2006-603: FACTORS AFFECTING STUDENT PERFORMANCE AND SATISFACTION IN DISTANCE LEARNING COURSES

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Factors Affecting Student Performance and Satisfaction in Distance Learning Courses

Abstract

During the past few years, the New Jersey Institute of Technology (NJIT) has initiated several projects to determine best practices in distance learning education and to apply them to courses in the Newark College of Engineering. The engineering college has lagged behind other colleges within the university in developing and implementing distance learning courses, and concerns about the quality of distance learning courses are one of the main reasons for this. The Office of Institutional Research and Planning at NJIT has undertaken a study of distance learning courses offered during the 2003-2004 academic year. The study examines a total of 150 courses, 3,491 students and 7,701 course enrollments; approximately 1/5 of the enrollments are in distance learning courses and the remaining students enrolled in traditional face-to-face courses and served as a control group. The study examines a wide variety of parameters, including overall course performance, student satisfaction with the course and the instructor, delivery format for distance learning courses (multimedia, text, multimedia + text), instructor rank, instructor training for distance learning instruction, distance learning platform (WebCT® and WebBoard®), and ease of use of technology. This paper presents the results of this study and how they can be applied to produce improved distance learning courses in the engineering college, in all colleges within NJIT, and at other universities. Among its most significant results, the study highlights the need for instructors to receive training in teaching, learning, and technology; the preference of students for courses that use multiple delivery formats; and the greater student satisfaction at NJIT for courses that use WebCT as their asynchronous learning network platform.

1. Introduction

Since offering its first distance learning courses in the 1970's, the New Jersey Institute of Technology, NJIT, has been a leader in distance learning education. From its inception, NJIT has emphasized the use of computer-mediated communication systems, or asynchronous learning networks (ALNs), as a means to keep distance learning students engaged in their coursework, to promote a sense of community among classmates, and to improve student learning. The first ALN used at NJIT was the Electronic Information Exchange System, EIES[1]. This system was expanded and modified to make it web-accessible, and became the Virtual Classroom ® system. More recently, NJIT has been using WebCT ® and WebBoard ® as its ALNs for distance learning courses.

NJIT currently offers a wide variety of distance learning courses and programs. Three complete

undergraduate degree programs and two graduate degree programs are offered entirely via eLearning, or distance learning mode, as well as over a dozen graduate certificate programs. However, the Newark College of Engineering has not been very active in NJIT's distance learning efforts. This is primarily due to concerns about the quality of distance learning courses and logistical concerns, such as the difficulty of offering meaningful laboratory experiences via this mode of instruction. In spite of these misgivings, many studies have compared face-to-face instruction to distance learning instruction and found no significant differences[2,3].

This study compares software platforms (WebCT vs. WebBoard/other types e-communications), assesses the efficacy of TLT (Teaching, Learning, Technology) training and teaching technology formats (multimedia only vs. text based only vs. a mixed format of multi-media and text) and their impact on learning outcomes (student performance and satisfaction with the course and the instructor) at a large public research university with a reputation as a pioneer and leader in information technology and distance learning.

Student performance was defined as grade earned for the course. Student satisfaction with the course and instructor were measured by the course evaluation. The online course evaluation website is available to student enrolled in distance education courses the last 2 1/2 weeks of the semester. The overall survey response rate was 43 percent.

The following research questions were asked:
  (1) Is there a difference in student satisfaction with the course and the instructor in course evaluations based on teaching technology formats (text vs. multimedia vs. mixed formats)?
  (2) Is there a correlation between instructor TLT participation and student satisfaction?
  (3) Is there a correlation between instructor rank and student satisfaction?
  (4) How did students evaluate the courses and instructors using WebCT as a platform compared to those who taught their courses using WebBoard?
  (5) Is there a difference in students' course evaluation responses on 'ease of course technology use' and "reliability of course software platform" questions between the WebCT and the WebBoard users?

The study seeks to determine factors that impact the quality of distance learning education and identify best practices that can be applied to all distance learning courses to improve the quality of education and overall student learning. The following sections present a literature review and discuss this study in greater detail, and the subsequent section presents results of the study. The next section examines a case study, applications to a junior-level computer architecture course. Finally, concluding remarks are presented.

