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# Reducing High Attrition Rate in a Business Statistics Course Using an Interpretative Approach Encompassing Diverse Teaching and Learning Styles

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# Reducing High Attrition Rate in a Business Statistics Course Using an Interpretative Approach Encompassing Diverse Teaching and Learning Styles

Pin Ng and James Pinto

## 1. INTRODUCTION

Data for this project were gathered from Fall 1998 to Spring 2001 on 39 different sections of the Introductory Business Statistics course, BA201, taught at the Northern Arizona University, College of Business Administration. This data revealed attrition rates, which consist of percentage of students receiving a grade of D, F or W (for withdrawal after the official drop date), that ranged from 13% to 63% with a mean of 31%, a median of 28% and a standard deviation of 15%. While central administrators at the university were concerned with the retention issue at the various gateway courses, instructors teaching BA201 had expressed concerns and frustrations that students were struggling with learning just the mechanics but not the basic statistical concepts. Many students viewed the content of the course as being dull and mechanical with no direct application to real problems in the business world. The interpretive approach teaching method we have developed is designed to address the above concerns. It has been noted in the literature that while the movement to alternative approaches to the first course in statistics is well established in mathematics and statistics departments, little is known about how the course is approached in other disciplines including business (Moore, 1997a and Garfield, Hogg, Schau, Whittinghill, 2002). Our redesign of the course is in part based on how business students actually used statistics in other higher-level business courses and how they will use statistics in the business world.

The interpretive approach to teaching business statistics is a learner-centered approach to teaching intuitive interpretations of the results of computer generated statistical output with heavy applications to real business problems. As noted in the heavily cited article Felder and Silverman (1988): "Students learn in many ways.… Teaching methods also vary.… Mismatches exist between common learning styles of engineering students and traditional teaching styles of engineering professors." We have witnessed similar phenomenon in teaching statistics at a business school. Felder and Silverman (1988) classify preferred learning styles into four dimensions: (1) sensory/intuitive, (2) visual/verbal, (3) active/reflective, and (4) sequential/global. These four dimensions focus, respectively, on the way people perceive the world, the way people receive information, the mental process by which perceived information is converted to knowledge, and the manner in which people understand and master the material. Teaching styles are also classified into four dimensions according to how well they address the four corresponding learning style components: (1) content can be concrete/abstract, (2) presentation can be visual/verbal, (3) student participation can be active/passive and (4) perspective can be sequential/global. Our redesigned course attempts to adopt a varied teaching style to match students' diverse learning styles in the hope of creating an optimal learning environment for most (if not all) students.

Our approach contains many of the components recommended by Hogg (1992) for a course designed to develop statistical thinking. Equations are introduced only for understanding of concepts, but hand calculations via formulae are not required of students. Instead, Excel® and a specific add-in, PHStat®, are utilized for all statistical computations. Emphasis is placed on interpretations and applications of results. This concrete teaching style on content should help learners who prefer a sensory perception process. On the other hand, the abstract teaching style of discussing equations only for concept understanding should benefit learners who prefer an intuitive perception process. To address the problem of students not being connected to the current material and to allow for a mastery approach of learning course content, students are allowed to take the pre-lecture, post lecture and lab quizzes an unlimited number of times in WebCT®. This self-paced, self-guided mastery approach to learning, which is highly recommended by Pressley and McCormick (1995), enables students who are sensing, active and sequential learners to learn more effectively through drill exercises. The more challenging questions on abstract concepts and fundamental understanding found in post-lecture quizzes, on the other hand, will stimulate and challenge intuitive, reflective and global learners. Our design also fosters a conducive environment for corporative learning among students as advocated by Dees (1991), Garfield (1993), Giraud (1997), Hogg (1991), Johnson and Johnson (1975, 1979 and 1985), Johnson, Johnson and Smith (1991), Keeler and Steinhorst (1995), Sharan (1980), Vygotsky

(1978), Webb (1982, 1983 and 1991), and Wood, Bruner and Ross (1976), among others. Teams are formed to facilitate cooperative learning from all the members of the team and to work together on project reports. This teaching style that emphasizes active mode of student participation will benefit both active and reflective learners. Real business data and problems are used in the lectures, labs, quizzes, exams and projects to help students with sensing and active disposition.

In the new era of information age in which knowledge has a much shorter half-life, the value of a college education needs reassessment. College education must play an important role in teaching students to become proficient life-long learners. In a recent article, Petocz and Reid (2003) study the relationships between students' conceptions of learning statistics and their conceptions of teaching statistics. Students' conceptions of learning are classified into "doing", "collecting", "applying", "linking", expanding" and "changing" while their conceptions of teaching are categorized into "providing essentials", "explaining ideas", "linking concepts", "anticipating learning needs" and "catalyst for open-mindedness". It was found that students demonstrated a range of conceptions of learning from limiting to expanding. It also showed that students expressed a range of ways that they experienced teaching, and their experience on learning and their conceptions on teaching were related. One of the implications of this finding on statistics pedagogy is that the design of a total learning environment will have to acknowledge these variations, and provide activities and assessment that encourage students to change their ways of thinking about learning and teaching statistics towards the more inclusive levels. They argue that:

> It is easy to construct classroom activities and assessment tasks that cater for the lower levels of learning statistics and that sit well within the realm of the lowest level of teaching statistics…. However, the same question set in a specific situation where students are asked to explain the *meaning* of these observations and summary statistics for the *people* involved (such as a client or a colleague) immediately shifts students' focus. This sort of question also implies a more reflective style of teaching rather than the provision of simple definitions and worked solutions in class, and technically-focused assessment questions that are so often the result of time pressures, constraints in content, and ease of marking (Petocz and Reid, 2003, pp. 50-51.)

To promote the highest level of learning, teachers are encouraged to influence students' conceptions of teaching by moving the focus of their teaching from the essentials towards supporting students in their own learning, holistically, and beyond the arbitrary boundaries of the subject, which can in turn encourage students towards more inclusive views of their own learning. Heeding this advice, also built into our redesign are various incentives to motivate students to take learning responsibility into their own hands. The major theme and philosophy of our redesigned course is that "Students must take responsibility for their education and instructors must assume the new role as facilitators of learning in a cooperative learning environment in addition to the traditional role as deliverers of knowledge."

Chance and Garfield (2002) argue that there are pressing needs to document evidence of the effects of the instructional changes on students and to identify the most effective instructional techniques. They also point out that in the educational setting, randomization is not really possible, especially when we are looking for semester long or long-term effects and, hence, it is impossible to maintain the independence of observations that is assumed in traditional statistical techniques. Nevertheless, we have collected data in a "not fully controlled" environment and attempted to perform statistical analysis in hope of shedding some light on the efficacy of the redesigned course. Our findings may not be fully generalized to other situations prior to the development of the more appropriate new statistical techniques, but it does provide a description and summary of our experiment. In Section 2, we describe our concerns on student learning in further detail while Section 3 discusses the interventions we have adopted and the rationale for the interventions. The data collection process and the analysis of the results from the interventions are discussed in Section 4. Section 5 summarizes our main findings and experience.

## 2. STUDENT LEARNING CONCERNS

BA201 had been taught through a traditional calculation-based approach that we believed had contributed to the disassociation of the connections among concepts and applications. Many of the current textbooks in business statistics rely on material that originated in the field of mathematical statistics; thus, they have put too much emphasis on calculations and proofs based on equations and formulae and not enough emphasis on interpretation and application. Students exert a tremendous amount of energy learning the mechanics of computing the various statistics with hand-held calculators and memorizing the recipes of the various testing and estimation techniques, but fail to take the additional step of internalizing the concepts behind the mechanics and applying them to real problem solving. They learned the "**How** to compute various test statistics and perform estimations?" but failed to see the

"**Why** is there a need to test or estimate?" and the "**What** implications and interpretations do the mechanical results provide?" However, most of our students do not plan to pursue a degree or a career in statistics. Statistics is just a tool needed for them to be effective managers in their chosen career path. Hence, knowing the **why** and **what** in statistics is more important than learning the **how**.

Majority of the students take the course not because they are interested in the subject, but because it is one of the core courses required to complete their degree. In addition, the quantitative nature of the subject also imposes a high demand on students' limited analytical thinking skills. Our students in general are very ill prepared in this area. Many in the College of Business have minimized the number of mathematics-related courses taken. Accentuated by their poor self-management skills, we believe high attrition rate is just a by-product or symptom of the root problem that students are not learning the basics of business statistics, because they do not have the skills to get beyond the formulae and equations no matter if the textbook does provide interpretations and applications related to business. This is further compounded by the lack of a proper motivation scheme in the course. Since students were assessed on their performance mainly through traditional exams, there was little or no incentive for them to go beyond learning the mechanics. They could simply memorize the formulae and the mechanics of the various testing and estimation techniques, and regurgitate them during the written exams. Applied problems in the assigned homework were treated as opportunities to refine the mechanical skills without any attempt to internalize the underlying fundamental concepts.

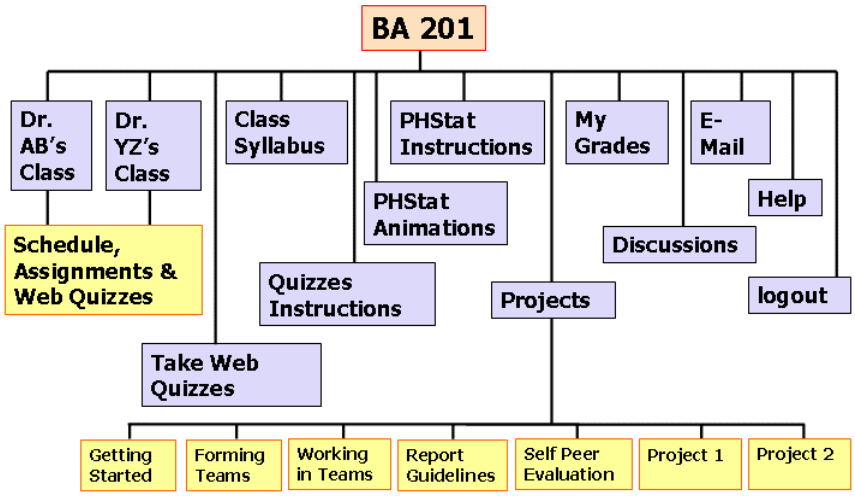
## 3. INTERVENTIONS

We view our biggest challenge as training students to be able to translate abstract business statistic concepts into daily language and to see how those abstract concepts are applied to solve real business problems via a more interpretive approach. In redesigning the course, we build in assessment components in addition to the traditional assess-through-exams model to help students succeed through continuous input of their efforts from day one. Our redesign of the course has a heavy cooperative learning component, because we believe that students can learn better when they are able to receive from and provide help to their fellow classmates. This also closely emulates the life-long learning environment in today's work place. Designing the whole course around a web course portal like WebCT allows us to include varied teaching style to better accommodate the diverse learning styles of the students.

