
	Beverly	Web	7.14 (3.93)	Unfamiliar
		Classroom	7.71 (3.86)	Mastery
11 (10)	Ann	Web	4.71 (2.81)	Unfamiliar
		Classroom	3.94 (3.59)	Unfamiliar
	Beverly	Web	7.14 (3.93)	Mastery
		Clasroom	7.71 (3.86)	Mastery
12 (7)	Ann	Web	2.88 (2.23)	Unfamiliar
		Classroom	3.50 (2.78)	Aware
	Beverly	Web	4.00 (2.94)	Aware
		Classroom	5.29 (1.89)	Mastery
13 (4)	Ann	Web	2.25 (1.91)	Aware
		Classroom	3.50 (1.16)	Aware
	Beverly	Web	2.29 (1.70)	Aware
		Classroom	5.86 (3.76)	Unfamiliar
14 a-c (9)	Ann	Web	5.00 (3.34)	Aware
		Classroom	6.625 (1.71)	Mastery
	Beverly	Web	5.14 (2.27)	Aware
		Classroom	5.86 (3.76)	Aware
14 d – I	Ann	Web	1.50 (1.60)	Aware
		Classroom	2.88 (.34)	Proficient
	Beverly	Web	2.14 (1.46)	Mastery
		Classroom	2.86 (.38)	Proficient

continued

continued

15- I (8)	Ann	Web	4.25 (2.49)	Aware
		Classroom	5.13 (2.42)	Aware
	Beverly	Web	6.00 (1.63)	Mastery
		Classroom	5.14 (1.57)	Aware
16 (14)	Ann	Web	7.25 (5.31)	Aware
		Classroom	10.75 (3.11)	Mastery
	Beverly	Web	8.57 (6.05)	Aware
		Classroom	10.14 (5.24)	Mastery
16 – I (d,f,g)	Ann	Web	4.50 (2.51)	Unfamiliar
		Classroom	4.69 (3.20)	Unfamiliar
	Beverly	Web	6.57 (4.28)	Aware
		Classroom	5.14 (2.55)	Aware
17 (24)	Ann	Web	15.25 (8.63)	Aware
		Classroom	15.38 (6.63)	Aware
	Beverly	Web	14.71 (9.74)	Aware
		Classroom	21.43 (2.76)	Proficient
Interpretation Total (52)	Ann	Web	30.75 (12.20)	Aware
		Classroom	33.19 (5.05)	Aware
	Beverly	Web	40.71 (8.71)	Mastery
		Classroom	35.86 (1.96)	Aware
Non Interpre-tation Total (148)		Web	99.9 (30.2)	Aware
		Classroom	106 (19.90)	Mastery
		Web	111.00 (33.9)	Mastery
		Classroom	110.00 (27.5)	Mastery

Table 4.45 contains item performance by instructor-modality combination along with the corresponding proficiency status as determined by the researcher. Exercise 5 seems to have yielded the most provocative results; here, Beverly's web class outperformed both Ann's web section and Beverly's classroom section. And at the .10 level of significance, Ann's classroom section outperformed the web-based section.

Exercise 8 also yielded strong results as Beverly's classroom section was near-perfect in responding (mean 1.857 out of 2).

The remaining statistics within the table seem quite comparable and further explain why Final Exam averages did not differ significantly at the .05 level of significance. The students enrolled in the in-class sections were even more similar than the web sections.

The researcher chose to categorize average section item score in the following manner: at least 85% of points available: proficient; 70 up to 85% of points available: mastery; 50 up to 70% of points available: awareness; under 50%: unfamiliar. Hopefully these results can inform researchers and readers of student strengths and opportunities for improvement.

For the web sections, in 7 of 8 cases, Beverly's web section produced a stronger proficiency status. This consequently led to a stronger Interpretation Total and Non-Interpretation Total. The fact that the majority of items yielded the same proficiency status underscores the reason why the higher overall totals for Beverly's students were not statistically significant.

For the classroom sections, in 5 of 11 cases, Ann's classroom section produced a stronger proficiency status, as shown in Table 4.45. The joint product of this and the fact that the other 10 items resulted in similar proficiency statuses led to the Interpretation and Non-Interpretation Totals being quite comparable. The instructor seems to have had far less of an impact on Final Exam performance. The Final Exam composition is reviewed in Table 4.46 with their corresponding weights identified in Table 4.47.

Table 4.46 Final Exam Items with Point Total and Comparable CAOS Topic

Exercise	Total	Comparable CAOS Topic
1 – (I)	20	Design
2	4	Design
3	12	Descriptive Statistics
4	12	Descriptive Statistics
5 – (I)	4	Descriptive Statistics
6	3	Probability
7	17	Probability
7- (I)	3	Probability
8 – (I)	2	Probability
9	16	Probability – random variables
10	16	Probability – random variables
11 a (I)	2	Probability – random variables
11	10	Probability – random variables
12	7	Sampling Distribution
13	4	Confidence Intervals
14 a-c	9	Confidence Intervals
14 d (I)	3	Confidence Intervals
15 – (I)	8	Confidence Intervals
16	14	Hypothesis Testing
16 – (I) (d,f,g)	10	Hypothesis Testing
17	24	Regression

The Final Exam topics are generally connected to the indicated comparable CAOS Topic, but the instruments are structured differently. The Final Exam is slightly more computational, whereas the CAOS Exam tends toward the conceptual. Formal discussion of random variables, their names, and properties have minimal presence on the CAOS Exam.

Table 4.47 Final Exam Point Totals and Weights for each Topic

Topic	**Points**	**Weight on Final Exam**
Design	24	12%
Descriptive Statistics	28	14%
Probability	25	12.5%
Probability – Random variables	44	22%
Sampling Distribution	7	3.5%
Confidence Intervals	24	12%
Hypothesis Testing	24	12%
Regression	24	12%

The Final Exam is designed to be uniform in its point allocation of each topic to corresponding chapters in the text as a better indicator of comprehensive mastery. This differs from the descriptive statistics emphasis (40% of total) found in CAOS Exam that tends to focus on depth of statistical reasoning.

Some differences are that Beverly’s web students are more Proficient on a few items and more Familiar overall. However, there was minimal difference in distribution by instructor (p-value = .338). There were few differences between the two classroom sections. Some differences between Mastery and Awareness levels, but minimal overall (p-value= .798). In sum, there seems to be minimal differences among proficiency statuses on Final Exam items across Instructor and Modality and their combinations.

Interpretations

Interpretations seemed to play a stronger role when aggregate scores were compared by instructor. The mean scores of 32.38 (7.96) and 38.29 (7.33) for Ann and Beverly, respectively, yielded a p-value = .027. Beverly's students performed better on the interpretation items.

Interpretation totals for Ann's web students was 30.75 and a standard deviation of 12.20. Beverly's interpretation totals were 40.71 with a standard deviation of 8.71 (p-value = .091). This has some practical, but not statistical, significance. The students in the classroom sections differed less by instructor. The average for Ann's students was 33.19, and 35.86 was the average for Beverly's. The non-interpretation totals for the two instructors were 104 and 110.5 (p-value =.487). There seemed to be no significant difference among the non-interpretation totals.

Beverly's students are scoring 6 points higher on each component (interpretations and non-interpretations). The difference is that the interpretation items are only out of 52 points and the other is out of 148. Even considering percentages of correct answers for Interpretation exercises, Ann's students yielded approximately 62.3% correct and Beverly's were about 73.6% (with, of course, the same p-value = .027).

There was a statistically significant difference in standard deviations of performance by classroom and web students, but this was less true when controlling for instructor. This further supports that there is significantly more variety in the web students' interpretations. Interpretation totals correlate well to non-interpretation values. One linear regression yields: Non-Interpretation Total = 25.77 +2.33(Interpretation Total). Figure 4.25 displays the corresponding scatterplot.

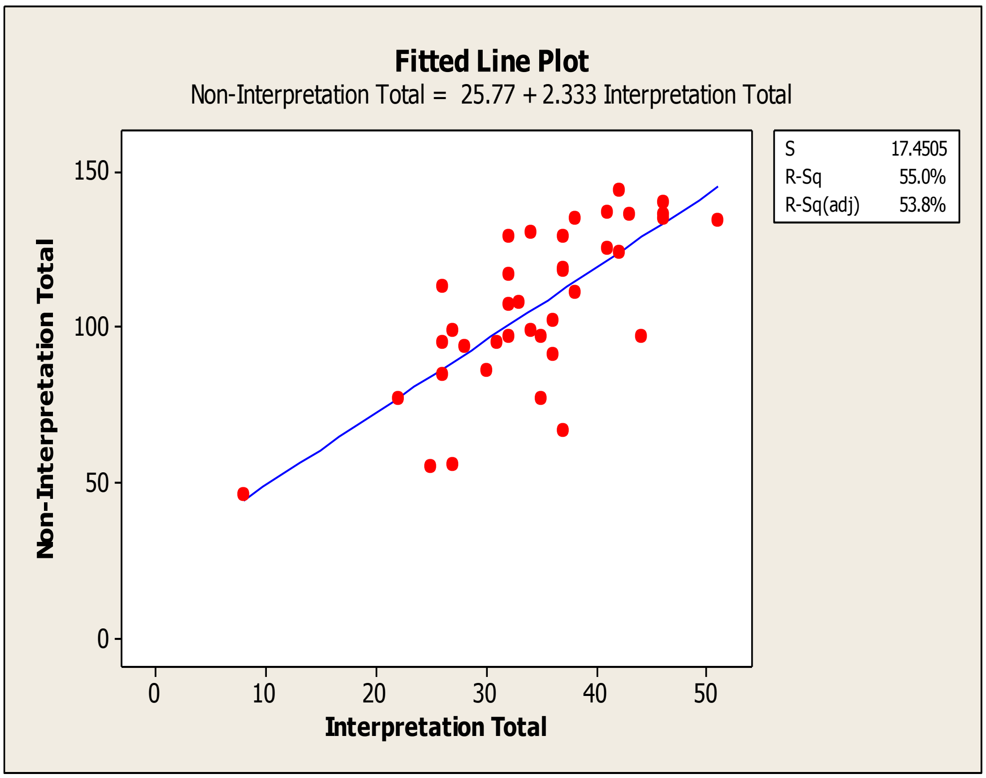

Figure 4.25 Regression Equation and ScatterPlot of Relationship between Non-Interpretation and Interpretation Final Exam Items

ESL

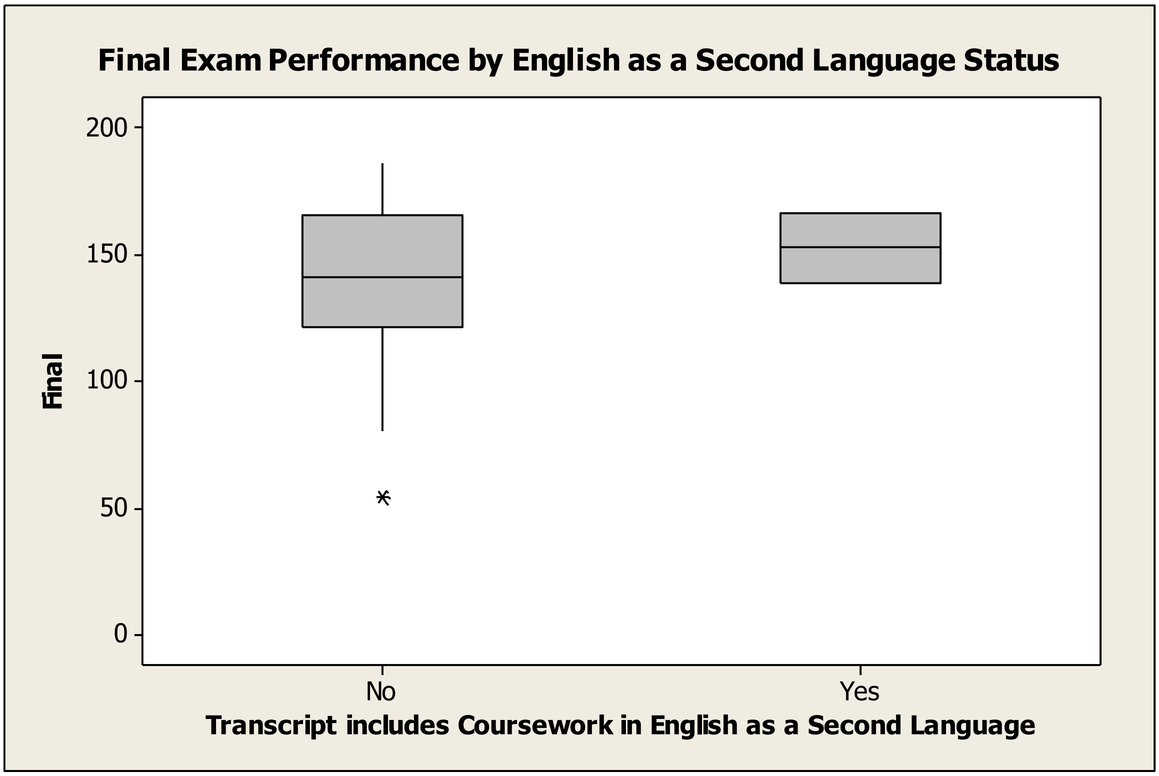

Figure 4.26 Side-by-Side Boxplots of Final Exam performance by ESL status

It would be naïve to assert that students with ESL coursework perform better on the Final Exam based upon only 2 students (Figure 4.26). Non-native English speakers may atone for potential deficiencies incited by language by performing better on the more computational exercises. With the Final Exam being more computational, it can have structural benefits to those with experience in this type of learning. There is also evidence that the text-driven presentation of the curriculum serves as a deterrent from enrolling in web-based education. Research on ESL and introductory statistics warrants greater dialogue.

Summary

The Final Exam analysis revealed that there was a substantial variety in scores. It was also evidenced that students in web-based sections could have comparable (if not better) achievement on common assessments: 151.7 vs. 145.9 on the 200-point final. Also, the stronger performance on interpretation items may account for the similarities in findings from interpretation totals and CAOS Exam scores. Beverly’s students tended to perform higher on CAOS largely due to the more conceptual questions posed on CAOS. Higher performance for these students on interpretation items on the Final Exam followed as well.

The colloquial “head start” factor must also be discussed. Those receiving WBI that participated in this study were better prepared than their classmates who chose not to participate in this study (Table 4.3). With attrition rates not being too dissimilar, for students receiving WBI to have comparable Final Exam performance as the CBI counterparts is not necessarily a desired outcome for a group that already began with an advantage. Be it due to self-motivation, or difficulties in learning the content, as a whole, the learning rates are not the same. For Beverly’s students, the gains were comparable. For Ann’s students’ the “head start” narrowed considerably. Hence, as an entire subpopulation, the levels of learning seem to not be equivalent with CBI, and because of the initial “head start” of preparedness, the measures of central tendency seem comparable with an above average amount of variation.

Overall, the Final Exam differed mostly in design from the CAOS Exam. The CAOS percentage of descriptive statistics question seemed quite high with over double the proportional representation compared to the Final Exam. More students seemed to have adjusted to the computational emphasis requisite with Final Exam. However, this remained an issue with the CAOS exam. When considering other variables that correlate with Final Exam, GPA was the strongest, but not enough alone. It was also true that high percentages of students at minimum preparation did not complete the course.

What is emphasized, structured, or presented by the instructors influences student learning and performance. After a review of the learning outcomes via the quantitative instrumentation discussed to this point, the researcher will now investigate the learning, pedagogy, and interactive experiences that had some influence on outputs.

Researcher Journal and Notes from Classroom and Virtual Observations

Classroom observations are critical to having a more complete understanding of student learning. The researcher chose to see, first-hand, the educational settings the participants were part of. In visits during the first and second half of the term, the researcher arranged visitations with each of the instructors. Observations were conducted within one week of each other in efforts to observe delivery of similar topics. The researcher also communicated with administration and staff at the institution to obtain guest access to each instructor’s web-based sections.

Classroom Observations

Descriptive Statistics – Ann's Classroom (First Half of Term)

The first hour instruction occurred in the classroom, and the second transitioned to the computer lab. Both rooms seat about 30 students and have overhead projector systems and white boards. Nineteen students were in attendance. The class consisted of a considerably younger population, with only a few over 25. The general setup of seats was a row-column arrangement.

Ann had a "brain gym" interwoven in the class as an activity to stimulate neurons and sharpen student awareness. In this instance, students were told to point the index finger of one hand horizontally and point their thumb of the same hand vertically. Then had them switch several times, to the students' enjoyment. This interactive activity definitely got the students engaged in the class.

Ann covered shapes of distributions and provided tips for discerning skewed left from right. She provided a handout with data comparing the shapes of two distributions of data to help in deciding which car to purchase (standard deviation). Ann provided a personal anecdote by recounting the data that can be gathered from putting a child to bed. Ann included an example from the Chebyshev Theorem and Coefficient of Variation regarding the consistency of the lengths of cutting boards. Reflecting on these connections did not occur extensively, but it was clear that the students identified with the situations presented. Ann then altered the discussion to instead provide an overview of tasks that were to occur during the second hour of class in the computer lab.

The lab required students to describe primary sources of income for tuition and textbooks and then to create histograms and boxplots accordingly. Students were advised to submit their labs after three printouts. Each station had a computer, and students collected the data in the previous class session.

The students clearly sat next to people most similar to themselves. For the most part, students sat in small clusters by gender with one workstation in between. The four students of African descent sat in fourth row. International students were some of last ones remaining at the end of the lab.

Overall, student learning was clearly occurring. The instructor used guided lecture notes to stimulate note-taking. The instructor established an atmosphere conducive to develop a rapport with students. However, there could have been more time to discuss interpretations. This could have been due, in part, to the class size. All students eventually completed the lab.

Hypothesis Testing – Ann's Classroom (Second half of term)

Ann covered Hypothesis Testing for Means for "Large" Samples. She impressed on the 17 students that Hypothesis Testing could be completed in four prescriptive steps:

1) Set up hypotheses.
2) Determine Rejection Region (using a=alpha = significance level = tail area)
3) Test Statistic using ZTest function on calculator.
4) Conclusion

Visual representations of critical regions were used. Ann supplemented core instruction with a variety of tips. Either the normal cdf or ZTest on the graphing calculator functions were used to compute probabilities for approximately Normal Distributions and p-values. A follow-up discussion regarding p-values delved more into statistical reasoning. Ann cleverly had students liken alpha to a glass. If the p-value is a liquid, then the goal is to not have the “liquid” overflowing. She also discussed reversal activities whereby the p-values were given, and students had to determine whether to reject the null hypothesis. These types of conversations could have been further extended.

All students were taking notes. Not many students asked questions. The instructor often asked “if ‘everybody was good,’” then she would move to the next part of the lesson plan.

There was self-segregated seating with minorities in particular sitting in a cluster along the periphery; African students sat in same row by window. The instructor moved quickly and seemed less confident than usual, and there were not many questions to slow her down. Students were given five minutes of independent practice on exercises from the text after the material was taught.

The interpretation question was “How can we change the standard deviation and sample size to give more credence to my sample mean as evidence against the claim?” There was good feedback: one student suggested decreasing the mean, and another suggested decreasing the standard deviation. Other students suggested increasing the sample size. However, the dialogue did not persist as the class session was virtually over.

As someone with a background in the discipline, I may have followed along better than the students. It seemed the students were either keeping up with the pace of instruction or were less in the habit of soliciting questions.

Descriptive Statistics – Beverly's Classroom (First half of term)

Beverly had been on leave the previous week and began reviewing material covered by the substitute. Students were considerably older; most were working adults with an average age over 25 and no teenagers.

The chalkboard had been used vigorously by the time the 8p class began. The classroom is designed for mathematics instruction (Cartesian coordinate grid, polar coordinates also). There was not much interaction, and the students were sparsely sprinkled across the classroom. 12 students were in attendance with one inquiring about a central tendency exercise from the homework, which lead to some classroom discussion.

Beverly reviewed measures of central tendencies and explained when best to use mean, median, and mode. There was a good review of the mean (used for ratio and interval data), median (the middle number), and mode being meaningful for nominal and ordinal data.

Beverly then began to discuss measures of spread. Standard deviation was covered well. Variance was just mentioned as the square of the standard deviation. Beverly wrote legibly, used good examples, discussed an activity on child development, and led students through an exercise in which U.S. percentiles cannot apply to children from other countries. Beverly discussed left and right skewnesss, taught on z-scores, and repeated concepts almost in excess.

Beverly handed out a Chapter 2 review, left for a few minutes, and then returned with a chapter review sheet and rubric. Students began a lab later that evening that required them to enter their favorite type of movie, gender, and amount spent on textbooks. Each student had a computer and worked on the exercises. The lab had roughly 30 PCs, one large workstation, and two laser printers. The instructor print screen showed to a projector perpendicular to the main wall of instruction. The students worked diligently and independently.

Beverly reminded students of the types of real-world applications that could be used for their upcoming class project. Beverly had a solid presentation of material. At times, it seemed a methodical, but good, approach. Her explanations of the mean, median, sample size, and mode were organized and appropriately used data. Beverly connected with students by briefly mentioning her recent trip to Asia.

Hypothesis Testing – Beverly's Classroom (Second Half of Term)

The students had higher levels of participation this time. Students placed ideal homework assignments on the board. A quieter student provided an interpretation of an exercise involving miles per gallon for sports cars. At one point, a minority student held his had down as if he was falling asleep in the back row. Beverly intervened with the student to get him to work with another fellow classmate (actually a student of similar ethnicity) who was quite attentive.

Beverly began her lesson on hypothesis tests after a review of confidence intervals. There were some calculator difficulties. Beverly provided a lot of explanations to support the solutions. She used a graph of f(x)= x(1-x) (where x was the sample population proportion) to show students the value of x that maximizes the function. "Cell phone data" introduced the need for Hypothesis Testing in terms of testing a claim supported by the impractical nature of surveying each member of a large population. Beverly referred to the "test of significance as a means of seeing if the difference between data and claim is significant." She also reviewed the trichotomy principle—two numbers being equal, one being larger than the other, or, vice versa.

Beverly distributed a three-by-four chart with null, alternative, type of test, rejection area, and critical values to aid students in processing related exercises. She was able to strengthen students' abilities to connect words with symbols. Type I and II errors were not covered extensively. The instructor guided students through the learning process via the chart. Students were encouraged to draw graphs to provide visual representations. After five minutes, students had a short break. The less attentive student did not return after the break but approached the instructor about attending office hours.

The instructor also had a variety of tips for hypothesis testing (e.g., comparing critical values to the notion of drawing lines in the sand, "dropping negative signs" for right-tailed tests, p-value = (# of tails) (tail area of the test statistic)). The Texas Instruments 84 calculator was used appropriately with the Z-Test and T-Test menus for hypothesis testing. The instructor also informed the students of the need for p-values with journal articles. The class closed with a reminder about the timeline remaining for their upcoming projects.

Both Ann and Beverly are committed instructors. Ann involved the larger class with calculator usage and “brain gyms” although they were still reluctant to communicate about the mathematics. Beverly focused on making sure each student in the smaller evening class was learning. She often walked around the classroom to help students. The classroom climate was markedly different upon my second observation; students were quite comfortable with the instructor. It seemed as if Ann focused slightly more on the calculator, and Beverly led more holistic discussions. Those were small differences in the larger context of learning. Both sets of students benefited from having these two instructors.

The content and timeline for assessment used in classroom instruction are designed to correspond with web instruction. The researcher will turn to describing the web-based learning environment for comparison to the established means of education.

Web Instruction

Curriculum Support

Ann used a variety of means to engage her distance learners. Some included the typical syllabus and calendars. Others were more creative, such as including applets and “Motivational Mondays.”

“Motivational Mondays” were designed to engage students in academic thought and provide them with college/life success strategies that probes their own learning. An example is provided below in Table 4.48. Weekly announcements were also provided with links to the instructional unit of the week.

Table 4.48 Motivational Monday Exercises

Creator victim Your task is to complete the Creator column below:

T a b l e 4 . 6	Victim Language Victims believe that their behaviors, thoughts, feelings, and outcomes are caused by forces beyond their control, such as powerful others and luck. Victim language is characterized by blaming, complaining, and making excuses.	Creator Language Creators believe that their behaviors, thoughts, feelings, and outcomes are the natural consequences of *their choices*. As the masters of their lives, they **create, promote, or allow** all of their outcomes and experiences. Creator language is characterized by accepting responsibility and then making a plan.
1 O	1. I can never find a parking space.	I'll leave early tomorrow to be sure I get a parking space and use the extra time to study.
n e	2. I failed because he's a lousy instructor.	
o f	3. It's not my fault that I'm late.	
A n n	4. I've been too upset to get my work done.	
' s	5. I just can't do math.	
	6. This is a stupid requirement anyway.	

