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An Interpretive Business Statistics Course Encompassing Diverse Teaching and Learning Styles

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1. INTRODUCTION

Data from thirty-four different sections of the Introductory Business Statistics course over a six semesters period taught at (to be provided later) revealed attrition rates that ranged from 13% to 63% with a mean of 31%, a median of 28% and a standard deviation of 15%. Attrition as used here is the percentage of students receiving a grade of D, F or W (for withdrawal after the official drop date). While central administrators were concerned with retention for various university gateway courses, instructors teaching the course expressed concern and frustration that students spent most of their time struggling to learn the mechanics and usually did not gain mastery of basic statistical concepts and their use. Many students viewed the content of the course as dull and mechanical without direct application to real business problems. The interpretive, learner-centered approach to teaching business statistics described here addresses the above concerns.

The movement to alternative approaches to the first course in statistics is well established in mathematics and statistics departments, but little is known about how an introductory statistics course is approached in other disciplines including business (Moore, 1997a and Garfield, Hogg, Schau, Whittinghill, 2002). The American Statistical Association (ASA) funded program "Guidelines for Assessment and Instruction in Statistics Education" (GAISE) created two draft reports of recommendations for introductory statistics courses at the college level and statistics education in Pre K-12 years (http://it.stlawu.edu/~rlock/gaise/). While not specifically aimed at business statistics, these draft reports contain some of the features in our redesigned course. The Making Statistics Effective in Schools and Business (MSESB) group has held conferences since 1986 (http://www.msmesb.org/). The papers presented at these conferences encourage interaction between teachers and students as they learn, but the overwhelming majority of the conference papers deal with how to best teach a specific topic. Only two articles contain individual features of our redesigned course.

Our new approach to teaching business statistics is learner-centered and focused on intuitive interpretations of computer generated statistical output with heavy emphasis on addressing real business problems. It is based on how business students actually use statistics in other higher-level business courses and how they will use statistics in the business world. As noted in the heavily cited article by 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 a 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 by Felder and Silverman (1988) 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. When redesigning the course, we attempted to incorporate varied teaching styles to match students' diverse learning styles in the hope of creating an optimal learning environment for most (if not all) students.

In an era in which knowledge has an increasingly shorter half-life, the college educational experience must encourage students to become proficient life-long learners. In a recent article, Petocz and Reid (2003) studied 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,"

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"linking concepts," "anticipating learning needs," and "catalyst for open-mindedness." Thus, students demonstrated a range of conceptions of learning from limiting to expanding. Students expressed a range of ways they experienced teaching, and their experience on learning and their conceptions on teaching were related. One implication of this finding for statistics pedagogy is that the design of a total learning environment must acknowledge these variations, and provide activities and assessment that encourage students to change the way they think about learning and teaching statistics toward more inclusive levels. These authors argue:

> 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, they encourage teachers to influence students' conceptions of teaching by moving the focus of their teaching efforts from the essentials toward supporting students as they learn independently, holistically, and beyond the arbitrary boundaries of the subject. This change in focus encourages students to raise their expectations of themselves and adopt a more inclusive view of their own learning. Heeding this advice, our redesigned course includes incentives to motivate students to take responsibility for their own learning. 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 is a pressing need to document evidence of the effects of 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 collected assessment data in a "not fully controlled" environment and performed statistical analysis in the hope of shedding light on the efficacy of our redesigned course. Our findings may not be fully generalized to other situations prior to the development of the more appropriate new statistical techniques, but they do provide a description and summary of our experiment.

In Section 2, we describe our concerns regarding student learning in further detail. Section 3 describes our redesigned course. Specific course design elements and supporting rationale are presented in Section 4. Data collection, analysis results, and course assessment information are presented in Section 5. Section 6 summarizes our main findings and experience.