2. Literature Review

With numerous studies finding no significant difference between face-to-face and distance learning instruction, several researchers[45,6] have suggested that it is time for research to move in the direction of investigating the best models for distance learning courses. The Office of

Institutional Research and Planning was approached by the Division of Continuing Education and the Teaching, Learning, and Technology Committee to assess the efficacy of multiple web platforms used for delivery of the distance learning courses with the ultimate goal of adopting a standard platform. Institutional Research saw this as an opportunity not only to compare platforms, but to assess the effect of technology training and teaching formats on learning outcomes by using existing data generated by the software platforms and combining them with the results of the student course evaluations.

WebCT and WebBoard are software platforms that have the following features: share/ store documents (syllabus, lecture notes, articles), online chats, discussion forums, calendar tools, assignments, quizzes and grade trackers. The existing evidence of their benefits consist mostly of company white paper, customer testimonials and attitudinal satisfaction surveys which tout ease of use, flexibility and the belief and/or perception of improved learning. A study of a bioethics course[7] found that most students enrolled in a bioethics course characterized the use of WebBoard as a positive experience and they liked the flexibility to contribute to class discussions at any hour or the day or night. A study[8] of WebCT usage in first-year chemistry courses reported that student felt that WebCT had a positive impact on their perceived learning and confidence. Another study[9] also found that students were generally positive about using WebCT. Using a linear regression analysis, this study reported that students who earned good grades used WebCT more extensively, especially the "Discussion" tool. However, the study cautioned it can yet not be demonstrated that the use of WebCT helps learning in a measurable way.

Other studies have focused on the format of the materials, either text, multimedia, or a combination of the two. Students in an anatomy course using WebCT as the course platform indicated the usefulness of videos and video clips[10]. Distance learning is synonymous with web-friendly multimedia. As in the case of distance learning platforms it is assumed that multimedia enhances learning. One study[11] cites cognitive research by Campbell, Lum and Singh that suggests that multimedia can actually improve the learning process. In contrast, Ellis and Cohen[12] state, "Although multimedia as an enhancement to learning is intuitively attractive, and anecdotal reports tend to support its value, research that is conducted with accepted controls does not tend to indicate significant benefits." Their study of a multimedia systems course revealed that although the response to multimedia was positive, the response in terms of facilitating the attainment of learning outcomes was less than definitive. Students rated text significantly more effective than interactivity, audio, animations, and videos. Similarly, Cragg, Andrusyszyn, and Humbert's[13] study of distance learning courses revealed that students selected print materials more often over video and audio tapes and teleconferencing. This preference was in part due to the fact that there were more technical problems experienced with non-text formats. A study of broadband-era news websites by Eyetrack[14] found a slight, marginally significant difference in how correctly recalled information that was presented in text vs. using multimedia. Text resulted in more correct information and overall recall. However, new, unfamiliar information about processes or procedures was more correctly recalled when participants received it in a multimedia graphic format.

3. Methods

The overall goal was to understand the impact of software platforms used in DL courses on student performance and satisfaction. In one set of analyses, the research compared the outcomes of those students whose instructors were consistently using WebCT and the others who were using WebBoard or other types of e-communication. The pseudo-experimental design was used; pure experimental design was impossible as the students could not be randomly assigned to specific course sections. In another set of analyses, the research compared the effectiveness of formats used by the instructors.

The study included the analyses of the quantitative data: students' SAT scores, course grades, number and type of files used by the instructors (either text or multimedia or a combination) and course evaluations. Student satisfaction with the course score was constructed by calculating the mean of means of the following course items from the course evaluation form: the quality of the recorded lectures (video, CD ROM, etc.), the quality of other instructional materials (website, textbooks, file downloads), the extent to which the course content is current and relevant, and the overall educational value of the course. Instead of using the overall rating of instructor, an instructor satisfaction score was constructed by calculating the mean of means of the following items concerning the instructor of the course: ability to communicate, ability to stimulate interest in course content, encouragement of active class participation, effective use of multimedia, availability and responsiveness, promptness in returning work, fairness and consistency in grading criteria, and knowledge of the course material. Students rated the course, the instructor, the ease of use of the software platform and the reliability of the platform on a Likert Scale of 0 (low) to 4 (high).