Ann worked with the college's instructional services division to create an online version of the well-established box of flashcards often used in education. Essentially, this is a game played with 12 cards. A situation is stated on one side with a corresponding question. No need for showing step-by-step processes, the student's job is to simply answer the question. The student then presses “flip card” to reveal the solution and move on to the next card of 12. These flash cards do not allow for multiple lines of solutions, but they do provide straight-forward solutions. They are intended to assess a student’s concept master and quickness of recall. This interactive tool was a great addition to the course.

A few applets were posted to encourage students to learn statistics through experimenting with parameters. The user can “slide” an icon to the left or right and view the corresponding modifications to the distribution. For the Normal Distribution, a fixed interval of outcomes, the Interactive slide shows the probability increasing as the population standard deviation is increased. At the same time, the graph, in this example, visually widens. Means, standard deviations, and intervals may all be adjusted.
There were also applets for the Binomial Distribution, the Central Limit Theorem, and Correlation. The potential next level could be to have Discussion Board questions on them to assess the extent of student usage and learning. The researcher did not observe applet exploration during the either of the two classroom observations. These types of demonstrations can benefit all learners. Table 4.49 lists additional resources for students.

Table 4.49 Links to Applets

Try this interactive link to see how adjusting the mean and standard deviation impacts a set of data: http://www.stat.sc.edu/~west/applets/normaldemo1.html
Try this interactive link to see how the empirical rule works: http://www.stat.sc.edu/~west/applets/empiricalrule.html
How it works: Students can change the binomial parameters n and p and see the effect on a bar plot representing the binomial probabilities.
Standard Normal Distributions (bell-shaped with a mean of zero) Try this interactive link: http://www.stat.sc.edu/~west/applets/normaldemo2.html

Table 4.50 contains a sample of a typical weekly announcement. These were used to communicate with the students and remind them of deadlines to aptly keep the students on track toward course completion. In the classroom setting, these are usually done at the beginning of the class session.

Table 4.50 A Sample Announcement

Sat, Jul 28, 2007 -- *Due Week 6*   **Motivator of the Week:** Negative thoughts actually limit cognitive resources and memory retrieval. While taking a test if you experience a "blank out", this is likely what has occurred. Any "I can't do this" thought that occurs while you take a test, blocks your memory retrieval for all of the questions that come after that negative thought. Take tests in your preferred order (not necessary in the order they are written) to reduce limiting your cognitive resources. And use the attached "Affirmation" activity to increase your positive thoughts and keep memory working efficiently.   1. Take Test 2 (over chapters 3,4,&5), available in CSCC testing centers 7/27-8/3. Prepare by completing the suggested homework, posted chapter reviews, and reviewing graded labs, quizzes, and DB postings. Tables will not be provided since you have the necessary functions on your calculator.   2. Work through my online notes, example even problems, and suggested homework for 6.1-6.3. Then complete my online Chapter 6 Review. Be sure to learn to correctly interpret each confidence interval.   3. Submit DB (Discussion Board) 6, Lab 6, and Lab/Quiz 6 before midnight 8/5/07. Be sure to show your work and round all answers to the nearest thousandth.

Syllabus

Syllabus
WEB syllabus SU07.doc (48 Kb)

Suggested Calendar
SU07-WEB calendar.doc (42.5 Kb)

Assignments and Due Dates
WEB Assignments and Due Dates - SU07.doc (98.5 Kb)
PLEASE PRINT THIS AND MAKE NOTE OF ALL DEADLINES SO YOU DON'T MISS ANY!!!

* All assignments (Minitab Labs, Quizzes, and Discussion Board Postings) are due before midnight on Sundays. They all require you to understand the content first, so don't wait until the last minute.
* Tests will be available in the testing centers during their hours of operation for the dates posted. **If you require other testing accommodations please contact the testing center the first week of the quarter**. Absolutely no test make-ups or extensions provided.

Figure 4.27 Regulations Repository

The syllabus page and other links in Figure 4.27 effectively communicated the assessments and due dates to the students. This allowed students to link to the appropriate document and download whenever necessary. There was also a Suggested Calendar with an array of important due dates. With the asynchronicity of Distance Learning, any efforts to organize student activity will lead to more successful outcomes.

The TI-83 links in Figure 4.28 had calculator keystroke guides to assist web-based learners in their usage of the graphing calculator and its statistical functionality. A link existed for each family of topics. The same handouts were available to classroom-based learners.

TI-83/84

Entering Data
TI 83 Entering Data.pdf (25.623 Kb)

Descriptive Statistics
TI 83 Descriptive Statistics.pdf (39.313 Kb)

Descriptive Statistics - grouped data
TI 83 Descriptive Statistics Grouped Data.pdf (21.439 Kb)

Figure 4.28 TI-83/84 links

Typically, the laboratory assignments in Figure 4.29 were completed weekly. Students would click on the link and download the file. Then they would reenter (once complete) and upload the document for the instructor to review. This arrangement was designed to circumvent electronic mailing of labs.

Labs

[Lab 1- Learning Styles Inventory]

This lab has three parts.

1. Learning Styles Inventory website. Be sure to print your helpsheet and refer it for study strategies that match your Learning Style Preference.

2. Minitab directions in a READ ONLY format... please copy and save these for you to add your graphs and analysis. The directions are provided for MTB 14. If you use version 15 the steps are a little different for the pareto chart.

3. MyMathLab Introduction (optional)

Lab analysis and minitab documents must be submitted through Blackboard. The Minitab printout itself is worth 3 points and the analysis will be assessed in the corresponding weekly quiz.

>> View/Complete Assignment: Lab 1- Learning Styles Inventory

Lab 2 - Graphs
Before completing this lab, you need to collect data. Use the attached Minitab directions to make 3 graphs from your collected data. Use my online Chapter 2 notes to assist you in the analysis. All three Minitab graphs need to be pasted to the end of the lab so that you attach only one document.

>> View/Complete Assignment: Lab 2 - Graphs

Lab 3 - Descriptive Statistics
This lab covers the content from chapter 2 - Descriptive Statistics. Open the data (EXAM.mtw) in Minitab first, then open the directions for Minitab and copy the READ ONLY document so that you can edit as required. As always, please paste all minitab worksheets and graphs to the end of the word document before you submit your completed assignment.
>> View/Complete Assignment: Lab 3 - Descriptive Statistics

Figure 4.29 Labs

Ann used Discussion Boards to stimulate statistics discussions and mini-investigations. Below are a few of her posts. The threads from her discussions would follow the links in Table 4.51 and appeared as shown in Table 4.52. Ultimately, students posted something and, recursively, the next person responded to the problem previously posed and posted a question for the next person, etc.

Table 4.51 Discussion Boards

DB1 - Survey scenarios

Come up with a scenario of a study for which you might be *interested* in collecting data. Describe a sampling method that is appropriate (without specifically naming the method) and include 2 survey questions. I have provided the first scenario.

Number of Messages: 76
[All New]

The first person to reply should identify the topic of the scenario and the following:

- population
- sampling method
- highest level of measurement for each survey question (see Chapter 1 online notes for help with these terms)
- finally post a new scenario for someone else to analyze.

The second person should analyze the new scenario and then post a new scenario and so on. Keep in mind the scenarios should reveal something about your interests. Be sure to clarify the problem you are responding to so that no one duplicates an answer (you don't get credit for problems that have already been solved by someone else).

DB2 - Boxplots

Table 4.52 Student Discussion Board Posts

Forum: DB1 - Survey scenarios

Date: Sun Jul 01 2007 08:50

Author:

Subject: Homework and GPA

I'd like to find the relationship between how much time a high school student spends on homework and what their grade point average is. I am mailing the parents of each student at the local high school and asking:
1. How much time does your son or daughter spend on homework per week?
2. What is your son or daughter's grade point average?

Reply

◄◄ Previous Message Next Message ►►

Thread Detail

Homework and GPA Sun Jul 01 2007 08:50

Re: Homework and GPA Sun Jul 01 2007 11:12

DB1 - Survey scenarios

Date: Sun Jul 01 2007 11:12

Author:

Subject: Re: Homework and GPA

---

1. Population: High school students

2. Sampling Method: Cluster sample

3. Level of measurement- Q1: Ratio Q2: Ratio

Reply

Other resources Ann included were a picture of the Mathematics Learning Resource Center and its schedule for walk-in tutoring availability. She also had a list of ten helpful hints which included the following: Encouragement to Take Notes on her Notes, Homework, Practice of Reviews, Minitab Lab Assignments, Weekly Quizzes, Computer Competence, and Comprehensive Exams. Ann’s class also included comments from previous students that recounted challenges and successes with web-based instruction.

Curriculum

Each Chapter has a folder lead-in that describes the key objectives for that chapter. After clicking on the link for that folder, students are able to also view similar links for each section within the chapter. A few chapters are included in Table 4.53.

Table 4.53 Curriculum by Chapter

Chapter 2 - Descriptive Statistics

In Chapter 2 you will learn ways to organize and describe data sets. The goal is to make the data easier to understand by describing trends, averages, and variations.

You will need to

- Interpret Graphs (pie graphs, pareto charts, frequency and relative frequency histograms, boxplots, ogives, polygons, time series plots, scatter plots)
- Identify Shapes of Distributions (uniform, normal, left skewed, right skewed, bimodal)
- Calculate Measures of Center (mean, median, mode, trimmed mean, weighted mean)
- Calculate and interpret Measures of Spread (range, standard deviation)
- Calculate and interpret concepts that require the standard deviation (Coeffiecient of Variation, Empirical Rule, Chebyshev's Theorem)
- Calculate and interpret measures of Position (Percentiles, Quartiles, z-scores)

You will be required to use your TI-83/84 extensively in this chapter. Use my online notes instead of the lengthy by-hand calculations presented in the text.

continued

continued

Chapter 6 - Confidence Intervals

In Chapter 6 you will being your study of the Inferential Statistics. You'll learn how to estimate population parameters based on sample Statistics. You should be able to use your TI-83/84 to calculate and interpret:

- Minimum required sample size
- Point estimates for means and proportions
- Confidence Intervals for means and proportions
- Margin of error
- Use the confidence level to find z or t depending on the sample size

Chapter 7- Hypothesis Testing

Hypothesis Testing (for means and proportions) is explained in this chapter. The TI-83/84 again will make your work much faster so you can concentrate on the overall conclusion. I'll look for you to provide 4 steps for each hypothesis test:

1. State the hypotheses
2. Determine the critical value and shade the rejection region (invnormal or t-table)
3. Calculate the test statistic (Ztest, Ttest, or 1PropZtest)

Make the conclusion in context Be prepared to use both the *p-value method* of testing a hypothesis and the *traditional method*.

Descriptive Statistics

Descriptions of descriptive statistics, and when each is best used, were provided. A step-by-step approach was within the notes page. Table 4.54 was provided to compare with the summary provided regarding the researcher's classroom observations.

Table 4.54 Descriptive Statistics Content

Measures of Center - represent a typical, or central value for the data set.
Mean

- Usually thought of as the average.
- Calculator symbol □ $\bar{x}$ (sample mean)
- Population mean = μ (the Greek letter mu)
- ***Not a resistant measure*** since the mean is always pulled toward the extreme data value
- The mean is the best measure of center when there are no outliers (see the boxplot to determine if outliers exist) to pull the mean away from the center

Median

- Middle piece of data
- Calculator symbol is **med**
- ***Median is a resistant measure*** since it is not affected by extreme data.
- The median is the best measure of center when a data set has outliers.

Mode

- Data value or response that occurs the most often
- If all data occurs the same number of times, there is no mode
- It is possible to have more than one mode if there is a tie

Weighted Mean

- Used for grouped data (frequency tables)
- In your calculator go to Stat>Edit and enter the midpoints for each class in L1 (add endpoints and divide by 2) and the frequencies in L2. Then go to Stat>Calc>1varstats(L1, L2) to find the sample mean, $\bar{x}$. Note that L1 must be the actual data variable for which you are calculating the average.

continued

continued

Trimmed Mean

- The mean calculated after a given proportion (%) of the extreme data values are deleted from the top and bottom of the sorted list of data
- Delete the values and then find $\bar{x}$ on the calculator

Not used with grouped data (see Example 2)

Example 1: (single list of data)

Resting Heart Rates of CSCC students:

66, 56, 57, 60, 72, 90, 68, 58, 78, 67

Find the mean, median, mode, and 10% trimmed mean.

Solution 1:

- **In your calculator go to Stat>Edit and enter all data in L1. To sort the list go to Stat > SortA(L1)and press enter. Then go to Stat>Calc>1varstats L1 to find the following:**

- **Mean** = $\bar{x}$ (first value on the calculator screen) = 67.2
- **Median** = med (scroll down to find this on your calculator screen) = 66.5
- **Mode** (go back to STAT > EDIT to find value that occurred the most) = no mode
- **10% trimmed mean**

1. (10% of 10 = .10x10 = 1)
2. Delete the 1 # off the top and bottom of the sorted list (DEL)
3. Trimmed mean = $\bar{x}$ = 65.75

Ann's Hypothesis Testing

Ann lays out the four steps for Hypothesis Testing (using both traditional method and p-value methods). Then she provides examples and corresponding solutions. The general format exhibited in Table 4.55 is consistent with her general web design schematic and is intended to serve as a point of comparison to the physical observation conducted by the researcher. The instructional unit closes with links to a review sheet, calculator keystrokes, and flash cards. Each of these three resources appears imbedded within the particular chapter and as separate pages with links of a similar nature.

Table 4.55 Hypothesis Testing Content

Chapter 7- Hypothesis Testing

Hypothesis Testing (7.1)
This is a segmented overview of hypothesis testing. Working through the notes for 7.2 may make it easier to see the entire process of testing a hypothesis about a population mean.

Chapter 7 Example Homework
Chapter 7 Homework Examples.doc (33 Kb)

Hypothesis Testing for Means (Large Samples) (7.2)

There are 4 basic steps to a hypothesis test using the traditional method where you use z-scores to make your final conclusion. In the p-value method you compare areas instead of z-scores to make the same conclusion. In both cases, you'll use your calculator to find the test statistic and/or p-value.

Hypothesis Testing for Means (Small Samples) (7.3)

The 4 step process is the same here, except you'll use the t-distribution table in step 2 to find the critical value. You'll still use your calculator to find the test statistic and/or p-value.

Hypothesis Testing for Proportions (7.4)

The 4 step process is the same here, except you're testing a population proportion, not a mean. You'll still use your calculator to find the test statistic.

Chapter 7 Review & key
ch.7 review.doc (45 Kb)

TI-83 Hypothesis Test
TI 83 Hypothesis Testing.pdf (46.932 Kb)

Chapter 7 Flashcards
Chapter7Flashcards (Package File)

Summary of Statistics Content

Generally, Ann's explanations were succinct. Ann often provided examples and tips. Each section had chapter reviews with answer keys, and calculator key strokes. The curriculum supports Discussion Boards, Weekly Announcements, etc. to encourage social interaction with either the instructor or students. Applets are used and can stimulate even greater discussions.

General Format of Beverly's Web Course

With Ann's website established as a model, I will now emphasize the points where Ann and Beverly differ.

Curriculum Support

Beverly opened with an inviting picture of a classroom of students staring back at you. Her Welcome Letter is pleasant, but also mentions,

> "Essentially by taking this course in a distance format, you have agreed to teach yourself the course material (with the aid of a textbook and website) and to complete the same assessments as the traditional classes do.

The letter continues to includea section on her family and tools for success in the course, warnings aboutonline courses, procrastination, mathematical challenges, and other scenarios were addressed.

Beverly's Methods of Evaluation differ in that she uses Problem Sets as opposed to quizzes. This is outlined in Table 4.56.

Table 4.56 Methods of Evaluation

METHODS OF EVALUATION

2 Tests @ 115 points each	**230 pts.**	**GRADING SCALE**	
Lab Test (30 points)	**60 pts.**	**540 - 600 points**	**A**
Group or Individual Project	**50 pts.**	**480 - 539 points**	**B**
Problem Sets (54 points possible)	**48 pts.**	**420 - 479 points**	**C**
Discussion Board Participation	**12 pts.**	**360 - 419 points**	**D**
Comprehensive Final Exam	**200 pts.**	**Less than 360 points**	**E**
TOTAL	**600 pts.**	**Grades posted online. See gradebook.**	

It seemed like there were other extra credit opportunities than what was described. Problem sets were viable alternatives to quizzes. This feature allowed Beverly's students an opportunity to save their work and return to it. Similar to Ann's Motivational Mondays, there was a joke of the week as in Table 4.57.

Table 4.57 Student Discussion Board Posts

Joke of the week

Did you hear about the statistician who had his head in an oven and his feet in a bucket of ice? When asked how he felt, he replied, "On the average I feel just fine."

Statistics Content

Beverly's content was broad and largely based on Power Point Presentations provided by the publisher. The overall structure reflected Ann's design. A folder existed for each chapter, and within each chapter were appropriate links. Beverly also included the same applets and Texas Instruments graphing calculator keystroke guides. She supplements Power Points with personal notes in each chapter. For example, with Hypothesis Testing, she describes Method 1 involving the Standard Normal Table and Method 2 with the Texas Instruments graphing calculator. Some test-taking strategies also accompanied test review materials.

The companion Web site for a textbook company with sample quizzes was used. Students can submit their quizzes for grades to get instant feedback on correct and incorrect answers. It contains sample multiple quizzes like this in Table 4.58.

Table 4.58 Course Compass Exercise

Identify whether the following data sets are populations or samples.
i) the age of 100 randomly selected participants in a race of 1200 runners
ii) the annual salary of each full-time professor at Florida State University
iii) a survey of 50 new Colorado homeowners

- population, sample, population
- sample, population, population
- sample, population, sample
- sample, sample, sample

2.

Determine whether the following numerical values are parameters or Statistics.
i) 80% of a company's board members were in favor of initiating a new training program
ii) in a survey of 100 customers, 92% were satisfied with the service they were given
iii) 72% of the undergraduate students at a university lived off campus last year

- statistic, statistic, statistic
- satistic, parameter, statistic
- parameter, statistic, parameter
- statistic, statistic, parameter

Within the Discussion Board, students were to introduce themselves in one forum and play a simulation game, such as http://www.shodor.org/interactivate/activities/racing/index.html (which looks at the long-run relative frequency of rolling pairs of dice), in another. There were also reflection questions for students to answer regarding proportion of Wins for player A and recalculations.

The discussions on this activity were more isolated and less recursive. An iterative approach was applied in the next Discussion Board forum with data collections of natural phenomena. In general, both instructors used Discussion Boards, but with slightly different functionality.

Sample Descriptive Statistics Power Point Slide

Beverly's comfort with Power Point and animations enhanced the delivery of her content. The fact that these resources were not produced by the instructor still indirectly distanced the teacher and learner. Figures 4.30 and 4.31 are slides associated with the chapters that the researcher conducted physical and virtual observations on for each instructor.

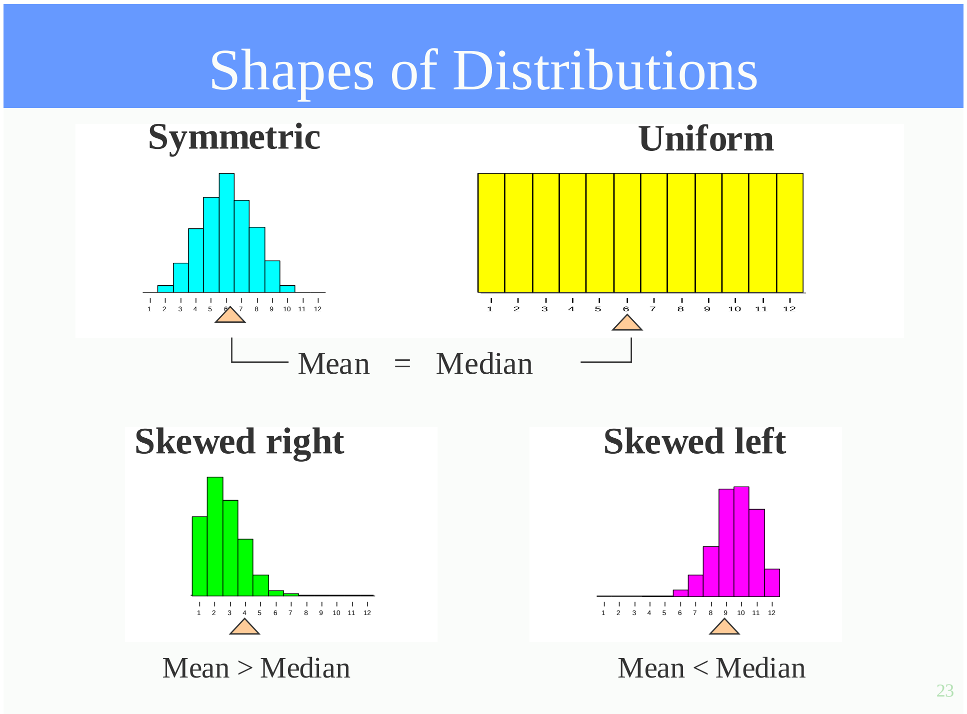

Figure 4.30 Sample Power Point Slide

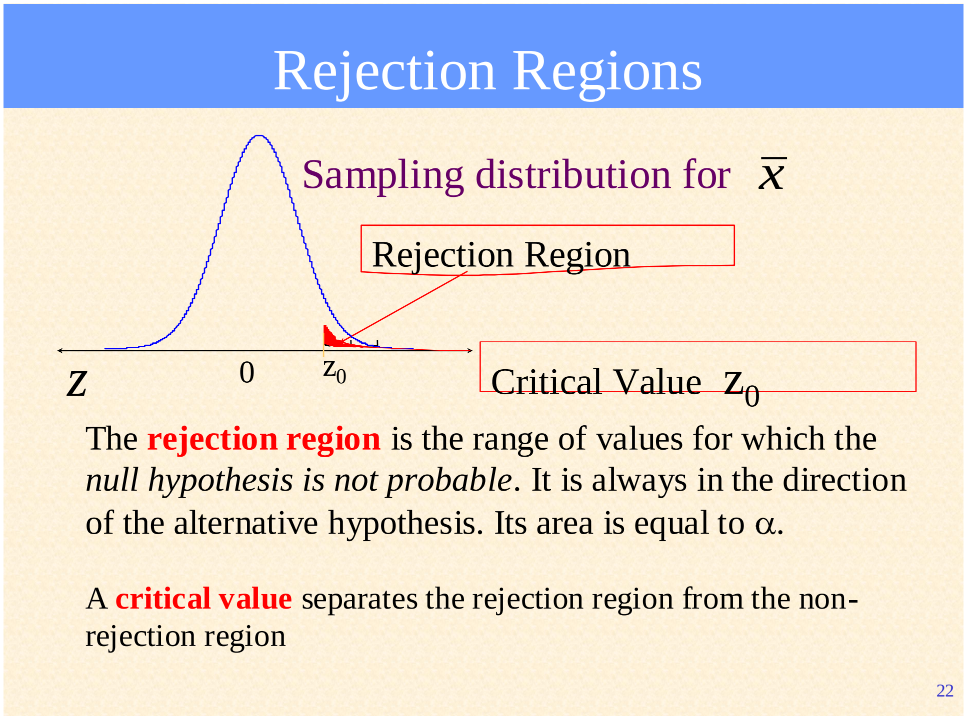

Figure 4.31 Hypothesis Testing Power Point Slide

Summary of Statistics Content

The Web provides the opportunity for curriculum to be "enhanced" through usage of more advanced technological tools. In the classroom, faculty write in color on the chalkboard or whiteboard. Online, color is used to make presentations more vibrant. But the human touch from classroom instruction is either directly or indirectly replaced by the "touch" of technology. For example, both instructors provided applets, but the researcher did not notice in-class presentations on applets. In class, faculty moved about and met each student's need and held brief discussions regarding student suppositions. The web-based environment had Discussion Boards, but how can the instructor "move about the classroom to engage the disinterested student?"