2. STUDENT LEARNING CONCERNS

Previously the business statistics course was taught using a traditional calculation-based approach we believed contributed to our students' poor understanding of the linkages between statistics concepts and applications. Many current textbooks in business statistics rely on material that originated in the field of mathematical statistics. Thus, they place too much emphasis on calculations and proofs based on equations and formulae and not enough emphasis on interpretation and application. Business students were exerting tremendous effort learning the mechanics of computing the various statistics with hand-held calculators and memorizing the recipes of the various testing and estimation techniques, but failing to internalize the concepts behind the mechanics and being able to apply them to solve real business problems. Students learned **How** to compute various test statistics and perform estimations but failed to understand **Why** there was a need to test or estimate and **What** implications and interpretations could be deduced from the mechanical results. Most of our students will not pursue a degree or a career in statistics. For them statistics is just a tool they will need to become effective managers in their chosen career path. Thus, knowing the **Why** and **What** in statistics is more important for them than learning the **How**.

Most business students take the course not because they are interested in the subject, but because statistics is one of the core courses required to complete their degree. Additionally, the quantitative nature of the subject imposes a high demand on students' analytical thinking ability. Our students in general are ill prepared in this area. Many of our students have minimized the number of mathematics-related courses they have taken. Adding poor self-management skills to the mix creates a recipe for high attrition. We believe high attrition is a by-product or symptom of the root problem. Students are not learning basic statistics concepts, because they do not have the skills

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to get beyond the formulae and equations. Attrition for this course was further compounded by the lack of an appropriate motivation scheme. 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 their mechanical skills. Students made little attempt to internalize the underlying fundamental concepts and be able to solve real business problems.

3. Redesigned Course Description

Our redesigned course 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. Hand calculations via formulae are not required of students. Instead, Excel® and a specific add-in, PHStat®, are utilized for all statistical computations[1]. Emphasis is placed on interpretation and application of results. This concrete teaching style based on content should help learners who prefer a sensory perception process. On the other hand, the abstract teaching style of discussing equations only for conceptual 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 statistical understanding found in post-lecture quizzes, on the other hand, stimulate and challenge intuitive, reflective and global learners. Our design also fosters a supportive environment for cooperative 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 both inside and outside the classroom. Our approach to teams emphasizes active student participation that benefits both active and reflective learners. Real business data and problems are used in lectures, labs, quizzes, exams and projects to help students with sensing and active dispositions.

The redesigned course consists of several major components. Multi-media learning resources with animations created by the authors are available to students 24 hours a day, 7 days a week. In-class lectures incorporate student-to-student interactions in addition to the traditional instructor-to-student interactions. Intense team projects utilize real data from real problems and require students to present their findings in the form of a formal business report. Quizzes are delivered via the web with immediate feedback to foster timely learning. These quizzes are due weekly to encourage students to take responsibility and discourage procrastination. E-mail and discussion areas are heavily utilized to foster student-to-student and instructor-to-student teaching and learning outside the classroom. WebCT plays a central role in the course and allows us to provide many materials via the web that have traditionally been delivered during lecture periods. This enables us to better use the contact time during lecture periods to emphasize concepts, illustrate interpretation of numerical results and demonstrate applications to business problems. WebCT is used as the course portal, because it provides the flexibility required by the redesigned course (BA201) and is supported by the university. The course site map is illustrated in Figure 1.

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[1] In its position paper to endorse the Mathematical Association of America (MAA) "Guidelines for the Programs and Departments in Undergraduate Mathematical Sciences", the American Statistical Association (http://www.amstat.org/education/index.cfm?pf=ASAendorsement&fuseaction=ASAendorsement) commented that "Generic packages such as Excel are not sufficient even for the teaching of statistics, let alone for research and consulting." Since Excel will be the most readily available software the majority of our students will have access to when they start working, we have decided that using Excel and its add-in is a small price to pay for the convenience it provides.