Courses were characterized as multimedia only, text only or mixture of both by using the internal tracking software of their respective platforms. A total of 150 courses, 3,491 students, and 7,701 course enrollments during the Fall 2003 and Spring 2004 semesters were included in the data set. The data was analyzed by using StatView to perform tests of significances.

4. Results of the Study

This section presents the results of this study. Overall, we found that student performance in distance learning (DL) courses, as measured by course grades, was significantly higher than for face-to-face (FTF) courses. We also found that students were more satisfied with DL courses and instructors that use both text and multimedia files, and with instructors that received TLT training. Students expressed a preference for professors, adjuncts, and research professors. Finally, students also preferred courses and instructors that used WebCT as the course platform, although they expressed no significant difference in the ease of use and reliability between the two platforms.

The rest of this section examines these results in greater detail. Before examining the results of the study, we note the following attributes of the DL (experimental) group and the FTF (control) group.

(1) There were more female students in the DL group (31% vs. 22%), as shown in Table 1.
(2) The ethnic composition of both groups was very close; there were no significant differences among ethnic populations of two groups (Table 2).
(3) The DL group's combined mean SAT scores were lower than the scores of the FTF group (1091 vs. 1106). Although the difference was not statistically significant, it could presume higher achievement for the comparison group based on the SAT scores.
(4) There were no significant differences among courses in engineering and non-engineering fields.

Table 1: Student Distribution by Gender

Gender	DL Group	FTF Group	Total
Female	357 (31%)	506 (22%)	863 (25%)
Male	799 (69%)	1829 (78%)	2628 (75%)
Total	1156 (100%)	2335 (100%)	3491 (100%)

Table 2: Distribution by Ethnicity

Ethnicity	DL Group	FTF Group	Total
Asian	464 (40%)	817 (35%)	1281 (37%)
African American	127 (11%)	221 (9%)	348 (10%)
Hispanic	85 (7%)	285 (12%)	370 (11%)
Native American	3 (0%)	5 (0%)	8 (0%)
White	329 (28%)	672 (29%)	1001 (29%)
Unknown	148 (13%)	335 (14%)	483 (14%)
Total	1156 (100%)	2335 (100%)	3491 (100%)

4.1 Student Grades

In this study, student grades were used as a measure of overall student performance in the course. Analysis of student grades showed the students in the DL group had consistently better results during the Fall 2003 and Spring 2004 semesters. The difference between the groups is both statistically significant and meaningful, as shown in Table 3. At the same time, if SAT scores are used as predictors of student achievement, the FTF group would be expected to show better performance. The result can be attributed to two factors: treatment (meaning that the DL group was getting better training and therefore showed better performance) and weak power of the SAT scores as valid predictors of student achievement.

Table 3: T-test for student grades

	DL Group	FTF Group
Mean	3.258	3.045
SD	1.070	1.070
N (# enrollments)	1683	6018
t-value	7.213	
p	< .0001	

4.2 Student Satisfaction with Courses, Instructors, and Materials

We compared courses and instructors that used media and text files for their courses. The courses and instructors were divided into three categories: (1) those using only text files; (2) those using only multimedia files; and (3) those using both text and multimedia files. The instrument of the comparison was the 2004 WebCT file and student course and instructor evaluations.

The study also compared student evaluations and course outcomes for different categories of instructors. The comparisons were based: (1) on training: the instructors who participated in TLT training and those who did not; and (2) on instructor rank: distinguished professor, professor, research professor, associate professor, assistant professor, special lecturer, visiting professor, teaching assistant and an adjunct. All evaluations were completed using a Likert scale of 0 (low) to 4 (high).

When comparing course evaluations, students were more satisfied with the courses that used both multimedia and text files than the courses where only text files were used and the difference between the two was statistically significant, as shown in Table 4. T-values are for unpaired T-tests for all tables in this section.