Faculty participants, as much as possible, strove to replicate their classrooms in the web-based environments. The worlds of touch and technology can become better connected to enhance learning experiences for all involved. The researcher will now reveal more about the web-based learning environment from the students themselves.

Surveys for Students in the Web-based Statistics Sections

The students in the web-based statistics sections were given the opportunity to share their impressions of the nature and types of learning that can occur in an online environment. The surveys were mailed electronically to the students and were accepted through an e–mail reply or submission to the researcher's office mailbox. Constructs alluded to in the theoretical framework, such as social interaction and active learning, were referred to on the instrument. As this was administered within weeks of the Final Exam, the numbers are fewer than the 22 who took the Pre-Test. As a qualitative instrument, the researcher coded responses to summarize the overall sentiment of the students' responses. Only 15 students completed the surveys.

Learning

From the beginning, students were asked about the levels of satisfaction with their own learning. The results varied with almost as many having "favorable" responses as "less than favorable." Specifically, as 4 students responded with positive comments and 4 with somewhat positive, 4 also mentioned comments centering around being 'dissatisfied.' One student said, "I know I didn't put as much time as I needed to." Others even mentioned that they would have taken the course in class, but didn't have the "time." Figure 4.32 summarizes student impressions.

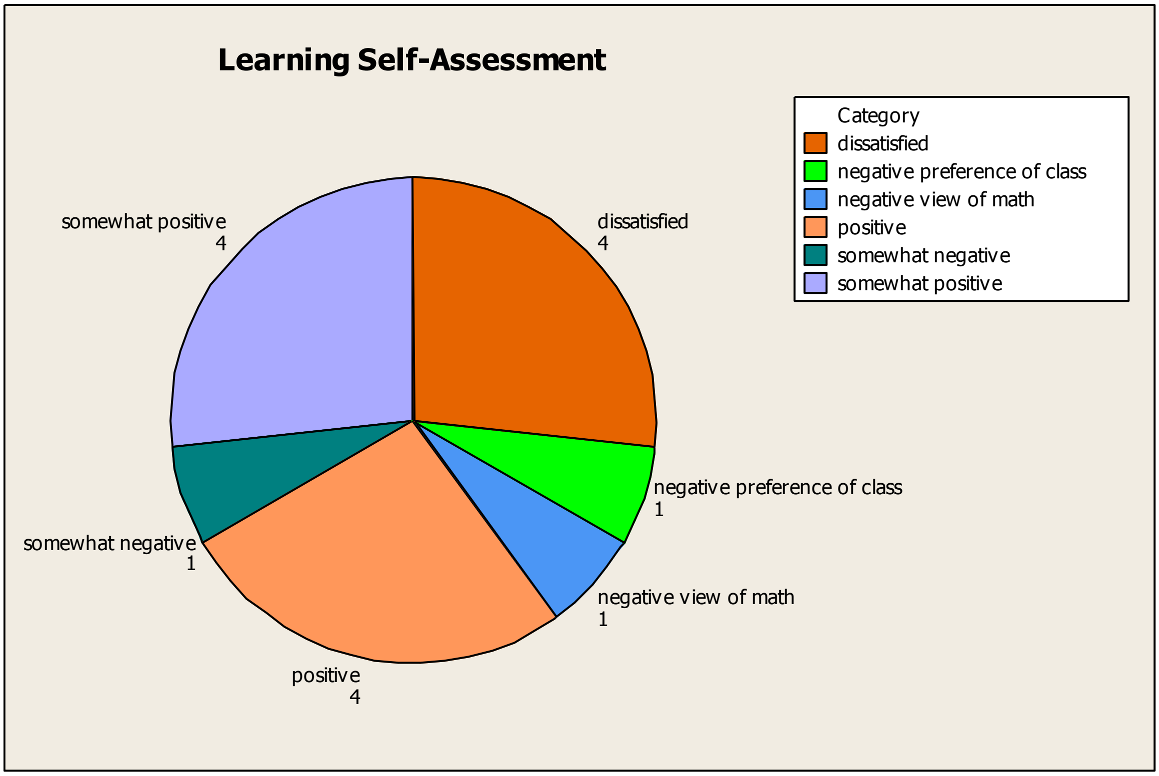

Figure 4.32 Student Learning Self-Assessment

Topics

Within the same question, students were allowed to articulate any notable areas of concern. Only a few responded. Figure 4.33 reveals that the most difficult topics pertain to probability concepts (Chapter 3) and distribution theory (Chapters 4, 5). The survey was available to students before the end of the quarter, so students may have had a limited view of all of the chapters in the curriculum.

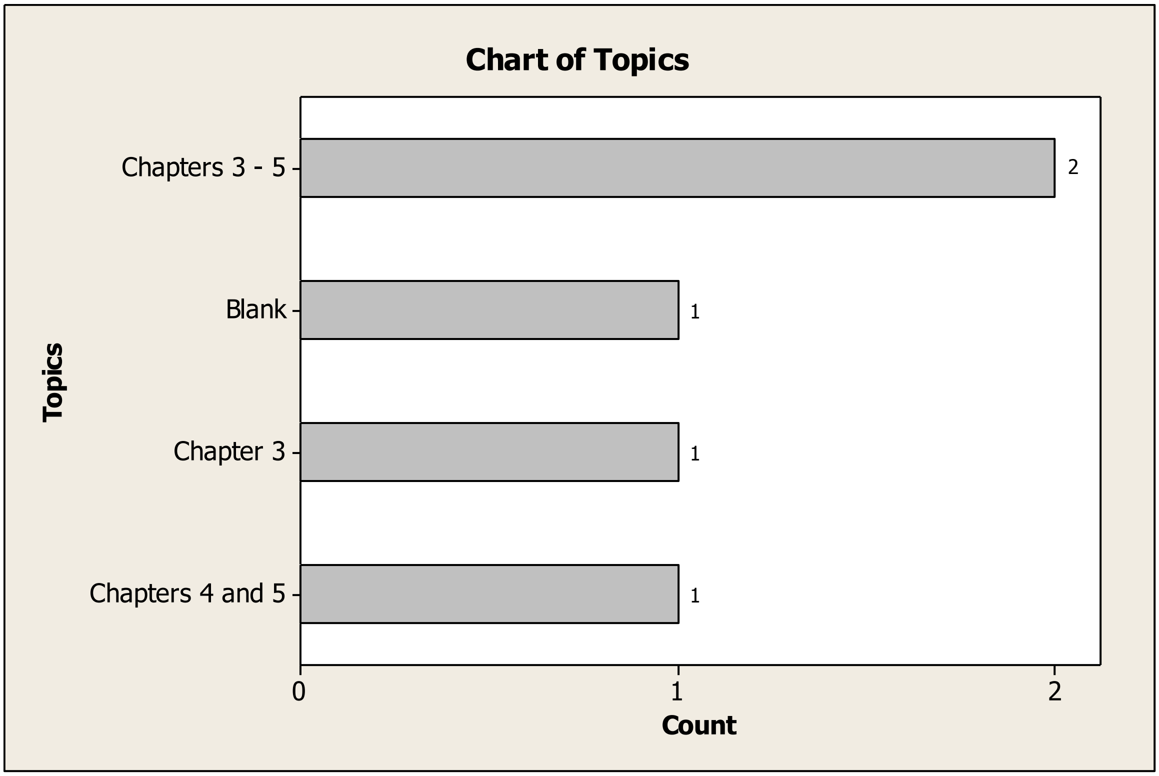

Figure 4.33 Bar Chart of Difficult Topics

Enjoy

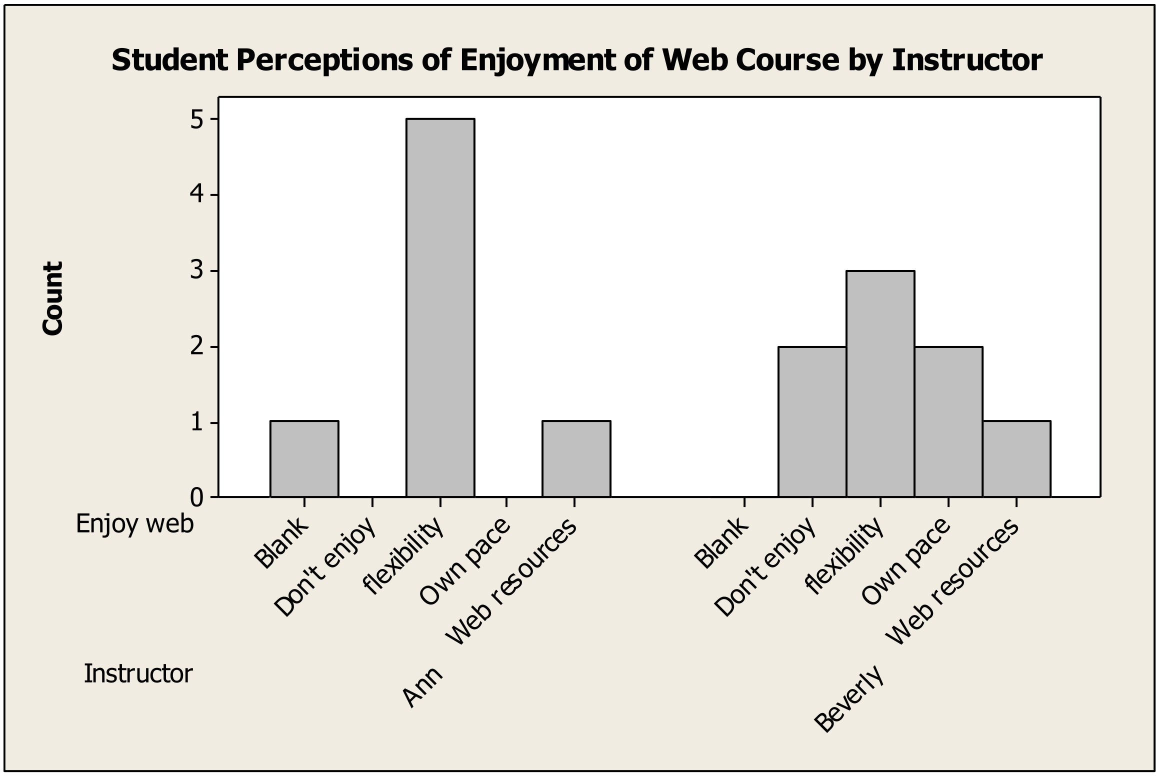

Figure 4.34 Bar Chart of Items that Enhanced Web-based Learning by Instructor

Figure 4.34 reflects attributes that were most beneficial for web-based learners. At first glance, “flexibility” and “own pace” could appear to be similar. However, for this study, “flexibility” refers to indication that the asynchronicity of Distance Learning assisted the student in management of their non-academic responsibilities. “Own pace” refers to the academic aspects of learning (e.g., “I can work every evening for a few hours on statistics.”). Figure 4.33 confirms that students prefer the flexibility of web-based instruction

There was scant support for the Web resources being beneficial to the students. The bottom line is that two-thirds of the students preferred “flexibility” and “own pace.” A few students from Beverly’s class indicated that they “didn’t enjoy” the course, indicating that it was not interactive or that they were somewhat disappointed by teacher unavailability.

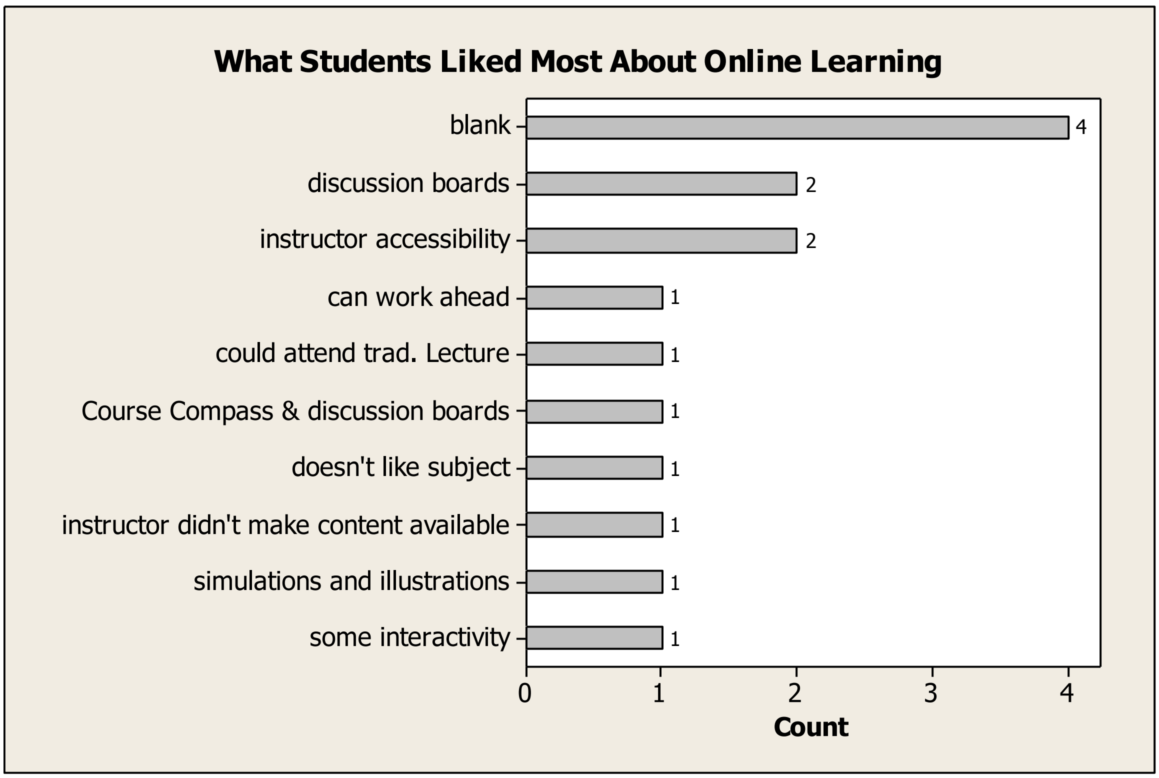

Figure 4.35 Bar Chart of Enjoyable Aspects of Web Instruction

Figure 4.35 indicates that a variety of reasons abound as to why students liked the course they were enrolled in. When asked about what specifically was enjoyed, the results varied: 4 students had no comment, and many others indicated positive aspects of Distance Learning included “D-Boards (Discussion Boards).”

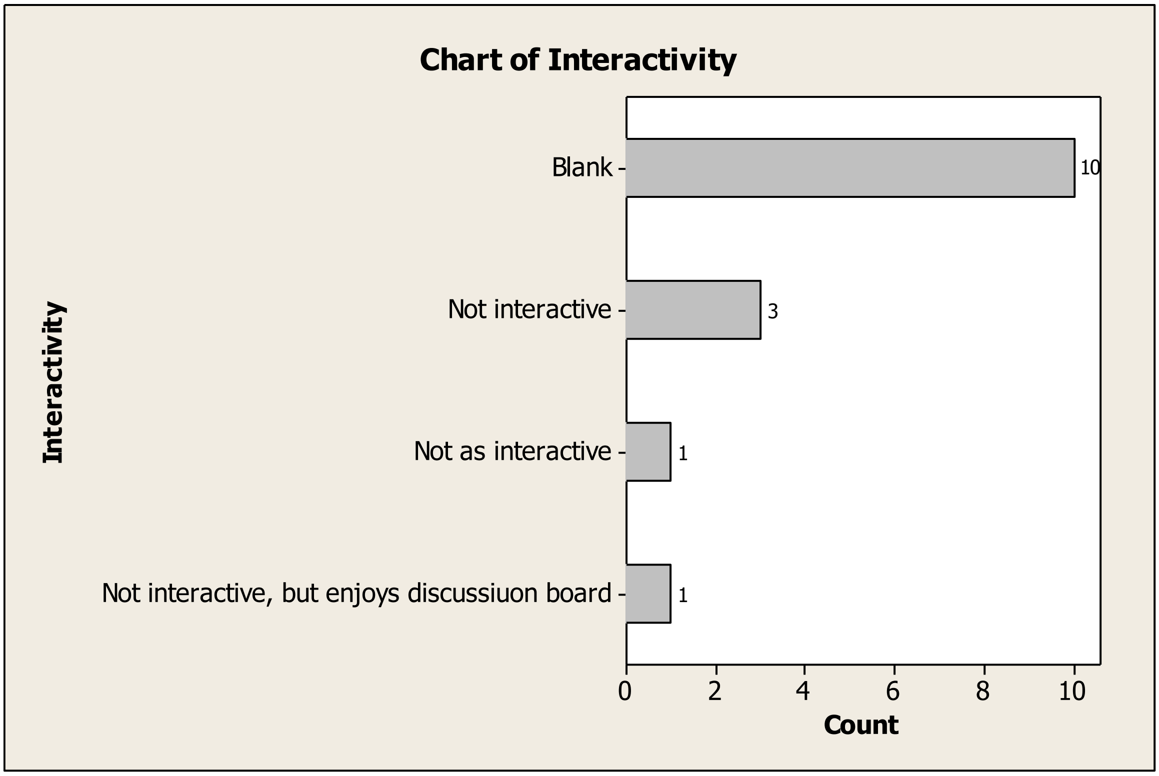

Figure 4.36 Bar Chart of Interactivity

The role of interactivity was also inquired after. Many of the students chose not to respond to this part of the question (Figure 4.36). Nevertheless, those who did respond were not impressed with the interactivity. During faculty interviews, Ann and Beverly were only asked how their courses and structures have evolved; they were not necessarily asked about interactivity.

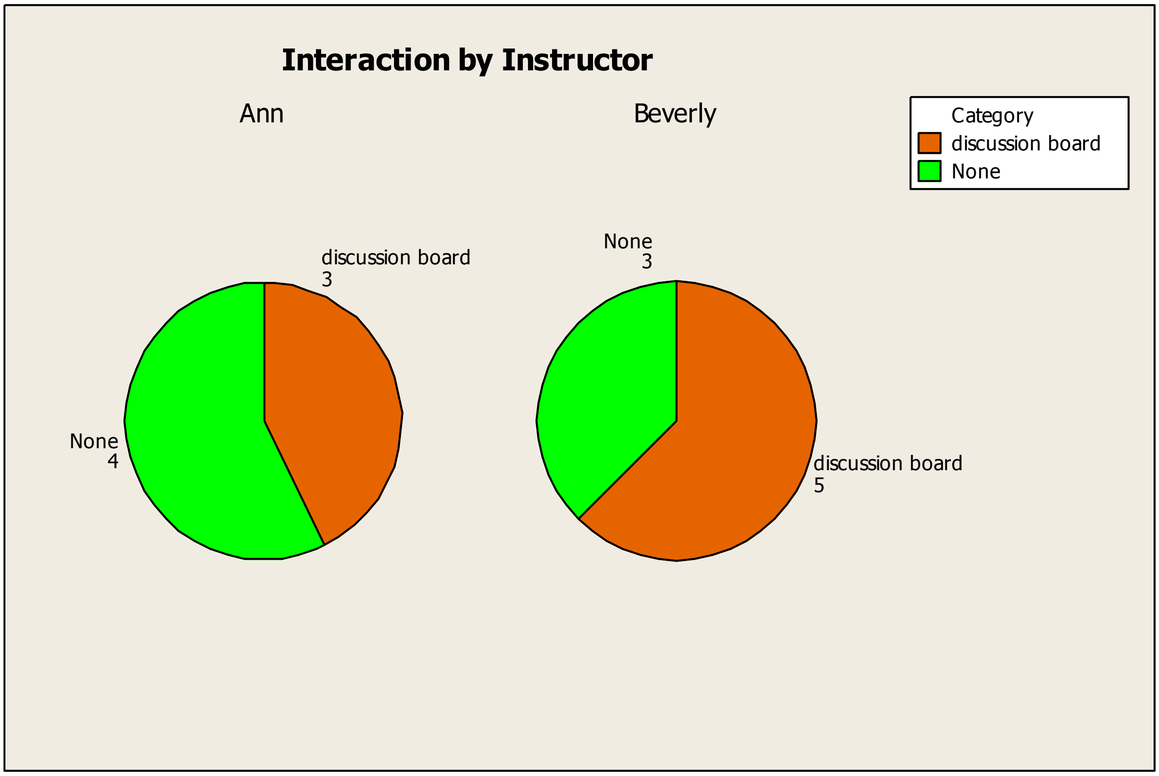

Figure 4.37 Pie Charts of Types of Interaction by Instructor

Figure 4.37 indicates that the type of interaction was similar by instructor with most students using the Discussion Boards to facilitate communication with classmates. Although the proportions were not overwhelmingly one-sided in either direction, this perhaps reveals that social interaction is not of paramount importance.

Effort

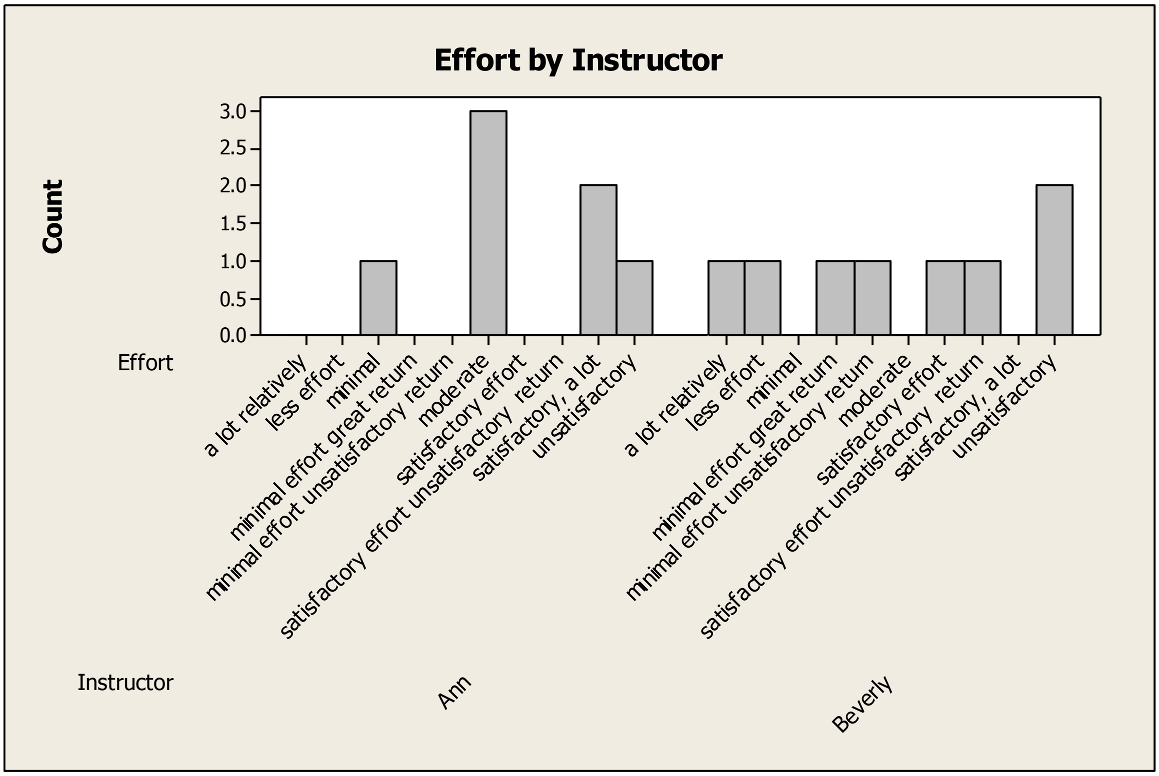

Figure 4.38 Bar Chart of Effort by Instructor

Students overall were not enthused by their instructor's effort exerted throughout the course, as evidenced by Figure 4.38. Many qualified it based upon their ability to obtain an "ideal return." Doing "just enough" at times is only "just enough." Ann's students were the ones who tended to identify troublesome topics.

