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ABSTRACT
        A recent study at California State University at Northridge
reported that students in a virtual classroom score 20% higher than students
in a traditional classroom. The primary purpose of the study presented in
this paper was to replicate these results and to investigate advantages and
disadvantages of a World Wide Web-based class. Major objectives were to: (1)
evaluate performance differences between students in a Web-based class and
those in a traditional classroom setting when students are allowed to select
the course they prefer; (2) evaluate the hypothesis that the background of
students who prefer to enroll in a Web-based course is not different from
those who prefer to enroll in a traditional class; and (3) identify what
advantages the technology used in a Web-based class has in terms of enhancing
learning objectives. Participants were 89 students enrolled in two sections
of an introductory statistics course at Texas A&M University Corpus Christi,
one taught in a traditional classroom and the other taught entirely via the
Internet. Dependent variables were student demographics, test scores, and
student withdrawal and passing rates. The major conclusion was that the
results reported in the earlier study do not appear to be reproducible, at
least with this student population. (Contains five tables and six
references.) (AEF)

A Comparison of an All Web-Based Class to a Traditional Class

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Abstract: A study at California State University at Northridge, (Schutte, 1997) and (Schutte, 1998), reported that students in a *virtual classroom* scored 20% higher than students in a traditional classroom ($p<0.001$). This paper describes the results of an investigation into the demographic and performance differences between students in an all web-based class in introductory statistics to students in a traditional classroom setting. It also presents some conclusions, recommendations and raises some questions requiring further study.

Introduction

A study at California State University at Northridge, (Schutte, 1997), (Black, 1997) & (Schutte, 1998), reported that students in a *virtual classroom* scored 20% higher than students in a traditional classroom ($p<0.001$). Professors at the University of Kentucky, reported a decrease in the failure rate of freshmen chemistry students using their web-based practice quizzes, (see Kiser & Toreki, 1997). Their work suggests that a web-based course could improve student retention and performance, at least in undergraduate mathematics and science courses.

Schutte speculates that the reason for the higher performance of his students in the web-based class is increased group interaction among students in a web-based class. Although he did not present data to support this finding, he concluded:

> "The number one residual finding of my study is that students placed in a virtual environment, performing the same work as classroom-based students, are more likely to engage others for help and understanding (not to be confused with collaboration or group tasking, as is done in Neal's review) than are students placed in a face-to-face environment where constant contact is the norm."
>
> (Schutte, J. G. 1998)

Ed Neal and others have criticized the research design and methodology of Schutte. Neal writes:

> "Unfortunately, Schutte's research design and methodology are so flawed that the results of the study are uninterpretable."
>
> (Neal, E. 1998)

(Schutte, 1998), counters the criticism of Neal and others. It appears that much of the criticism and debate may be precipitated by a general lack of rigorous, well-designed studies of web-based learning. The primary purpose of this study was to attempt to replicate the results reported by Schutte and to investigate the advantages and disadvantages of a web-based class. The major objectives can be summarized as:

1. To evaluate the performance differences between students in an all web-based class and those in a traditional classroom setting when students are allowed to select the course they prefer,
2. To evaluate the hypothesis that the background of students who prefer to enroll in an all web-based course is not different from those who prefer to enroll in a traditional class, and
3. To identify what advantages, if any, the technology used in a web-based class enhances the learning objectives of an introductory statistics course.

Methodology

Since, the experiment described by Schutte detailed a remarkable claim of success by the virtual classroom, a similar, but larger, study has been conducted at Texas A&M University Corpus Christi with a similar protocol. During the Fall of 1997, 89 students enrolled into two sections of an introductory statistics course, one taught in a traditional classroom and the other taught entirely via the Internet.

Similar to the Schutte study, this was an undergraduate statistics class. Likewise, the web-based class used the same general means employed by Schutte – lecture notes, on-line quizzes, a discussion listserver, email and biweekly live web classes (chat sessions). (Schutte, 1998) reported that his server crashed 14 times during the semester. In this study, the server was only off-line for 4 hours during a scheduled power outage. In addition, the lecture notes over the more difficult material were served as a PowerPoint lecture with synchronized audio; Real Audio compressed to server over a 28.8k modem connection (visit http://stat.tamucc.edu/m2342/chap12/xrchart/ for an example lecture).