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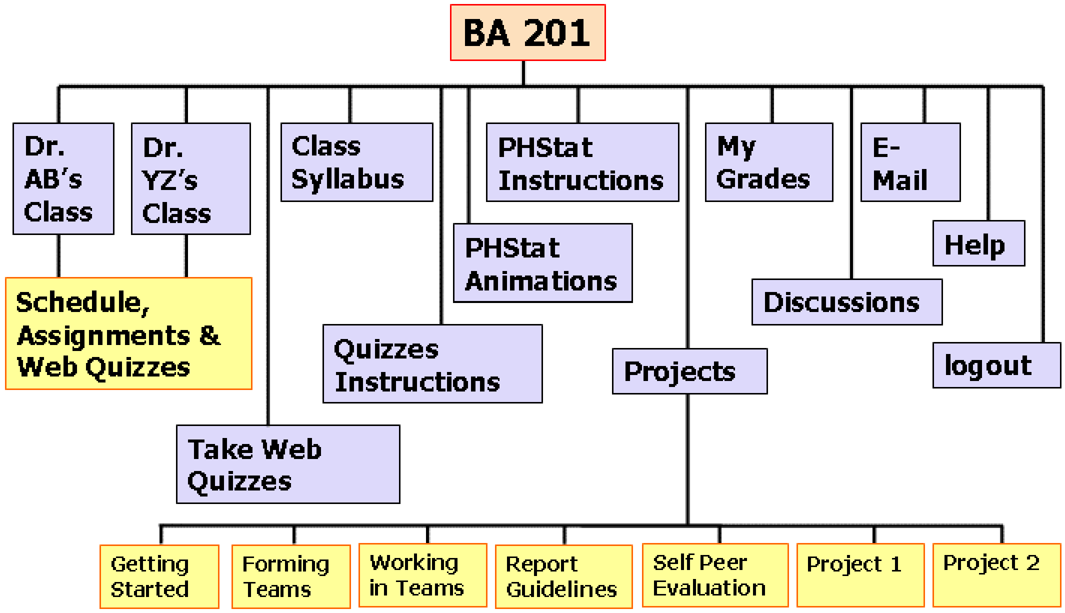

Figure 1. Course Site Map

Students meet at least once a week in lecture and once a week in a computer lab. Realistic business problems and data serve as the central connecting thread between activities in lectures and lab sessions. Lecture time is used primarily to provide motivation, discuss appropriate solutions, demonstrate related Excel skills that are needed and provide interpretations for select problems. Lab sessions provide students with hands-on experience with problem solving using Excel generated output. To closely replicate the team culture that dominates modern business environments, students are assigned to teams. The teams sit together during lectures and lab sessions to facilitate interaction among team members and between teams.

PowerPoint slides of material relevant for a lecture as well as animation movie files illustrating the procedure for generating the needed Excel and PHStat output are assigned as reading and delivered to students via WebCT. Students are expected to complete these reading assignments before class so that they can effectively participate in discussions. 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 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 students have internalized the fundamental concepts learned in lecture. These questions are more challenging than the pre-lecture quiz questions and address the higher order "comprehension", "application", and "analysis" levels in Bloom's taxonomy. Lab quizzes are designed to assure students are able to perform the Excel and PHStat procedures to generate output for the relevant analysis. Lab quiz questions cover not only the mechanics of how to use these procedures but also require students to use the output to answer questions associated with business problems.

Students are required to complete two team projects. The first project deals with descriptive statistics and is assigned early in the semester. The second project is focused on confidence intervals and hypothesis tests. In an ideal setting, we would like to have a third project associated with regression analysis, but the material is not covered until the end of the semester making it difficult to complete such a complex assignment during a time when students are pressed for time. We ask students to perform more analysis than can be fit within a five-page business report. Thus, team members must decide 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. Students are not allowed to use statistical jargon ("statistics speak") in the executive summary and the body of the report. Students' learning from this project is assessed based on (1) an executive summary, (2) the statistical analysis and interpretation of output, (3) intuition, (4) initiative and the overall presentation in their project reports. Self/Peer evaluations are completed by every member of the team to discourage

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free-riders while the project web quiz is used to assess the accuracy of the data analyses. A typical project grading scheme is presented in Table 1 and described below.

The Executive Summary is a one page summary of all aspects of the report. It usually includes identification of who wrote the report, who the intended audience is, a brief description of the background and the sample, the major findings (usually involving interpretation of Excel output) and recommendations. Points are given for intuition if the report contains insights about the problem that are not obvious from the questions asked. We define intuition here as a general understanding of the basic concepts covered in the project. One can gauge whether the intuition of a report is correct by determining whether the terms, phrases and sentences used in the project make sense. Report recommendations should be useful and valuable for the intended audience. What is being sampled and the sample size must be clear. Students are to minimize the use of charts and PHStat output in the body of their report. Relevant charts and PHStat output are to be presented in the appendix. The appendix should be annotated to explain the included chart or PHStat output. Actual numbers from the PHStat output must be used in the report and explained. References in the body of the report are made to the more detailed material in the appendix. Statistical jargon may be used in the appendix. Statistical analysis includes the results of the analysis. The relevant numbers and statistics generated must be identified and analyzed. Students must intuitively interpret the output generated by Excel using layman language. Points are given for initiative if the report contains relevant analysis beyond what is required. Our requirement of no statistical jargon is more challenging with the second project, but students rise to the task since they have already had practice in doing so with the first project.

