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Comparison of Student Outcomes for a Classroom-based vs. an Internet-based Construction Safety Course

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Abstract

Web-based courses and the use of on-line technology are expanding rapidly across a wide variety of academic disciplines and settings. Previous studies have compared student outcomes in classroom-based courses with their Internet-based counterparts. The individual studies have shown either significant or non-significant differences in student academic performance between the two delivery modes. The overall objective of the present study is to compare examination performance across examination items that represent the first three levels of Bloom's taxonomy. Specifically, the study was designed to determine if there are differences in performance with knowledge-based, comprehension-based, and application-based examination items in the traditional classroom version and the Internet version of a *Construction Safety* course.

Student outcomes from the Internet version of the course are comparable to classroom version outcomes, except for the performance on application-based examination items. Students in the Internet version of the course scored statistically higher in the application scores ($p = 0.036$). Multiple regression analysis was used to eliminate possible confounders of the study results, including: student personality type (as revealed by the Myers-Briggs Personality Type Indicator®), prior academic background, including high school grade-point average, and standardized admissions test score.

Introduction

Web-based courses and the use of on-line technology are expanding rapidly across a variety of academic disciplines and settings (Merisotis, J. and R. Phipps 1999; Hazzan, O. 2000; Andrusyszyn, M-A., C.E. Cragg, and J. Humbert 2001; Billings, D.M. 2000; Leasure, A.R., L. Davis, and S.L. Thievon 2000; Lynch, T. 2002). A study conducted by the Illinois Virtual Campus (IVC) Network points to the increasing demand for distance education courses and curricula. (http://www.ivc.illinois.edu/pubs/enrollment.html?customerid=21877). To keep pace with the current paradigm shift from teacher-centered to student-centered instruction, the Illinois State University (ISU) Department of Health Sciences has implemented a self-paced, and independent strategy to deliver courses through distance education in *Safety* and the other four programs in the Department. The Health Sciences Department has significant experience with distance education; five courses are currently offered via distance education. One study —based on a survey of student feedback on the motivations and perceptions of students who have taken a *Medical Terminology* course over the Internet through ISU's Health Information Management Program— has been published (Miller, P., M.A. Temple, H.F. Thomas, and M.J. Morrow 2004).

Data from the Illinois Board of Higher Education (IBHE) indicate that *Illinois State University is the only institution in the State to offer a B.S. degree program in Safety.* (Illinois Board of Higher Education 2004). Several factors drive the Illinois State University's Safety Program towards making its *Safety* courses accessible to larger audiences. There is a high demand for Safety courses and a degree program at Illinois State University as well as throughout the United States (Winn, G.L., L.J. Frederick, and P.E. Becker 2000; Ryan, T.J. 2000). Consistent maximum enrollments for this course have placed demands on ISU Health Sciences departmental resources, such as available classroom resources and faculty course loads. At the same time, recent workforce developments have increased the demand for ISU *Safety* graduates. The Construction Management degree option requires the *Construction Safety* course, and this course is also a popular elective for *Safety* majors.

All of ISU's May 2004 *Safety* majors found full-time employment within 1-2 months of graduating. After the insurance industry, the most significant employer of ISU *Safety* graduates is the construction industry. In recent

years, the construction industry has become more reliant on accredited construction technology degree programs to supply individuals who have the technical and management skills to be successful in an increasingly complex and demanding work environment (D. Bilbo, T. Fetters, R. Burt, and J. Avant, 2000). Accreditation standards for construction management degree programs include coursework in safety (American Council on Construction Education 2004). Accompanying this demand for *Construction Management* graduates is a strong demand for *Safety* graduates who have cross-training in construction management.

Providing an Internet version of the *Construction Safety* course (HSC 272) enables the ISU *Safety* Program to reach a larger audience of construction management professionals who have safety responsibilities, individuals interested in careers in safety, and also serves to meet continuing education demands from the safety profession. Students enrolled in the *Construction Safety* course will, in many cases, assume leadership for the protection of construction worker health and safety The *Construction Safety* course is technical in nature, and the existing Internet site enables the course author to provide pertinent static resource information to enrolled students. Further, the website design is structured in such as way as to enable enrolled students an opportunity to master many course essentials at their own pace.