Table 4: Student satisfaction with DL courses based on the file types

File type comparison	Mean	Mean difference	t-value	P-value
Text & multimedia vs. multimedia	3.051 / 2.932	.119	1.550	.12
Text & multimedia vs. text	3.051 / 2.645	.405	2.578	.01
Multimedia vs. text	2.932 / 2.645	.287	1.935	.05

The analysis of the instructor evaluations showed that students are more satisfied with those instructors who use both text and multimedia than the ones that use multimedia only or text only and the difference is statistically significant (Table 5).

Table 5: Student satisfaction with DL instructors based on the file types used

File type comparison	Mean	Mean difference	t-value	P-value
Text & multimedia vs. multimedia	3.031 / 2.871	.160	1.886	.06
Text & multimedia vs. text	3.031 / 2.691	.340	2.578	.05
Multimedia vs. text	2.871 / 2.691	.181	1.098	.27

Research compared student satisfaction with the instructors who were trained in the TLT workshops and those who were not. The instrument of the analysis was the course and instructors evaluation survey. The items related to the course content and instructors' teaching were summarized and mean values were obtained. Then the means were compared based on whether instructors were trained in the TLT workshops. The analyses show that students are more satisfied with the instructors who had TLT training and also with the courses they taught and the differences in both cases are statistically significant, as shown in Table 6. We note that instructors using WebCT were more likely to have TLT training than those using WebBoard.

Table 6: Student satisfaction with DL courses and instructors based on the instructors' TLT training

Category	Mean (TLT Training / No TLT Training)	Mean difference	t-value	P-value
Evaluation of Instructor	2.970 / 2.842	.128	2.166	.03
Evaluation of Course	2.889 / 2.842	.142	2.097	.04

The analysis of the students' satisfaction with the DL courses was also conducted based on the instructors' rank. The research compared students' responses on satisfaction with both instructors and courses. Overall, the results are very close with some preference shown by the DL students towards Teaching Assistants, Research Professors and Adjuncts when the instructors are evaluated and Professors when the courses are evaluated. There is very little difference in student satisfaction with the courses based on instructors' rank with some slight preference towards professors (Table 7). When comparing student satisfaction with the instructors based on the instructors' rank, there were clear preferences: students evaluated higher the adjuncts, professors and research professors while giving lower evaluations to visiting and associate professors, as shown in Table 8. This phenomenon is hard to explain; more research is needed before making any conclusions. In these tables the following abbreviations are used:

AdPr – Adjunct Professor   Prof – Professor   SL – Special Lecturer
AstPr – Assistant Professor   DiProf – Distinguished Professor   VisProf – Visiting Professor
AsoPr – Associate Professor   ResProf – Research professor   TA – Teaching Assistant

Table 7: Student satisfaction with DL courses based on the instructor's rank (t-value in rows); statistically significant values underlined

Instructor	AdPr	AstPr	AsoPr	Prof	DiProf	ResProf	SL	VisProf	TA
AdPr		-0.008	0.935	-1.829	-1.829	-1.409	1.133	0.413	-0.834
AstPr			0.789	-1.492	-0.058	-1.338	0.895	0.388	-0.772
AsoPr				_-2.522_		-1.857	-0.002	0.042	-1.258
Prof					1.186	-0.482	_3.011_	1.061	0.037
DiProf						-1.337	0.785	0.415	-0.722
ResProf							1.848	1.369	0.475
SL								-1.284	0.043
VisProf									-0.804
TA									

Table 8: Student satisfaction with DL instructors based on the instructor's rank (t-value in rows); statistically significant values underlined

Instructor	AdPr	AstPr	AsoPr	Prof	DiProf	ResProf	SL	VisProf	TA
AdPr		0.35	_1.892_	0.113	1.217	-0.281	_2.957_	_2.057_	-0.896
AstPr			1.323	-0.23	0.871	-0.492	_2.006_	1.896	-1.078
AsoPr				-1.65	-0.25	-1.338	0.63	1.277	-1.861
Prof					1.04	-0.312	_2.650_	1.84	-0.871
DiProf						-1.185	0.723	1.419	-1.68
ResProf							1.581	_2.299_	-0.621
SL								0.975	_-2.082_
VisProf									_-2.329_
TA									

The format of course materials, multiple (text and multimedia) vs. single (either text only or multimedia only) that the instructors used for teaching played an important role in student course evaluations, the difference between multiple and single being statistically significant. Students found the use of technology much easier when the instructors used multiple formats, as shown in Table 9.