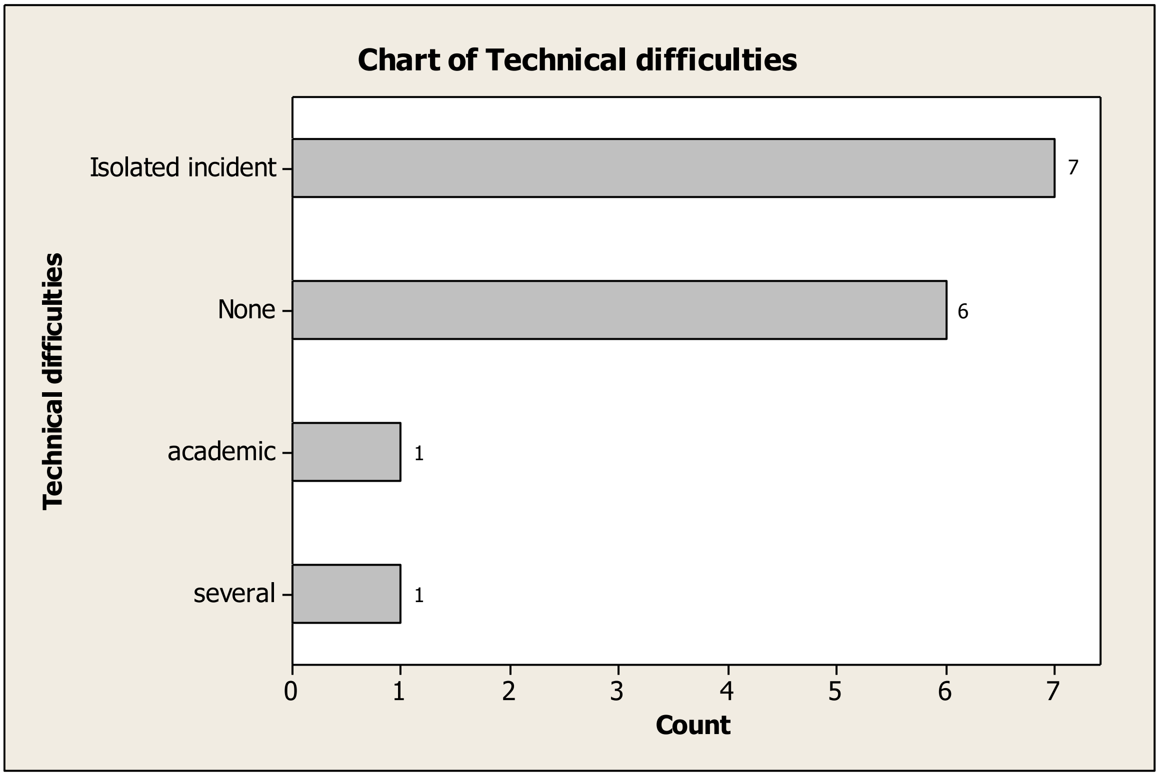

Figure 4.39 Bar Chart of Technical Difficulties

Technical Difficulties

A potential barrier to a learning modality so heavily dependent on technology is that it would be susceptible to hindrances (Figure 4.39). The institution may experience widespread system outages, the instructor may delay making content available, and the student may have unreliable Internet service. Overwhelmingly, students indicated that this was not an issue. Seven of the students referred to an isolated problem. Six other students indicated that they never noticed a problem.

Detachment

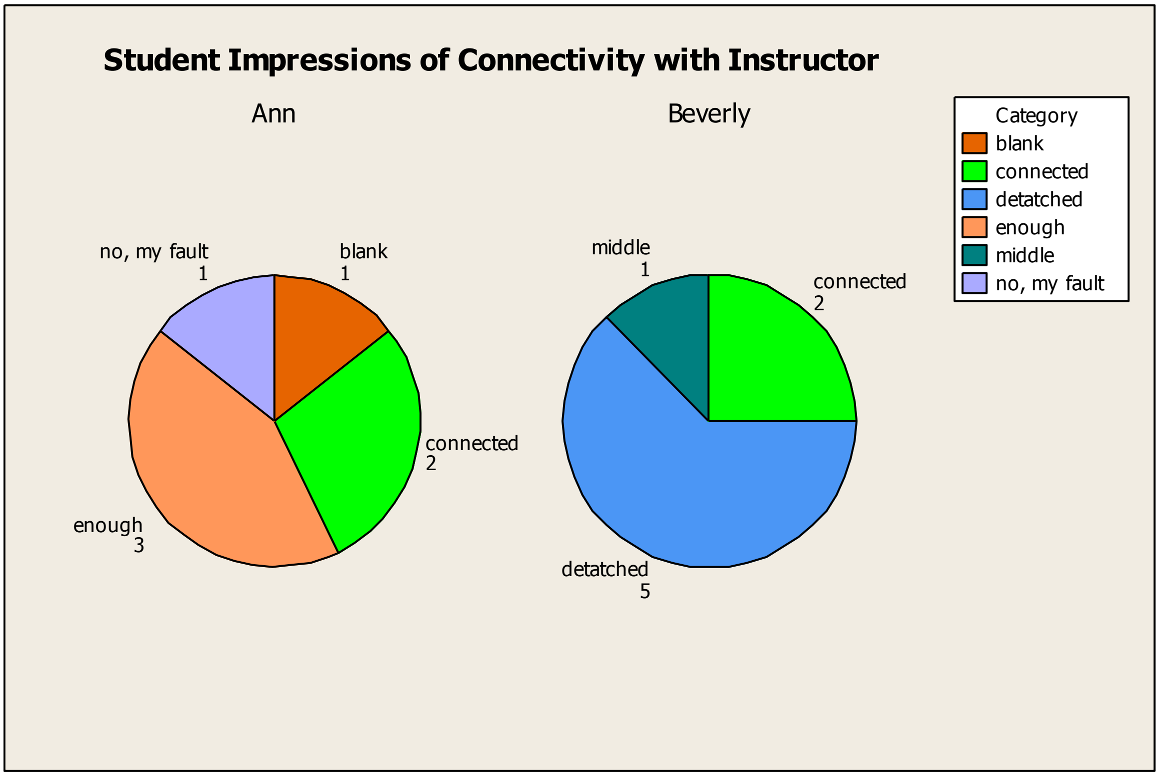

Figure 4.40 Student Impressions of Connectedness to Instructor by Instructor

Figure 4.40 shows some difference in student perceptions of connectedness to the instructor between the two instructors. With the need for social interaction referenced earlier, the researcher expected greater need for this to be evidenced among students. The modal response was for a student to feel both detached from fellow students and from their instructor; each student with this distinction was a member of Beverly's web section. Some commented that they "don't mind feeling detached. If I wanted to feel close to someone, I would have taken it in the classroom." Four more students mentioned that they felt a variety of levels of familiarity with classmates, but they did feel connected to their instructor, and this latter connection is what they valued most.

Interactivity

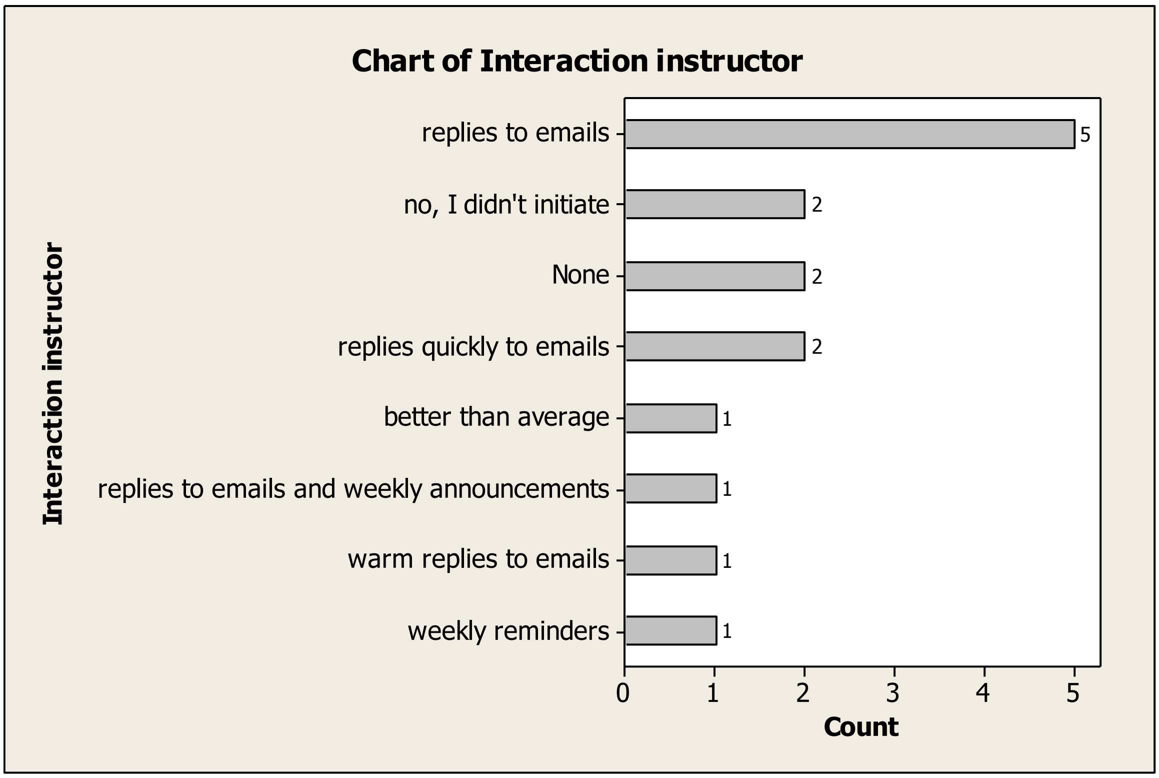

Figure 4.41 Type of Interaction with Instructor

Those who replied indicated that there was minimal interactivity. None felt detached from Ann. Yet, five felt detached from Beverly with two of them accepting responsibility for not initiating enough with her. For both instructors, students articulated that when initiated, the faculty respond to e–mails (Figure 4.41).

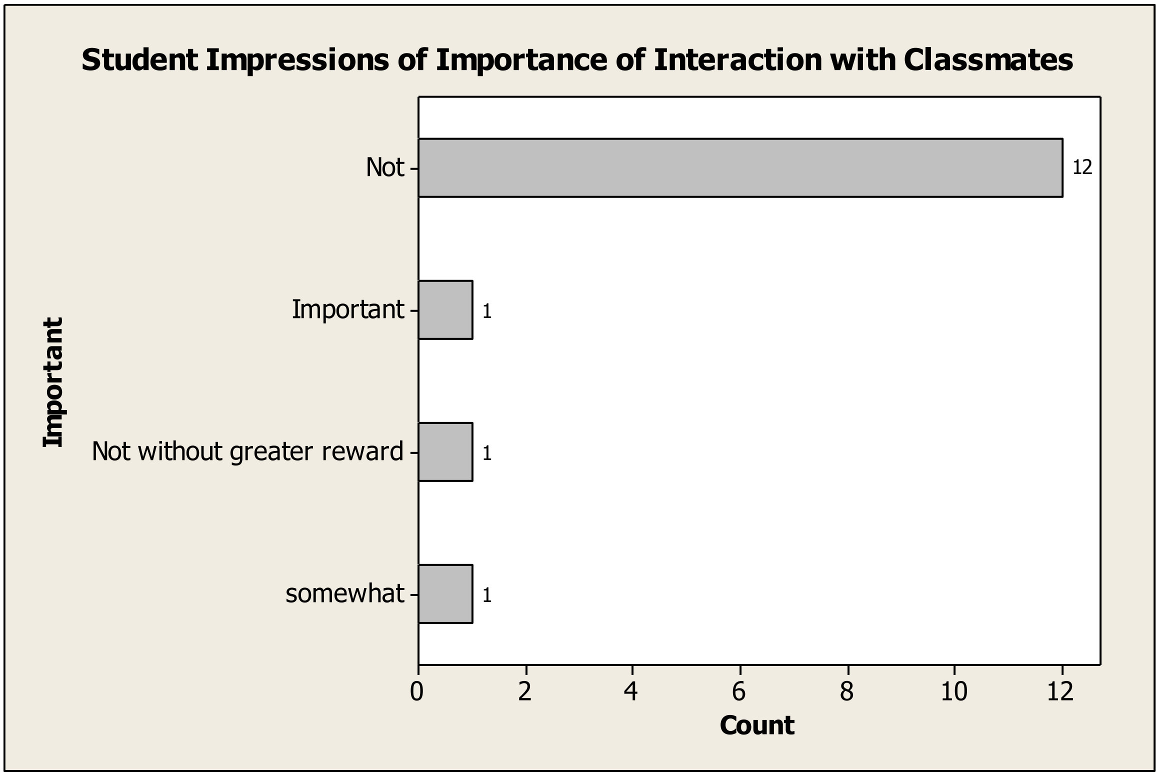

Figure 4.42 Bar Chart of Importance of Interaction with Classmates

The other telling side of this chart is that 80% of students who returned their surveys did not consider "detachment" from classmates to be an important issue. As confirmed by Figure 4.42, an overwhelming majority did not consider interaction with classmates important.

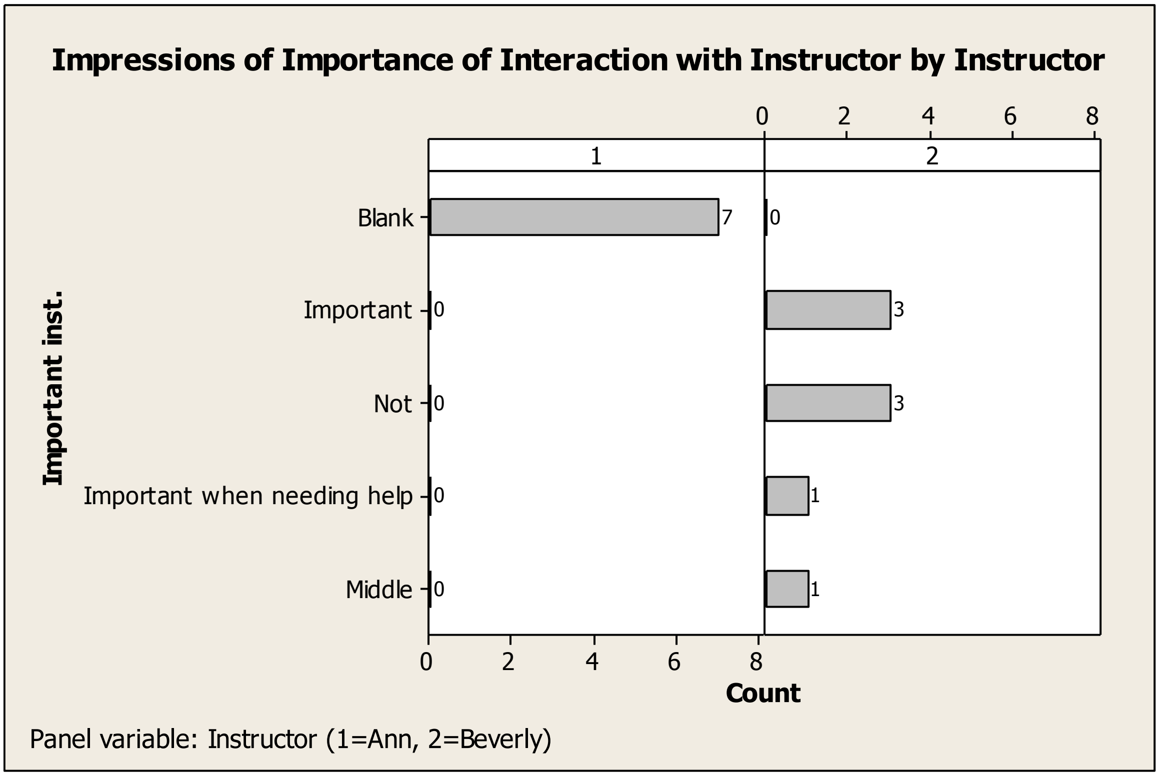

Figure 4.43 Bar Chart of Importance of Interaction with Instructor by Instructor

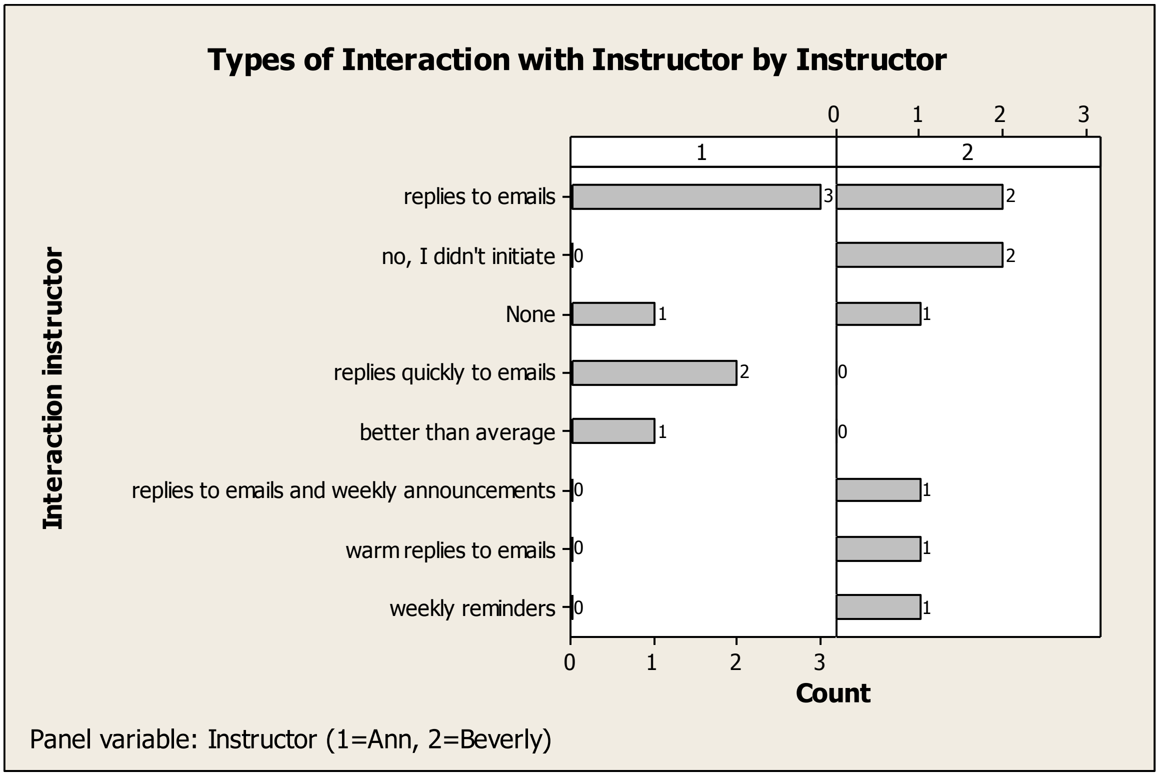

Figure 4.44 Bar Chart of Types of Interaction with Instructor by Instructor

Interestingly, Ann's students from the survey had no opinion on the importance of feeling connected to their instructor (Figure 4.43). Three of Beverly's students felt that the interaction was important. Three others disagreed. The tiebreaker could be found in the student who said, "It's important when needing help." Students desire quick responses to e–mails, and the faculty have been up to par (Figure 4.44). The weekly announcements also provide a means of interacting with the instructor.

Most Beneficial Resource

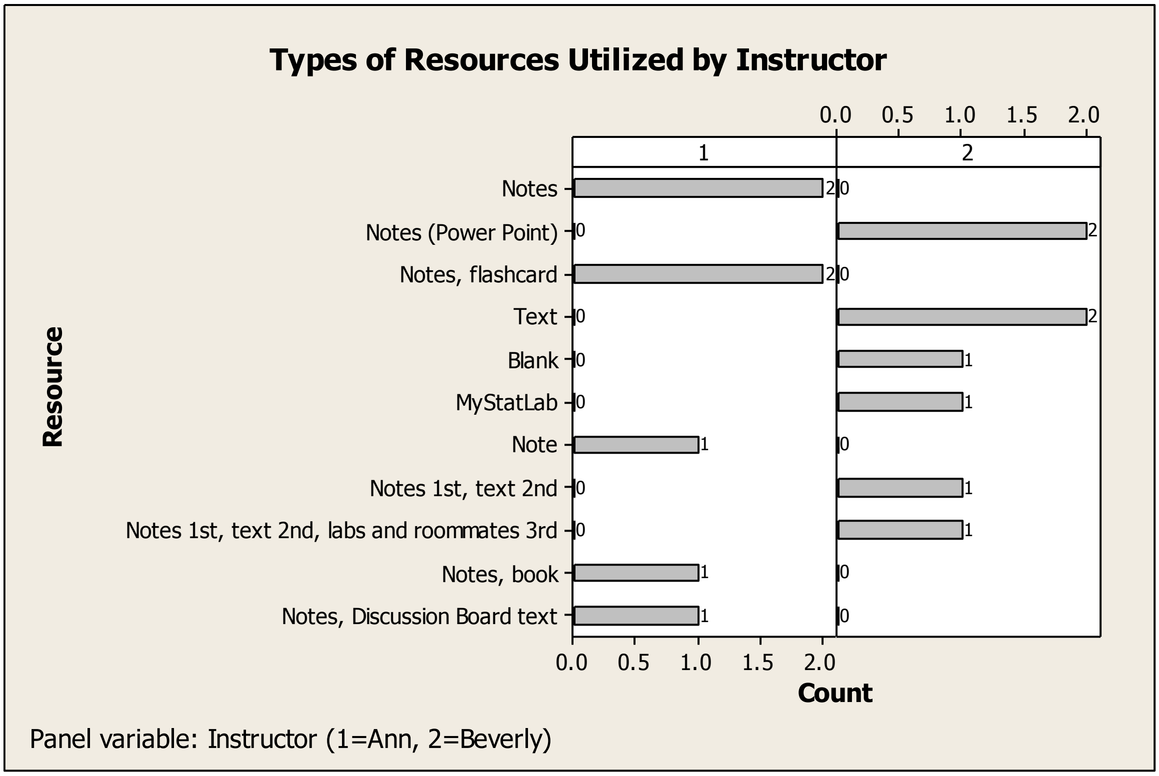

Figure 4.45 Bar Chart of Resources Utilized by Instructor

Students have a strong preference for the notes provided. Figure 4.45 includes other ancillaries, study guides, and links to Web sites, but the consistency that the notes provided from chapter to chapter was of great benefit to the students. Some of Ann's students mentioned the flashcards as being helpful for giving them opportunities to electronically practice familiarity with key terms and approaches succinctly. Beverly's students mentioned the textbook as being important.

The researcher noticed that neither set of students were emphatic about the Discussion Boards being a resource that would stimulate learning. This could also be supported by the fact that not many students deemed concerns about “detachment” to be important.

Students also mentioned that they converged to the resource that made them successful. For Ann’s students, they preferred the flashcards. Beverly’s students preferred the Power Point slides which organized course content and the StatLab software that algorithmically generated exercises for further practice. Students also indicated that the “ability to get instant feedback,” “ability (for material) to be easier understood,” and the common “ability to equate to test” supported the rationale for their most preferred source.

Summary of Survey for Students in Web-based Sections

Many of the students had no additional comments for the researcher. There were two that mentioned StatLab (the auto-generated software package and management system) as being beneficial to them.

The students often mentioned that what they liked most was the ability to either learn at their “own pace” or because of the “flexibility” web-based instruction affords them. The “own pace” preference reflects the ability to not have to learn per the typical schedule outlined weekly as with CBI. Students can spend extra time reviewing certain material and less time with other topics. “Flexibility” references the ability of asynchronous learning to be independent of traditional parameters of time and place. Students can structure their learning around their schedules— late at night or early morning. Figure 4.46 resoundingly intimates that how you learn ("own pace") and when you learn ("flexibility") are what they like most about online learning.

