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Measuring Online Students' Ability To Apply Programming Theory: Are Web Courses *Really* Working?

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ABSTRACT

As a response to troubling doubts about the success of Web-delivered courses that include problem solving and critical thinking skills, the authors gathered data from two online sections of the CIS Application Programming with Visual Basic course at Metropolitan State College of Denver over two semesters and compared it with the data from classroom sections. T-tests showed a significant difference in the means of student projects and tests that required application of theory learned. All sections of the course used the same syllabus and assignments and were taught by the same instructor. Internet students scored significantly lower in theory portions of exams and in projects. The authors conclude that more study is needed, but design and delivery of problem solving courses via the Web needs careful attention.

INTRODUCTION

As we move into the 21st century, educators know that Web courses at institutions everywhere are here to stay. The last decade of the 20th century saw a mad rush to put college courses, and entire college curricula online so that students could earn an entire degree without setting foot on a campus. Initial evaluations and statistical analyses consistently pointed to equality between classroom and the Web courses. Time and again, no significant differences were found in final grades between Web and classroom delivery of courses. The general consensus was that Web courses were working, and that colleges were justified in forging ahead with plans to put entire curricula online.

The first courses to be put online in Information Systems departments were generally the lower level elective courses and courses which were survey or retention-oriented courses. That is, the material of the first computer literacy course, the first information systems survey course, introduction to the Internet, productivity software courses, and self-paced courses was simpler to port to the Web environment. An average knowledge of instructional design and a crash course in Web page editing with Front Page®, or even Web CT® or other course authoring software, was enough to move these "to-do list" type of courses to the Web. The actual content of the course was not within the Web pages of the course, but in textbooks and assigned readings listed on the course Web pages. When faced with putting courses that involve problem solving and higher analytical reasoning on the Web, there was concern that the initial success of the first Internet courses would not be repeated. Was there something missing? If so, it should be identified and action could be taken. It was time to re-examine the first successes of Web course deployment, and move to examining online courses in more depth. Are *all* Web courses working? And if not, why?

RESEARCH QUESTIONS

The authors of this study were instructors of upper level Information Systems courses at a large (17,000 students) urban state college in Denver, Colorado. They had recently offered sections of CMS 3145 Business Application Development with Visual Basic on the Web, following the other department courses that had been developed for Internet delivery. The investigation and data analysis of this study stemmed from the authors' observations of student performance in the initial Web-delivered semester of the course. In the first semesters of the online course, authors noticed numerous egregious errors by online students in application of theory on tests, homework, and projects. Errors in work demonstrated student lack of understanding of crucial topics.

The authors consulted with other department faculty who were teaching upper level courses on the Web and found their concerns were similar. A pilot study of this same research was done in 2000 combining data from two courses--Telecommunications and Visual Basic. Although results were interesting, they were inconclusive (Haga *et al.* 2001.) The authors decided to re-examine the question the following year when there were more data available on Web students; the sample could be drawn from just one course instead of a combination of the two. Results of one course could indicate a potential serious problem with upper level Web courses offered by their department; studies on other courses could follow. Observation and anecdotal notes were not enough evidence to declare a problem with upper level Web courses, but a more robust analysis of one course could indicate the need to examine all upper level courses. Lack of true understanding of concepts appeared to be a problem, but it was not certain how widespread it was. The authors suspected the level of learning in their 3000 level classes delivered on the Web was not at the 2 or 3 (apply, relate, analyze) level of Bloom's taxonomy that it should be for junior level college courses (Bloom, 1956.)

They suspected that Web courses above the survey or intro level (ones where content centered on familiarizing and identifying) that involved problem solving, thinking, analyzing and generally applying theory learned were not working as well. They suspected from observation and grading of assignments and tests that there may be significant differences in student ability to apply IS theory. They wanted to know if this was true, and if it was what could be done to improve the delivery of these upper level Information Systems courses.

LITERATURE REVIEW

A wealth of research has already been done on final grades, design of Web courses, and delivery of hybrid courses (Presby, 2001.) Research has reported the advantages and disadvantages of Web courses, for both students and faculty (Mawhinney, 1998.) The social aspects of online student behavior has been researched (McCloskey, 1998.) McCloskey found that student satisfaction with the Internet is growing. Communication habits of instructor and students was found to be greater in online courses (McGinnis, 1998.) Burgstahler found that students participate more in class discussions when the course is delivered electronically than they would in a traditional class (1997.) Dager found that online training and Web-based training can have greater value today because the courses can be much more interactive, and the results can be tracked automatically (1998.) Student demand for complete degrees and certificates of training was found to be increasing significantly (Nixon, 1998.) Kroder reported that 8 out of 10 students who responded to a survey of Web course satisfaction said they would take another Internet-based course even though it took more time than a classroom course (1998.)