### 3.1 SETUP OF THE REDESIGNED COURSE

The redesigned course consists of the following major components: (1) multi-media learning resources with animations are delivered to students 24 hours a day, 7 days a week via WebCT, (2) in-class lectures have shifted from the traditional instructors-to-students interaction to incorporate students-to-students interactions, (3) students work intensively in teams on team projects that utilize real data and real problems, and are required to present their findings in a form of a formal business report, (4) pre-lecture, post-lecture and lab quizzes are web quizzes delivered through WebCT with immediate feedback to foster timely learning, and they are due weekly to encourage students taking responsibility and discourage procrastination, and (5) e-mail and discussion areas are heavily utilized to foster students-to-students and instructors-to-students teaching and learning outside the classroom. Web technology plays a heavy role in the whole design to help us provide many of the materials that have to be delivered traditionally through lectures. This enables us to better use the contact time in lectures to emphasize concepts, illustrate interpretation of numerical results and demonstrate applications to business problems. WebCT is being used as the course portal because it is the platform adopted and supported by the university. The site map for the course is illustrated in Figure 1.

Figure 1
**Site Map for the Course**




On a three-day schedule, students meet in regular classrooms for two days and spend the remaining day in a computer lab. On a two-day schedule, one of the days is spent in the computer lab (See Appendix 6: Class Schedule). Realistic business problems and data set serve as the central connecting thread of activities in lectures and lab sessions. Lecture time is used primarily to provide motivation, discuss appropriate solution, demonstrate related Excel skills needed and provide interpretations for the chosen problems. Lab sessions are used to provide students with hands-on experience on problem solving using Excel generated output. To closely replicate the team culture that dominates modern day business environments, the class is divided into teams. The teams sit together in lectures and lab sessions to facilitate interaction among team members and between teams.

PowerPoint slides on material relevant for a lecture and animation movie files illustrating the procedure of generating the needed Excel and PHStat output are assigned as reading and delivered to students via WebCT. Students are expected to have completed these reading assignments before coming to class to enable them to effectively participate in discussions. The three different types of web quizzes play a significant role in the course design. Pre-lecture web quizzes are due before a lecture and serve as an incentive for students to complete the assigned reading before attending class. These quizzes contain questions that are at the "knowledge" level in the Bloom's taxonomy (Bloom and Krathwohl, 1956). They only require students to be able to elaborate, encode and retrieve information from memory after completing their reading assignment. Post-lecture quizzes, on the other hand, are designed to ensure that the students have internalized the fundamental concepts learned in lecture. These questions are more challenging than the pre-lecture quiz questions. They are at the higher "comprehension", "application", and "analysis" level in the Bloom's taxonomy. Lab quizzes are designed to assure that students are able to perform the Excel and PHStat procedures to generate output for the relevant analysis. The actual questions cover not only the mechanics of how to use Excel but also using the output to answer questions associated with business problems. If the correct Excel tools are not used, then the answers to the questions will not be correct. Samples of the pre-lecture, post-lecture and lab quizzes are presented in Appendix 1, 2 and 3, respectively. In addition to completing lab quizzes, lab time is also used to work on other web quizzes and to work on team projects.

There are two team projects that the students are required to complete. The first project deals with descriptive statistics. It is assigned early in the semester. We ask the students to perform more analysis than can be fit within a five page business report. The idea is for the team members to make decisions on what is important enough to be included in the report. The report has the following format constraints: (1) a one page executive summary, (2) five pages in the body and (3) an annotated appendix of unlimited length. No statistical jargon ("statistics speak") is allowed in the executive summary and the body of the report. A typical grading scheme that we adopt is presented in Table 1.

Table 1
**Breakdown of Point Assignments on a Project**

| | High | Medium | Low |
|---|---|---|---|
| **Presentation of Results** | **40** | **32** | **24** |
| Executive Summary | 10 | 8 | 5 |
| Intuition | 10 | 7 | 6 |
| Recommendations | 10 | 9 | 7 |
| Sample Description | 5 | 4 | 4 |
| Charts, PHStat and Appendix | 5 | 4 | 2 |
| **Statistical Analysis** | **40** | **32** | **23** |
| Formulation of variables | 10 | 7 | 5 |
| Analysis of Excel output | 10 | 7 | 5 |
| Interpretation of the Excel output | 20 | 18 | 13 |
| **Points for Initiative** | **20** | **16** | **10** |
| **Raw Report Score** | **100** | **80** | **57** |
| **Self/Peer Evaluation %** | **100** | **50** | **0** |
| **Self/Peer Evaluation Score (Self/Peer Evaluation % * 0.20)** | **20** | **10** | **0** |
| **Report Score (Raw Report Score * 0.60 ) [if Self/Peer Evaluation % >= 80%]** | **60** | | |
| **(Raw Report Score * 0.60 * Self/Peer Evaluation %) [if Self/Peer Evaluation % < 80%]** | | **24** | **0** |
| **Score Earned from Project Web Quiz (Project Web Quiz Score % * 0.20)** | **20** | **16** | **10** |
| **Total Individual Project Score** | **100** | **50** | **10** |

Points are given for intuition if the report contains insights about the problem that are not obvious from the questions asked. Points are given for initiative if the report contains relevant analysis beyond what is required. The Self/Peer evaluation score serves the purpose of discouraging free-riders in the teams while project web quiz is used to assess the accuracy of the data analyses. The second project focuses on confidence intervals and hypothesis tests. Our requirement of no statistical jargon is more challenging with this project, but the students have in the past risen to the task since they have already had practice in doing so with the first project. In an ideal setting, we would like to have a project associated with regression analysis, but the material is not covered until the end of the semester making it difficult to have such a complex assignment during a time when students are pressed for time.

Discussion areas (bulletin boards) are created and organized according to their functional aspect in WebCT to foster communications among students, and between students and instructors. They are the first place students go for help for questions on the quizzes, lecture materials, and team projects. Each team has its private discussion area that they use to coordinate activities on the team projects. A snap-shot of the discussion areas is presented in Appendix 4. E-mail is used only for private matters including the turning in of the team projects. At the end of the semester, we expect students to

1. have a sound understanding of the relationship between a population and a sample, and the stochastic (random) nature of various test statistics
2. feel comfortable about applying the various statistical techniques learned in the class to real problems
3. be competent in performing statistical analysis in EXCEL
4. have become an effective self-learner
5. have acquired skills needed to work effectively in a team environment
6. have learned good business report writing skills
7. feel comfortable in front of a computer

### 3.2 INTERVENTIONS FOR NOT LEARNING THE BASIC CONCEPTS

Given the way our students will actually use statistics in the business world, it is more important for them to be able to translate abstract statistical concepts into daily non-technical language rather than to use "statistics speak" or statistical jargon. For example, if a student were attempting to explain to others in the firm in a report or in an oral presentation the coefficient of variation in order to compare the relative returns on two investment portfolios, very few people would remember or understand that $CV = \left( \frac{S}{\overline{X}} \right) \bullet 100\%$. But if the student would speak in terms of comparing the risk of possible returns normalized to the same per unit expected returns in each portfolio, then his or her audience would be much more likely to understand the relevant points. We believe that students will more likely to have learned and internalized the underlying abstract concepts when they are able to communicate their findings in simple everyday language instead of regurgitation with jargon. Thus, the lectures emphasize interpretation of the results rather than the process of obtaining the numerical results.

In a business world situation, our students are more likely to either (a) generate statistics and inferences using a spreadsheet or statistical package, or (b) be given the results of such analysis to interpret rather than use the equations and formulae found in business statistics textbooks. There has been a trend over the last several years to include Excel®, SAS®, Minitab® and other such output in these texts, but the old holdovers of equations and formulae still dominate. (Albright, Winston & Zappe, 2003, Anderson, Sweeney & Williams, 2003) These texts have also begun to include case studies and real data sets. But, the body of the texts does not in general provide intuitive interpretations of the material presented and there is a general lack of guidance on how to apply material to case studies and real data sets. In our approach, Excel and PHStat are used but not as ends in themselves. We rely on in-class and lab demonstrations of how to use Excel. Students are expected to know what the output means and be able to provide intuitive explanations to be applied to actual problems. We still introduce conceptual equations to students in order to develop an intuitive understanding of the fundamental concepts, but we never show the actual computation involving the equations. They are not expected to be able to perform hand calculations. This de-emphasis on formulae and emphasis on interpretation attempts to provide a better balance of concrete information (facts, data, results) and abstract concepts (theories, mathematical models) and work in favor of students who have inclination towards both the sensing and intuitive learning styles.

### 3.3 INTERVENTIONS FOR THE DISCONNECTION FROM REAL BUSINESS WORLD

As argued in Felder and Silverman (1988, p. 678), majority of the students are inductive learns who "need motivation for learning. They do not feel comfortable with the 'Trust me – this stuff will be useful to you some day approach: like sensors, they need to see the phenomenon before they can understand and appreciate the underlying theory." To help students see that what they learn in the course are essential tools expected from managers in the various functional areas of business, data sets and problems encountered by real businesses play a central role in the whole design of the course. The use of real data in our approach differs from the typical case study found in most textbooks by actually demonstrating to the students how data are used in the context of a problem. This process is integrated into all aspects of the course including lectures, labs, quizzes, exams and team projects. Data analysis becomes just one step in the process of solving business problems. In this sense, the mechanical skill of data analysis is useless to the student unless intuitive insights on the type of analysis must be performed, and non-technical interpretations can be applied using the results of the analysis.