However, unlike the Schutte study, the students were not randomly divided between the classes. Instead, students registered for the class of their choosing during normal registration. This was done since:

1. an objective of this study was to evaluate differences in demographics between students who prefer to enroll in a web-based class and those that do not, and
2. it was felt that it would be unfair to force students into the web-based class since it required some familiarity with the use of a web-browser and convenient access to the Internet.

To account for the non-random assignment of students to these classes, the overall university GPA of all students was recorded and all students completed test A/4F distributed by the Mathematical Association of America on college-level algebra, the only prerequisite for the course. This same test is administered every semester to incoming freshman, providing a large database of information about the average scores on this test and how they correlate with student performance in introductory statistics and other mathematics courses.

In addition, both classes ran concurrently for 15 weeks and were taught by the same instructor. Both covered the same content, had the same homework assignments, used the same text, Elementary Statistics by (Triola, 1997), and followed the same syllabus (visit http://stat.tamucc.edu/classes/m2342.html for the syllabus). Grades were based upon the same three written in-class, multiple-choice examinations administered at weeks 5, 10 and 15. The week 15 exam was the final exam which was a 2.5 hour comprehensive examination. Both classes took these examinations under the same conditions, and student names were obscured during grading to minimize testing bias.

The primary dependent variables under analysis were:

1. Student demographics - age, GPA, completed hours, and pretest scores
2. Scores on the three, in-class, multiple-choice in-class examinations
3. Student withdrawal and passing rates

Student demographics (1) were compared using the Wilcoxon test. Examination scores (2) were compared using the repeated measures analysis of covariance. This analysis was conducted both with and without the use of the covariates - GPA and algebra pretest. Withdrawal rates (3) were compared using Fisher's exact test. All calculations were done using the Statistical Package for the Social Sciences, SPSS version 8.0 (visit http://www.spss.com for a description), and all were conducted using a significance level of 0.05.

Comparison of Student Demographics

As (Table 1) indicates, the students who enrolled in the all web-based class were somewhat more mature students. The web-based class was statistically significantly older than the traditional class ($p<0.001$).

Likewise, they had a higher GPA and had completed more university hours. However, the differences in GPA and university hours for enrolling students were not statistically significant. Interestingly, although the students in the web-based class had an average GPA about 7% higher than the traditional class, their algebra pretest scores were only about 2% higher.

	Number of Students	Avg. Algebra Pretest	Avg. GPA	Avg. Univ. Hours Completed	Avg. Age
Web-Based Class	33	18.7	2.93	80.5	29.6
Traditional Class	56	18.3	2.72	68.6	22.9
Wilcoxon p-value		0.891	0.081	0.079	<0.001

Table 1: A comparison of demographics for enrolling students.

Comparison of Examination Scores

The following figure depicts the average scores between the two classes for the three major examinations. On average, the web-based class did score higher than the traditional class. Notice, however, that the difference between the two classes appears to narrow as the semester proceeded.
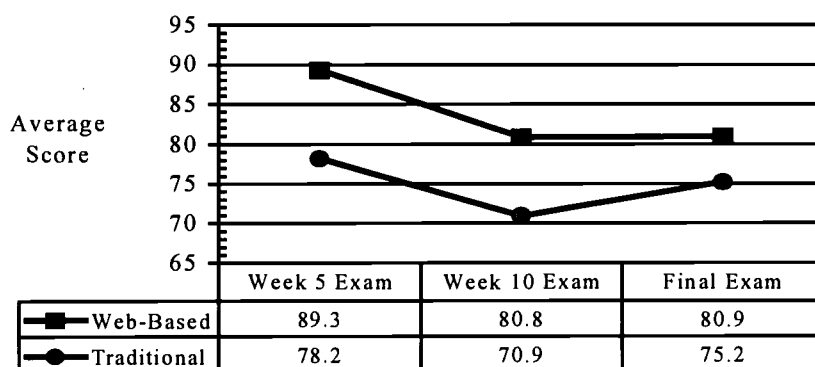

	Week 5 Exam	Week 10 Exam	Final Exam
Web-Based	89.3	80.8	80.9
Traditional	78.2	70.9	75.2

Figure 1: Average Unadjusted Examination Scores

Source	Df H	Df E	F-test	p-value
Exams	2	66	7.99	<0.001
Classes	1	67	7.14	0.009
Exams by Classes	2	66	1.28	0.289

Table 2: Repeated measures analysis of variance (ANOVA) of examination scores.