Differences in final grades between Internet students and classroom students have been found not to be statistically significant (Schulman, 1999; Mawhinney, 1998; Bowman, 1995; McCloskey, 1998.) The differences in performance and achievement among Web students and classroom students have even been analyzed. Achievement, as evidenced by testing, was found to be higher in the Web students; however, performance on projects and homework submissions was found to be higher in classroom students and lower in Web students (Marold, 2000.) The credibility of courses completed online as opposed to the classroom has been analyzed (Moreno, 2000.) Research on the levels of computer literacy by students taking Web courses showed that most students were at a competent level on the Bodker scale, but not at the proficient or novice level.[†] What is more, by the time students took a 3000 level course, 63% of them had taken an Internet course before (Marold, 2000.) Web literacy and computer literacy in general, did not seem to be a barrier to taking an upper level course online. This is an indication that the delivery environment was not an impediment to the course mastery.

The attrition rates and failure rates for online courses, and all distance education courses in general has always been higher than in the classroom (Larsen and Helms, 1998.) Terry found that the attrition rates for online MBA courses not only were higher than in the classroom, but as the courses became more analytical and theoretical,

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[†] Authors' Note: The scale developed in 1991, rates individuals on a five point scale, from Novice to Beginner, to Competent, to Proficient, to Expert.

the attrition rates increased. The attrition rate in Quantitative Analysis was 33%, and in Statistical Methods in Business was an astounding 43% (Terry, 2001.) The Finance courses also had a higher than normal attrition rate (24%.) The natural conclusion was that courses requiring extensive mathematics and problem solving were more difficult to convert to an Internet format. The course that was the subject of this study requires a higher degree of analytical and problem solving ability; its prerequisite is a business programming logic course.

While there is a myriad of studies on Internet courses and their success, there is not enough on the more subtle aspects of the success or failure of these courses in relation to their content and the level of course objectives. The authors decided to investigate the differences in ability of Internet and classroom students to apply the theory contained in their courses.

RESEARCH PLAN

The authors gathered data from matched groups of online and classroom sections of one programming course. The Visual Basic course had been Web-delivered for two semesters. Grades from projects and application portions of tests were gathered and analyzed. The plan was to compare (one tailed t-test) grades on application of theory , both on tests and on project assignments turned in to see if there were difference in student ability to apply concepts learned.
The research question, then could be phrased as follows:

Null Hypothesis

Students taking a programming course via the Internet can apply IS theory learned as well or better than students taking a programming course in a traditional classroom, as evidenced by grades on projects and applied test problems.

Alternate Hypothesis

Students taking a programming course via the internet cannot apply IS theory learned as well as students taking a programming course in a traditional classroom, as evidenced by grades on projects and applied test problems.

Methodology

The authors developed a plan to collect data for two semesters from student scores on applied portions required of all students in the Business Application Development with Visual Basic course.

Analysis

In the Visual Basic programming course, students were required to submit three phases of a semester-long project. Each phase covered four or five chapters of programming concepts. Students were required to apply concepts from each chapter by designing, coding, and debugging functions and subroutines to process forms. Students were also required to design the form layouts, choosing appropriate controls. Visual Basic students also took three exams, with each exam covering the same material as the three phases of the project. Part II of each of these exams consisted of approximately six essay/coding problems. The average of the three phases of the project was calculated, as was the average of the applied portions of the three exam scores (weighted at 40% of the exam.). It was decided that students would be graded only on work attempted, assuming at least two of the three scores were completed. Thus, the average for a project score or exam score could be based on either two or three scores. No average was calculated for students completing only one of the three scores. A one-sided t-Test was then used to compare the difference between classroom and Internet students.