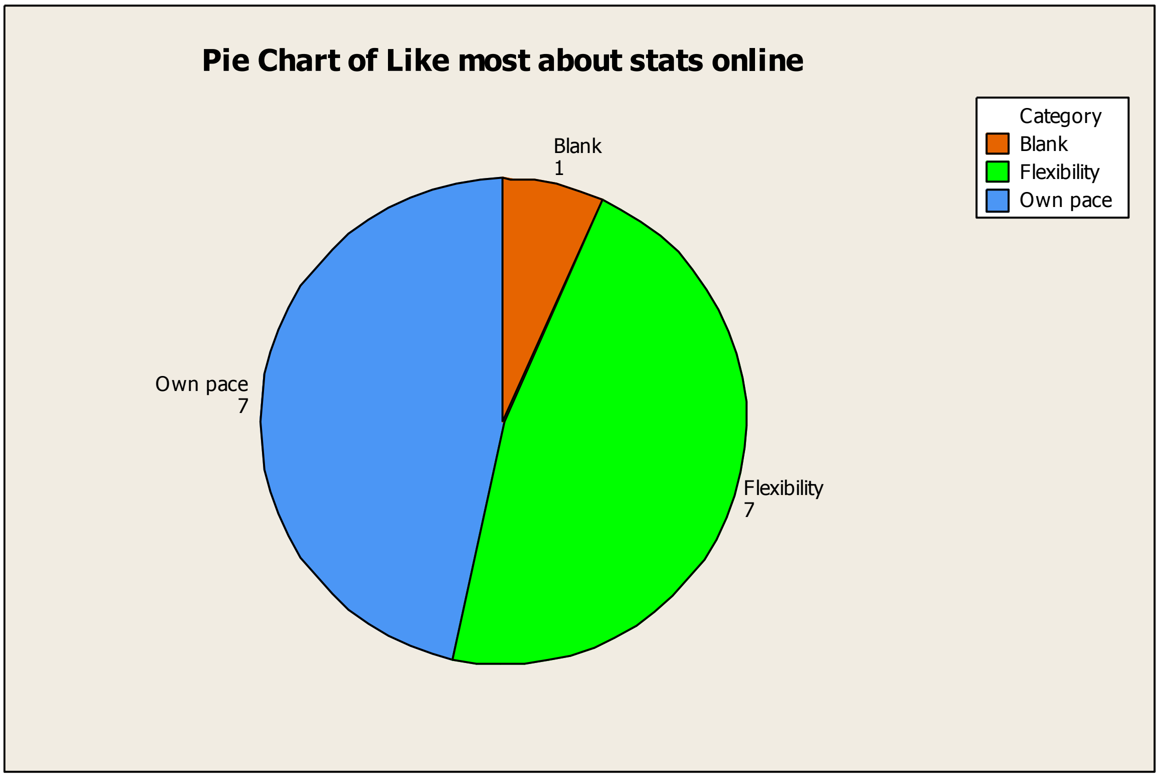

Figure 4.46 Pie Chart of What Students Liked Most about Web-based Instruction

The students resoundingly disliked what they considered having to “teach themselves.” They were more vocal about related barriers, as indicated in Table 4.59:

Table 4.59 Barriers Posed to Web-based Instruction of Statistics

Structural Matters	**Statistics Curriculum**
Can’t see more examples	Boring material
Commute for proctored tests	Calculator steps
Group projects with strangers	Hypothesis Testing and Regression
Inability to readily pose questions	Conditional Probability
Text-oriented instruction	Formulas
Difficulty in e–mailing math steps	Notation and e–mail syntax for Math
Personal patience and persistence	Minitab
Personal ISP concerns	Standard Deviation
Teaching yourself	
Infringes on free time	

To some extent, these were the students who, in all likelihood, earned a grade in the web-based course. Hence, in the midst of these drawbacks, their satisfactory performance, supported by their mathematics preparedness, self-efficacy, and desire for flexibility or to work at their own pace, enabled them to endure. It would be interesting to have had obtained this information from students who did not take the course.

Summary of Qualitative Analyses

Important constructs that underpin the instruction of statistics online identified in the theoretical framework in chapter one center on Experiential Learning , Vygotskian Theories of Social Interaction, uses of the computer to enhance instruction, adult learning theories, and asynchronous learning theories. These theories were evidenced in a variety of practices and techniques used by both of the instructors in both modalities.

Adult learners are self-directed in nature and have a need for social interaction. Faculty expressed in their interviews that they are attentive to student questions and aspire to respond to them quickly. This was confirmed by the survey results from the students as a definite strength of the faculty. This strength ameliorates notions that WBI creates a chasm between teacher and student that cannot be narrowed. Weekly Announcements, Brain Gyms, Motivational Mondays, and "Jokes of the Day" help with the social interaction. Theoretically, students' Zones of Proximal Development were expanded by even these communiqué. But, having communication that is mostly curriculum-driven are most effective and most desired by students. Students in this study indicated that some of the other challenges to human interaction (e-mailing formulas, working in groups of anonymous individuals, etc. …) pose some barriers for WBI. Everson and Garfield (2008) means of establishing Discussion Board forums for small groups and for those groups to communicate with the instructor could be one of many means of further mitigating this issue.

The students' survey responses indicated that extensive social interaction with the instructor or student was "not important." This was curious and seemed to downplay the social interaction need discussed in some of the Adult Learning literature. The other persons in the virtual environment seemed to serve as secondary resources. This does support the notion that WBI helps students value construction of their own knowledge more than attempting to build from someone else's. Also, is the case that the stronger performing students tended to persist until the end, and thereby, complete this survey. The heterogeneity of preparedness could be more problematic for the advanced students, and therefore, consider social interaction to be more difficult than with less direct benefit for them. Conversely, lesser prepared students would find social interaction of great benefit. Greater attention to the persons who might withdraw or fail an online course could provide a more favorable perspective on the benefits of social interaction.

Computer-mediated instruction serves as the vehicle for curriculum to be accessed by students. Technology is of great interest to both instructors. The faculty are now using Tablet computers and other resources to better replicate classroom techniques. Computers are now able to better communicate mathematical syntax and language, as in the classroom where the teachers explicitly writes formulas on the chalkboard. The advances in technology afford the instructor opportunities to emphasize concepts and de-emphasize procedures, allowing the instructor to serve more as a facilitator.
Zhang predicts, “with the advance of technology, I foresee that distance education via the web will be more wide spread and more accepted by future students” (2002, p.4). For this vision to be realized in statistics, the worlds of Curriculum Support and Statistics Content must continue to merge per the GAISE recommendations (2004). As witnessed in this study, the two realms can tend to be more mutually exclusive than inclusive in terms of WBI. Ann’s usage of Discussion Boards to recursively create problems for students to work on is a good start. Beverly’s Power Points and both instructors incorporation of applets were also efforts in this direction. Nevertheless, these items were peripheral to the core text of notes, regulations, and formulas.

Students receiving WBI also mentioned that they converged to the resource that made them successful. Ironically, the classroom instruction seemed proportionately more experiential than the web-based environment. In observation of the teaching of descriptive statistics, the instructors' heavy emphasis on actual data analysis using textbook prices and other variables was effective in transferring knowledge to the students with great satisfaction. Students were able to see step-by-step progressions from data collection to the interpretation of the results.

As evidenced by probability theory, and fundamental distribution theory being some of the key areas disliked by students, it seems that formulas should continue to be de-emphasized to focus more on conceptual understanding. The dice simulation game shared by Beverly is a positive beginning in this endeavor. Student conceptual understanding of the curriculum can help drive active-learning to the central means of how to deliver content. Less formula-based, more ideas (case studies, multimedia, etc…) are important. Beverly's use of Power Points is a good start. Both faculty using lab assignments and applets were helpful. Ann's Flashcards are more consistent with the eventual movement associated with the GAISE principles.

Activity-based learning deepens understanding of probability improves attention, uses of real data, are all important and should be reflected in assessments also and assessments should be in concert with pedagogy. This consistency is important for students to embrace even a cultural learning change for them.

A web course relies heavily on self-discipline and self-motivation as the students do not have an instructor urging them forward. Technology via digital pictures, videotaped lectures, and vocal instruction enables students to overcome some of the barriers inherent to distance learning (Zhang, 2002). Organization, communication, videotaped lectures are some keys to academic success.

The faculty are expanding their instructional repertoires to minimize the distance between WBI & CBI as mentioned in the interviews, and seen in evolving ways through the observations and surveys. Students must make the appropriate conceptual leap as they are largely viewing some of the technology components as mere resources for success. Use of the Internet in creative ways along with video-taped lectures (Zhang, 2002) can help optimize web-based learning per the resources it is afforded. The faculty in this study know that it is a matter of teaching different than how we they were taught - which is an eternal challenge for all instructors.

Summary of Results

Six instruments were used in answering the research questions. “Do students receiving web-based instruction have comparable levels of achievement as those who receive classroom instruction?” Yes, in terms of average performance, but 'no' in terms of variability and overall learning. Background demographic information informed the researcher that students are entering the Web sections better prepared mathematically and more interested in being independent learners, so the expectation – at least in this study – is that if distance learners are entering better prepared, then they should achieve at greater levels throughout. Colloquially, no one who is given a “head start” in a race is content with a tie; nor, would the assertion that the runners have comparable levels of speed be a consideration.

The Pre-Test and Post-Test intimated that the instructor also plays a critical role in terms of the emphasized material. The Final Exam scores provide the most evidence and use the operative word, as the sample means did not differ significantly when several caveats were considered.

To address the type of learning that occurs in the Distance Learning environment, Faculty Interviews, Observations, and Student Online Surveys were used. Faculty have a fundamental commitment to technology and are, in many ways, learning as the students are learning. The instructors in this study are already great teachers and attempting to replicate the established classroom in the virtual classroom with Discussion Boards, Applets, and an organization of content chapter by chapter, section by section. There was an absence of instructor voice and video in these web courses, but an abundance of content. The students indicated that they like the flexibility, prefer to work independently, and in some ways consider instructors as resources that they have access to at an "as needed" basis, much like the digital Flash Cards (animations that recursively pose questions in anticipation of concise responses from the students), Power Point Slides, and Labs.

If education truly aspires for educators to be "guides on the side," web-based instruction does just that and has not resulted in a modality that is categorically inferior to the classroom and not necessarily always "as good as" classroom instruction either. The next steps, among many, for web-based instruction include addressing the variability in amounts of learning, and attrition. Once that is better understood, WBI can begin transcending the educational experience by leveraging the added technological advantages it affords its students and instructors.

CHAPTER 5: CONCLUSIONS

Description of Study

In this study, the researcher endeavored to answer two key questions:

1. Do students in web-based Statistics courses have comparable levels of achievement as those who receive classroom instruction?

2. What types of learning, pedagogy, and interactive experiences describe the web-based learning environment as compared to classroom-based instruction?

The researcher believed that modality of instruction would not significantly affect student achievement. The literature (Wisenbaker, 2002, Gunnarson 2004) suggests that comparable levels of learning can occur. And assuming there is significant social interaction between the faculty and the students, performance on common assessments should be similar.

The conceptual framework underpinning student learning in this study stemmed from research in statistics education and distance education. Active Learning pedagogy, usage of Technology to Enhance Instruction, Vygotskian Theories of Social Interaction, Asynchronous Learning, and Adult Learning Theories served as foundational components for student learning.

A Non-equivalent Control Group Design Study was used to compare the performances of students in a web-based statistics course with that of those receiving classroom-based instruction for two different instructors at a large midwestern community college. This particular type of Quasi-Experimental Design was appropriate as the two groups were naturally assembled and each given the same Pre-Test and Post-Test (Campbell & Stanley, 1963). Four key instruments were used to solicit answers to the two research questions. An Interview Protocol was used whereby Key Personnel, Leigh Slauson, interviewed both instructors to gauge their educational philosophies, experiences, and perspective with both web-based and classroom-based instruction. There were only two faculty members at this particular institution with the required two year minimum experience who taught statistics via both modalities. A Background Questionnaire gathered information from students regarding factors that posed as potential inhibitors of student learning (e.g., learning style, attitude, mathematical preparedness, etc.). The most influential instrument was the CAOS (Comprehensive Assessment of Outcomes in a First Statistics Course) Exam. The CAOS was administered in the initial week of the course as a preliminary assessment of student knowledge of statistics. It was again administered at the end of the course to measure overall student learning. Students receiving web-based instruction took this exam in the institution's Testing Center under the supervision of a proctor. The researcher proctored examinations for students receiving classroom instruction. Unique to the students receiving web-based instruction was the Online Survey. This instrument sought information that focused solely on identifying the types of learning and pedagogy, instructional strategies, social interaction, and other events that might typify web-based instruction in the context of the second research question. The researcher obtained guest access and conducted two observations of each instructor in each modality. For the web sections, the researcher perused the appropriate Web site, and classroom observations were pre-arranged with the instructor. The departmental Final Exam was administered the last week of the quarter in ways similar to those used with the CAOS Exam.

After scores of electronic and postal mailings, 58 people of a possible 110 participated in the study—two instructors (Ann and Beverly) and 56 students.

Table 5.1 Participants by Instructor and Modality with Study Completers Listed Parenthetically

	Classroom	Web
Ann	22 (15)	13 (8)
Beverly	11 (7)	10 (6)

As indicated in Table 5.1, only 36 students persisted and completed all of the required instruments. Hence, only two-thirds of participants were able to have knowledge gain scores based upon Pre-Tests and Post-Tests.

At the broadest level of analysis, the students in the web-based statistics courses did have levels of achievement comparable to that of those who received classroom instruction. There was no significant difference in the mean performance among the modalities, as confirmed by net gains in Pre-Test/Post-Test comparisons and Final Exam performance. Table 5.2 summarizes the basic comparisons in average performance among the modalities.

Table 5.2 Averages by Instrument and Modality

	Web	Classroom
Gain Scores on 40-item CAOS Exam (Post-Test – Pre-Test)	1.93	2.409
Final Exam	140.5	141.22
Gains on CAOS Exam for Ann's students*	-1.25	1.467
Gains on CAOS Exam for Beverly's students	6.00	4.429

*- statistically significant at .05 level

The Final Exam averages were 130.6, 139.19 (out of 200) for Ann and 151.7, 145.9 for Beverly for each of their web and classroom sections respectively. It became apparent that instructor was of more importance than expected.

The assertion that students with higher levels of mathematical preparedness coincidentally enrolled in Beverly's classes was investigated. There was minimal evidence that preparedness differed in the web-based sections (p-value = .34). Then, on observation of the classrooms, the researcher noticed a difference in demographics that was commensurate with patterns found in comparing enrollment in day sections with evening sections. Ann's class met three days per week beginning at 9 a.m. and was largely from a traditionally college-aged population. Beverly's class met twice a week beginning at 8p.m. Beverly's class also had fewer students. Beverly had a slightly higher proportion of students with a preparedness level of at least College Algebra (60% vs. 50%). What was more telling was that the web classes (for both instructors) had higher levels of mathematical preparedness than the classroom sections. Final Exam performance was comparable when comparing preparedness by instructor and modality. A distinct limitation in usage of the Final Exam as an instrument to measure "gains" in learning is that it was only administered at the end of the course and there was no means of determining initial knowledge levels. The Final Exam also had low levels of correlation to the CAOS Exam. The smaller numbers of classroom-instructed students with higher levels of preparation and web-instructed students with lower levels of preparation made analysis across instructor in this regard impractical (in one case, sample sizes were 5 and 2).

Instructors enjoy teaching via the Web. They used Discussion Boards to replicate and extend the traditional classroom discourse. Content is placed online for student review in a largely text-oriented format. Students admitted to feeling detached from their classmates, yet they preferred this level of emotional investment. One student mentioned that "this is why I chose an online course," implying that had the connection with others been of paramount importance, he would have enrolled in the classroom-based alternative. Beverly indicated that regression analysis and the ability to attend to detail were strengths of students who took the course on the Web.

Instructors consider web-based instruction to have limitations in terms of graphing calculator usage. Students in web-based sections were not as strong in interpretations. Instructors' notes were even considered more beneficial than the text itself.

Descriptive statistics accounted for 16 items of the CAOS Test. Strong improvements in this category would facilitate an increase in gains more than any other. The fact that Beverly's students were able to experience substantial increases in these areas further supported her substantial increases in comparison to Ann's students. The fact that a student was previously enrolled in this course had no bearing on CAOS score gains from Pre-Test to Post-Test, nor on the Final Exam score.

When investigating the performances on the 200-point Final Exam of the students receiving web-based instruction learning (by instructor), the results yielded Ann's students having an average of 130.6 (standard deviation=41.3, sample size=8) and Beverly's students having an average of 151.7 (standard deviation=42.2, sample size=7). Both of these subpopulations had comparable standard deviations, albeit relatively large, with Beverly's student scoring 10% higher. However, the difference was not statistically significant at the .05 level (p-value = .348).

The Final Exam analysis revealed that there was a substantial variety in scores and that students in web-based sections can have comparable (if not better) achievement—151.7 vs. 145.9. Also, the stronger performance on items that required students to interpret responses out of 52 points may explain the differences in interpretation totals and the CAOS exam scores. Beverly's students tended to perform higher on CAOS than Ann's (average gains of 5.154 and .564, respectively). This could be due in part to the conceptual questions posed on CAOS. Similarly, Beverly's students averaged 38.29 points on the interpretation responses from the Departmental Final, Ann's students averaged 32.38 (p-value = .027). The item-by-item analysis did not uncover many discrepancies across modalities, but only a few across instructors within for the web modality.

Overall, the Final Exam differed mostly in composition. The CAOS percentage of Descriptive statistics question seemed quite high. More students have adjusted to the computational emphasis requisite with the Final Exam. It was also true that high percentages of students at minimum preparation did not complete the course.

Discussion

Faculty Interviews

Web-based instruction is causing many instructors (including the two in this study) to reassess personal definitions of teaching and learning in the 21st century. Many are having to engage with the notion of teaching in a different setting than that with which they were taught. With increased opportunity to teach in this new modality, faculty are beginning to expand their instructional repertoires to better replicate the classroom. The participating instructors from this study considered students stronger in mathematics, maturity, technological skills, motivation and attitude to be more likely to be successful. Currently, there is little in place to identify students with lower levels in these areas that would be considered "at-risk" for web-based instruction. Conceptual understanding is improving, but communication and loss of personal contact with students have been problematic for those who are not considered at risk.

Students' attitude can be more influenced by the instructor's attitude. When students are frustrated, the key is to obtain help from the instructor as soon as possible. Beverly describes the interaction between two of the constructs in the following way: "If they're open to being socially interactive and vulnerable to their instructor or to another student, they can get some help with their attitude. I think attitude, if it's going to inhibit your social interaction, could be a detriment."

Background Survey

Background information on the students was obtained in two ways: through the institution's database of student records and the Background Survey. Through the former, it was found that participants in the web sections had higher GPAs and lower non-completion rates than the general population of students in the web courses. The students in our study had slightly higher GPAs and lower non-completion rates than a random sample of their classmates who chose not to participate in the study. Hence, it could be inferred that the web-based participants were stronger than those in the general web population. Web students were also more likely to be transient students with stronger preparation in mathematics. They were not failing at significantly higher rates than their in-class counterparts. However, students who previously did not complete the course successfully were less likely to repeat the course via the Web. A brief investigation of the entering characteristics supported that GPA and mathematical preparedness were critical to success in introductory statistics courses.

The Background Survey provided some additional results. The students receiving web-based instruction were not categorically older. Non-academic responsibilities did not vary among modality and instructor. Students enrolling in web-based sections tended to be more independent learners. Almost all of the students had high-speed Internet service. Graphing calculator familiarity, College Math and Math GPA correlated strongly with many of the affective variables, such as confidence and attitude. GPA correlated strongly with performance on quantitative instruments.

Taking more mathematics courses and doing well in them instills self-confidence. Many students enter mathematics with low self-efficacy about their abilities in mathematics, and many more of them may have had too many non-academic responsibilities to participate in the study.

Preparedness proved to be the greatest factor influencing performance. GPA was a proven factor in understanding both Pre-Test and Post-Test performances. This further underscores the need for adequate preparedness for success. However, further review also indicates that of the 16 students that took the Pre-Test and did not take the Final Examination, 9 had prior preparation at the level of Beginning Algebra, 4 were at the Intermediate/Technical level, 1 Pre-Calculus, 1 College Algebra, 1 Calculus.

CAOS Instruments (Pre-Test and Post-Test)

Neither instructor began their courses at an advantage over their colleague. However, it was also revealed that the distance learners, and students in general with preparation at the level of College Algebra, who were entering with stronger mathematics preparation were more likely to complete the course. It was consistent that the distance learners performed better upon entry and exit, but they had similar overall gains of two additional correct answers. Gains differed by instructor. Beverly's students showed significant gains in performance overall with no significant differences in performance gains by modality (5 additional points each on a 40-item exam). This was not as apparent with Ann's students as her students experienced differences in gains by modality.

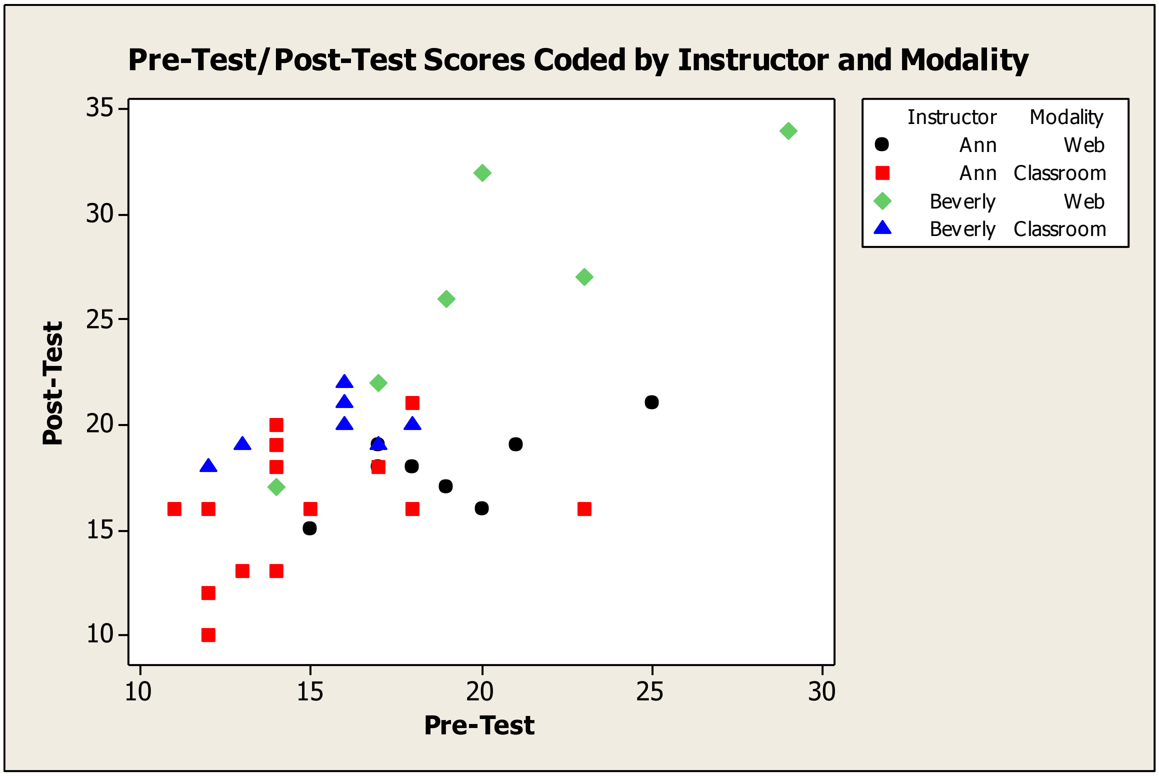

Figure 5.1 Pre-Test Post-Test Scatterplot Coded by Instructor and Modality

The scatterplot in Figure 5.1 shows some of the key findings of this study and has been further categorized from its previous appearance in Figure 4.6. There seems to be a pattern of students from WBI entering with a higher performance on CAOS (diamonds and circles) than their CBI counterparts. Another component is that the WBI performance seems non-constant, whereas, the students receiving CBI (squares and triangles) are more closely dispersed. And consistent with a theme from chapter 4, Beverly's students had greater than anticipated performance on the Post-Test.

The reasons for the improvements in gains were largely due to the performance on descriptive statistics items, which accounted for 40% of the instruments. Beverly's students showed strong increases in this area on the Post-Tests. Ann's students had strong improvements with Confidence Intervals, but that was not as heavily weighted.

So when we ask, "Do students in web-based statistics courses have comparable levels of achievement as those who receive classroom instruction?," The answer seems to be yes, in terms of central tendency, but recognizing that the entire distribution has more variability than the classroom set of learners. This makes any definitive claims about WBI having comparable levels achievement problematic without knowing more about the audiences involved. Specific to this study, given that the CAOS exam heavily emphasized descriptive statistics, gains in achievement were strongly linked to proficiency with that component of the introductory statistics course. The existence of confounding factors, such as preparedness and instructor, require that any claims about achievement be contextualized within the context of these variables. If it becomes increasingly apparent that students seeking WBI possess greater amounts of preparedness and coursework in mathematics, then a revised goal for WBI in statistics should not be to simply aim for being "as good as."