Table 1. Project Grading Scheme.

Presentation of Results		**40 %**
Executive Summary	10 %	
Intuition	10 %	
Recommendations	10 %	
Sample Description	5 %	
Charts, PHStat and Appendix	5%	
Statistical Analysis		**40 %**
Formulation of variables	10 %	
Analysis of Excel output	10 %	
Interpretation of the Excel output	20 %	
Points for Initiative and Overall Presentation		**20 %**
Total Project Report Score		**100 %**

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 with questions on quizzes, lecture materials, and team projects. Each team has its private discussion area used to coordinate activities on the team projects. E-mail is used only for private matters including the turning in of the team project reports.

At the end of the semester, we expect students to (learning objectives):

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

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7. demonstrate an understanding of why there is a need to test or estimate
8. interpret mechanical results from Excel and communicate the implications of results in non-technical everyday language.

4. Course Design Elements

We view our biggest challenge as training students to translate abstract business statistic concepts into daily language and to understand how they are applied to solve real business problems. Clearly, this challenge requires a more interpretive approach than is traditionally employed to teach business statistics. In redesigning the course, we created new assessment components and used them in addition to the traditional assess-through-exams model. This helps students succeed through continuous input of their efforts from day one. The redesigned course emphasizes cooperative learning because we believe students learn better when they are able to receive help from and provide help to their classmates. Importantly, cooperative learning closely emulates the life-long learning environment in today's work place.

4.1 Basic Concepts

In a business situation, our graduates are more likely to either (a) generate statistics and make inferences using a spreadsheet or statistical package, or (b) be given the results of such analysis to interpret. They are not likely to use the equations and formulae found in business statistics textbooks. While Excel®, SAS®, Minitab® and other such output are increasingly found in statistics texts, equations and formulae still dominate. Texts for business statistics courses increasingly include 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 to help our students understand how to use these tools. 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. We do not expect our students to be able to perform hand calculations. We do expect them to know what the output means and be able to provide intuitive explanations related to actual problems. This de-emphasis on formulae and heightened emphasis on interpretation attempts to provide a better balance of concrete information (facts, data, results) and abstract concepts (theories, mathematical models) and works in favor of students with both the sensing and intuitive learning styles.

Given the way our graduates will actually use statistics in business situations, 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 one of our former students were attempting to explain to others in the firm via a report or 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 $CV = \left(\frac{S}{\bar{X}}\right) \bullet 100\%$. But if they were to speak in terms of comparing the amount of risk for every unit of possible expected returns or the amount risk as a percentage of the possible expected returns in each portfolio, then his or her audience would be much more likely to understand the relevant points. We believe students are more likely to learn and internalize the underlying abstract concepts when they are able to communicate their findings in simple everyday language instead of regurgitation with jargon. Thus, our lectures emphasize the interpretation of the results rather than the process of obtaining the numerical results.

4.2 Real World

Felder and Silverman (1988, p. 678) argue the majority of students are inductive learners 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." We have found students are motivated to learn to the extent they see a clear linkage between course material and their potential careers after graduation. It is for this reason that data sets and problems encountered by real businesses play a central role in our course. The use of real data demonstrates to students how data are used in the context of solving a business problem. Real data and real business problems are integrated into all aspects of our course including lectures, labs, quizzes, exams and team projects. Data analysis becomes just one step in the process of solving business problems. The mechanical skill of data analysis is of no value to business students unless they gain intuitive insights of the type of analysis that must be performed and can make non-technical interpretations of the results of the analysis.

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In our typical lecture, once the facts for an example problem are presented and studied we ask student teams 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, we demonstrate how the relevant Excel output can be generated. Teams are then asked how the output can be used to intuitively explain the solution to the problem. At this point, 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 challenging intuitive, reflective and global learners.