Table 9: *T-test* comparing student course evaluations of ease of technology use based on format (multiple: text + multimedia, vs. single: only text or only multimedia)

	Multiple	Single
Mean	3.038	2.891
t-value	2.135	
p	.03	

4.3 ALN Platform

When comparing student evaluations of the instructors who teach their courses using WebCT with those who use WebBoard, it was found that students prefer those instructors who use WebCT, and there is statistically significant difference between the two, as shown in Table 10. At the same time, research has not found any difference in student evaluations of courses based on WebCT or WebBoard use by the instructors. Here we note that there is significantly more training available to instructors and course developers for the WebCT platform than for the WebBoard platform at this university, and this should be considered when evaluating this data.

Table 10: Instructor evaluation and course evaluation based on platform use in student evaluations: WebCT vs. WebBoard

Category	Mean (WebCT / WebBoard)	Mean difference	t-value	P-value
Evaluation of instructor	2.959 / 2.771	.188	1.934	.05
Evaluation of course	2.986 / 2.871	.115	1.309	.19

Data analysis did not find any statistically significant difference between WebCT and WebBoard on the responses on ease of technology use question (Table 11).

Table 11: Student course evaluations based on (i) ease of use of course software platform and (ii) reliability of course software platform

Category	Mean (WebCT / WebBoard)	Mean difference	t-value	P-value
Ease of use of technology	3.061 / 2.922	.139	1.430	.15
Reliability of platform	3.072 / 2.935	.137	1.396	.16

5. Case Study: Applications to a Junior-level Computer Architecture Course

The lessons learned from this study can be applied to the development and implementation of many distance learning courses. To illustrate, this section examines a junior-level computer architecture course that is offered in both face-to-face and distance learning modes. ECE 353, Advanced Computer Architecture, is a required course for computer engineering undergraduate

junior students at the New Jersey Institute of Technology (NJIT). Other students may also take this course as a technical elective. It covers several topics in microprocessor and computer system design. The same textbook[15] is used for both the face-to-face and distance learning versions of the course, and the same weekly syllabus is used for both modes of delivery.

As noted in the previous section, students preferred courses taught by instructors that received TLT training. The instructor received formal training in the use of WebCT during a 3-day workshop offered by the university before preparing the course lectures, which has led to improved development and implementation of the course. The availability of training was the primary factor leading the instructor to choose to use WebCT rather than WebBoard for this course. To incorporate both multimedia and text, the instructor first created PowerPoint presentations. With the assistance of the Office of Instructional Technology and Media Services, the instructor recorded narrations of lectures using these slides and converted these narrated presentations to streaming media files. To make the lectures usable for students living off campus with limited bandwidth connections, the streaming media lectures are made available to students on CD. Also to incorporate more multimedia content into the course, the instructor created several Java applets that allow students to simulate various aspects of microprocessors and computer systems[16,17,18,19]. The instructor did not post lecture notes for students because, as author of the course textbook, he had already prepared descriptive text for students to reference throughout the course.

Interestingly, the developer and instructor for this course is an associate professor, a rank that had one of the lowest ratings for student satisfaction with both instructors and courses, ranking ahead of only special lecturers and visiting professors in Tables 5 and 6. In spite of this, the instructor's and course's ratings by students have been consistently above average, most likely due to the factors listed earlier in this section.

6. Summary

The study presented in this paper confirms the importance of instructor training in distance learning course development and delivery in achieving increased student grades and student satisfaction with the course, instructor, and course materials. All faculty members delivering or teaching courses in distance learning mode at this university are encouraged to take advantage of formal training offered by the Office of Instructional Technology and Media Services. The study also indicates that the WebCT platform is preferred by students at this university, although it is not clear if this is due to inherent qualities of the platform or the level of instructor and developer training available for WebCT. The difference in instructor and course evaluations based on the academic rank of the instructor is of interest, but we can offer no likely explanation at this time. We continue to research this question to determine factors that correlate with instructor rank that may impact student evaluations, and hope to use this information to develop methods to address these factors and improve student learning in distance learning courses.