In a typical lecture, once the facts for an example problem are presented and studied, individual teams are asked to collectively determine intuitive approaches to solving the problem and decide what statistical methods are most suitable for the analysis. After consensus is reached on the statistical analysis, the instructor demonstrates how the relevant Excel output can be generated. The teams are then asked how the output can be used to intuitively explain the solution to the problem. At this point, the students are expected to explain the solution with and without the use of statistical jargon in order to practice looking at technical statistical output and then translating it into everyday language. The combination of fact, real data, result presentation with emphasis on problem-solving methods and in-class discussions and brain-storming allows sensing, active and sequential learners to better perceive and process the knowledge while still challenges intuitive, reflective and global learners.

### 3.4 INTERVENTIONS FOR STUDENTS NOT TAKING RESPONSIBILITY

In our traditionally taught business statistics course, students hold the view that the professor should teach them everything necessary for the course as they sit as isolated individuals not actively connected to the current material or the class. They percolate their conceptions, learning and expectations of teaching to the lowest level of Petocz and Reid's classification. In addition, procrastination in completing all aspects of the course is a major obstacle to learning and retention of what is learned. Our approach to the course attempts to minimize both of these types of problems through a teaching style that emphasizes an active student participation.

We attempt to make the students active stake-holders in the course by allocating 50% of the course grade to activities entirely under their control. Twenty percent of the course grade is tied to web quizzes. Multiple attempts are allowed on these quizzes (not major exams) to encourage the students to take responsibility for their education by mastering the material. They can retake the quizzes as many times as necessary to master the material. Feedback is given on each question to lead the student to the correct answer without giving them the answer. There is a greater chance they have read the assigned material before the lecture since a pre-lecture quiz is to be completed before they come to that lecture. Rolling deadlines are used for all types of quizzes to help assure that the students are activity connected to the current lecture material when it is being presented, reduce procrastination and achieve just-in-time learning. Thirty percent of the course is tied to team projects. Using the self-peer evaluation system, students as individuals on a team as well as a group control the output of the project and help assure they are active members of the class. The interactive drill exercises through the web quizzes provide sensing, active and sequential learners with a more conducive environment to master the fundamental concepts through active participation while the more abstract conceptually oriented questions in post-lecture quizzes and the open-ended nature of the team projects allow intuitive, reflective and global learners an opportunity to shine.

In addition, we use the name card system to automatically take attendance. Our cumulative 40 years of teaching business statistics have given us an insight on what is very obvious. Students who attend class have better results in all aspects of the course. We allow 0.5 points to be added to the course average for each class attended to a maximum of 2.5 points. We subtract 2 points from the course average for each class missed up to a possible loss of one letter grade. This system puts the student in control of the adjustment to the course average at the end of the semester. In addition this system enables us to learn the students' names quickly.

So our students take responsibility for their own education by mastering material found in web quizzes, by taking web quizzes when the associated material is in lecture, by being an active member of a team and by attending class.

## 4. DATA COLLECTION AND ANALYSIS RESULTS

Eight different sections of the redesigned course were taught by the first and second authors from the Fall 2002 to Spring 2003 semesters. One section of the traditional course was still offered and taught by the second author in Fall 2002 so that data on the pre and post-design change could be collected and compared. The traditional course relied heavily on the use of calculator-aided solving of equations, the use of both conceptual and computing equations, the use of statistical tables to determine probabilities and critical values, and the use of problem-based exams with written answers. After deleting the missing data, the sample for the redesigned course contains 173 observations. The descriptive statistics for the various components of the redesigned course are presented in Table 2. The same assessment test was administered on the first day and the last day of the semester to measure their learning gain. The scores are named "pre-assessment" and "post-assessment" in Table 2. "Classes missed" is the number of classes that a student has missed out of a total of 30 classes. "Exam score" is the average of two mid-term and one final exams with weights, 15%, 15% and 20%, respectively. "Quiz average" records the average of 13 pre-lecture, 13 post-lecture and 11 lab quizzes while "project average" is the individual average score of 2 team projects, which includes the team report scores, individual project web quiz scores and individual self-peer evaluation scores. Data on learning styles were collected when students took a learning styles survey designed by Felder and Soloman at http://www.ncsu.edu/felder-public/ILSdir/ilsweb.html at the beginning of the semester. Scores on the four indices: active/reflective, sensing/intuitive, visual/verbal and sequential/global are coded on a scale from 11 to –11 in decrements of 2. They are named ACT/REF, SEN/INT, VIS/VER and SEQ/GLO in Table 2. A score between 9 and 11 on ACT/REF indicates a strong preference for active (ACT) learning style, a score between 5 and 7 indicates a moderate preference for active learning style, and a score between 1 and 3 indicates a fairly well balanced disposition while a score in the negative range points to a preference for the opposite dimension.

Table 2
**Descriptive Statistics of the Various Components in the Redesigned Course**

| | Pre-Assessment | Post-Assessment | Classes Missed | Total | Final Exam | Exam Score |
|---|---|---|---|---|---|---|
| Mean | 50.40 | 66.01 | 2.06 | 84.65 | 75.24 | 76.13 |
| Standard Error | 0.98 | 1.14 | 0.16 | 0.79 | 1.43 | 1.12 |
| Mode | 45.00 | 75.00 | 0.00 | 84.14 | 72.51 | N/A |
| Standard Deviation | 12.85 | 14.94 | 2.16 | 10.36 | 18.77 | 14.71 |
| Sample Variance | 165.24 | 223.24 | 4.68 | 107.25 | 352.36 | 216.51 |
| Kurtosis | -0.32 | 0.08 | 2.06 | 1.17 | -0.30 | -0.26 |
| Skewness | 0.20 | -0.60 | 1.35 | -0.78 | -0.18 | -0.20 |
| Range | 60.00 | 75.00 | 10.00 | 68.10 | 96.87 | 80.71 |
| Minimum | 25.00 | 20.00 | 0.00 | 41.74 | 26.86 | 37.25 |
| First Quartile | 40.00 | 55.00 | 0.00 | 78.94 | 61.49 | 66.50 |
| Median | 50.00 | 70.00 | 2.00 | 86.41 | 76.41 | 77.36 |
| Third Quartile | 60.00 | 75.00 | 3.00 | 91.60 | 89.47 | 85.73 |
| Maximum | 85.00 | 95.00 | 10.00 | 109.84 | 123.73 | 117.96 |
| Sum | 8720.00 | 11420.00 | 356.00 | 14644.29 | 13017.22 | 13170.60 |
| Count | 173 | 173 | 173 | 173 | 173 | 173 |

| | Quiz Average | Project Average | ACT/REF | SEN/INT | VIS/VER | SEQ/GLO |
|---|---|---|---|---|---|---|
| Mean | 89.96 | 88.84 | 0.70 | 2.57 | 5.04 | 1.14 |
| Standard Error | 0.82 | 0.53 | 0.38 | 0.40 | 0.38 | 0.32 |
| Mode | 100.00 | 97.60 | 1.00 | 5.00 | 9.00 | -1.00 |
| Standard Deviation | 10.84 | 7.01 | 4.94 | 5.29 | 4.97 | 4.19 |
| Sample Variance | 117.48 | 49.15 | 24.39 | 28.03 | 24.74 | 17.54 |
| Kurtosis | 2.66 | 11.04 | -0.87 | -0.49 | 0.27 | -0.19 |
| Skewness | -1.56 | -2.53 | -0.13 | -0.45 | -0.96 | -0.05 |
| Range | 54.45 | 54.85 | 18.00 | 22.00 | 20.00 | 22.00 |
| Minimum | 45.55 | 42.75 | -9.00 | -11.00 | -9.00 | -11.00 |
| First Quartile | 84.13 | 87.28 | -3.00 | -1.00 | 2.00 | -1.00 |
| Median | 93.37 | 91.09 | 1.00 | 3.00 | 7.00 | 1.00 |
| Third Quartile | 98.17 | 92.70 | 5.00 | 7.00 | 9.00 | 5.00 |
| Maximum | 100.00 | 97.60 | 9.00 | 11.00 | 11.00 | 11.00 |
| Sum | 15563.02 | 15369.41 | 121.00 | 444.00 | 872.00 | 198.00 |
| Count | 173 | 173 | 173 | 173 | 173 | 173 |

### 4.1 ATTRITION RATE

The combined attrition rate (D, F or W) of the redesigned course from Fall 2002 to Spring 2003 is 14.75% with a 95% confidence interval of [10.3%, 19.2%]. This is a significant reduction from the combined rate of 29.50% with a 95% confidence interval of [27.06%, 31.95%] from before Fall 2002. The attrition rate of the one traditional section offered in Fall 2002 that had 22 students was 25% with a 95% confidence interval of [7.7%, 42.3%].

### 4.2 LEARNING GAIN

There are 20 questions in the assessment test. The questions on the assessment test can be found in Appendix 5. Unlike all the web quizzes, students have only one try on the pre and post-assessment tests. To provide an incentive for students to take the test, we counted the pre and post-assessment tests as two of the web quizzes and gave

students a 100% as long as they completed the tests regardless of their actual scores on the tests in Fall 2002. However, we felt that the actual scores did not accurately measure their true effort and knowledge because many of them would simply complete the test with minimal effort to receive the 100%, especially since the post-assessment was administered after the final exam. In Spring 2003, we modified the incentive scheme and gave students a 100% when they completed the pre-assessment test but their scores on post-assessment scores were used as extra credit points towards their final exam for which they could earn 0.25 of an extra credit point for each correctly answered question to a maximum of 5 points. We believe this provides a better motivation for students to take the post-assessment test more seriously and, hence, reflects their true knowledge better. Based on the results from 88 students in the Spring 2003 semester, the one-tail pair-sample *t* test on the average improvement from the beginning to the end of the semester yields a one-tail p-value of 3.55 E-27, which shows significant evidence of improvement in the average assessment score. The 95% confidence interval for the average difference score is [15.93%, 22.02%], which corresponds to an improvement of at least 3 out of 20 questions. The 95% confidence interval for the average difference score for the traditional section with 14 students who completed both quizzes in Fall 2002 is [-3.14%, 15.28%]. The p-value of the one-tail *t* test on average improvement is 8.9%. There is no statistically significant improvement on learning gain for students in the traditional sections at 5% level of significance.