4.3 Responsibility

In our traditionally taught business statistics course, students held the view that the professor should teach them everything necessary for the course as they sat as isolated individuals not actively connected to the current material or the class. Students percolated their conceptions, learning and expectations of teaching to the lowest level of Petocz and Reid's (2003) classification. Additionally, procrastination in completing all aspects of the course was a major obstacle to learning and retention. The redesigned course attempts to minimize both types of problems by emphasizing active student participation.

We encourage students to become active stake-holders in the course by allocating one half of the course grade to activities entirely under their control via web quizzes and team projects. Web quizzes make up twenty percent of the course grade. Multiple attempts are allowed on these quizzes (but not on major exams) to encourage students to take responsibility for their education by mastering the material. While multiple attempts are allowed, a new set of questions is presented each time a student takes a quiz. Feedback is given on each question to lead the student to the correct answer without revealing it. Importantly, students are more likely to have read the assigned material before lectures since the pre-lecture quizzes must be completed prior to the associated lecture. Rolling deadlines are used for all quiz types to encourage students to be actively connected to the current lecture material when it is being presented, reduce procrastination and achieve just-in-time learning. Thirty percent of the course grade is tied to team projects. Using the self-peer evaluation system, student team members are able to exert both individual and group control over the quality of team projects and the class participation of their teammates.

The pre-lecture web quizzes are interactive drill exercises that provide sensing, active and sequential learners a more conducive environment to master fundamental concepts through active participation. 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.

Thus, our students take responsibility for their own education by mastering material found in web quizzes associated with lecture material, by being an active member of a team and by attending and actively participating in class.

5. DATA, ANALYSIS OF RESULTS AND COURSE ASSESSMENT INFORMATION

Eight different sections of the redesigned course were taught by the two lead authors during the 2003 – 2004 school year. After deleting incomplete observations, 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 again on the last day of the semester to measure student learning gain. These scores are labeled "Pre-Assessment" and "Post-Assessment" in Table 2. "Classes Missed" is the number of classes 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. "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. Students took a learning styles survey designed by Felder and Soloman (http://www.ncsu.edu/felder-public/ILSdir/ilsweb.html) at the beginning of the semester. Scores on the four learning style component 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 labeled 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. A score in the negative range indicates a preference for the opposite dimension.

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Table 2. Descriptive Statistics of Redesigned Course Components

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

5.1 Attrition Rate

The combined attrition rate (D, F or W) of the redesigned course 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 prior semesters.

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5.2 Learning Gain

The assessment test used to determine learning gain contains 20 questions. Unlike all 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 the first semester of the redesign. Actual scores for the first semester may not accurately measure student knowledge because there is the possibility that some students completed the test with minimal effort to receive the 100%. This possibility is especially relevant to the post-assessment since it was administered after the final exam. For the second semester, 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 score. Students could earn 0.25 of an extra credit point for each correctly answered question to a maximum of 5 points. We believe this change motivated students to take the post-assessment test more seriously and, hence, reflects a more accurate indication of their knowledge. Based on the second semester results for 88 students 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 virtually 0, 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.

5.3 Performance and Attendance

Using total score as the measure of course performance and partialing out the effects 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 virtually 0. Hence, at any reasonably small level of significance, there is ample evidence of a negative correlation between performance and absence.

5.4 Performance and Learning Style

To test whether learning styles affect total score, we performed a partial *F* test on the null hypothesis that the four indices of 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 provided 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%.

Table 3. Least Squares Regression Output of Total Score on all Components

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	3.5840	2.3669	1.5142	0.1319
Exam Score	0.4902	0.0132	37.1795	< 2e-16
Classes Missed	-0.7400	0.0927	-7.9800	2.4e-13
Quiz Average	0.2095	0.0223	9.3780	< 2e-16
Project Average	0.2976	0.0284	10.4862	< 2e-16
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

Residual standard error: 2.176 on 164 degrees of freedom Multiple R-Squared: 0.9579, Adjusted R-squared: 0.9559
F-statistic: 466.5 on 8 and 164 DF, p-value: < 2.2e-16

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Table 4. Least Squares Regression Output of Total Score on all Components but Learning Style Indices

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	4.4688	2.3390	1.9105	0.0578
Exam Score	0.4881	0.0127	38.3973	< 2e-16
Quiz Average	0.2054	0.0218	9.4103	< 2e-16
Classes Missed	-0.7471	0.0918	-8.1410	8.42e-14
Project Average	0.2935	0.0280	10.4823	< 2e-16

Residual standard error: 2.183 on 168 degrees of freedom Multiple R-Squared: 0.9566,
Adjusted R-squared: 0.9556
F-statistic: 925.9 on 4 and 168 DF, p-value: < 2.2e-16

Hence, none of the learning style indices are significant in affecting performance in the course collectively or individually. This is reassuring because we were concerned that the heavy reliance on the web technology might hinder students who have a preference for reflective and sequential learning styles.