Observations

Both Ann and Beverly are instructors dedicated to their crafts. Ann was able to engage the larger class involved with calculator usage and "brain gyms." Beverly focused on making sure that each student in the smaller evening class was actively learning. It seemed as if Ann's focus slightly emphasized tips for student success, and Beverly led more holistic discussions. Beverly's emphasis on conceptualizing topics and student understanding were helpful. These were small differences in the larger context of learning.

The Web provides the opportunity for curriculum to be "enhanced" through usage of more advanced technological tools. In the classroom, faculty write in color on the chalkboard or the whiteboard. Online color is used to make presentations more vibrant. But the human touch from classroom instruction is either directly or indirectly replaced by the "touch" of technology. Faculty participants extended themselves by striving to replicate their classrooms in the web-based environments. The curriculum was presented in an organized fashion with each chapter having a folder of the section's content within. The web-based courses are designed to place the locus of instruction over to the student's responsibility. These particular web courses were heavily text-driven. By incorporating Flash Cards, Applets, Power Point slides, and other items, faculty endeavored to provide students with a plethora or resources and were the means of supplementing section-by-section text.

Departmental Final Exam

The answer to the research question "Do students in web-based statistics courses have comparable levels of achievement as those who receive classroom instruction?" would be yes, in terms of central tendency, but 'no' in terms of variability, according to the departmental Final Exam. Each modality-instructor combination yielded Final Exam averages between 65–75%. Beverly's students performed better on the interpretation items and earned an average of 62.3–73.6%`.

The Final Exam was more computational in nature, whereas the CAOS Exam was more conceptual. The CAOS Exam even surprised students by not even requiring a calculator. Students' abilities to think and reason statistically with data were stressed in the CAOS. This is consistent with at least two of the GAISE recommendations—stressing conceptual understanding rather than mere knowledge of procedures and using technology for developing conceptual understanding and analyzing data. Ann's students improved performance on the Final Exam reflects their broader mastery of material and the exam's approximately uniform point allocation across the curriculum.

There was a statistically significant difference in standard deviations of performance by classroom and web students (25.2 and 41.7, respectively with a p-value of .035). Also, the stronger performance on interpretation items by instructor may explain the differences in CAOS exam score gains (.6 for Ann and 5.2 for Beverly). When considering other variables that correlate with the Final Exam, GPA was the strongest with a correlation of .405 and a p-value of .044. A theme of increased variation in performance for students receiving WBI continues to emerge.

Survey for Students in the Web-based Sections

Many of the students seemed less than satisfied with their own time invested in preparing for this course and their learning. I suspect that this was merely an acknowledgement and not a commitment to change. The 15 students that submitted the survey often mentioned that they most enjoyed the ability to either learn at their "own pace" or because of the "flexibility" it allowed them to still pursue their non-academic activities. And even though the instructors had Discussion Boards to promote interaction and dialogue, the students tended to consider them less important and non-essential. They even went as far as to say that they considered themselves "detached" from their classmates. Hence, the Vygotskian theories seemed to apply less than anticipated. Technical difficulties were non-existent. Students largely considered faculty as just another set of resources to be solicited as necessary.

Forcing students to learn the material as independent learners leads to long-term gains. Key words, points of emphasis, voice inflections, etc. are sometimes lost with web-based instruction. Copious non-verbal cues are lost. There seems to be a distinct need for video, chat, and other media to better replicate the current classroom.

Another supreme advantage to the classroom is the instantaneous response time between posing a question to the instructor and receiving an answer. The e–mail replies are timely but rarely instantaneous. Ann considers them to have the best of both worlds with immediate access to the instructor and 24-hour access to content. Having the instructor there seems to make students more comfortable with posing a question. When the question is posed, other students realize they have similar concerns in this area. This process is replicated in the Web environment, but it is slightly inhibited nonetheless.
The students' feedback was quite helpful with ideas for curriculum design. Students often mentioned pursuing other sources (Internet and roommates) in addition to the instructor. One student asserted an almost one-letter grade penalty for being a web student by

stating, "If I get a B online, I could have gotten an A in the classroom." It seems that a variety of sources are of great benefit to students receiving web-based instruction, with the more animated items being better received. This informed the researcher that a concerted effort to reach all types of learners is still warranted. To that end, the instructor's presence should emerge. Audio and video presentations by the instructor of key concepts can help bring the text provided on the websites to life. Instructors can also consider making tools for web-based learning available for classroom learners. The two instructors for this study did so in emerging ways by placing syllabi and some notes online for both sets of students.

Now, the second research question, "What types of learning, pedagogy and interactive experiences, describe the web-based learning environment as compared to classroom-based instruction?" will be addressed. The classroom pedagogy and instruction are largely driven by lecture-discussion, with students' learning developing in evolving ways. In this case, examples and activities serve as supplements. Web-based instruction is far less constructivist in nature and reflects text descriptions of lecture notes with discussions, applets, and other activities used peripherally to partially compensate for the non-verbal clue loss and other idiosyncrasies of classroom instruction that are less prevalent in web-based instruction.

Implications

There is significantly more that could be done in the web-based statistics classroom. The participating instructors have some usage of applets and other technologies, but they are used in an ancillary capacity. The ever-evolving expansion to center Distance Learning on active learning strategies would best replicate the traditional classroom. Pelz (2004) mentioned the role "presence" (the ability to which the instructor's classroom-based practices, including voice and video, permeate the distance course) plays in Distance Learning classroom. The next level could also be to have Discussion Board questions on them to assess the extent of student learning. The worlds of touch and technology can become better connected to enhance learning experiences for all involved.

Faculty could also consider ways to further generate social interaction within the course. Current measures in place are in accordance with departmental guidelines, so there may need to be further consideration for incentives. Ann and Beverly believe web-based instruction will remain a formidable part of the community college as its mission is to make education available to their service areas. And the practical pressures of time vs. non-academic responsibilities may lead to some selecting Distance Learning even when they might have a notion that a traditional classroom would best suit them. Hence, the deficiencies must be addressed, or else the quality of the product could reduce web-based education to a mere trend.

Professional development for faculty in this emerging modality will empower more faculty to embrace it. Instructors will need to continue to expand their digital repertoires with content and strategies. At-risk students will need to be formally identified and presented with intervention strategies. A new modality will require a new paradigm for serving this expanding group of students and instructors.

The institution may want to consider strengthening mathematics preparation by at least one course. A limitation of this study was the inability to compare performance of distance learners who barely met the pre-requisite. This was largely the case because of the attrition rates among these students (in the web classes, only two of the students with minimum preparation completed the course). It was also the case that the students with stronger preparation scored higher, although not significantly. However, only one of seven students in web-based sections with prior coursework below College Algebra finished the course, and this student's Post-Test score was four points lower than their Pre-Test. In most cases, students are self-selecting better than one may think by either word-of-mouth or trial-and-error. Either way, strengthening the mathematics preparedness levels for web-based instruction would be a noble cause.

What the instructors emphasized, structured, or presented influenced learning. The institution's set of statistics educators may have to discuss whether a shift in the weighting of exam items or content will be in order to better align with the nationally-recognized CAOS exam. The six GAISE recommendations have been established for individual institutions to decide how to best make the epistemological adjustments. The CAOS exam is one exemplar of consistency between instructional recommendations and assessment.

Increasing the pre-requisite required to enroll in the web class would be consistent with the growing trend and would support the previous paragraph. Because of the transient population during the time of this study, 60%+ entered the course with pre-requisite preparation in College Algebra or higher. A formal change in this matter would codify what is already occurring. Students with lack of comfort with the graphing calculator could benefit from an online tutorial. (Those enrolled in classroom sections would benefit as well.) There seems to be a distinct need for video, chat and other media to better replicate the traditional classroom.

Native students (students for whom either their most recent or penultimate mathematics course was taken at the institution where the research in this document was conducted) were less likely to complete the course. Also, it could be noted that native students were far more likely to enter with minimum preparedness. Negative case analyses will need to be done to ascertain further information about inhibitions to course completion. There will need to be studies as to whether those dropping the course are consistently the lesser prepared students. This study provides an inkling of truth to that assertion. Students receiving web-based instruction had scores that were far more likely to be widely distributed, with more As but also more Es. Students receiving classroom instruction had lower proportions of students at the extremes. This makes any assertion that students in web-based sections can have comparable levels of achievement a true statement, but the caveat of higher proportions of As and Es should be anticipated. Eradicating the barriers to instruction that tend to lead to lower performance could allow a more definitive assertion that students in web-based sections could have higher levels of achievement than their classroom-based counterparts to develop.

In the interim, it will be critical for researchers and practitioners to probe into the amounts of learning that occur via WBI. In this study, even with greater initial preparation, learning gains were not guaranteed. As a brief anecdote, in track-and-field, it is usually speaks better to the speed of the runner who is able to finish a race tied with a competitor who began the race with a "head start." To date, it has been common to view WBI as ending in a "tie" with CBI, without tending to the differences in the student populations and looking at overall learning gains. The study from this research will help steer the "as good as traditional" dialogue in this direction.

In this study, it became apparent that the students felt "detached" from the instructor, and that some preferred this option. Again, this could be undermined by student performance at the extremes. Specifically, that in this study, the Survey for Students in the Web-based Sections was administered to students who had persisted into the 2nd half of the course, and there is the added knowledge that participants in this study tended to have higher GPAs than non-participants. Jointly, one effect could be that these higher performing students also had to endure working with, in a variety of ways, classmates that might have had lower levels of preparedness, involvement, and ultimately, success. A burden often carried by the stronger students in social instructional settings (especially where there is less opportunity for them to reflect on the information they are transferring to classmates) could be exacerbated in distance learning when this subpopulation is queried.

Even in its infancy, web-based instruction of statistics can yield at least some of the learning and experiences witnessed in the classroom setting. It is now time to replicate best practices from the classroom and transfer them to the Web, if possible. Video-streamed faculty demonstrations, chat rooms and comments can begin to enhance the web students' learning experience with these topics. Better addressing these matters can begin to provide students in web-based courses a more comparable learning experience overall.

Also, students with more familiarity with the web-based instruction should be the ones to enroll in it via the Web. In addition to the instructors, some students are indicating that math is better learned in the classroom. One student indicated that he missed the ability to be affirmed that he is “not the only one who is confused.” This is not unique to just mathematics.

There are distinct advantages for web-based instruction. A student could spend less time on what is already known and more on the more difficult topics and be truly learning at his or her own pace. There is no need to have the rest of the class hinder a student at an accelerated pace; conversely, a student would not have to feel as if he or she is proving to be an roadblock for the instructor and the rest of the students because he or she needs additional time to review certain concepts. Hopefully, the numbers of lectures and videos online will increase. Flashcards, applets, Power Point presentations and other dynamic learning tools are transcending classroom-based instruction.

The online survey revealed that there is still substantial growth for Distance Learning to achieve its potential. Mathematics and related disciplines may need to further consult other disciplines with greater familiarity with web-based instruction. Students would benefit greatly from having the majority of their explanations be audio or video directly from their instructor.

Distilling the student suggestions indicate that some of the nuances of classroom education are compromised for convenience. With the demand for web-based instruction in mathematics growing at the community college level, it seems prudent to assert that students will continue to be motivated its asynchronicity. Any efforts to replicate the actual instructor's instructional characteristics and personality into distance instruction will only result in more students being able to complete courses and not merely having to tolerate their enrollment decision. Web-based instruction of statistics must to continue to replicate the current classroom instructional practices before it is consistently viewed by the students as a modality that transcends classroom instruction.

Limitations and Delimitations

Limitations

A clear limitation was that the researcher had to use intact groups. Students could self-select into or out of the courses used for the research study. The web-based enrollment guide did not denote the sections differently. This structure also inhibited any randomization of faculty or students and led to lower participation rates, especially among web-based learners. It was determined that the smaller numbers of participating web-based learners had stronger academic records than the general web-based population. This limitation must be noted as performance on quantitative instruments could have been potentially lower with a more representative set of participants. Students of comparable preparedness from both modalities would need to be investigated as there is support that mathematical preparedness could influence performance. This was a clear limitation of the research study, as the participants with minimal preparedness were too few in number to formally test any initial assertions.

Summer quarter yields far more transient students. Since statistics is a graduation requirement for many four-year institutions, the course has appeal among transient students. Transient students reflect the general population of higher education undergraduates and not just the community college population. Hence, administering the same instrument in the fall, winter, or spring quarters could yield different (potentially lower) performance on quantitative instruments.

Students in web-based sections had a one-week window to come to the Testing Center to take each of the assessments. Those receiving classroom instruction had to take the assessment the day indicated on the syllabus. It could be argued that those receiving classroom instruction could have performed better on assessments with a similar flexibility for emergencies and non-academic commitments.

Limitations were placed by virtue of the synchronicity of the courses based on instructor teaching schedules and availability. Teaching assignments were not randomized. The number of faculty with two or more years teaching statistics online was minimal. The researcher could only select these two participants and had to be more purposeful.

Given that the researcher assumed the role of the observant, he could not assign faculty to classroom sections of similar offering and composition. Instead, the researcher had to adjust to the instructors' availabilities. In an objective position, the researcher could not enforce strict usage of research-proven instructional strategies for either web-based or classroom-based sections. The strategies observed in this study were strictly the practices of the participating faculty in general. Certain teaching strategies were not suggested since the researcher aspired for objectivity. The absence of this component resulted in a raw exposure the typical classroom devoid of additional emphasis on GAISE standards, formal attention to social interaction, presence, and other research-based constructs.

It was not a limitation for the researcher to have been the supervisor of the participating faculty. In fact, this dynamic actually led to increased communications, protection of teaching course loads, and shared expectations.

The computational orientation of the Final Exam was a limitation. This made the Final Exam less reflect the CAOS exam and the emerging direction of the statistics education community. This issue will need to be re-visited at the particular participating institution.

Delimitations

The wording of items on either the surveys or the interview protocols may have influenced the data gathered. A prime example is apparent with the wording of non-academic responsibilities. To maximize the integrity of the data collected, the researcher required distance learners to take their Pre-Test and Post-Tests in the Testing Center. This concept is not unfamiliar to distance learners at this particular institution in mathematics as mid-terms and finals are taken via paper-and-pencil in this proctored setting. The fact that participation was optional also led to lower participation rates. But, from a human subjects perspective, the participant should be free to make decisions independent of researcher needs.

The researcher considered Multiple Factor Analysis and usage of knowledge on Gain scores to determine significant factors for the model. While Gain controls for particular cases, Logistic Regression could also be used to control for cases and the difficulty of particular items within CAOS. Taking logarithms of Pre-Test and Post-Test could also reduce heteroskedasticity. Nevertheless, the research elected to discuss findings as they related to critical factors in simplest and statistically reasonable forms.

Recommendations for Future Research

This research will extend the existing body of distance learning literature by further probing of the "as good as" argument by including an investigation into the increased variability of performance in distance learners. A theme from the faculty interviews, the Final Exam performance and in even the CAOS Exam, is this notion that distance learners tend to have higher representation at the extremes of the grade distribution, and, by default in many ways, have performance that could be interpreted as being "as good as." Explanations of this variation could include student preparedness, instructor, and pedagogy as evidenced in this study. Negative Case Analyses and other qualitative research methodology specifically targeted at the higher performing and the at-risk students would contextualize the "as good as" argument and serve as better explanations for the higher standard deviations. As research tends to the learners, the focus must look at the net learning gained during the course and not snapshots of performance at discrete moments. Attention to the experiences and needs of the at-risk students could improve student performance and, perhaps, lead WBI student performance to become “better than” CBI.

The research questions posed in this study are structurally designed to have application to other disciplines. For a given discipline with online courses, it could be posed that the performance in those courses be investigated via instrumentation for quantitative analyses. Then, the corresponding online pedagogy could be researched via qualitative methods. In tandem, understanding why WBI performance was similar, or dissimilar to CBI, would benefit those individuals who are currently pondering this issue in their respective areas.

After the research in WBI of statistics at community college increases, the next step would be to capture the students in Hybrid sections. Hybrid instruction occurs by having the instructor present curriculum online and through traditional classroom instruction. The in-class components are commonly a blend of instruction typical of classroom-based instruction and work commonly associated with graduate-facilitated recitations. For the mathematics department at this institution, faculty typically supplement web-based learning with one hour of weekly instruction. Students may try to fit all of the learning for the particular week in one hour, but that would be highly discouraged. Kim & Bonk (2006) mentioned that blended and hybrid offerings could become the new means of conducting Distance Learning. Yet, some of the personal touch absent the current web-based option are evident in the Hybrid offering (e.g., instructor voice, presence, etc.). There is variability in the nature of the in-class component, but it is largely similar to a recitation session at a four-year university, and there is still only one faculty member involved in the instruction.

Both instructors in this study had not taught Hybrid sections for one year and had substantial experience with web-based instruction. The researcher decided that Hybrid instruction needs to be looked at further in the future to see if the additional face-to-face time is beneficial to students. But, its novelty within the mathematics department of this institution led it to be deemed beyond the scope of this particular study.

It seems as if many students invested "enough to get by." But what about the students who dropped? It was also true that high percentages of students at minimum preparation did not complete the course. There will be great value in projects looking into persistence in web-based instruction and researching the experiences and perspectives of course non-completers.

The study also revealed other potential research areas regarding web-based instruction and students for whom English is their second language. Students with English as a Second Language credit did not enroll in either of the web-based sections. There also were higher proportions of students from other institutions enrolled. The apathy toward web-based instruction by the first sub-population and the heightened interest by the other would be intriguing sources of information.

Statistics educators may consider research on minority groups and achievement of students for whom English is a second language as an area for research. This (ESL) at-risk subpopulation of students will need further exploration in years to come. Students with English as a Second Language coursework refrained from web-based instruction and were probably having difficulty relative to peers in the classroom environment. An early indication of the problem was their lack of enrollment in the web-based section.

If 21st century education truly aspires for educators to serve as “guides on the side,” web-based instruction can do just that and has not resulted in a modality that is categorically inferior to the classroom. The next steps for web-based instruction involve transcending the educational experience to optimally utilize the technology web-based instruction affords its learners and instructors. For their benefit, let us seize the day!

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Appendix A: Comprehensive Assessment of Outcomes for a

First Course in Statistics Test

Comprehensive **A**ssessment of **O**utcomes for a first course in **S**tatistics (CAOS)

CAOS 4

Developed by the Web ARTIST Project https://app.gen.umn.edu/artist/

Funded by a grant from the National Science Foundation NSF CCLI ASA- 0206571

Principal Investigators: Joan Garfield and Bob delMas, University of Minnesota Beth Chance, Cal Poly – San Luis Obispo Post-doctoral Research Assistant: Ann Ooms, University of Minnesota

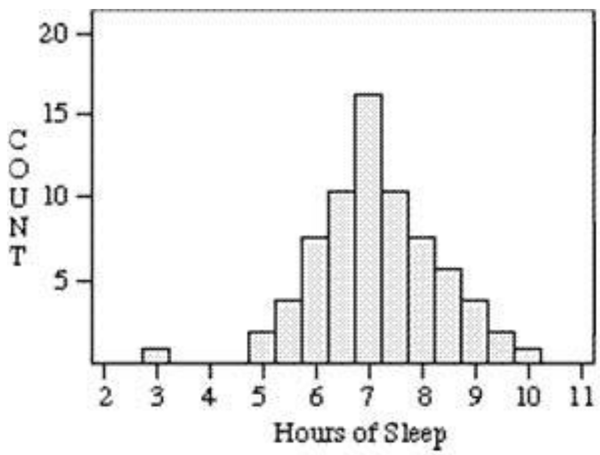
Version 31

September 8, 2005

ARTIST CAOS 4 POSTTEST

The following graph shows a distribution of hours slept last night by a group of college students.

1. Select the statement below that gives the most complete description of the graph in away that demonstrates an understanding of how to statistically describe and interpret the distribution of a variable.



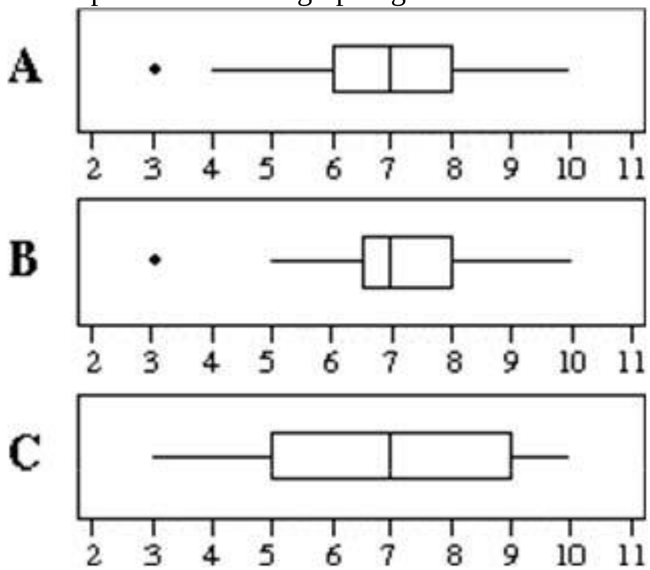
a. The bars go from 3 to 10, increasing in height to 7, then decreasing to 10. The tallest bar is at 7. There is a gap between three and five.

b. The distribution is normal, with a mean of about 7 and a standard deviation of about 1.

c. Most students seem to be getting enough sleep at night, but some students slept more and some slept less. However, one student must have stayed up very late and got very few hours of sleep.

d. The distribution of hours of sleep is somewhat symmetric and bell-shaped, with an outlier at 3. The typical amount of sleep is about 7 hours and overall range is7 hours.

2.Which box plot seems to be graphing the same data as the histogram in question 1?

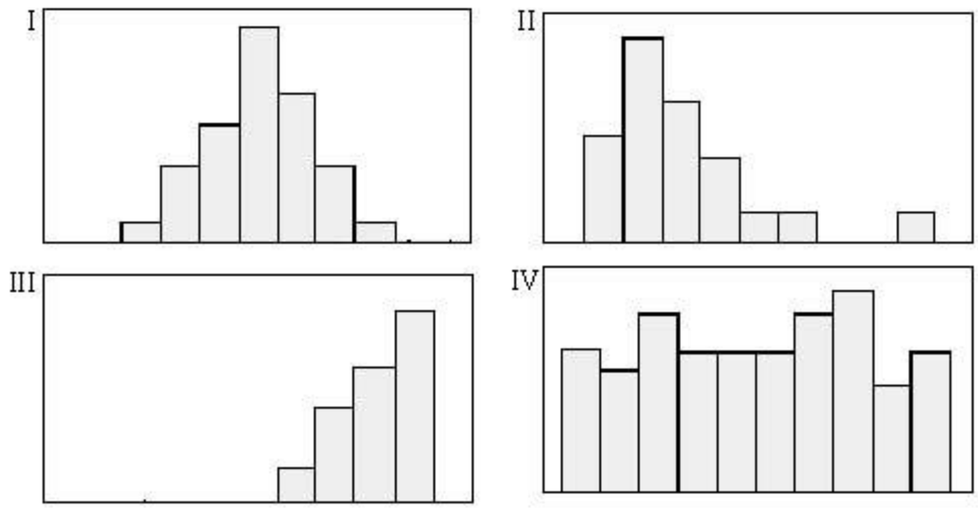


a. Boxplot A.

b. Boxplot B.

c. Boxplot C.

Items 3 to 5 refer to the following situation:
Four histograms are displayed below. For each item, match the description to the appropriate histogram.



3. A distribution for a set of quiz scores where the quiz was very easy is represented by:

    a. Histogram I.
    b. Histogram II.
    c. Histogram III.
    d. Histogram IV.

4. A distribution for a set of wrist circumferences (measured in centimeters) taken From the right wrist of a random sample of newborn female infants is represented by:

    a. Histogram I.
    b. Histogram II.
    c. Histogram III.
    d. Histogram IV.