Bibliography

1. S. R. Hiltz. *The Virtual Classroom: Learning without Limits*, Ablex Publishing Company, Norwood, NJ, 1994.
2. T. L. Russell. *The No Significant Difference Phenomenon: A Comparative Research Annotated Bibliography on Technology for Distance Education*, IDECC, Montgomery, AL, 2001.
3. S. B. Steinweg, M. L. Davis, and W. S. Thompson. "A Comparison of Traditional and Online Instruction in an Introduction to Special Education Courses," *Teacher Education and Special Education*, vol. 28, no. 1, 2005, pp. 62-73.
4. C. Twigg. *Innovations in Online Learning: Moving Beyond No Significant Difference*," Center for Academic Transformation, Rensselaer Polytechnic Institute, Troy, NY, 2001.
5. C. Twigg. "Improving Learning and Reducing Costs: New Models for Online Learning," *Educause Review*, vol. 38, no. 5, Sept.-Oct. 2003, pp. 28-38.
6. S. B. Conger. "If there Is No Significant Difference, Why Should We Care?" *Journal of Educators Online*, vol. 2, no. 2, July 2005, http://www.thejeo.com.
7. W. Ellenchild-Pinch and J. Graves. "Using Web-based Discussion as a Teaching Strategy; Bioethics as an Exemplar," *Journal of Advanced Nursing*, vol. 32, no. 3, Sept. 2000, pp. 704-712.
8. P. Charlesworth and C. Vician. "Leveraging Technology for Chemical Sciences Education: An Early Assessment of WebCT Usage in First-year Chemistry Courses," *Chemical Education Research*, vol. 80, no. 11, Nov. 2003, pp. 1333-1337.
9. C. Cervato. "Getting Help from Course Management Software to Teach a Large-enrollment Introductory Geology Class," *Journal of Geoscience Education*, vol. 51, no. 2, March 2003, pp. 185-193.
10. T. R. H. Bacro. "Using a Course Management System and Web-friendly Multimedia to Enhance an Anatomy Course," *The Technology Source*, Sept.-Oct. 2002, http://www.technologysource.org.
11. V. Michelich. "Streaming Media to Enhance Teaching and Improve Learning," *The Technology Source*, Jan.-Feb. 2002, http://www.technologysource.org.
12. T. Ellis and M. Cohen. "Integrating Multimedia into a Distance Learning Environment: Is the Game Worth the Candle?" *British Journal of Educational Technology*, vol. 32, no. 4, Sept. 2001, pp. 495-497.
13. C. E. Cragg, M. A. Andrusyszyn, and J. Humbert. "Experiences with Technology and Preferences for Distance Education Delivery Methods in a Nurse Practitioner Program," *Journal of Distance Education*, vol. 14, no. 1, Spring 1999, pp. 1-13.
14. L. Ruel and S. Outing. "Recall of Information Presented in Text vs. Multimedia Format," http://www.poynterextra.org/eyetrack2004/multimediarecall.htm Retrieved November 22, 2005.
15. J. D. Carpinelli. *Computer Systems Organization and Architecture*, Addison Wesley Publishing Company, Boston, MA, 2000.
16. J. Carpinelli. "The Relatively Simple Computer System Simulator – A Visualization tool for Computer System Organization and Architecture," *ASEE Computers in Education Journal*, vol. 14, no. 4, October-December 2004, pp. 36-41.
17. J. Carpinelli and M. Dokachev. "The Wallace Tree Simulator," *ASEE Computers in Education Journal*, vol. 14, no. 3, July-September 2004, pp. 10-14.
18. J. Carpinelli. "The Very Simple CPU Simulator," *Proceedings of the 2002 Frontiers in Education Conference*, Boston, MA, November, 2002, pp. T2F.11-14.
19. J. Carpinelli. "The Relatively Simple CPU Simulator," *Proceedings of the 2001 ASEE Annual Conference*, Albuquerque, NM, June, 2001.