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 (1978). 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 a solid curve with filled circles in each panel of Figure 2 are 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.

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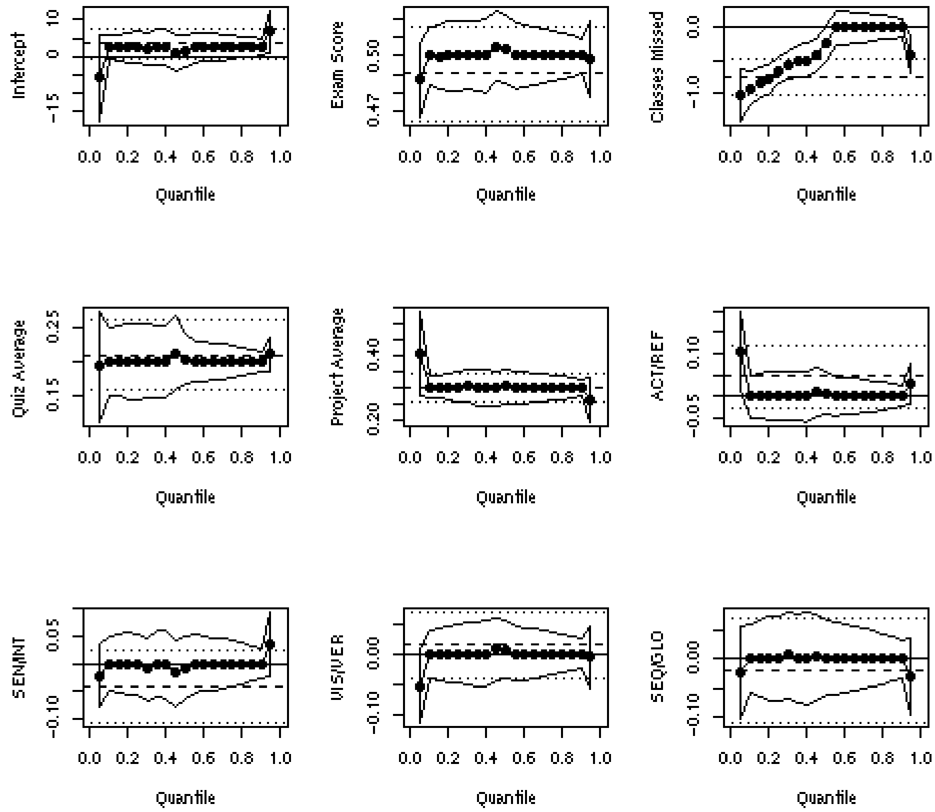

Figure 2. Regression quantile estimates from regression of Total Score on Exam Score, Classes Missed, Quiz Average, Project Average, ACT/REF, SEN/INT, VIS/VER and SEQ/GLO

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 95th 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 45th 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 5th percentile student. For students between the 50th and 90th 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 95th percentile of the conditional distribution. This suggests that attending classes is crucial for the weaker students. What is encouraging from the last four panels in Figure 2 is that none of the learning style indices have any impact on total score. This is consistent with the finding obtained from the least squares conditional mean estimates.

5.5 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 has positive impacts 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

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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 since many exam questions 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. Reflective learners are in general good at abstract concepts.

Table 5. Least Square Regression Output of Exam Score on all Components.