Across various academic disciplines, (http://nosignificantdifference.org/, 2004) some studies support the notion that there is no significant difference in educational outcomes between web-based and traditional classroom-based education, (Gagne, M and M. Shepherd 2001; and Johnson, M. 2000), while other studies suggest that there are significant differences (Nesler, M. and M. Hanner 2001; Kashy, D., G. Albertelli, E. Kashy, and M. Thoennessen 2001). The objective of the present study was to compare examination performance —across the first three levels of Bloom's taxonomy (Bloom, B.S., T. Hastings, and G.F. Nadaus 1971)— between students enrolled in an Internet-based version and students enrolled in a classroom-based version of a specialized course, *Construction Safety*.

The *Construction Safety* course was selected as the focus of this study for the following reasons:

- The classroom-based and Internet-based offerings were taught by the same instructor;

- Both versions of the course were taught on a semester basis;
- A face-to-face orientation and introduction meeting was held with students in both versions of the course;
- The same textbook was used in both versions of the course;
- The same Internet site —with identical lecture content, instructional materials, and e-learning management tools— was used for both versions of the course (These instructional materials include course lessons, notes, homework assignments, and hyperlinks to relevant web sites.);
- WebCT®, an e-learning platform for higher education institutions (http://www.webct.com), was used as a database and electronic interactive medium (for practice quizzes as well as course examinations) in both versions of the course;
- Students were given an opportunity to interact with the instructor through electronic mail in both versions of the course; and
- On-site, University-proctored examinations were administered through WebCT® for both versions of the course.

Methods

Design of the course

We have applied criteria for the evaluation of web sites (Ferguson, L. and K. Wijekumar 2000; Sternberger, C.S. 2002; Sorg, S., B. Truman-Davis, C. Dziuban, P. Moskal, J. Hartman, and F. Juge, 1999; Dillon, A. and E. Zhu, 1997) to the *Construction Safety* course web site to identify potential design features that can increase the quality of learning for both the classroom-based and Internet-based student populations. These include a logical, hierarchical design to all supporting materials for a particular topic, making it easy for the student to take charge of their own learning.

The *Construction Safety* course learning objectives and performance measures were designed to enable students to begin by extracting knowledge from a series of lessons, assigned readings, and corresponding PowerPoint™ summaries accessible through the Internet or through classroom interaction and instruction. Lessons were designed

to foster comprehension of the knowledge-based information, often showing relationships between various elements in factual parameters. The lessons were also designed to give the students practice in applying the knowledge-based information towards *best-practice* solutions to problems drawn from the construction industry. *Best-practice* solutions are emphasized in the course because of the construction industry's recognition of the benefits (to productivity and schedule) that are gained by going beyond the minimum required by government standards.

Finally, the four course examinations were designed to assess student performance across the first three levels of Bloom's taxonomy (Bloom, B.S., T. Hastings, and G.F. Nadaus 1971) of cognitive learning: knowledge, comprehension, and application. Application-type questions tested students' ability to apply knowledge and comprehension skills to real-life scenarios. It is upon these examination performance data that the results described in this paper are based.

Statistical Methodology

Statistical Analysis of Examination Results

All statistical analyses were conducted using SPSS 12.0 for Windows (SPSS, Inc., Chicago). A critical value of $p \leq 0.05$ was used for all statistical significance tests. The statistical analysis is divided into three parts. The first part examines student demographics and academic background information. The second part compares the student outcomes (scores on application, knowledge, comprehension, as well as overall exam score) between classroom-based and Internet-based instruction. The third part of the analysis examines potential confounding variables.