### 4.3 PERFORMANCE AND ATTENDANCE

Using total score as the measurement of performance in the course and partial out the effect of average exam score, average project score, average quiz score and the learning style indices, the partial sample correlation coefficient between performance and number of classes missed is –0.53. The p-value of the *t* test on the zero population correlation is 7.47 E-14. Hence, at any reasonably small level of significance, there is ample evidence of a correlation between performance and attendance.

### 4.4 PERFORMANCE AND LEARNING STYLE

To test whether learning styles affect total score, we perform a partial *F* test on the null hypothesis that the four indices on learning styles do not affect total score collectively after taking into account the effect of exam score, number of classes missed, quiz average score and project average score. The regression outputs are given in Table 3 and Table 4. The value of the partial *F* test statistic is 1.27 with a *p*-value of 0.28. At the usual 5% level of significance, there is not sufficient evidence to show that learning styles affect performance in the course. The *p*-value of the *t* test on the effect of each of the learning style index on the total score is also larger than 5%. Hence, none of the learning style indices are significant in affecting performance in the course collectively or individually. This is reassuring because we are somewhat concerned that the heavy reliance on the web technology may hinder students who have a preference on reflective and sequential learning styles.

Table 3
**Least Squares Regression Output of Total Score on All Components**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9787 |
| R Square | 0.9579 |
| Adjusted R Square | 0.9559 |
| Standard Error | 2.1759 |
| Observations | 173 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 8 | 17670.2217 | 2208.7777 | 466.5231 | 1.3306E-108 |
| Residual | 164 | 776.4664 | 4.7346 | | |
| Total | 172 | 18446.6882 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 3.5840 | 2.3669 | 1.5142 | 0.1319 |
| Exam Score | 0.4902 | 0.0132 | 37.1795 | 8.1767E-82 |
| Classes Missed | -0.7400 | 0.0927 | -7.9800 | 2.4023E-13 |
| Quiz Average | 0.2095 | 0.0223 | 9.3780 | 5.3397E-17 |
| Project Average | 0.2976 | 0.0284 | 10.4862 | 5.1903E-20 |
| ACT/REF | 0.0467 | 0.0355 | 1.3156 | 0.1902 |
| SEN/INT | -0.0411 | 0.0366 | -1.1229 | 0.2631 |
| VIS/VER | 0.0145 | 0.0352 | 0.4122 | 0.6808 |
| SEQ/GLO | -0.0200 | 0.0458 | -0.4371 | 0.6626 |

Table 4
**Least Squares Regression Output Of Total Score On All Components But Learning Style Indices**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.9781 |
| R Square | 0.9566 |
| Adjusted R Square | 0.9556 |
| Standard Error | 2.1828 |
| Observations | 173 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 17646.2113 | 4411.5528 | 925.8742 | 2.848E-113 |
| Residual | 168 | 800.4769 | 4.7647 | | |
| Total | 172 | 18446.6882 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 4.4688 | 2.3390 | 1.9105 | 0.0578 |
| Exam Score | 0.4881 | 0.0127 | 38.3973 | 4.3507E-85 |
| Quiz Average | 0.2054 | 0.0218 | 9.4103 | 3.7149E-17 |
| Classes Missed | -0.7471 | 0.0918 | -8.1410 | 8.4212E-14 |
| Project Average | 0.2935 | 0.0280 | 10.4823 | 4.2493E-20 |

In their influential text, Mosteller and Tukey (1977, p. 266) remarked that:

> What the regression curve does is give a grand summary for the averages of the distributions corresponding to the set of $x$'s. We could go further and compute several different regression curves corresponding to the various

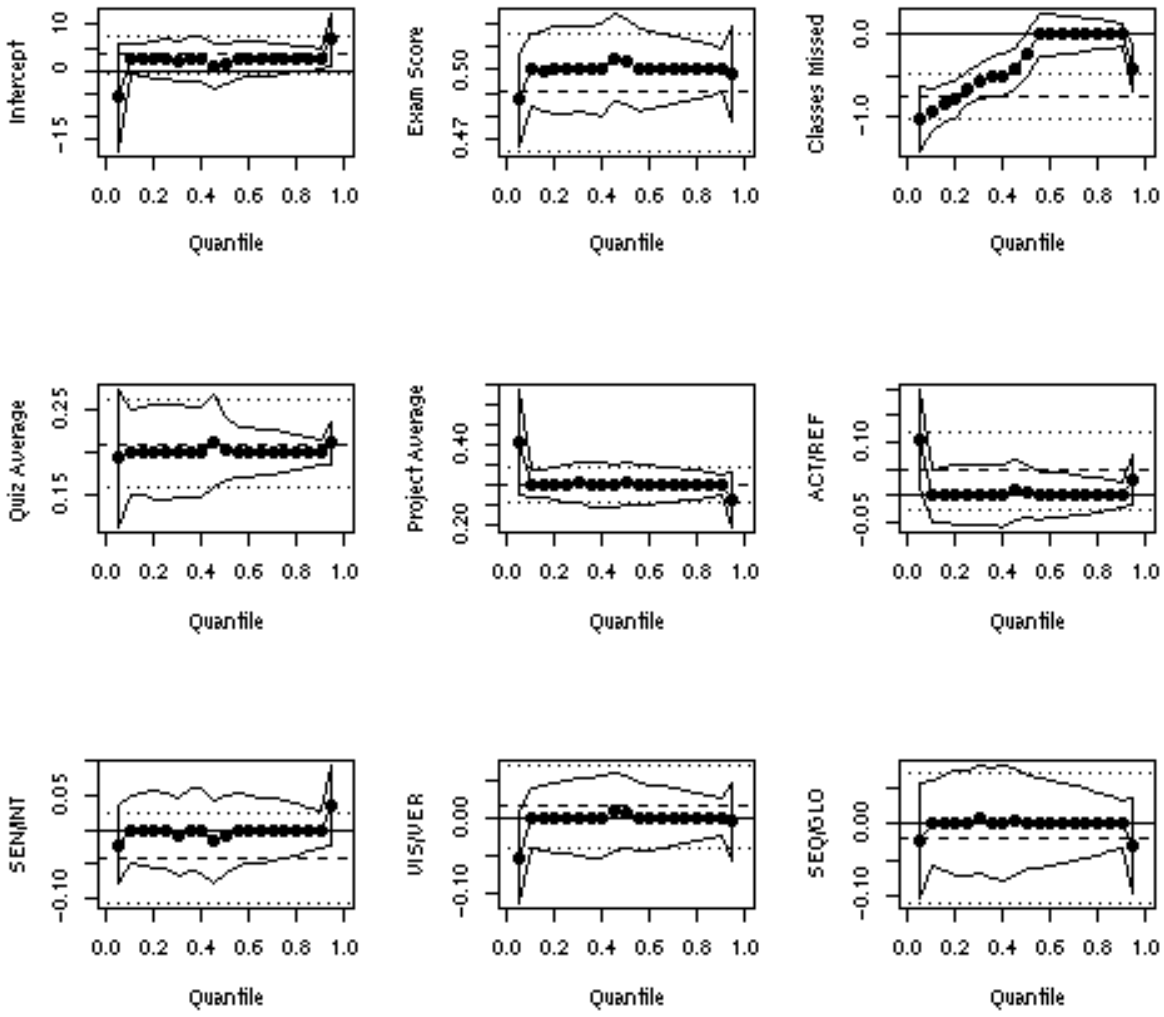
> percentage points of the distributions and thus get a more complete picture of the set. Ordinarily this is not done, and so regression often gives a rather incomplete picture. Just as the mean gives an incomplete picture of a single distribution, so the regression curve gives a correspondingly incomplete picture for a set of distributions.

In an attempt to obtain a more complete picture of the effect of learning styles on students' performance, we also performed a regression quantile analysis first proposed by Koenker and Bassett (1982). Koenker and Hallock (2001) give an excellent non-technical introduction to quantile regression. The quantile regression estimates are obtained using algorithms based on Koenker and D'Orey (1987), and Portnoy and Koenker (1997) written for the *R* package available at http://www.r-project.org/. Plotted as solid curve with filled circles in each panel of Figure 2 is the 19 distinct quantile regression estimates corresponding to the 19 different quantiles ranging from 0.05 to 0.95 in steps of 0.05 for each of the eight covariates plus the intercept. For each covariate, these 19 point estimates can be interpreted as the impact of a one-unit change in the covariate on the change in the corresponding quantile total score. The bands around the solid curve are the 95% point-wise confidence band for the quantile regression estimates. The horizontal dash lines represent the least squares estimate of the conditional mean effect while the two dotted lines depict the 95% confidence interval for the least squares estimated coefficient.

The solid curve with filled circles in the first panel for the intercept can be interpreted as the estimated conditional quantile function of a student who receives a zero on exam score, has not missed a single class, scores a zero on quizzes average, earns a zero on project average and has no particular preference on all four of the learning indices. From the first panel, we can see that the estimated total score for such a student is zero for all quantile values except for a $95^{th}$ percentile student who will have an estimated total score of 6.78 points with a 95% confidence interval of [1.08, 12.48] points. The effects of exam score, quiz average and project average on total score are quite uniform across the different quantiles of the conditional distribution and their values are quite consistent with those of their least-squares counterparts. An interesting exception is the effect of the number of classes missed. It appears that holding the values of all the other covariates fixed, students in the lower percentile suffer more negatively for skipping classes. For example, for a $45^{th}$ percentile student, the total score decreases by about an estimated half a point for each class missed while the total score decreases by as many as one estimated full point for each class missed for a $5^{th}$ percentile student. For students between the $50^{th}$ and $90^{th}$ percentiles, the number of classes missed does not have any effect on their total score while it has a negative impact of about half a point for students in the extreme $95^{th}$ percentile of the conditional distribution. This suggests that attending classes is crucial for the weaker students. What is encouraging from the last four panel of Figure 2 is that none of the learning style indices have any impact on total score, which is consistent with the finding obtained from the least squares conditional mean estimates.