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	8.4587	13.9600	0.6059	0.5454
Classes Missed	-0.2841	0.5471	-0.5192	0.6043
Quiz Average	0.5141	0.1257	4.0895	6.74e-05
Project Average	0.2846	0.1661	1.7129	0.0886
ACT/REF	-0.4093	0.2073	-1.9746	0.0500
SEN/INT	-0.2383	0.2155	-1.1059	0.2704
VIS/VER	-0.4358	0.2049	-2.1266	0.0349
SEQ/GLO	-0.1553	0.2704	-0.5743	0.5666

Residual standard error: 12.85 on 165 degrees of freedom Multiple R-Squared: 0.2686,
Adjusted R-squared: 0.2376 F-statistic: 8.658 on 7 and 165 DF, p-value: 4.924e-09

Table 6. Least Square Regression Output of Exam Score on all Components but Learning Style Indices

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	6.8121	14.1439	0.4816	0.6307
Quiz Average	0.5043	0.1263	3.9941	9.67e-05
Classes Missed	-0.0626	0.5553	-0.1128	0.9104
Project Average	0.2710	0.1681	1.6118	0.1089

Residual standard error: 13.21 on 169 degrees of freedom Multiple R-Squared: 0.2083,
Adjusted R-squared: 0.1942
F-statistic: 14.82 on 3 and 169 DF, p-value: 1.306e-08

The quantile regression estimates for the effects of the various covariates on exam score are presented 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 performance in the exams. The 15^{th}, 20^{th}, 25^{th}, 30^{th}, 40^{th}, 45^{th}, 50^{th}, 55^{th}, 80^{th} and 85^{th} percentile students seem to do better on exams from being verbal learners for the possible reasons previously discussed.

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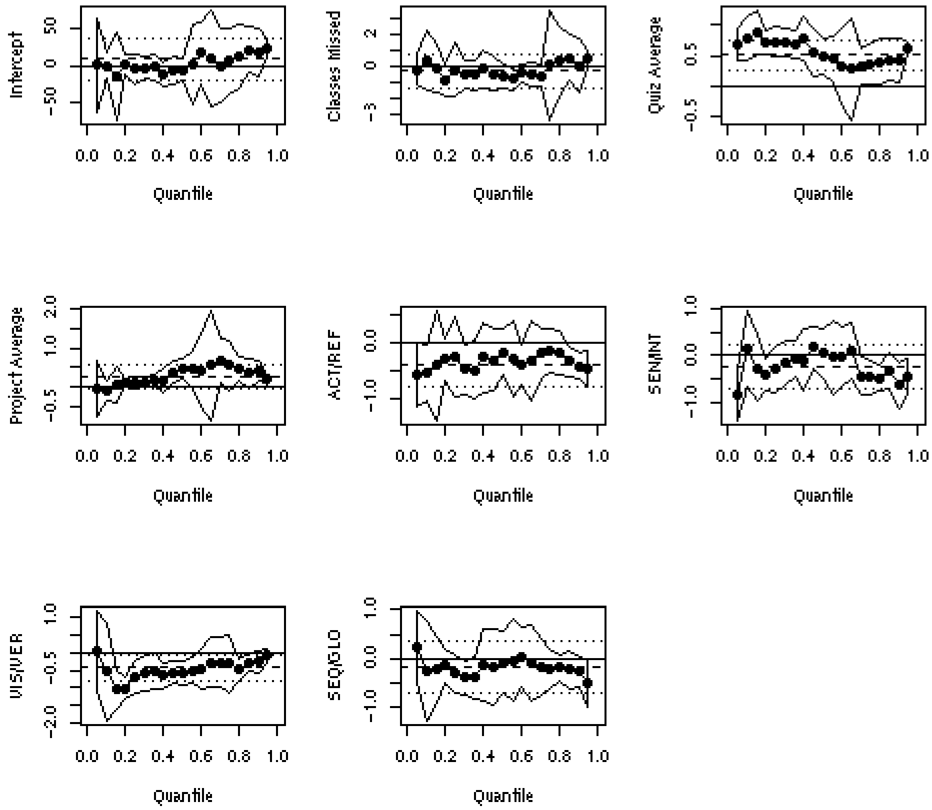

Figure 3. Regression quantile estimates from regression of Exam Score on Classes Missed, Quiz Average, Project Average, ACT/REF, SEN/INT, VIS/VER and SEQ/GLO.

5.6 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. The quantile regression estimates presented in Figure 3 reveal that almost all students (except the 60th and 65th percentile) benefit from a positive impact of quiz average on exam score.