Results. Tables I and II shows the results of the comparison between classroom and Internet students for the Business Application Development with Visual Basic course. Results confirmed what the authors had suspected. Classroom students strongly outperformed online students by an average score of 87% vs. 75% on the

three projects. This was highly significant with p= .001. On the application exam questions, the average was 79% vs. 70%; not quite as strong, but still very significant with p=.012. (Classroom student's final grades in this selective study of *only* junior level and above students *were* also significantly better than the Internet sections, unlike most earlier published studies.)

Table I. CMS 3145 Exam Results

Delivery (n)	Exams Mean (st dev)
Classroom (39)	.79 (.16)
Internet (43)	.70 (.20)
t-Test (p-value)	2.28 (.012)

Table II. CMS 3145 Project Results

Delivery (n)	Projects Mean (st dev)
Classroom (37)	.87 (.14)
Internet (40)	.75 (.18)
t-Test (p-value)	3.11(.001)

Discussion. The results confirm what the authors suspected, that Internet students are having trouble applying the concepts of programming they are attempting to learn. As noted earlier, a previous study done by these same authors gave mixed results in the comparison of online and classroom students in the Visual Basic course (Haga, 2001.) [*] This study incorporated that data, as well as two additional sections of the course, bringing the sample size to approximately eighty students. The fact that each of these observations is based not on one score, but at least two and usually three scores lends credibility to the results, especially since each score is based on numerous questions or sections of programming code.

The analysis of the data gathered on the two CIS classes researched indicates that at the very least, such application of theory classes offered online merit more in-depth research and some serious attention. It is very clear that demonstration of theoretical knowledge in Internet classes is below that of traditional classes within the IS program at this institution. The students who did not attempt essay questions or one of the phases of the project were also more numerous in the Internet group.

AUTHORS' INTERPRETATIONS AND SUGGESTIONS
FOR POSSIBLE SOLUTIONS

The authors' institution is completely dedicated to putting entire degrees in IS online, as are many other institutions. The administration is not directly involved in mastery and application of concepts; the majority of the instructors are involved, however.

Evolving Instructional Methods

Instruction in the online environment is still in its infancy and faculty, as instructors and course designers, have not yet developed the most effective methods for delivering some types of content in this context. Instructional design is not necessarily a strength of the faculty developing online versions of existing courses. Effective classroom instructors are often effective because they mimic effective strategies they have seen in their own experience during hundreds of hours as students in classroom settings. Nothing comparable exists yet in the online environment because instructors have rarely had the opportunity to take online courses themselves. If they did have this opportunity, they might gain a first-hand feeling for what kinds of course delivery elements work and what kinds do not.

Technology Differences

Classroom instructors emphasize important content and encourage application of that content in ways that are not even apparent to the instructor – often through subtle changes in voice or body language that are simply instinctive for effective instructors. Application of theory may be effectively illustrated in the classroom by simple choice of examples or answers given to questions – none of which constitute a conscious effort on the part of the instructor. Simple repetition can be effective in the classroom, but is difficult to implement online. Since there is no way to ensure that a student in an online course will return to an important concept, the first exposure may well be the only exposure to that particular concept.

Group Discovery

Group interaction can be a significant component of the learning process in the classroom setting, but even thoughtful attempts to use online forums, chat sessions, and e-mail don't necessarily duplicate classroom group experience in the online environment. Students also get more immediate feedback to questions in the classroom environment, which may result in more and better questioning. The group investigation and discovery often found in the classroom can be much more rewarding. Students feed off of each other's thoughts and comments and find true satisfaction in the joy of recognition as a group. Although active chat sessions and virtual office hours were used in the Visual Basic programming course in this study, group discovery at a distance is simply not the same. The cohesiveness and satisfaction of class discovery is not duplicated online. What is more, only a maximum of six or seven students were in the chat session with the instructor at any one time. The virtual office hours via Chat with Whiteboards were not obligatory; they were a synchronous online equivalent of physical office hours at campus.

Online Learner Profile

While the profile of a successful online student would reveal a self-directed, interested, active learner, the population of students who actually choose to enroll in online courses may include passive learners and individuals who are not particularly interested in the content but merely seek to complete a course requirement. Conscientious efforts to discourage inappropriate enrollment in online versions of courses (when the courses are offered in both formats) seem to have little impact. There are optional "suitability" evaluations and even WBTs (Web based training) modules instructing students how to take Web courses and succeed. Once again, these are optional, and often not even accessed by a student enrolling in a Web course. Whether or not they are suited for online learning is not one of their major considerations when signing up for a course. Convenience, independent learning, freedom from driving to campus, and flexibility are more important in their decisions. With the recent downturn in the Information Technology industry, students are conscious of the implications voiced by researchers on the trend of outsourcing IT jobs abroad (Crow, 2003.) If students are already currently employed in the industry, they see the need to compete to retain those jobs. They can take online courses such as the Visual Basic course in this study to upgrade their programming skills. If they have not completed their degree, they feel pressure to do so without leaving their current employment. Online programming courses meet their needs.