Figure 2

**Regression Quantile Estimates from Regression of Total Score on Exam Score, Classes Missed, Quiz Average, Project Average, ACT/REF, SEN/INT, VIS/VER and SEQ/GLO**




**4.5 EXAM SCORE AND LEARNING STYLES**

When analyzing the effect of learning styles on exam performance, we found that disposition to reflective and verbal learning styles have positive impact on exam performance as can be seen from Table 5. The *F* test statistic computed from Table 5 and Table 6 for testing the collective impact of learning style on exam score is 3.40 with a *p*-value of 0.01. Hence, there is sufficient evidence to conclude that different learning styles impact on exam performance at the 5% level of significance. Investigating the *t* test on the effect of individual learning style indices reveals that ACT/REF is marginally significant at 5% and VIS/VER is significant at 5% in affecting performance on exams. The reflective and verbal learners tend to perform better on the exams. This finding is not surprising at all because many questions on the exam test interpretation of abstract concepts rather than the concrete mechanical process of generating statistical output. Since interpretation of abstract concepts involves verbalization, it is natural for verbal learners to gain a slight edge over visual learners.

Table 5

**Least Square Regression Output of Exam Score on All Components**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.5183 |
| R Square | 0.2686 |
| Adjusted R Square | 0.2376 |
| Standard Error | 12.8479 |
| Observations | 173 |

ANOVA

| | *Df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 7 | 10003.6074 | 1429.0868 | 8.6575 | 4.9245E-09 |
| Residual | 165 | 27236.3855 | 165.0690 | | |
| Total | 172 | 37239.9929 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* |
|---|---|---|---|---|---|
| Intercept | 8.4587 | 13.9600 | 0.6059 | 0.5454 | -19.1045 |
| Classes Missed | -0.2841 | 0.5471 | -0.5192 | 0.6043 | -1.3644 |
| Quiz Average | 0.5141 | 0.1257 | 4.0895 | 0.0001 | 0.2659 |
| Project Average | 0.2846 | 0.1661 | 1.7129 | 0.0886 | -0.0434 |
| ACT/REF | -0.4093 | 0.2073 | -1.9746 | 0.0500 | -0.8187 |
| SEN/INT | -0.2383 | 0.2155 | -1.1059 | 0.2704 | -0.6639 |
| VIS/VER | -0.4358 | 0.2049 | -2.1266 | 0.0349 | -0.8404 |
| SEQ/GLO | -0.1553 | 0.2704 | -0.5743 | 0.5666 | -0.6891 |

Table 6

**Least Square Regression Output of Exam Score on All Components but Learning Style Indices**

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.4564 |
| R Square | 0.2083 |
| Adjusted R Square | 0.1942 |
| Standard Error | 13.2083 |
| Observations | 173 |

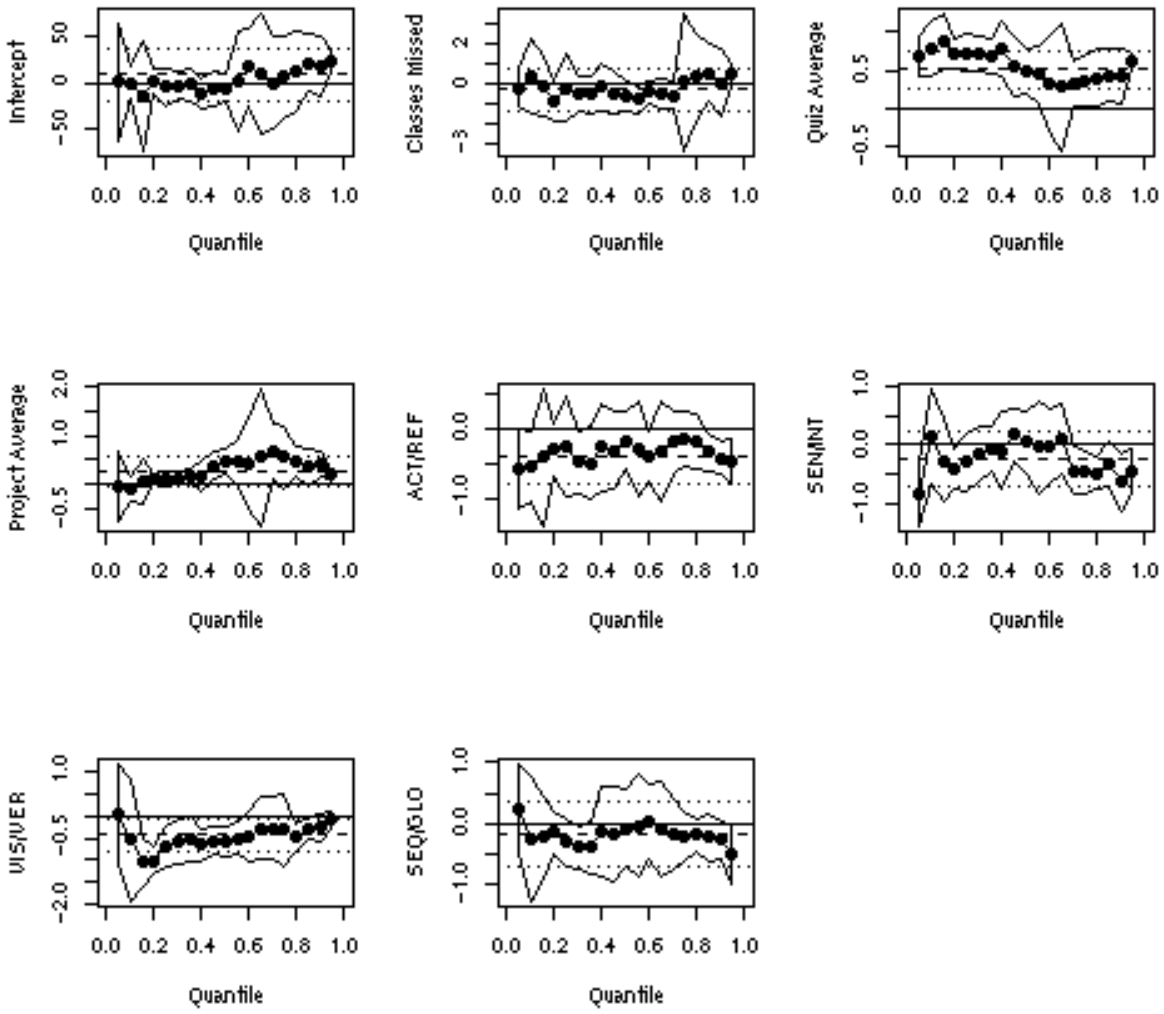
ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 7756.2241 | 2585.4080 | 14.8195 | 1.3060E-08 |
| Residual | 169 | 29483.7687 | 174.4602 | | |
| Total | 172 | 37239.9929 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 6.8121 | 14.1439 | 0.4816 | 0.6307 |
| Quiz Average | 0.5043 | 0.1263 | 3.9941 | 0.0001 |
| Classes Missed | -0.0626 | 0.5553 | -0.1128 | 0.9104 |
| Project Average | 0.2710 | 0.1681 | 1.6118 | 0.1089 |

The quantile regression estimates for the effects of the various covariates on exam score is given in Figure 3. The quantile regression estimates reveal more information on the effect of the four learning style indices on performance on exams. For the higher percentile students, having a preference on reflective, intuitive and verbal learning style appears to help perform better in the exams. The 15th, 20th, 25th, 30th, 40th, 45th, 50th, 55th, 80th and 85th percentile students seem to do better on exams from being verbal learners. The quiz average has a higher impact on exam score for the lower percentile students than the higher percentile students.

Figure 3
**Regression Quantile Estimates from Regression of Exam Score on Classes Missed, Quiz Average, Project Average, ACT/REF, SEN/INT, VIS/VER and SEQ/GLO**




### 4.6 EFFECT OF WEB QUIZZES ON EXAM PERFORMANCE

Investigating the *t* test statistic of quiz average on exam score in Table 5 reveals that performance on web quizzes is highly significant in impacting performance on exams. This indicates that the web quizzes are useful tools in preparing students for the traditional assessment through exams format. Investigating the quantile regression estimates presented in Figure 3, almost all students except the 60th and 65th percentile benefit from a positive impact of quiz average on exam score.

### 4.7 DIFFERENCE BETWEEN THE TRADITIONAL AND REDESIGN COURSE

To compare the performance of students between the traditional and redesigned versions of the course, we incorporated a common set of 10 questions for each of the two mid-term and the final exam in Fall 2002 for both versions of the course. The 95% confidence intervals for the difference between the redesigned and traditional versions are [0.49, 2.01], [1.31, 2.67] and [-0.84, 0.84] for the first, second mid-term and final exam, respectively. There are significant differences between the average performances for both mid-term but not the final exam at 5% level of significant. One possible explanation for the lack of significant difference in final exam performance can be attributed to the fact that the final exam in the traditional course was not comprehensive and, hence, students had less material to study compared to the comprehensive final exam in the redesigned course.

## 5. SUMMARY AND CONCLUSIONS

This study was initiated to help solve the problem of high attrition rates in Introductory Business Statistics in the College of Business at Northern Arizona University. Given that few such studies had been conducted in business statistics, it was deemed appropriate to utilize methods proven in other fields of study modified and expanded to fit this case. Since business students will not become statisticians and the traditional method of teaching business statistics had relied too much on equations and formulae, an interpretive learner-centered approach was taken. This approach placed emphasis on **why** there is a need for a test or estimate and **what** the implications and interpretations are related to real business problems and data. The general philosophy of the course was that the student is responsible for his or her education; thus, a mastery approach of learning was adopted utilizing pre-lecture, post-lecture and lab web quizzes all with multiple attempts allowed using WebCT. All quizzes were tied to the time the associated lecture material was being presented. Cooperative learning was introduced by the use of teams. Teams worked together in lectures, labs and on the two projects assigned during the semester. The projects resulted in a business report where all statistical jargon was translated into everyday language. Formal exams were deemphasized counting fifty percent of the course grade and fifty percent on the web quizzes and the projects. Learning styles of the students were measured and used to help students determine how they should approach the course. Attendance was required. A traditional section was taught in one semester by the second author as a control. Pre and post- assessment quizzes were given to determine learning gain.