5.7 Course Assessment Information

We assessed student learning by both conducting a class assessment project and examining student scores on various course components. Guided by Angelo and Cross (1993) the class assessment project gathered student perceptions of the value of various aspects of the course including class activities, assignments and resources for all sections and semesters taught to date. The specific instrument we used was the Student Assessment of Learning Gains (SALG). Instructors can use this free, on-line instrument (http://www.wcer.wisc.edu/salgains/instructor/SALGains.asp) to determine the specific gains students perceive they have made in any aspects of a course that instructors have identified as important to their learning.

SALG data from the most recent semester indicate our students place the most value on the following aspects of the course: how the class activities, labs, readings, and assignments fit together; the course grading system that places equal emphasis on exams and non-exam components; lab activities, lab web quizzes and lab organization; WebCT as the main depository of all class related materials; Speednotes (PowerPoint slides) and allowing multiple attempts on web quizzes.

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While we anticipated the results of the assessment project would suggest course design changes, none were indicated. However, the assessment project was still of considerable value because learner responses to open-ended questions suggested we change the manner in which we interact with students during lecture periods.

Student scores for various components of the redesigned course suggest students accomplished many of the course learning objectives presented in Section 3. Specifically, learning objective 1 is reflected in the project 2 component score for Sample Descriptions. The median score for this component was 9 out of 10 possible points. This suggests students were well able to describe the samples used for their projects. Learning objective 3 is associated with the project components labeled “Charts, PHStat and Appendix” and “Analysis of Excel Output.” The median score for “Charts . . .” was 9 of a possible 10 points. The median was 13 of 15 possible points for “Analysis of Excel Output.” These median scores suggest students are reasonably competent in performing statistical analysis in EXCEL. Project web quiz scores which have a median of 100% also support this assessment.

Scores on quizzes can be viewed as a measure of the degree to which students are self-learners, since they are given unlimited attempts to master the material andimprove their grades (Learning Objective 4). The average quiz scores have a median of 93.37 as shown in Table 2.

Student accomplishment for learning objectives 6 and 8 are indicated by the Total Report Score. The median score was 85 out of 100 possible points. This suggests students were able to interpret the results of statistical analysis, understand and communicate the implications to others in a written report. Objective 8 is associated with the project component scores for 1.) Executive Summary, 2.) Intuition, 3.) Recommendations and 4.) Interpretation of Excel Output. The median scores were 8.5 of 10, 8.5 of 10, 9 of 10 and 12 of 15 points respectively. These project component scores indicate students are able to interpret the results of their statistical analysis in non-technical language and identify implications for the project related organization.

Learning gain as measured by comparisons of pre and post assessment scores provide additional evidence that course learning objectives were met.

6. SUMMARY AND CONCLUSIONS

The redesigned course described here was initiated to address the problem of high attrition rates in Introductory Business Statistics in the College of Business at (to be provided later). Given that few such studies had been conducted in business statistics, the authors utilized methods proven in other fields of study but modified and expanded to fit this context. Since business students will not become statisticians and the traditional method of teaching business statistics relied too heavily on equations and formulae, an interpretive learner-centered approach was taken. This approach emphasized why a need for a test or estimate existed and what the implications and interpretations were for real business problems.

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 through the use of teams. Students worked together during lecture periods, labs and the two team projects. The projects resulted in a business report where all statistical jargon was translated into everyday language. Formal exams were deemphasized and accounted for only fifty percent of the course grade. The remaining fifty percent of students’ performance was based 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 in class was enforced. Pre and post- assessment quizzes were given to determine learning gain.

First, this study’s findings indicated a statistically significant reduction in the attrition rate for the redesigned course as compared to sections of the course taught in prior semesters with the previous approach. Second, learning gain measured by difference between pre and post-assessment tests revealed statistically significant evidence of improvement for learning in the redesigned course. Third, a negative correlation was found between the total score in the course and the number of classes missed. The appropriate hypothesis test generated very small observed level of significance indicating evidence of this negative correlation in the underlying population. Fourth, regression analyses revealed that none of the indices of learning styles were significant in affecting performance in the course collectively or individually. Finally, regression quantile estimates revealed students in the lower percentile suffered more negatively on their final course grades for skipping classes and their performance on quizzes had a higher impact on exam scores than for the higher percentile students.

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