The repeated measures ANOVA, (see Table 2), of the examination scores indicates that the difference in examination scores is statistically significant (p=0.009). However, these differences can be explained by the higher average GPA and pretest scores of the web-based class.

(Table 3) gives the same analysis using the pretest scores and student GPA as covariates. A graphical display of the least squares means from the adjusted analysis are displayed in (Figure 2) and (Figure 3). When the algebra pretest score is taken into account, the differences between the two classes narrowed to only 3% for the final examination, and the difference is no longer statistically significant (p=0.096). This is in spite of the fact that the difference in pretest scores among students finishing the course is not statistically significant (p=0.812), (see Table 5).

The difference between the two classes is even smaller when student GPA is taken into account (p=0.390), (see Figure 3). However, among students who completed the course, the web-based class did have a higher mean GPA (p=0.016), (see Table 5). Note that not only does the difference in adjusted scores

narrow as the semester proceeded, by the final exam, the average adjusted score for the traditional class was higher than the web-based class.

Source	p-value adjusting for algebra pretest scores	p-value adjusting for student GPA
Exams	0.023	0.066
Classes	0.096	0.390
Exams by Classes	0.379	0.152
Pretest	<0.001	<0.001

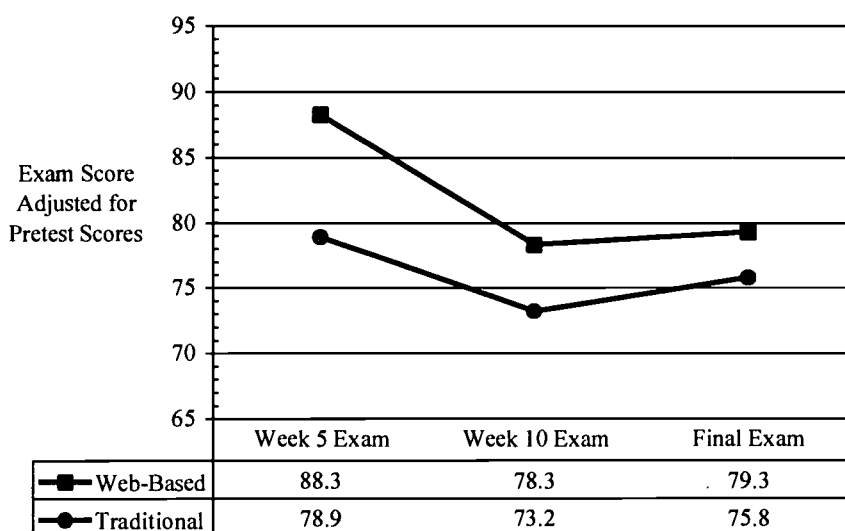**Table 3:** Repeated measures Analysis of Covariance of examination scores.

Exam Score Adjusted for Pretest Scores

	Week 5 Exam	Week 10 Exam	Final Exam
Web-Based	88.3	78.3	79.3
Traditional	78.9	73.2	75.8

Figure 2: Average examination scores, after adjusting for pretest scores

Exam Scor Adjusted for GPA

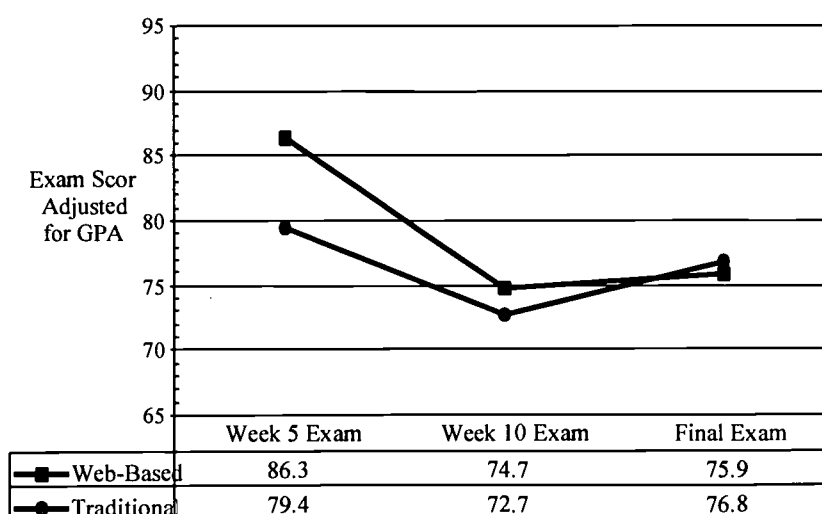|	Week 5 Exam	Week 10 Exam	Final Exam
Web-Based	86.3	74.7	75.9
Traditional	79.4	72.7	76.8