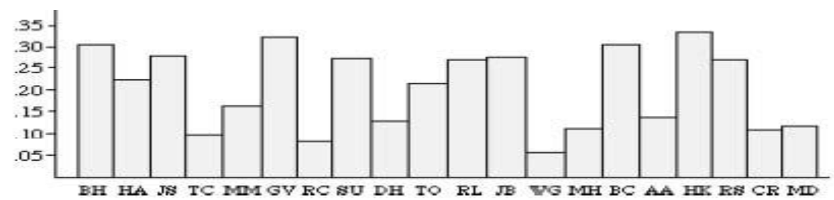
5. A distribution for the last digit of phone numbers sampled from a phone book (i.e.,for the phone number 968-9667, the last digit, 7, would be selected) is represented by:

    a. Histogram I.
    b. Histogram II.
    c. Histogram III.
    d. Histogram IV.

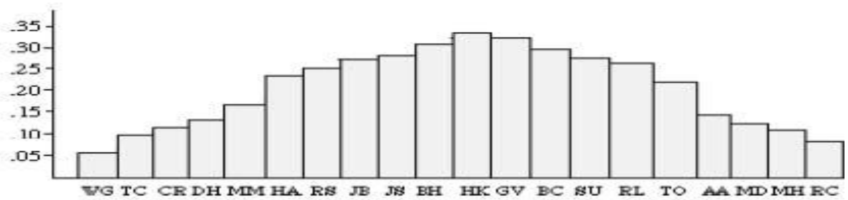
6. A baseball fan likes to keep track of statistics for the local high school baseball team. One of the statistics she recorded is the proportion of hits obtained by each player based on the number of times at bat as shown in the table below. Which of the following graphs gives the best display of the distribution of proportion of hits in that it allows the baseball fan to describe the shape, center and spread of the variable, proportion of hits?

Player	Proportion of hits	Player	Proportion of hits	Player	Proportion of hits
BH	0.305	SU	0.27	BC	0.301
HA	0.229	DH	0.136	AA	0.143
JS	0.281	TO	0.218	HK	0.341
TC	0.097	RL	0.267	RS	0.261
MM	0.167	JB	0.27	CR	0.115
GV	0.333	WG	0.054	MD	0.125
RC	0.085	MH	0.108		

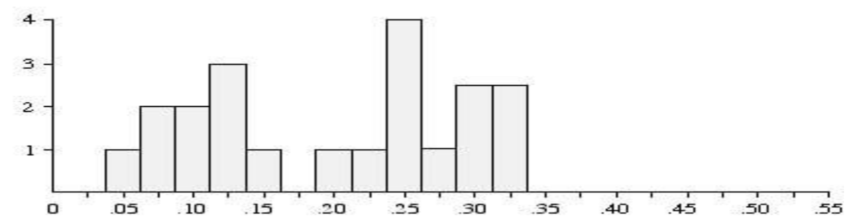
A



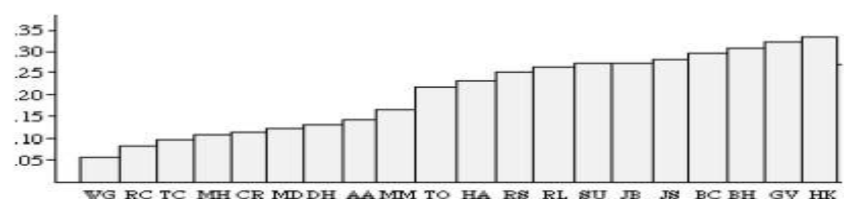
B



C



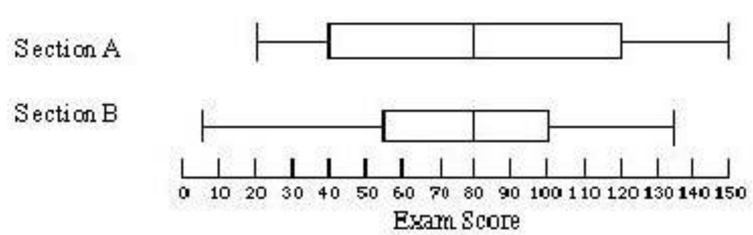
D



7. A recent research study randomly divided participants into groups who were given different levels of Vitamin E to take daily. One group received only a placebo pill. The research study followed the participants for eight years to see how many developed a particular type of cancer during that time period. Which of the following responses gives the best explanation as to the purpose of randomization in this study?

a. To increase the accuracy of the research results.
b. To ensure that all potential cancer patients had an equal chance of being selected for the study.
c. To reduce the amount of sampling error.
d. To produce treatment groups with similar characteristics.
e. To prevent skewness in the results.

Items 8 to 10 refer to the following situation:
The two boxplots below display final exam scores for all students in two different sections of the same course.



8. Which section would you expect to have a greater standard deviation in exam scores?

a. Section A.
b. Section B.
c. Both sections are about equal.
d. It is impossible to tell.

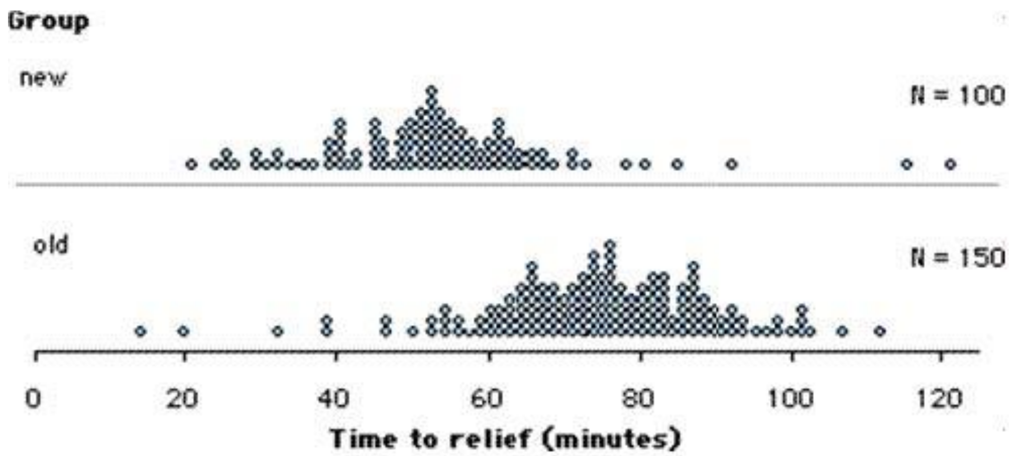
9. Which data set has a greater percentage of students with scores at or below 30?

a. Section A.
b. Section B.
c. Both sections are about equal.
d. It is impossible to tell.

10. Which section has a greater percentage of students with scores at or above 80?

a. Section A.
b. Section B.
c. Both sections are about equal.

Items 11 to 13 refer to the following situation:
A drug company developed a new formula for their headache medication. To test the effectiveness of this new formula, 250 people were randomly selected from a larger population of patients with headaches. 100 of these people were randomly assigned to receive the new formula medication when they had a headache, and the other 150 people received the old formula medication. The time it took, in minutes, for each patient to no longer have a headache was recorded. The results from both of these clinical trials are shown below. Items 11, 12, and 13 present statements made by three different statistics students. For each statement, indicate whether you think the student's conclusion is valid.



11. The old formula works better. Two people who took the old formula felt relief in less than 20 minutes, compared to none who took the new formula. Also, the worst result - near 120 minutes - was with the new formula.

a. Valid.
b. Not valid.

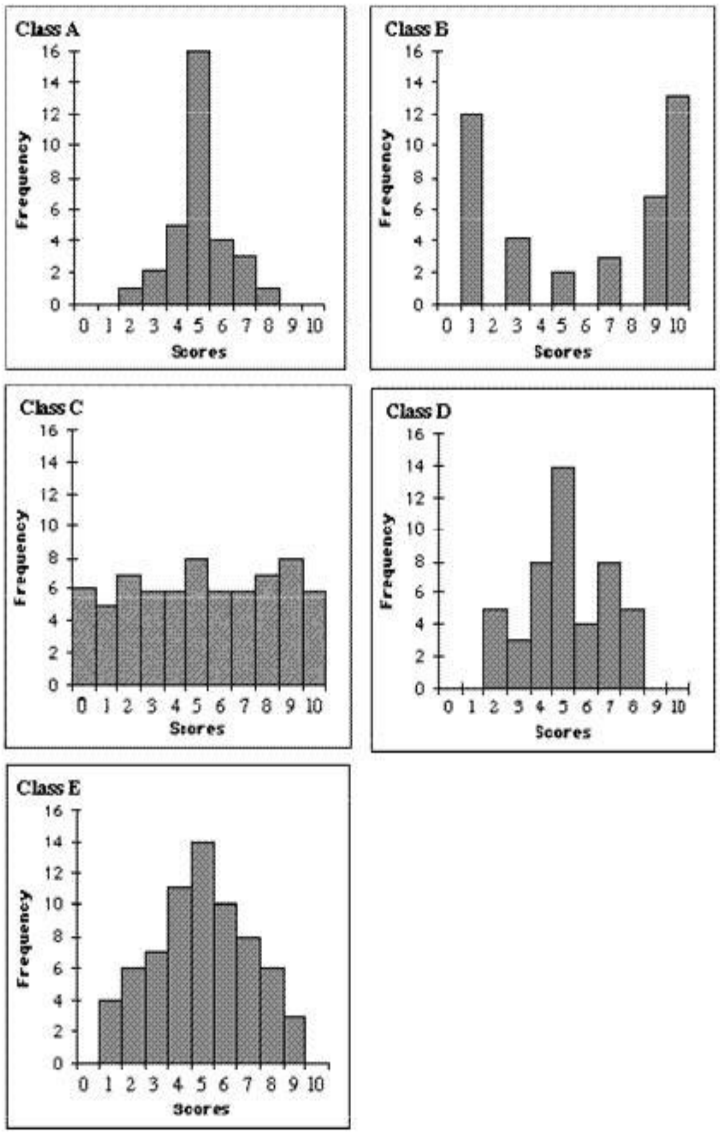
12. The average time for the new formula to relieve a headache is lower than the average time for the old formula. I would conclude that people taking the new formula will tend to feel relief about 20 minutes sooner than those taking the old formula.

a. Valid.
b. Not valid.

13. I would not conclude anything from these data. The number of patients in the twogroups is not the same so there is no fair way to compare the two formulas.

a. Valid.
b. Not valid.

Items 14 and 15 refer to the following situation: Five histograms are presented below. Each histogram displays test scores on a scale of 0 to 10 for one of five different statistics classes.



14. Which of the classes would you expect to have the lowest standard deviation, and why?

a. Class A, because it has the most values close to the mean.
b. Class B, because it has the smallest number of distinct scores.
c. Class C, because there is no change in scores.
d. Class A and Class D, because they both have the smallest range.
e. Class E, because it looks the most normal.

15. Which of the classes would you expect to have the highest standard deviation, and why?

a. Class A, because it has the largest difference between the heights of the bars.
b. Class B, because more of its scores are far from the mean.
c. Class C, because it has the largest number of different scores.
d. Class D, because the distribution is very bumpy and irregular.
e. Class E, because it has a large range and looks normal.

16. A certain manufacturer claims that they produce 50% brown candies. Sam plans to buy a large family size bag of these candies and Kerry plans to buy a small fun size bag. Which bag is more likely to have more than 70% brown candies?

a. Sam, because there are more candies, so his bag can have more brown candies.
b. Sam, because there is more variability in the proportion of browns among larger samples.
c. Kerry, because there is more variability in the proportion of browns among smaller samples.
d. Kerry, because most small bags will have more than 50% brown candies.
e. Both have the same chance because they are both random samples.

17. Imagine you have a barrel that contains thousands of candies with several different colors. We know that the manufacturer produces 35% yellow candies. Five students each take a random sample of 20 candies, one at a time, and record the percentage of yellow candies in their sample. Which sequence below is the most plausible for the percent of yellow candies obtained in these five samples?

a. 30%, 35%, 15%, 40%, 50%.
b. 35%, 35%, 35%, 35%, 35%.
c. 5%, 60%, 10%, 50%, 95%.
d. Any of the above.

18. Jean lives about 10 miles from the college where she plans to attend a 10-week summer class. There are two main routes she can take to the school, one through the city and one through the countryside. The city route is shorter in miles, but has more stoplights. The country route is longer in miles, but has only a few stop signs and stoplights. Jean sets up a randomized experiment where each day she tosses a coin to decide which route to take that day. She records the following data for 5days of travel on each route.

Country Route -17, 15, 17, 16, 18

City Route -18, 13, 20, 10, 16

It is important to Jean to arrive on time for her classes, but she does not want to arrive too early because that would increase her parking fees. Based on the data gathered, which route would you advise her to choose?

a. The Country Route, because the times are consistently between 15 and 18minutes.

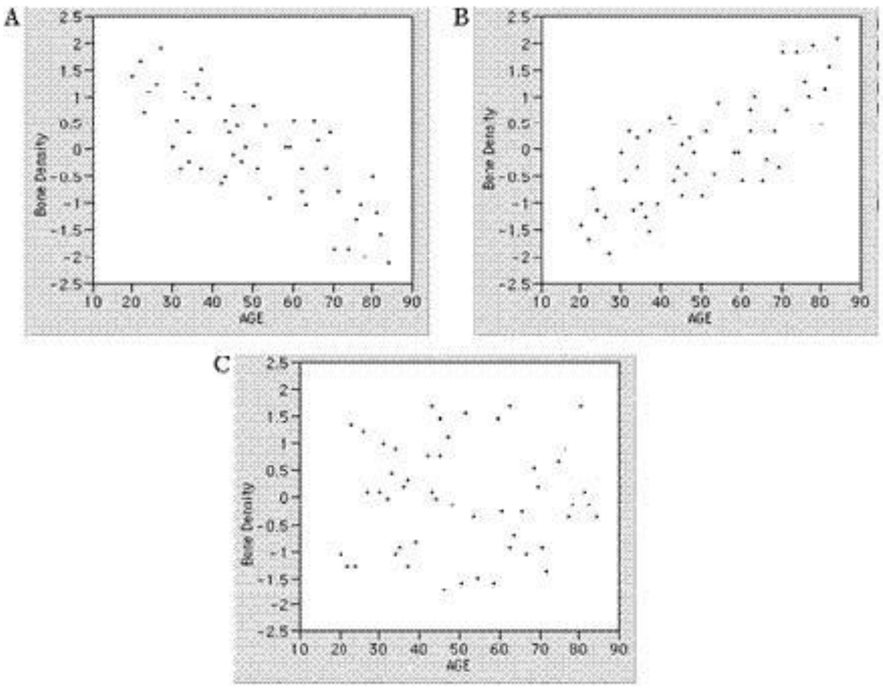
b. The City Route, because she can get there in 10 minutes on a good day and the average time is less than for the Country Route.

c. Because the times on the two routes have so much overlap, neither route is better than the other. She might as well flip a coin.

19. A graduate student is designing a research study. She is hoping to show that the results of an experiment are statistically significant. What type of *p*-value would she want to obtain?

a. A large *p*-value.
b. A small *p*-value.
c. The magnitude of a *p*-value has no impact on statistical significance.

20. Bone density is typically measured as a standardized score with a mean of 0 and a standard deviation of 1. Lower scores correspond to lower bone density. Which of the following graphs shows that as women grow older they tend to have lower bone density?

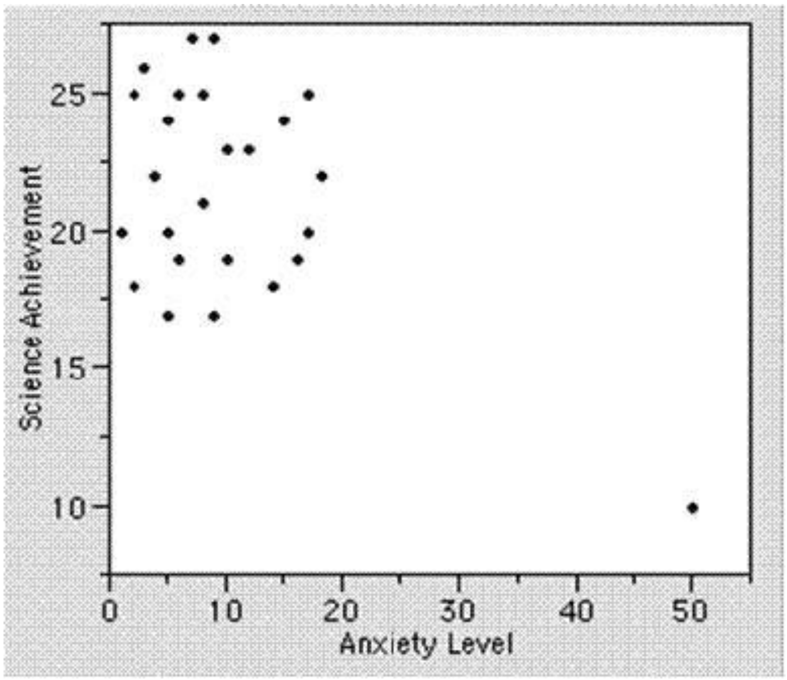


a. Graph A.

b. Graph B.

c. Graph C.

21. The following scatterplot shows the relationship between scores on an anxiety scale and an achievement test for science. Choose the best interpretation of the relationship between anxiety level and science achievement based on the scatterplot.



a. This graph shows a strong negative linear relationship between anxiety and achievement in science.
b. This graph shows a moderate linear relationship between anxiety and achievement in science.
c. This graph shows very little, if any, linear relationship between anxiety and achievement in science.

22. Researchers surveyed 1,000 randomly selected adults in the U.S. A statistically significant, strong positive correlation was found between income level and the number of containers of recycling they typically collect in a week. Please select the best interpretation of this result.

a. We can not conclude whether earning more money causes more recycling among U.S. adults because this type of design does not allow us to infer causation.

b. This sample is too small to draw any conclusions about the relationship between income level and amount of recycling for adults in the U.S.

c. This result indicates that earning more money influences people to recycle more than people who earn less money.

Items 23 and 24 refer to the following situation:

A researcher in environmental science is conducting a study to investigate the impact of a particular herbicide on fish. He has 60 healthy fish and randomly assigns each fish to either a treatment or a control group. The fish in the treatment group showed higher levels of the indicator enzyme.

23. Suppose a test of significance was correctly conducted and showed no statistically significant difference in average enzyme level between the fish that were exposed to the herbicide and those that were not. What conclusion can the graduate student draw from these results?

a. The researcher must not be interpreting the results correctly; there should be as a significant difference.
b. The sample size may be too small to detect a statistically significant difference.
c. It must be true that the herbicide does not cause higher levels of the enzyme.

24. Suppose a test of significance was correctly conducted and showed a statistically significant difference in average enzyme level between the fish that were exposed to the herbicide and those that were not. What conclusion can the graduate student draw from these results?

a. There is evidence of association, but no causal effect of herbicide on enzyme levels.
b. The sample size is too small to draw a valid conclusion.
c. He has proven that the herbicide causes higher levels of the enzyme.
d. There is evidence that the herbicide causes higher levels of the enzyme for these fish.

Items 25 to 27 refer to the following situation:

A research article reports the results of a new drug test. The drug is to be used to decrease vision loss In people with Macular Degeneration. The article gives a *p*-value of .04 in the analysis section. Items 25, 26, and 27 present three different interpretations of this *p*-value. Indicate if each interpretation is valid or invalid.

25. The probability of getting results as extreme as or more extreme than the ones in this study if the drug is actually not effective.
 a. Valid.
 b. Invalid.

26. The probability that the drug is not effective.
 a. Valid.
 b. Invalid.

27. The probability that the drug is effective.
 a. Valid.
 b. Invalid.

Items 28 to 31 refer to the following situation:

A high school statistics class wants to estimate the average number of chocolate chips in a generic brand of chocolate chip cookies. They collect a random sample of cookies, count the chips in each cookie, and calculate a 95% confidence interval for the average number of chips per cookie (18.6 to 21.3). Items 28, 29, and 30 present four different interpretations of these results. Indicate if each interpretation is valid or invalid.

28. We are 95% certain that each cookie for this brand has approximately 18.6 to 21.3chocolate chips.
 a. Valid.
 b. Invalid.

29. We expect 95% of the cookies to have between 18.6 and 21.3 chocolate chips.
 a. Valid.
 b. Invalid.

30. We would expect about 95% of all possible sample means from this population to be between 18.6 and 21.3 chocolate chips.
 a. Valid.
 b. Invalid.

31. We are 95% certain that the confidence interval of 18.6 to 21.3 includes the true average number of chocolate chips per cookie.
 a. Valid.
 b. Invalid.

32. It has been established that under normal environmental conditions, adult large mouth bass in Silver Lake have an average length of 12.3 inches with a standard deviation of 3 inches. People who have been fishing Silver Lake for sometime claim that this year they are catching smaller than usual largemouth bass. A research group from the Department of Natural Resources took a random sample of100 adult largemouth bass from Silver Lake and found the mean of this sample to be 11.2 inches. Which of the following is the most appropriate statistical conclusion?

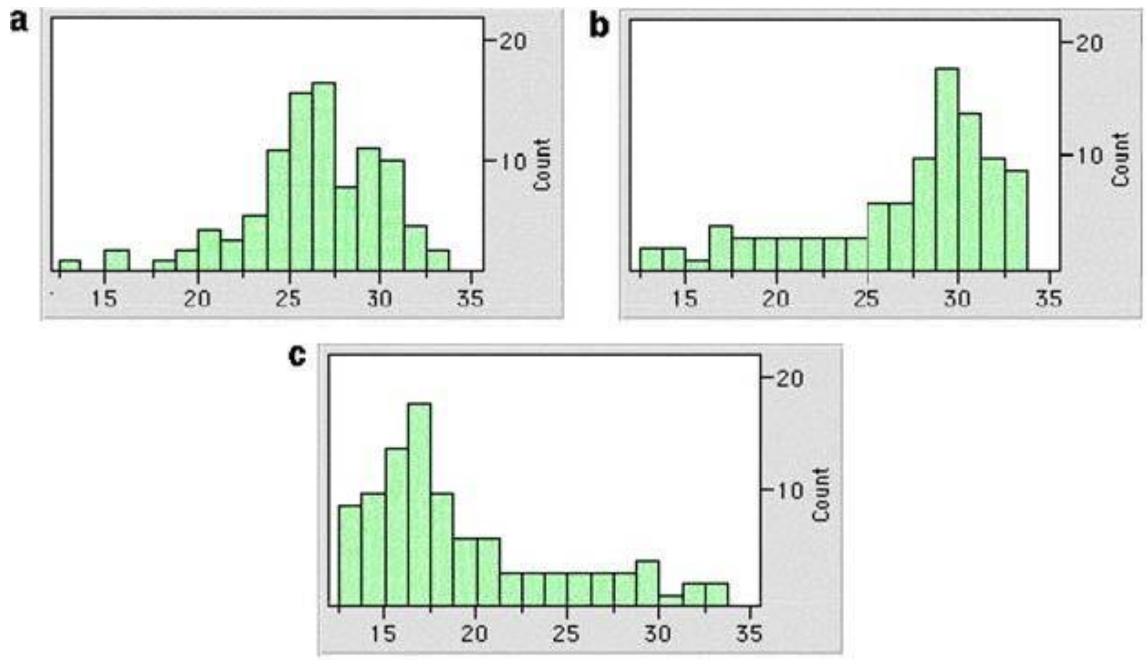
a. The researchers cannot conclude that the fish are smaller than what is normal because 11.2 inches is less than one standard deviation from the established mean (12.3 inches) for this species.

b. The researchers can conclude that the fish are smaller than what is normal because the sample mean should be almost identical to the population mean with a large sample of 100 fish.

c. The researchers can conclude that the fish are smaller than what is normal because the difference between 12.3 inches and 11.2 inches is much larger than the expected sampling error.

A study examined the length of a certain species of fish from one lake. The plan was to take a random sample of 100 fish and examine the results. Numerical summaries on lengths of the fish measured in this study are given.