First, the findings of the study included a statistically significant reduction in the attrition rate in the redesigned course compared to sections of the course taught in prior semesters. In addition, the attrition rate in the traditional control section was nearly twice as high as the redesigned course. Second, learning gain measured by the pre and post-assessment quizzes revealed statistically significant evidence of improvement on learning for the redesigned course. More importantly the same tests for the traditional section show no statistically significant improvement on learning gain. Third, there was a negative correlation between the total score in the course and attendance. The appropriate hypothesis test generated very small observed level of significance indicating evidence of this negative correlation in the underlying population. Fourth, analysis indicated that none of the learning styles were significant in affecting performance in the course collectively or individually. Finally, regression quantile estimates revealed that students in the lower percentile suffered more negatively on their final course grades for skipping classes and the performance on the quizzes had a higher impact on exam scores for the lower percentile students than the higher percentile students.

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## APPENDICES

### Appendix 1. A sample pre-lecture web quiz on Introduction to Simple Linear Regression

**Question 1 (15 points)**

In a simple linear regression model, the intercept of the population regression line measures

a. the change in *Y* per unit change in *X*.
b. the change in *X* per unit change in *Y*.
c. the expected change in *Y* per unit change in *X*.
d. the expected change in *X* per unit change in Y.
e. the value of *Y* when *X* equals 0.
f. the value of *X* when *Y* equals 0.
g. the average value of *Y* when *X* equals 0.
h. the average value of *X* when *Y* equals 0.

**Question 2 (15 points)**

In a simple linear regression model, the slope of the population regression line measures

a. the change in *Y* per unit change in *X*.
b. the change in *X* per unit change in *Y*.
c. the expected change in *Y* per unit change in *X*.
d. the expected change in *X* per unit change in *Y*.
e. the value of *Y* when *X* equals 0.
f. the value of *X* when *Y* equals 0.
g. the average value of *Y* when *X* equals 0.
h. the average value of *X* when *Y* equals 0.

**Question 3 (15 points)**

The least-squares method is used to compute which of the following? Two correct answers.

a. $Y_i$
b. $X_i$
c. $\beta_0$
d. $\beta_1$
e. $b_0$
f. $b_1$
g. $\varepsilon_i$

**Question 4 (15 points)**

Suppose the fitted model is yhat = 2.0 - 0.3x . The predicted average value of when x = 10 will be

Be sure to copy and paste your answer from PHStat into the blank.

Answer _____

**Question 5 (20 points)**

Which of the following provides a measure of the proportion of variation in the dependent variable that can be explained by the variation in the independent variable?

a. Total sum of squares
b. Regression sum of squares
c. Error sum of squares
d. Coefficient of determination
e. Standard error of the estimate
f. Residuals
g. Predicted value of the dependent variable

**Question 6 (20 points)**

Which of the following measures the variability of the individual Y values from the predicted Y values?

a. Total sum of squares
b. Regression sum of squares
c. Error sum of squares
d. Coefficient of determination
e. Standard error of the estimate
f. Residuals
g. Predicted value of the dependent variable

## Appendix 2. A sample post-lecture web quiz on Introduction to Simple Linear Regression

**Question 1 (20 points)**

An agent for a residential real estate company in a large city would like to be able to predict the monthly rental costs for apartments based on the size of apartment as defined by square footage. A sample of 25 apartments in a particular residential neighborhood was selected, and monthly rents ($) and Size (Square Feet) for the apartments were collected. The following Excel regression output is obtained using the collected data:

Regression Analysis

| | |
|---|---|
| Multiple R | 0.8501 |
| R Square | 0.7226 |
| Adjusted R Square | 0.7105 |
| Standard Error | 194.5954 |
| Observations | 25 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2268776.545 | 2268776.545 | 59.9138 | 7.5183E-08 |
| Residual | 23 | 870949.4547 | 37867.3676 | | |
| Total | 24 | 3139726 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 177.1208 | 161.0042 | 1.1001 | 0.2827 | -155.9414 | 510.1831 |
| Size | 1.0652 | 0.1376 | 7.7404 | 7.5183E-08 | 0.7805 | 1.3498 |

What are the appropriate dependent and independent variables in the simple linear regression model?

**Question 2 (20 points)**

Based on the information in the Excel output of the previous question, which of the following is correct?

a. For each additional square foot, the monthly rent will increase by $1.065.
b. For each additional square foot, the average monthly rent will increase by $1.065.
c. For each additional square foot, the estimated average monthly rent will increase by $1.065.
d. For each additional square foot, the monthly rent will increase by $177.12.
e. For each additional square foot, the average monthly rent will increase by $177.12.
f. For each additional square foot, the estimated average monthly rent will increase by $177.12.

**Question 3 (20 points)**

What is the predicted monthly rent for an apartment that has a size of 700 square feet?

Be sure to copy and paste your answer into the blank.

Answer _____

**Question 4 (20 points)**

An agent for a residential real estate company in a large city would like to be able to predict the monthly rental costs for apartments based on the size of apartment as defined by square footage. A sample of 25 apartments in a particular residential neighborhood was selected, and monthly rents ($) and Size (Square Feet) for the apartments were collected. The following Excel regression output is obtained using the collected data:

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.850060796 |
| R Square | 0.722603356 |
| Adjusted R Square | 0.710542633 |
| Standard Error | 194.5953946 |
| Observations | 25 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2268776.545 | 2268776.545 | 59.91376452 | 7.51833E-08 |
| Residual | 23 | 870949.4547 | 37867.3676 | | |
| Total | 24 | 3139726 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 177.1208202 | 161.0042766 | 1.100100096 | 0.282669853 | -155.9414484 | 510.1830889 |
| Size | 1.065143906 | 0.137608412 | 7.740398215 | 7.51833E-08 | 0.780479605 | 1.349808208 |

(1) What is the estimated change in average rental cost per one square feet decrease in apartment size? (2) What is the estimated average monthly rental cost for an apartment with 1200 square feet?

**Hint:** Denote an increase with a positive sign and a decrease with a negative sign. E.g. An increase of $20 should be entered as +$20 and a decrease of $20 should be entered as -$20. Do NOT put a space between a "-" or "+" sign and the numbers or dollar signs which follow them.

Be sure to copy and paste your answer into the blanks.

Answer _____
Answer _____

**Question 5 (20 points)**

Each year ninth-grade students in southwestern Ohio must take a proficiency test. The superintendent of the school district would like to know if attendance affects percentage of students passing the proficiency test.

Data on percentage of students passing the ninth-grade proficiency test (% passing) and daily average of the percentage of students attending class (% attendance) are collected and the following Excel output is obtained.

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.776171075 |
| R Square | 0.602441537 |
| Adjusted R Square | 0.593606905 |
| Standard Error | 10.57871589 |
| Observations | 47 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 7631.191042 | 7631.191042 | 68.19089951 | 1.45741E-10 |
| Residual | 45 | 5035.915341 | 111.9092298 | | |
| Total | 46 | 12667.10638 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | -771.5868596 | 100.9110801 | -7.646205536 | 1.1337E-09 | -974.8321993 | -568.3415199 |
| % Attendance | 8.844692225 | 1.071074095 | 8.257778122 | 1.45741E-10 | 6.687438354 | 11.0019461 |

Which of the following is correct?

a. 8.84% of the total fluctuation in % passing can be explained by the variation in % attendance.
b. 59.36% of the total fluctuation in % passing can be explained by the variation in % attendance.
c. 60.24% of the total fluctuation in % passing can be explained by the variation in % attendance.
d. 77.62% of the total fluctuation in % passing can be explained by the variation in % attendance.
e. 8.84% of the total fluctuation in % attendance can be explained by the variation in % passing.
f. 59.36% of the total fluctuation in % attendance can be explained by the variation in % passing.
g. 60.24% of the total fluctuation in % attendance can be explained by the variation in % passing.
h. 77.62% of the total fluctuation in % attendance can be explained by the variation in % passing.

## Appendix 3. A sample lab web quiz on Introduction to Simple Linear Regression

**Question 1 (33 points)**

Is the daily performance of stock market affected by changes in interest rates? The Excel spreadsheet here contains information concerning interest rates and the Down Jones Industrial Average from March 22, 1999, to June 15, 1999. The variables included are:

Date: Current day

30 Year Bond: Change in the interest rate for U.S. Treasury 30-year bonds (measured as the percentage change from previous day's closing rate to current day's closing rate)

DJIA: Change in the Dow Jones Industrial Average (measured as the percentage change from previous day's closing number to current day's closing number)

What are the dependent and independent variables?

| | |
|---|---|
| 1. Dependent variables | a. DJIA |
| 2. Independent variables | b. Date |
| | c. 30 year bond |

1 -->_____

2 -->_____

**Question 2 (33 points)**

Refer to the information given in Question 1.

What are the values of (1) the sample size, (2) coefficient of determination, (3) total sum of squares, (4) regression sum of squares, (5) error sum of squares and (6) the standard error of the estimate?

Be sure to copy and paste your answers from PHStat into the blanks.

Answer

1._____

2. _____

3. _____

4. _____

5. _____

6. _____

**Question 3 (34 points)**

Refer to the information given in Question 1.

(1) What percentage of the total variation in the change in DJIA can be explained by the variation in the change in 30 year bond rates? This answer must be entered as a percentage (without the % sign).

(2) What is the value of the measure of variation of the change in DJIA around the fitted regression line?

Be sure to copy and paste your answers from PHStat into the blanks.