In the first part of the analysis, a frequency table is used to summarize categorical variables. Means and standard deviations are used to analyze continuous variables. In the second part of the analysis, a Student's t-test was conducted on difference of test scores between the Internet and traditional classroom students. In the third part of the analysis, academic/demographic variables that demonstrated a significant association with instruction type were evaluated—one at a time—for confounding of the relationship between instruction type and student outcome

variables. To examine the bivariate association with instruction type, categorical variables such as gender were analyzed using the chi-square test. Continuous variables were evaluated using the student's t-test. Confounding was defined as a dramatic change in the beta and p-value for instruction type when the potential confounder was added to the regression model.

Compilation of student warehouse information

To support multiple regression analyses that were aimed at identifying potential confounders, student demographic information was gathered from student warehouse data, using Query Management Facility (QMF) for Windows, which is supplied by Rocket Software, an IBM partner. QMF for Windows is a graphical application tool that assists in building queries. QMF allows query capability with Administrative Information System (AIS) DB2 ("Database 2") tables and warehouses. It is used to create detail and summary reports as well as to export data to other functions. It is primarily a tool for data retrieval and has limited use for sorting or display. QMF is available for multiple platforms. QMF allows two types of queries, Prompted Queries and Standard Query Language (SQL) Syntax. Prompted Queries are graphical representations of existing components, as opposed to SQL Queries, where the query statement is written in standard query language syntax. *Tables, "join" conditions, columns, sort conditions,* and *row* conditions are selected from the DB2 and warehouses. The data for the present study were gleaned using a Prompted Query.

The query parameters were selected by the research team. QMF was then used to retrieve the data and export it to Microsoft Excel™, where it was sorted, grouped, and manipulated for comparison and study.

The Myers-Briggs Type Indicator® Student Form G (Bayne, R. 1995) was administered to all students within the cohorts to generate data on personality type. This information, along with other demographic and student warehouse data, was tested through regression analysis to identify potential confounders.

Results

A total of 127 students took *Construction Safety* (HSC 272) from Fall 2002 through Spring 2004. Table 1 summarizes demographics and academic background of these students. As indicated, students who take HSC 272

are primarily white, male seniors. They majored in technology, safety, environmental health and others. Based on their ACT scores, high school GPA and percentile as well as ISU GPA, these students are average students in terms of their academic background.

Table 1. Demographics and academic background of students enrolled in *Construction Safety*, Fall 2002-Spring 04, Illinois State University

Variables	Frequency	Percent (%)
Gender (n = 127)		
Female	17	13.4
Male	110	86.6
Race (n=127)		
White	118	92.9
Black	6	4.7
Asian or Pacific Islander	2	1.6
Hispanic	1	0.8
Major (n=127)		
Technology	80	63.0
Safety	29	22.8
Environmental Health	8	6.3
Others	10	7.9
Classification (n=127)		
Junior	21	16.5
Senior	105	82.7
Graduate student	1	0.8
Variables	**Mean**	**Standard Deviation**
Age (n=127)	23.2	3.0
*CACT (n=93)	21.2	2.9
*MACT (n=93)	21.3	3.6
*SACT (n=93)	22.1	3.0
*High School percentile (n=94)	54.5	23.7
*HS GPA (n=72)	3.16	0.44
ISU GPA (n=127)	2.87	0.44

*Notes: CACT = Composite ACT score (includes math, science and English)

MACT = Mathematics ACT score

SACT = Science ACT score

Academic data is incomplete for transfer students.

Comparison of student outcome between two instruction types is presented in Table 2. Over the course of the four examinations, students who took the Internet-based version scored higher than students who took the classroom-based version in application-type questions. However, in terms of overall examination performance, the Internet-based students scored lower than the classroom-based students.

Table 2. Student outcome comparison, *Construction Safety*, Fall 2002-Spring 2004, Illinois State University, using Student's t-test.