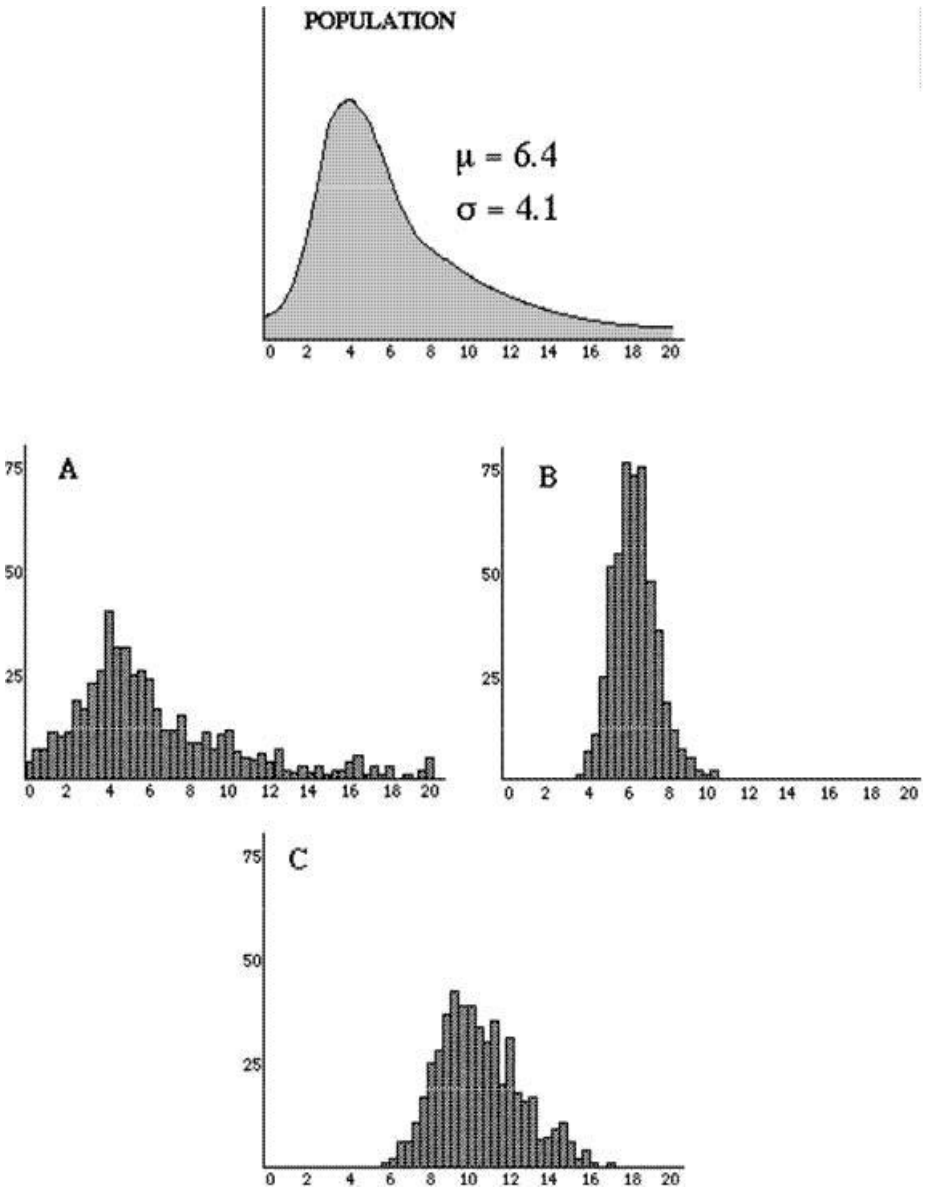
Mean	26.8mm
Median	29.4mm
Standard Deviation	5.0mm
Minimum	12mm
Maximum	33.4mm



33. Which of the following histograms is most likely to be the one for these data?

a. Histogram a.
b. Histogram b.
c. Histogram c.

Items 34 and 35 refer to the following situation:
Four graphs are presented below. The graph at the top is a distribution for a population oftest scores. The mean score is 6.4 and the standard deviation is 4.1.



34. Which graph (A, B, or C) do you think represents a single random sample of 500 values from this population?

a. Graph A
b. Graph B
c. Graph C

35. Which graph (A, B, or C) do you think represents a distribution of 500 sample means from random samples each of size 9?

a. Graph A
b. Graph B
c. Graph C

36. This table is based on records of accidents compiled by a State Highway Safety and Motor Vehicles Office. The Office wants to decide if people are less likely to have a fatal accident if they are wearing a seatbelt. Which of the following comparisons is most appropriate for supporting this conclusion?

a. Compare the ratios 510/412,878 and 1,601/164,128
b. Compare the ratios 510/577,006 and 1,601/577,006
c. Compare the numbers 510 and 1,601

Safety Equipment in Use	Injury		ROW TOTAL
	Nonfatal	Fatal	
Seat Belt	412,368	510	412,878
No Seat Belt	162,527	1,601	164,128
COLUMN TOTAL	574,895	2,111	577,006

37. A student participates in a Coke versus Pepsi taste test. She correctly identifies which soda is which four times out of six tries. She claims that this proves that she can reliably tell the difference between the two soft drinks. You have studied statistics and you want to determine the probability of anyone getting at least four right out of six tries just by chance alone. Which of the following would provide an accurate estimate of that probability?

a. Have the student repeat this experiment many times and calculate the percentage time she correctly distinguishes between the brands.

b. Simulate this on the computer with a 50% chance of guessing the correct soft drink on each try, and calculate the percent of times there are four or more correct guesses out of six trials.

c. Repeat this experiment with a very large sample of people and calculate the percentage of people who make four correct guesses out of six tries.
d. All of the methods listed above would provide an accurate estimate of the probability.

38. A college official conducted a survey to estimate the proportion of students currently living in dormitories about their preference for single rooms, double rooms, or multiple (more than two people) rooms in the dormitories on campus. Which of the following does NOT affect the college official's ability to generalize the survey results to all dormitory students?

a. Five thousand students live in dormitories on campus.
A random sample of only 500 were sent the survey.
b. The survey was sent to only first-year students.
c. Of the 500 students who were sent the survey, only 160 responded.
d. All of the above present a problem for generalizing the results.

39. The number of people living on American farms has declined steadily during the last century. Data gathered on the U.S. farm population (millions of people) from1910 to 2000 were used to generate the following regression equation: Predicted Farm Population = 1167 - .59 (YEAR). Which method is best to use to predict the number of people living on farms in 2050?

a. Substitute the value of 2050 for YEAR in the regression equation, and compute the predicted farm population.
b. Plot the regression line on a scatterplot, locate 2050 on the horizontal axis, and read off the corresponding value of population on the vertical axis.
c. Neither method is appropriate for making a prediction for the year 2050 based on these data.
d. Both methods are appropriate for making a prediction for the year 2050 based on these data.

40. The following situation models the logic of a hypothesis test. An electrician uses an instrument to test whether or not an electrical circuit is defective. The instrument sometimes fails to detect that a circuit is good and working. The null hypothesis isthat the circuit is good (not defective). The alternative hypothesis is that the circuitis not good (defective). If the electrician rejects the null hypothesis, which of thefollowing statements is true?

a. The circuit is definitely not good and needs to be repaired.
b. The electrician decides that the circuit is defective, but it could be good.
c. The circuit is definitely good and does not need to be repaired.
d. The circuit is most likely good, but it could be defective.

Appendix B: Departmental Final Exam

Math 135 – Elementary Statistics

Final Exam Summer 2007 (Form B) Name:________________________________

Please show all work and circle your final answers. Tables and formulas have been provided for your assistance. Round all numeric answers to three decimal places.

New Zogby Poll Finds 45 Percent Support Making Cigarettes Illegal
A new Zogby Poll commissioned by the Drug Policy Alliance (DPA) found that 45 percent of Americans polled would support a federal ban on cigarettes within the next five to ten years.

Question: "Would you strongly support, somewhat support, somewhat oppose, or strongly oppose a federal law making cigarettes illegal within the next five to ten years?"

Strongly Support	31%
Somewhat Support	14%
Somewhat Oppose	16%
Strongly Oppose	36%
Not Sure	3%

Survey Methods
Zogby International surveys employ sampling strategies in which the selection probabilities are proportional to the population size within an area code. The sample is 1200 telephone interviews with randomly selected likely voters. The margin of error is $\pm$ 3 percentage points at a 95% confidence level.

1. Identify the following for the Zogby poll (given above): (2 points each, unless noted)

a. Identify the population: ____

b. Identify the sample: ____

c. Please describe the sampling technique Zogby used?

d. Is the data variable for this poll qualitative or quantitative? ____________________

e. What is the highest level of measurement for the data variable of this poll (nominal, ordinal, interval, or ratio)?

f. Write a statement about the results of this poll that would be an example of inferential statistics. (3 points)

g. Would the results displayed in the table above be examples of parameters or statistics?

h. What two graphs could be used to display the results of this poll? Explain why.

i. Provide the point estimate for the proportion of all U.S. likely voters who would strongly oppose a federal ban on cigarettes.

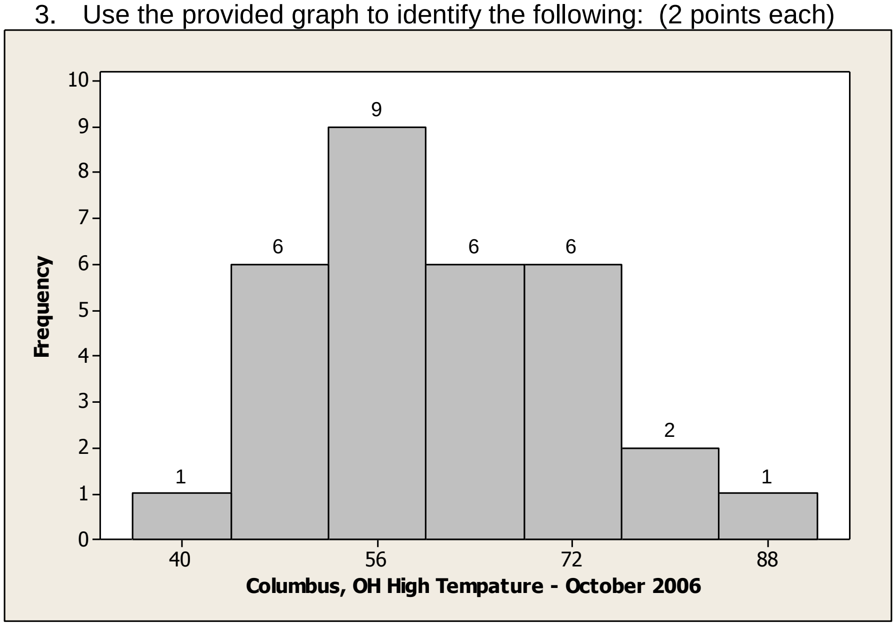
j. Write the 95% confidence interval for the proportion of all U.S. likely voters who would somewhat support a federal ban on cigarettes. All of the information for this confidence interval is given in the results of the poll. You **do not** need to calculate anything.

2. Zogby also asked for the age of each person surveyed. (2 points each)

a. Is the age considered qualitative or quantitative data? _______________

b. What is the highest level of measurement for the age of the person surveyed (nominal, ordinal, interval, or ratio)?

3. Use the provided graph to identify the following: (2 points each)



a. Type (name) of graph:_____________________ d. Shape:_______________

b. Class width:________________________________ e. Mean:________________

c. Mode (midpoint of modal class):_______________ f. Standard deviation:_____

4. The following data represent the amount of sales (in thousands of dollars) earned by Frosted Nibbles Cereal in 12 locations:

275 315 316 333 337 343 347 349 356 359 361 365

a. Make a boxplot. Clearly label and show the values of the minimum, maximum and quartiles. (5 points)
(Use the scale provided below)

270 280 290 300 310 320 330 340 350 360 370

b. What is the shape of the data? What is the expected relationship between the median and the mean? (2 points)

c. Determine the mean and median for the amount of sales listed above. (2 points)

Mean _______________ Median _____________

d. Determine the range and standard deviation for this sample data and determine what they measure.
(3 points)

Range _______________ Standard Deviation ________________

What do these two values measure? (Circle the correct answer)

shape center spread

5. A research company is assessing feasibility of producing two new types of cereal, Raw Grain Delight and Sugar Bites. After subjecting the general public to numerous taste tests, the research company developed a probability distribution for the sales of the two cereals. Assume the distributions are normally distributed. A summary of their findings follows (in thousands of dollars):

	Mean of sales	**Standard deviation of sales**
Raw Grain Delight	284	43
Sugar Bites	197	82

Which cereal should the company produce? Justify your choice by *explaining what the mean and standard deviation reveal about the expected sales of the cereal*. (4 points)

6. Suppose a grocery store cooler holds a total of 20 milk cartons (7 of which are expired). What is the probability that a person will randomly select two expired cartons in a row (selecting without replacement)? (3 points)

7. A random sample of 60 customers at Cedar Point is used to determine the preferred attraction of men and women. Use the table to answer the questions below: (3 points each, unless noted)

	Men	**Women**
Water park	12	10
Roller Coasters	18	15
Shows	3	2

a. What is the probability that a randomly selected customer prefers the water park?

What type of probability is this? (Circle the correct answer) (2 points)

Classical Empirical Subjective

b. What is the probability that a randomly selected customer is a male or prefers the shows?

c. What is the probability that a randomly selected customer does not prefer the roller coasters?

d. Given that a randomly selected customer is male, what is the probability that he prefers the water park?

e. Given that a randomly selected customer is female, what is the probability that she prefers the water park?

f. Is a male or female more likely to prefer the water park? Why?

8. Casinos are always guaranteed a profit from their betting games (blackjack, roulette, craps, etc.) because they have a large number of people playing these games on a regular basis. Please identify the statistical principle that addresses this issue and *explain how it works in this situation.* (2 points)

9. A recent survey found that 45% of all CSCC students take summer classes. Suppose that fifteen CSCC students are randomly selected. (4 points each)

a. How many would you expect to be enrolled for summer classes?

b. What is the standard deviation?

c. What is the probability that at most six of these students are enrolled for summer classes?

d. What is the probability that at least nine of these students are enrolled for summer classes?

10. The probability distribution below displays the probability that a current CSCC student will register for X classes next quarter. (4 points each)

X classes	P(x)
0	.12
1	.25
2	.44
3	.17
4	.02

a. Is the variable "Number of classes" discrete or continuous? Explain.

b. Calculate the mean for the number of classes registered for next quarter. Explain what the mean indicates in the context of this problem.

c. Calculate the standard deviation.

d. What is the probability that a current CSCC student will register for more than 2 classes next quarter?

11. Suppose the amount of rain in May in Central Ohio is normally distributed with an average of 2.9 inches and a standard deviation of 1.8 inches. Please remember to draw and shade the normal distribution.

a. What is the probability that a randomly selected May rain amount in Central Ohio will be between 5 and 7 inches? Interpret your answer. (6 points)

b. Jym Ganahl has predicted that next May will be rainier than 85% of the May amounts on record. At least how much rain is Jym Ganahl predicting for next May? (5 points)

12. According to a recent report, families spend an average of $92 per game for parking, concessions, and tickets for Wyandot Lake Amusement and Water Park. The standard deviation is $16.

a. Suppose 40 families are surveyed, what is the probability that the sample *mean* $\overline{X}$ will be more than $89? (5 points)

b. Which theorem allows you to assume that the distribution of means (from samples of size 30 or more) is Normal? (2 points)

13. How many hospital nurses will need to be surveyed to estimate the mean number of hours worked per week with 94% confidence? Suppose the standard deviation is 2.4 hours and you want your estimate to be within 0.5 hours of the population mean. (4 points)

14. The number of pups in wolf dens of the southwestern United States is recorded for 16 wolf dens: (3 points each)

5	8	7	5	3	4	3	9
5	8	5	6	5	6	4	7

a. What is the point estimate for the population mean number of wolf pups per den in the southwestern United States?

b. Calculate the 95% confidence interval for the population mean number of wolf pups per den in the southwestern United States

c. Find the margin of error, E, for the 95% confidence interval estimate of the population mean number of wolf pups per den in the southwestern United States.

d. Interpret this confidence interval in the context of the problem.

15. Determine whether the following are True or False. (2 points each)

a. As the confidence level increases, the interval width also increases. __________

b. Confidence Intervals estimate sample statistics. _____________

c. Small samples produce narrower Confidence Intervals than large samples produce. ____

d. If I do not have a preliminary estimate, the minimum sample size required to estimate the population proportion is larger than if I had a preliminary estimate. __________________

16. A study conducted by the National Education Association claims that the proportion of learners who have a visual learning preference is 23%. In a random sample of 1000 CSCC students, only 206 were visual learners. Use the steps below to test the National Education Association's claim at the 0.05 level of significance. (4 points each, unless noted)

a. State the null and alternative hypotheses (indicate the claim as well).

b. Make a sketch of the rejection region(s) and label the critical value(s).

c. Calculate the test statistic and use it to make a decision about the null hypothesis (reject or fail to reject).

d. State your conclusion in terms of the original claim.

e. Give the P-value for this test. (2 points)

f. When do you reject the null hypothesis using the p-value method? (2 points)

g. Suppose I believe H_O **IS NOT** valid. For which of the **TWO** following conditions would the conclusion be "reject H_O?" Circle your answer(s).

Use the same values but increase the level of significance to 0.10

Use the same values but decrease the level of significance to 0.01

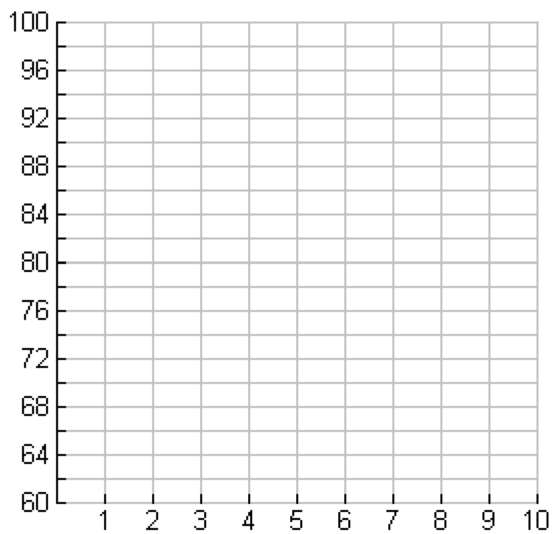
Use the same values (keeping the sample proportion $\hat{p}$ the same) but increase the sample size n to 2000

Use the same values (keeping the sample proportion $\hat{p}$ the same) but decrease the sample size n to 500

17. A student wants to determine the relationship between the number of negative thoughts they have during a test and the grade they get on the test. So the student records the number of negative thoughts and the test grade for six tests he has taken. The student would like to predict the test grade given the number of negative thoughts. (4 points each)

Negative	0	2	3	5	7	9
Test	92	88	82	70	68	65

a. Provide a scatterplot below. Be sure to label both axes with the appropriate measure. (2 points)



b. Compute the correlation coefficient (r).

c. Sketch the rejection region(s) and label the critical values(s) to test for a significant correlation at the .05 level of significance.

d. Calculate the standardized test statistic.

e. State whether there is a significant correlation. (2 points)

f. Provide the regression equation for this data.

g. If this student has 4 negative thoughts during a test, what would you expect to be the test grade?

Appendix C: Background Questionnaire

Background Questionnaire

Student ID ______________

1. Estimate the number of hours per week that you MUST allocate to other responsibilities (i.e., work, parenting, membership in clubs, etc...) __________

2. What is your age? __________
3. Which would you prefer?:
   a) learning on your own   b) learning from another person

4. On a scale of 1(inexperienced beginner) - 10 (expert) assess your expertise with using a computer and the Internet. _____________

5. What is your approximate average (numeric) in this course? _____________

6. How many years did you take mathematics in high school? _____________

7. Do you have High-Speed Internet access at home? _____________

8. What's your cumulative GPA? _____________

Please Circle accordingly.

9. How well did you do in your collegiate mathematics courses?
   Poorly   Straight A's
   1   2   3   4

10. How often do you use computers personally and professionally?
   Never   Multiple hours daily
   1   2   3   4

11. How proficient are you in using the graphing calculator?
   Not at all   Extremely Confident
   1   2   3   4

12. How confident are you that you can MASTER Introductory Statistics Material?
   Not at all   Extremely Confident
   1   2   3   4

13. I typically have a __________ attitude towards my mathematics/statistics courses.
extremely negative   negative   positive   extremely positive

14. I am a self-motivated learner.
   Not at all   Absolutely
   1   2   3   4

Appendix D: Interview Schedule for Faculty

Interview Schedule for Faculty

I am interested in how students in web-based statistics courses perform in comparison to their classroom-instructed counterparts. Also of interest are the experiences shared by both groups of students and you as faculty.

I may occasionally glance up and down at this list of questions just to make sure I am addressing key issues and concerns. When I use the word success, I am referring to a student receiving a C or better.

I am interested in your views and experiences with teaching Statistics in each setting. Also, for anonymity, you may choose the name I use to recant some of your quotes. OKAY?

1) Mr.(s) ______, tell me a little about yourself include your name, background, etc…
a. Encounters with technology (model rockets, BASIC programming, etc.)
b. Personal Path to current position
c. How long you have been in this position?

2) What experience have you had with web-based instruction outside of the Statistics course you currently teach on-line?

3) How has the structure of your web-based course evolved? Describe the interactivity of the content of your course. You may allude to any videos, applettes, or methods of delivering content that actively engages the students in the learning process.

4) Describe your students' response to and familiarity with web-based instruction.

5) In your opinion has conceptual understanding gotten better, worse or been about the same as when you first began? Elaborate.

6) Is there a certain type of student that is more successful in your web-based statistics courses? Conversely, please comment on your experiences with student retention in these courses and what can be done to increase this in the future.

7) How do you handle instruction of topics that you believe to be better understood in an actual classroom?

8) On a scale of 1 – 10 (10 highest), how much value do you place on the incorporation of hand-held technology into Statistics courses? Is it the same for web courses?

9) Do technical requirements affect student success? If so, how?

10) Research has indicated that motivation, attitude, computer expertise, and social interaction with peers can serve as predictors of success in on-line courses.

i) Which 2 of these have you found to have had the most impact on a student's success?

ii) Contrast your traditional students with your "web" ones in terms of each of these variables

11) Which topics do students in web-based courses understand better than students receiving classroom instruction? Select from among:

Descripitive Statistics
Probability
Discrete Random Variables
Continuous Random Variables
Confidence Intervals
Hypothesis Testing
Regression Analysis

12) Same question for topics that are better understood by students receiving classroom instruction.

13) Can students learn Statistics via web-based instruction?

14) Who enjoys the web-based instruction more, you or your students?

15) What are the advantages and disadvantages to teaching statistics via the Web?

16) What are the advantages and disadvantages to learning statistics via the Web?

17) In terms of the future of web-based instruction: Do you foresee the number of sections of web-based courses taught increasing or decreasing over the next 3 years? What about for Hybrid sections. Elaborate on both your teaching and your student's learning experiences with the Hybrid format of instruction.

18) Do you offer your web students the same assessments as your traditional ones? Is there a difference in performance? If so, how?

19) What are the more significant issues with web-based statistics instruction and how do you address them?

20) Are there any areas/questions in reference to web-based statistics instruction that you would like to elaborate on or discuss?

Thank you for the interview and good luck with the rest of the quarter.

*I will give you a copy of a draft of the interview transcription if you'd like.

Appendix E: Survey for Students in the Web-based Sections

Survey for Students in the Web-Based Statistics Sections

Student ID ________________

Directions: Please complete this eight question survey and return via email to jbaker03@cscc.edu. Your responses to this survey will be completely confidential - not even your instructor will know how you answered these questions. You are encouraged to answer these questions as completely as possible.

Q1) How do you feel about your own learning in this course?
**Compare this to other mathematics and/or web-based courses you've taken. **
You may also describe any topics that have been particularly easy or difficult.

Q2) How much do you enjoy the web-based learning environment in general?
How much are you enjoying the web-based learning environment for this class?
Would you consider this course interactive? Explain.

Q3) How much effort are you investing in this course? Why or why not?

Q4) To what extent have any technical difficulties affected your learning of Statistics? Examples may include, but are not limited to, reliability of Internet access, your access to course content, college technical support, etc...)

Q5) What type of interaction do you have with your classmates? Also would you generally say you feel "connected to" or "detached from" your classmates? How important is this type of connection to you?

Q6) What type of interaction do you have with your instructor? Also would you generally say you feel "connected to" or "detached from" your instructor? How important is this type of connection to you?

Q7) Which resource have you found most beneficial? Why? ____

a) Animations, Applettes, or Videos
b) Course Management System (e.g. Hawkes Learning Systems, MyMathLab, etc…)
c) Discussion with classmates
d) Notes posted by instructor (including Power Point Presentations)
e) Supplemental tutorial services
f) Textbook
g) Other: __________________

Q8) What do you like most about learning Statistics in a web-based environment?
What do you like least?