Answer
1. _____
2. _____

## Appendix 4. Snap shot of a portion of the discussion area

**Select a topic to see its messages**

Compose Discussion Message | Search | Topic Settings | Manage Messages | Manage Topics

| Topic | Unread | Total | Status |
|---|---|---|---|
| All | 0 | 0 | |
| (A) Announcements (Postings by Dr. AB & Dr. XY only) | 0 | 0 | public, unlocked |
| (B) General Logistics | 0 | 0 | public, unlocked |
| (C) Suggestions and Comments | 0 | 0 | public, anonymous, unlocked |
| (D) Lectures | 0 | 0 | public, unlocked |
| (E) Excel and PHStat | 0 | 0 | public, unlocked |
| (F) Pre-lecture Web Quizzes | 0 | 0 | public, unlocked |
| (G) Lab Web Quizzes | 0 | 0 | public, unlocked |
| (H) Post-lecture Web Quizzes | 0 | 0 | public, unlocked |
| (I) Project Web Quizzes | 0 | 0 | public, unlocked |
| (J) Project 1 | 0 | 0 | public, unlocked |
| (K) Project 2 | 0 | 0 | public, unlocked |
| (L) 1st Midterm Exam | 0 | 0 | public, unlocked |
| (M) 2nd Midterm Exam | 0 | 0 | public, unlocked |
| (N) Final Exam | 0 | 0 | public, unlocked |
| (O) Tutoring | 0 | 0 | public, unlocked |
| Team 1-1 | 0 | 0 | private, unlocked |
| Team 1-2 | 0 | 0 | private, unlocked |
| Team 1-3 | 0 | 0 | private, unlocked |
| Team 1-4 | 0 | 0 | private, unlocked |
| Team 1-5 | 0 | 0 | private, unlocked |

## Appendix 5. The pre and post-assessment quiz

**Question 1 (5 points)**

The College of Business Administration at NAU is very much interested in designing BA201 to be a highly intuitive, realistically applicable, and technically challenging course. We would like students to be able to grasp and understand the core concepts in statistics omitting most of the hand calculation formulae that a student usually encounters in a traditional offering of the course. We want students to understand WHY they are doing WHAT they are doing and be able to explain what they have done in DAILY LANGUAGE. The ability to accomplish the above is a clear indication that students have internalized the fundamental abstract concepts in Statistics and applied them to concrete problem solving.

To measure the effectiveness of such a design, we need to collect information on students' knowledge on statistics before and after taking such a course and analyze the information collected. The survey that you are completing now is a major component in

the information collection process. Your genuine effort in providing what you think is the best answer without enlisting the help of any textbook, notes, internet or any other resources will help us achieve accurate assessment on the effectiveness of this course. For that we would like to express our sincere appreciation for your participation and effort. You will receive 100 as a quiz score for taking this survey, but your grade will not appear under My Grades until I post them later in the semester.

This information collection process that you are participating now is a good example of

a. data are needed to provide the necessary input to survey
b. inferential statistics.
c. data collected from published sources.
d. forecasting in statistics.

**Question 2 (5 points)**

The population of this study consists of

a. only everyone who is taking BA201 this semester.
b. only everyone who will be taking BA201 in the future.
c. all the students currently enrolled at NAU.
d. everyone who is taking BA201 this semester and all those who will be taking BA201 in the future.

**Question 3 (5 points)**

The scores collected from this survey is an example

a. qualitative data
b. numerical data
c. categorical data
d. poor survey design

**Question 4 (5 points)**

After we have collected information on the scores from this survey, we will compute the average, range, variance of the scores. This is an example of

a. evaluating survey worthiness.
b. inferential statistics.
c. descriptive statistics.
d. data collection.

**Question 5 (5 points)**

A statistic is a number that

a. is used to summarize a collection of numbers.
b. is used to summarize a sample.
c. is used to summarize the population.
d. is compiled by the government.

**Question 6 (5 points)**

Which of the following is an example of measure of central tendency?

a. lowest score
b. average score
c. the difference between the highest and lowest scores
d. highest score

**Question 7 (5 points)**

Which of the following is an example of unethical practice in statistics?

a. Subjectively interpret the implication of the scores collected from the survey.
b. When we selectively fail to report pertinent findings because it would be detrimental to show that the course is effective.
c. Objectively report the mean, range, variance of the scores from the survey.
d. We have overlooked the ethnic background of the students taking this survey.

**Question 8 (5 points)**

For each question in this survey, your answer can either be "correct" or "incorrect" and the probability of getting the correct answer is 0.25 if you just randomly guess the answer. The probability of getting exactly 5 correct answers in the whole survey can be computed using

a. the normal distribution
b. the binomial distribution
c. the Poisson distribution
d. the empirical distribution

**Question 9 (5 points)**

Which one of the following distributions has a bell-shape?

a. a Poisson distribution
b. an empirical distribution
c. a normal distribution
d. a binomial distribution

**Question 10 (5 points)**

The average scores from the suvey taken by one section of BA201 will be different from that from another section of BA201. This phenomenon is captured and explained by

a. the sampling distribution.
b. the Poisson distribution.
c. the binomial distribution.
d. the empirical distribution.

**Question 11 (5 points)**

Suppose we report that we are 90% confidence that between 25% and 35% of the students taking the survey will answer more than 1/2 of the questions correctly, this is an example of

a. an interval estimate.
b. a hypothesis testing.

c. a point estimate.
d. a forecast.

**Question 12 (5 points)**

From the survey result, we claim that 75% of the students taking the survey will answer more than 1/2 of the questions correctly. This is an example of

a. a hypothesis.
b. a point estimate.
c. an interval estimate.
d. an unsubstantiated claim.

**Question 13 (5 points)**

Suppose the survey result indicates that only 25% of the students taking the survey manage to answer more than 1/2 of the questions correctly. This 25% is an example of

a. a forecast.
b. an interval estimate.
c. a hypothesis testing.
d. a point estimate.

**Question 14 (5 points)**

We believe that a student's score on the survey is positively related to the grade point of his/her Math 119. This can be verified by

a. performing a regression analysis.
b. performing a test to see if the average survey score is above 90%.
c. computing the average and range of the survey scores.
d. performing a test to see if the average grade point of Math 119 is above 3.0 out of a 4.0 scale.

**Question 15 (5 points**)

Which of the following best describes the subject of Business Statistics?

a. A discipline that uses mathematics to calculate the probability of various events.
b. A discipline that helps managers make decisions about populations based on sample information.
c. A discipline that helps managers make decisions about a sample based on a population census.
d. A study which relies heavily on hand calculation formulae to have any significant impact on business decisions.

**Question 16 (5 points)**

Which of the following best describes the meaning of correlation?

a. Is there a causal relationship between two variables?
b. What is the relationship between the dependent and the independent variable?
c. Is there a linear relationship between two variable?
d. Does the value of one variable affect the value of another variable?

**Question 17 (5 points)**

Which of the following best describes a simple random sample?

a. Each item in the population is given a equal likely chance of being selected.

b. The population is divided into equal parts. The sample is made up of randomly selected parts.

c. Every 10th item in the population is selected when the population is put in order.

d. All items of the population are measured.

**Question 18 (5 points)**

When we say that the expected score of this survey is 76%, it means

a. your score can be no lower than 76%.

b. your score will be 76%.

c. the average score of all the students taking the survey is 76%.

d. you can expect to score 76% the next time you take this survey.

**Question 19 (5 points)**

You are given 6 survey scores: 3%, 67%, 72%, 88%, 92%, 99%. Which of the following measures will be most affected by the lowest score 3%?

a. average

b. mode

c. median

d. the 2nd quartile

**Question 20 (5 points)**

In our judiciary system, the accused is always assumed innocent until proven otherwise. When the jury verdict is passed down to convict the accused, then

a. it is possible that the person is in fact guilty but set free.

b. there is always a chance that the person might be wrongly convicted.

c. it is impossible that the person might be wrongly convicted.

d. only the judge knows whether the person might be wrongly convicted.

## Appendix 6. Class Schedule

### Dr. XY's Schedule of Assignments and Web Quizzes
### Fall 2003

**Click here for instructions.**

All dates below are subject to change. So should you miss a class, please make sure that you check with your instructor or the announcement in **Discussion** for any possible changes. Go to **Take Web Quizzes** to take your quizzes.

| Week | Date | Topics & Resources | Reading Assignments | Assignments Due& Some Important Dates |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Monday<br>8/25/03<br>Course Orientation<br>Room 204 | | LKB = Levine, Krehbiel & Berenson, *Business Statistics, 3rd*. (required) | |
| 1 | Wednesday<br>8/27/03<br>Lecture 1<br>Lab 1<br>Lab Room 10 | • 1.1 Why a Manager Needs to Know about Statistics<br>• 1.2 The Growth and Development of Modern Statistics<br>• 1.3 What Readers of This Textbook Need to Know About Microsoft Excel and PHStat<br>• A1.1 Basics of the Windows User Interfaces<br>• A1.2 Introduction to Microsoft Excel | LKB: pp. 2-6, 31-41 (required) | • **All due 1:35PM**<br>• Learning Style Quiz<br>• University Policies Quiz<br>• Classroom Management Quiz<br>• Fulfillment of Prerequisite Quiz<br>• Assessment Survey<br>• Pre-lecture 1 Quiz |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 2 | Monday<br>9/01/03<br>**Labor Day-** no class | | | |
| 2 | Wednesday<br>9/03/03<br>Lecture 2<br>Lab 2<br>Lab Room 10 | • 1.4 Why Data Are Needed?<br>• 1.5 Sources of Data<br>• 1.6 Types of Data<br>• 1.8 Sampling Method<br>• 1.9 Evaluating Survey Worthiness<br>• A1.2 Introduction to | LKB: pp. 6-25 (required)<br>LKB: pp. 33-42 (required) | • **All due 1:35PM**<br>• Pre-lecture 2 Quiz<br>• Post-lecture 1 Quiz<br>• Lab 1 Quiz |

| | | | | |
|---|---|---|---|---|
| | | Microsoft Excel | | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 3 | Monday 9/08/03 Lecture 3 Room 204 | • 3.1 Exploring Numerical Data and Their Properties<br>• 3.2 Measures of Central Tendency, Variation, and Shape<br>• 3.3 Exploratory Data Analysis<br>• 3.4 Obtaining Descriptive Summary Measures from a Population<br>• 3.6 Recognizing and Practicing Proper Descriptive Summarization and Exploring Ethical Issues | LKB: pp.100-128, 134-135 (required) | • **All due 1:35PM**<br>• Pre-lecture 3 Quiz<br>• Post-lecture 2 Quiz<br>• Lab 2 Quiz |
| 3 | Wednesday 9/10/03 Lab 3 Lab Room 10 | • A3.1 Using Microsoft Excel for Descriptive Statistics | LKB: pp. 142-145 (required) | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 4 | Monday 9/15/03 Lecture 4 Room 204 | • 5.1 The Probability Distribution for a Discrete Random Variable<br>• 5.2 Covariance and Its Application in Finance<br>• 5.3 Binomial | LKB: pp. 176-190 (required) | • **All due 1:35PM**<br>• Pre-lecture 4 Quiz<br>• Post-lecture 3 Quiz<br>• Lab 3 Quiz |