Figure 3: Average examination scores, after adjusting for student grade point average (GPA)

Comparison of Withdrawal Rates

At Texas A&M University Corpus Christi, students are allowed to withdraw from any course up to the last day of class without the instructors approval and without receiving a grade for the course on their transcript. It is not unusual to have a student who is passing a course withdraw from the course in the final weeks of the semester because of unforeseen personal circumstances or because they needed an "A" in the course to get into a medical school or a highly selective graduate program. Additionally, this course is a service course to science majors. That is, everyone taking this course is doing so because it is a required course outside the core courses of their particular major. This creates an environment with a higher than desired student withdrawal rate and a lower than desired passing rate.

	Total Students	Withdrew from Class	Percent Withdrawing	Number with Grade of C or Better	Percent with Grade of C or Better
Web-Based Class	33	9	27%	20	60%
Traditional Class	56	10	18%	37	66%
Fisher's p-value			0.301		0.652

Table 4: Comparison of withdrawal and passing rates.

The withdrawal and passing rates for the two classes are summarized in the above table. Although the differences in withdrawal and passing rates are not statistically significant, the web-based class did experience a higher withdrawal rate and a lower passing rate than the traditional class.

	Students Completing Course	Avg. Algebra Pretest	Avg. GPA	Avg. Univ. Hours Completed	Avg. Age
Web-BasedClass	24	19.1	3.04	75.3	30.7
Traditional Class	46	18.4	2.73	68.7	22.8
Wilcoxon p-value		0.812	0.016	0.344	<0.001

Table 5: A comparison of student demographics for students completing course using the Wilcoxon test.

The above table, (Table 5), describes that analysis of the demographics for students completing the course. Notice that although the average pretest scores and average university hours completed are still not statistically significantly different between the classes ($p=0.892$ & $p=0.344$ respectively), the average GPA of students completing the web-based class was about 11% higher than the traditional class ($p=0.016$).

Summary and Conclusions

(Schutte, 1997) reported that the students in his web-based class scored 20% higher than his traditional class. In this study, the difference between average scores on the final exam is only 6 points higher in the web-based class. Similar to the Schutte study, no statistically significant differences in GPA were seen among the students enrolling in the two sections ($p=0.081$). There was an even smaller difference between pretest scores ($p=0.891$). However, when the examination scores are adjusted for either the pretest scores or student GPA, differences in the average examination scores are no longer statistically significantly different ($p=0.379$ & $p=0.390$ respectively). Hence one would conclude that the higher average GPA of the students completing the web-based class could explain the 6% difference in the average score on the final exam.

This raises the question of why this study did not replicate the results of Schutte. It is unlikely that the lack of complete randomization in this study accounts for the different results since the students in the web-based class had better preparation, as measured by their pretest scores, GPA and number of completed university hours. This would have predicted an even larger advantage for the web-based class than that reported by Schutte.

Schutte also claims that students in a web-based class are more likely to "engage others for help and understanding." This was not seen in this study. In fact, every attempt to organize the web-based class around a team project and introduce them to one another was strongly resisted. Students complained that the reason they enrolled in the web-based class was for schedule flexibility and that it was too hard to coordinate schedules between students to meet as a team. Likewise participation in the class discussions on the listserver and the voluntary weekly live web-classes was poor. On average, only 15%-20% of students attended the live web-classes, although they were loyal and enthusiastic toward these classes.

It could be that the students in Schutte's classes were more motivated since his course was probably not a service course. Likewise, his students may have been younger and less involved raising families and working. In this study, the average age of the students completing the web-based class was 30.7. On average they were enrolled in 11.8 semester hours and were employed 22.3 hours per week. It can also be speculated that Schutte's teaching style may be more suited to a web-based class than a traditional class.

The major conclusion of this study is that the results reported by (Schutte, 1997) do not appear to be reproducible, at least with our student population. This also points to the need for further careful research into the best teaching methodology for web-based classes. It is unlikely that a simple translation of a course from a traditional classroom format to an all web-based class will improve or degrade student learning performance.

However, at Texas A&M Univ. Corpus Christi, we are continuing to offer web-based classes since they offer an alternative learning format that seems to be increasingly popular with a segment of our student population. Like many universities, we will continue to explore new teaching methodology for web-based classes.

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