Assessment Deficiencies

Traditional grading practices may not focus sufficiently on the ability to apply learned content, leading to grades based more on recognition and recall than on application or analysis. This is perhaps because the ability to

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apply learned material is more subtly achieved in the classroom and at least minimal level of application is assumed rather than measured. It may also be due to the fact that measuring higher level learning objectives is considerably more difficult than measuring recognition and recall. Assessment and evaluation of students is complex and educators have long recognized the need for better testing. Roger Shank notes that America is "test obsessed", but it is reluctant to change the methods of testing (2000.). Perhaps inappropriate testing and grading methods everywhere are simply magnified with Web courses.

ADDRESSING THE DEFICIENCIES

More explicit emphasis on the actual application of theory or content could be included in the online course delivery materials. Materials that in some way duplicate the use of examples and questions in the classroom might improve on the application aspect once the problem is appropriately recognized. Application of smaller content elements can be required (using simple worksheets or open-ended questions) before major projects are presented. Frequent interactive elements in course materials could be especially effective. The "to-do list" of pages that directed the online student to a textbook or readings characterized earlier Web courses. It appears this is simply not sufficient for more advanced problem solving, analytical courses. More interactive exercises and presentation of examples of application of theory might be indicated. The programming course contained slide lectures of theory and links to programming examples, and practice quizzes to prepare for exams. They were largely unused.

The above observations highlight the above-mentioned profile of the online learner. That is, both the instructors and the students are new to this environment. There is a need for sophistication of the Web student. Developing a profile (or set of profiles) of the online learners would be useful. If certain student characteristics correlate well with online course success (or its absence), the design of course elements can either utilize the positive characteristics or take steps to remediate the deficiencies. Students who took previous Web courses before they took a 3000 level course may have experienced only the "to-do list" type course with expectations set at 1 or 2 of Bloom's level of immersion (Bloom, 1956.). They must be educated on how to succeed in an interactive environment, and must have practice doing it. This requires time and experience. We must also recognize that regardless of sophistication of instructional design and the interactivity built into Web courses, a certain proportion of online registrants want the easiest and the fastest way to get a credit. Some of the Internet students may have been passive learners in the classroom, and are not particularly well suited for online learning. Students signing up for Web-based distance education are sometimes those who have been previously excluded from post-secondary education and are the most dependent on face-to-face interaction. The president of The Canadian Association of University Teachers, Tom Booth, notes that these students "are the least able to deal with the frustration and isolation of Web-based distance education" (CAUTNOW, 2001.) A definitive profile of the Web learner would most certainly improve our ability to develop Web courses that would be more successful.

CONCLUSIONS

It is clear that more research on the success of Web-based courses needs to be done at a detail beyond the comparison of final grades and efficacy of the courses. That research was a necessary first step, but courses at the analytical and problem-solving level must teach students how to think and apply concepts learned to new situations. The current course offerings may not achieve this. The authors of this research are currently involved in collecting more data for the current semesters, and refining the research plan in an effort to delve deeper into the success of Web-based learning. Such research continues as academia commits to improving the delivery of Information Systems curricula.

Future Research on this Topic

The authors plan to continue to gather and analyze data comparing classroom sections and Web sections of upper level IS classes. A more formal experimental design that examines differences between Internet and classroom students by a number of factors, such as gender, age group, race, primary language (English or other), and grade point average is indicated. Finally, other upper level courses that concentrate on application of theory need to be examined. These refinements in methodology promise to strengthen and improve the ongoing research project.

SUMMARY

The authors remain committed to Web delivery of department courses. They also justifiably remain concerned about the reality of developing critical thinking skills and analytical reasoning online. They realize how far business schools have to go before they are completely successful at offering Web courses that encompass an entire degree. The realization that we have survived the initial Web-delivered environment moves us to be more committed to completing more in depth research and better delivery of Web courses.

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