| | | | | |
|---|---|---|---|---|
| | | Distribution<br>• Poisson Distribution (Extra material) | | |
| 4 | Wednesday 9/17/03<br>Lab 4<br>Lab Room 10 | • A5.1 Using Microsoft Excel for the Covariance and for Probability Distributions | LKB: pp. 223-225 (required) | • **Due 1:35PM**<br>• Project 1 Web Quiz (completed by each member of a team) |
| 4 | Friday 9/19/03 | | | • **Due 3:00PM**<br>• Project 1 **First** Draft<br>• Last day to Drop/Delete without record on transcript |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 5 | Monday 9/22/03<br>Lecture 5<br>Room 204 | • 5.4 The Normal Distribution<br>• 5.5 Evaluating the Normality Assumption | LKB: pp. 192-215 (required) | • **All due 1:35PM**<br>• Pre-lecture 5 Quiz<br>• Post-lecture 4 Quiz<br>• Lab 4 Quiz |
| 5 | Wednesday 9/24/03<br>Lab 5<br>Lab Room 10 | • A5.1 Using Microsoft Excel for Probability and Probability Distribution | LKB: pp. 223-225 (required) | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important** |

| | | | | |
|---|---|---|---|---|
| | | | | **Dates** |
| 6 | Monday 9/29/03 **Midterm#1 Review** Room 204 | • Chapter 1, Chapter 3, Chapter 5<br>• Sample 1st Mid-term<br>• Midterm #1 Practice Exam<br>• Lectures 1 - 5. | All of the above | • **Due 3 PM**<br>• Project 1 **Final** Draft<br>• **All due 1:35PM**<br>• Post-lecture 5 Quiz<br>• Lab 5 Quiz<br>• Sample 1st Mid-term (no grade recorded, no deadline)<br>• Midterm #1 Practice Exam (no grade recorded, no deadline) |
| 6 | Wednesday 10/01/03 **1st Mid-term Exam** Lab Room 10 | | | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 7 | Monday 10/06/03 Lecture 6 Room 204 | • 6.1 Sampling Distributions<br>• 6.2 Introduction to Confidence Interval Estimation<br>• 6.3 Confidence Interval Estimation of the Mean (Sigma Known) | LKB: pp. 230-246 (required) | • **Due 1:35PM**<br>• Pre-lecture 6 Quiz |

| | | | | |
|---|---|---|---|---|
| 7 | Wednesday 10/08/03 Lecture 6 Lab Room 10 | | | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 8 | Monday 10/13/03 lecture 7 Room 204 | • 6.4 Confidence Interval Estimation of the Mean (Sigma Unknown)<br>• 6.5 Confidence Interval Estimation for the Proportion<br>• 6.6 Determining Sample Size<br>• 6.7 Confidence Interval Estimation and Ethical Issue | LKB: pp. 274-276 (required) | • **All due 1:35PM**<br>• Pre-lecture 7 Quiz<br>• Post-lecture 6 Quiz |
| 8 | Wednesday 10 /15/03 Lab 6 Lab Room 10 | • A6.1 Using Microsoft Excel for Random Sampling, Sampling Distribution, Confidence Interval, and Sample Size Determination | LKB: pp. 274-276 (required) | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 9 | Monday 10/20/03 Lecture 8 Room 204 | • 7.1 Hypothesis-Testing Methodology<br>• 7.2 *Z* Test of Hypothesis for the Mean (Sigma Known) | LKB: pp. 294-309 (required) | • **All due 1:35PM**<br>• Pre-lecture 8 Quiz<br>• Post-lecture 7 Quiz<br>• Lab 6 Quiz |

| | | | | |
|---|---|---|---|---|
| 9 | Wednesday 10/22/03 Lab 7 Lab Room 10 | • A7.1 Using Microsoft Excel for One-Sample Tests of Hypothesis | LKB: pp. 314-315 (required) | |
| 9 | Friday, 10/24/03 | | | • Last day to drop with a "W" |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 10 | Monday 10 /27/03 Lecture 9 Room 204 | • 7.3 One-Tailed Tests<br>• 7.4 *t* Test of Hypothesis for the Mean (Sigma Unknown)<br>• 7.5 *Z* Test of Hypothesis for the Proportion<br>• 7.6 Potential Hypothesis-Testing Pitfalls and Ethical Issues | LKB: pp. 294-309 (required) | • **All due 1:35PM**<br>• Pre-lecture 9 Quiz<br>• Post-lecture 8 Quiz<br>• Lab 7 Quiz |
| 10 | Wednesday 10/29/03 Lab 8 Lab Room 10 | • A7.1 Using Microsoft Excel for One-Sample Tests of Hypothesis | LKB: pp. 314-315 (required) | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 11 | Monday 11/03/03 **Midterm#2 Review** Room 204 | • Chapter 6, Chapter 7<br>• Sample Mid-term #2<br>• Midterm #2 Practice Exam<br>• Lectures 6, 7, 8 & 9 | All of the above after 1st mid-term | • **All due 1:35PM**<br>• Post-lecture 9 Quiz<br>• Lab 8 Quiz<br>• Sample Mid-term #2 (no grades recorded; no |

| | | | | |
|---|---|---|---|---|
| | | | | deadline)<br>• Midterm #2 Practice exam (no grades recorded; no deadline) |
| 11 | Wednesday 11/05/03 **2nd Mid-term** Lab Room 10 | | | • **Due 1:35PM**<br>• Project 2 Web Quiz (completed by each member of a team) |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 12 | Monday 11/10/03 Lecture 10 Room 204 | • 10.1 Types of Regression Models<br>• 10.2 Determining the Simple Linear Regression Equation<br>• 10.3 Measures of Variation<br>• 10.10 Computations in Simple Linear Regression | LKB: pp. 420-435, 463-469 (required) | • **Due 1:35PM**<br>• Pre-lecture 10 Quiz |
| 12 | Wednesday 11/12/03 Lecture 10 Lab Room 10 | | | |
| 12 | Friday 11/14/03 | | | • **Due 3:00PM**<br>• Project 2 **First** Draft |

| Week | Date | Topics & Resources | Reading Assignments | Assignments Due & Some Important Dates |
|---|---|---|---|---|
| 13 | Monday 11/17/03 Lab Room 10 Lecture 11 Room 204 | • 10.7 Inferences about the Slope | LKB: 448-453 (required) | • **All due 1:35PM**<br>• Pre-lecture 11 Quiz<br>• Post-lecture 10 Quiz |
| 13 | Wednesday 11/19/03 Lab 9 Lab Room 10 | • A10.1 Using Microsoft Excel for Simple Linear Regression | LKB: pp. 479-481 (required) | |
| 13 | Friday 11/21/03 | | | • **Due 3:00PM**<br>• Project 2 **Final** Draft |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 14 | Monday 11/24/03 Lecture 12 Room 204 | • Correlation Coefficient<br>• 10.8 Estimation of Mean Values and Prediction of Individual Values<br>• 10.9 Pitfalls in Regression and Ethical Issues | LKB:pp. 129-133, pp. 455-463 (required) | • **All due 1:35PM**<br>• Pre-lecture 12 Quiz<br>• Post-lecture 11 Quiz<br>• Lab 9 Quiz |
| 14 | Wednesday 11/26/03 Lab 10 Lab Room 10 | • A10.1 Using Microsoft Excel for Simple Linear Regression and Correlation | LKB: pp. 479-481 (required) | |

| | | | | |
|---|---|---|---|---|
| 14 | **Thanksgiving-** no classes Thursday 11/27/03 and Friday 11/28/03 | | | |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 15 | Monday 12/01/03 Lecture 13 Room 204 | • 11.1 Developing the Multiple Regression Model<br>• 11.3 Testing for the Significance of the Multiple Regression Model<br>• 11.4 Inferences Concerning the Population Regression Coefficients<br>• 11.11 Pitfalls in Multiple Regression and Ethical Issues | LKB: pp. 486-493, 497-502 (required) | • **All due 1:35PM**<br>• Pre-lecture 13 Quiz<br>• Post-lecture 12 Quiz<br>• Lab 10 |
| 15 | Wednesday 12/03/03 Lab 11 **Final Exam Review** Lab Room 10 | • A11.1 Using Microsoft Excel for Multiple Regression to the Topics and Resources<br>• **Review**<br>• Chapter 10<br>• Chapter 11<br>• **All chapter summaries**<br>• **All lectures**<br>• Sample Final Exam<br>• Practice Final Exam | LKB: p. 558 (required) | • Sample Final Exam<br>• Practice Final Exam<br>• No grades recorded; no deadline on either of the above<br>• Post Assessment Survey |
| 15 | Friday 12/05/03 | | | • **All due 1:35PM** |

| | | | | |
|---|---|---|---|---|
| | | | | • Post-lecture 13 Quiz<br>• Lab 11 Quiz |
| **Week** | **Date** | **Topics & Resources** | **Reading Assignments** | **Assignments Due & Some Important Dates** |
| 16 | Monday 12/08/03 **Final Exam: 3:00-5:00PM** Lab Room 10 | For 3:45-5PM, MW class | | • **The final exam is comprehensive. Study the Sample 1st Midterm Exam, the Midterm #1 Practice Exam, the Sample 2nd Midterm Exam, the Midterm #2 Practice Exam, the Sample Final Exam and the Practice Final Exam. (all above)** |
| 16 | Wednesday 12/10/03 **Final Exam: 12:30 pm 2:30 pm** Lab Room 10 | For 1:50-3:05PM, MW class | | • **The final exam is comprehensive. Study the Sample 1st Midterm Exam, the Midterm #1 Practice Exam, the Sample 2nd Midterm Exam, the Midterm #2 Practice Exam, the Sample Final Exam** |

| | | | | |
|---|---|---|---|---|
| | | | | **and the Practice Final Exam. (all above)** |
| | | | | |