Outcome	Type of instruction		P-value
	Internet (n=61)	Classroom (n=60)	
Knowledge	80.9%	78.5%	0.189
Comprehension	75.4%	73.0%	0.161
Application	69.6%	64.8%	0.036*
Overall exam score	75.5%	72.6%	0.084

* Statistically significant at α=0.05

The bivariate relationship between instruction type and each of the academic background/demographic variables is explored in Table 3. None of the variables appear to be significantly related to instruction type, except for high school percentile and personality type [Myers-Briggs Type Indicator® scale, Extraverted vs. Introverted, (E/I)]. Students enrolled in the Internet-based version of the course tended to have a higher high school class standing percentile and to be more extraverted than their classroom-based counterparts. This raised the question as to whether high school class standing percentile or MBTI® (E/I) were *truly* related to student outcomes (i.e., the instruction type correlates with student outcome, only due to a confounding effect). No bias in student performance outcome due to personality type has been identified in the current study.

Table 3. Bivariate relationship between instruction type and various academic/ demographic variables.

Variables	Type of Instruction		P-value
	Internet (n=67)	Classroom (n=60)	
Age	23.5	23.0	0.311
CACT[a]	21.4	21.0	0.544
MACT[a]	21.4	21.2	0.745
SACT[a]	22.0	22.2	0.779
High school percentile[b]	64.1	45.3	<0.001*
High school GPA[c]	3.14	3.17	0.823
ISU GPA	2.82	2.93	0.164
Gender (% male)	88.1%	85.0%	0.613
Race (% White)[a]	94%	91.7%	0.280
Major (% Technology)[d]	64.2%	61.7%	0.429
Classification (% senior)[d]	85%	80.6%	0.387
MBTI® (%Extraverted)	67.2%	44.4%	0.020*
MBTI® (%S)	76.1%	74.1%	0.796
MBTI® (%T)	69.8%	77.8%	0.458
MBTI® (%J)	52.4%	61.1%	0.342

* Statistically significant at α=0.05

[a, b, c] sample size = 93, 94, 72

[d] The entire distribution was tested for statistical significance; however, only the dominant category is presented.

Multiple linear regression analysis showed that neither high school percentile nor MBTI® (E vs. I) is confounding the relationship between instruction type and student outcomes. The results of regression analysis on application score are presented in Table 4. As indicated in Table 4, adding high school percentile into the model produced little change in the relationship between instruction type and application score (as measured by slope, a change from 4.777 to 5.744) and little improvement in the explanatory power of the model (a change of R from 0.190 to 0.244). Similarly, adding E/I type into the model produced little change in the relationship between instruction type and application score (as measured by slope, a change from 4.777 to 5.474) and little improvement in the explanatory power of the model (a change of R from 0.190 to 0.249). This indicates that the relationship

between instruction type and application score is more likely to be causal. Similarly, analysis was also conducted for knowledge, comprehension and overall score; no confounding was shown (results not included).

Table 4. Result of multiple regressions on application score

Models	R	Beta	p-value
Model I	0.190		
Independent var.			
Instruction type		4.777	0.033
Model II	0.244		
Independent var.			
Instruction type		5.744	0.047
High school percentile		-0.113	0.063
Model III	0.249		
Independent var.			
Instruction type		5.474	0.018
E/I		-2.939	0.737

Discussion/Conclusions

Results from this study suggest that Internet-based student performance across the four examinations of the course —with specific reference to application-type examination items— may be significantly higher than the classroom-based student performance. Though there are many factors that could contribute to this observation, the increased "student-centeredness" of the Internet-based version of the course may contribute to better preparation for dealing with these types of examination items. Currently, efforts are underway to develop teaching strategies to increase the student-centeredness of the classroom-based version of the course, such as use of group exercises that foster application-type thinking.

Another interesting finding is that average age of the cohort is not a confounder, based on the results of the multiple regression analysis. Had there been a direct correlation between age and maturity, we would expect the regression

analysis to identify age as a positive performance factor when the populations are normalized. The current data set does not suggest this outcome.

Based on these results, future revisions to the course will incorporate instructional methods specifically designed to enhance performance in application-type examination items. The conclusions drawn from this study will drive continuous improvement of the *Construction Safety* course, and may also have general applicability to web-based instruction applications in other disciplines.

The results of this research may assist the Department's advising staff as they counsel students regarding selection of classroom-based vs. Internet-based courses. As the Safety Program adds additional Internet-based courses, subsequent assessments of performance with respect to delivery mode will be undertaken.

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