Learning Effectiveness in Online vs. Traditional Courses

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Abstract

The way instruction is being delivered to students is undergoing an unprecedented transformation as a result of various social, economic and technological factors. In particular, online and other forms of long distance education are becoming ubiquitous. An important question that arises for instructors is how well the students learn the course material when using these non-traditional modes of instruction. This paper describes an attempt to gage the learning effectiveness of an online course when compared to a traditional course. The paper describes an online course developed by the author, which was also taught simultaneously as a traditional course in a parallel section. The student performance and course evaluations in parallel sections of the course were tracked over several semesters. The findings indicate that learning effectiveness in an online course can be just as good as in a traditional course.

1. Introduction

The traditional approach to higher education involves a cohort of students coming together at a specified time and location in a formal classroom setting to meet with an instructor. Students typically learn in a lecture format in which the students are mostly passive recipients of knowledge disseminated by the 'expert' instructor. The emergence of new educational technologies, especially online education, is seriously challenging this traditional model [1]. In many cases, time, location or cost constraints on either the student or the educational institution (or both), mean that the traditional approach is not viable and alternative methods have to be applied. The course described in this paper was adapted from a traditional chalk-and-board course to a fully online course. Parallel online and traditional sections of the course were offered over several semesters and student performance in these sections is the subject of this paper.

2. Course Description

The course that is the subject of this paper is a typical semester-long course in Engineering Economic Analysis. The sole pre-requisite is a course in college algebra. The textbook used for the course is 'Engineering Economy' by Leland Blank and Anthony Tarquin; published by McGraw-Hill. The normal topical coverage is summarized in Table 1.

Table 1: Course Content

Week	Topic
1	Introduction, Time Value of Money
2	Interest and Equivalence
3	Compounding periods, Series payments
4	Unusual Cash Flow Patterns
5	Present Worth Analysis
6	Annual Cash Flow Analysis
7	Rate of Return Analysis
8	Incremental Rate of Return Analysis
9	Benefit/Cost Ratio Analysis
10	Depreciation Methods
11	After-Tax Economic Analysis
12	Replacement and Retention
13	Effects of Inflation
14	Breakeven Analysis

The course is offered every semester because it is a required course in all the six programs offered in the department. It had been offered in the traditional chalk-and-board format until 2001 when we first added a section of the course offered as long-distance course using interactive television (ITV). Starting 2003, we added an online section in addition to the traditional and ITV sections.

3. Design of Instructional Materials

The design of instructional materials for an online course is challenging. The roles of both the instructor and the students necessarily have to change in comparison to those in a traditional classroom. Students do not have to follow a set schedule as in the traditional format and therefore they have to be much more proactive in acquiring knowledge. The instructor becomes more of a coach and students take more active control of how and when they engage in course activities. Therefore, learning materials should be designed to capture and retain the interest of a wide variety of students. Because of the need to keep students actively engaged with the learning materials, it is important to build interactivity into the course materials. Since an online course will inherently be accessed via computer, using computer-based animations and simulations becomes almost a necessity. The successful online course, like any distance education course, should be a multimedia presentation including a mix of the following characteristics:

- Active involvement by all students
- Multiple presentation media to help engage and retain student interest
- Animations and simulations where appropriate
- Actual physical models of reasonable size if possible
- Multiple examples of practical applications

These principles were implemented in several of the author's courses as reported elsewhere [2,3]. For the online Engineering Economic Analysis course under discussion, computer-based instructional tools were applied in ways intended to be engaging for the students and enhance their learning. The primary design tools were PowerPoint and Excel. The course materials were uploaded and delivered to students via the Blackboard online learning system. Advantage was also taken of Excel's built-in financial analysis functions to build interactive simulations that allowed the students to explore and experiment with the fundamental concepts in Engineering Economic Analysis. Consider for example the foundational concept of Time Value of Money (TVM). TVM can be established using either simple or compound interest. To help students appreciate the difference in the two approaches, the Excel-based simulation shown in Table 2 was built. The simulation allows students interactively to change the values of *principal, interest rate* or *duration (# periods)*. The equivalent future values for both simple interest and compound interest are determined automatically by the computer. By playing around with different combinations of principal, interest and duration, students get a visual demonstration of the effects of interest on the value of money. More importantly, students get to see that the three different amounts of money in the simulation are equivalent in value, when the time and interest differentials are taken into account.

Table 2: Simulating Equivalency Based on Time Value of Money

Principal	Interest rate	# Periods	Future Value Simple	Future Value Compound
$1,000.00	5%	5	$1,250.00	$1,276.28

An important issue that arises when dealing with compound interest, but which is often confusing to students, is the frequency of compounding. This leads to the concepts of nominal and effective interest rate. Once again, Excel's financial analysis tools were used to build the financial simulation shown in Table 3. This shows the relationship between nominal interest rate, effective rate per compounding period (CP), and effective annual rate. In this simulation, students can change the value(s) of nominal rate and/or compounding frequency and note the effect on the effective rates. The computer automatically calculates the values of resulting effective rate per period and effective annual rate.

Table 3: Simulating Effects of Compounding Frequency

Nominal Rate *(r%)*	Compounding Frequency *(m)*	Effective Rate (per CP) $i\%$	Effective Rate (annual) $i_a\%$
8.00%	12	0.6667%	8.3000%

Simulations like the ones described here take advantage of the fact that the course is being accessed via a computer, and utilize the built-in computing power to enhance the learning experience. Because online courses presume the students have the use of computers, these computer-based tools become an important means of enhancing student learning that may not normally be possible in a traditional course. In this case, use of Excel-based tools was easily integrated into the online course. All Excel spreadsheets, animations, and simulations were stored on the course web site for students to retrieve and review later at their leisure.

The above examples demonstrated the use of animations and simulations in helping make important concepts easy for the students to understand. Another powerful use of animations is in demonstrating solutions to problems requiring multi-step solutions. Figure 1 shows a PowerPoint slide with an animation of a multi-step problem solution. In this example, the procedure for determining the present value of a time-shifted uniform series is demonstrated. This is one of those concepts that is difficult to explain clearly on the blackboard (traditional classroom) or on paper (textbook). PowerPoint's animation capabilities proved to be of great value as they allowed the instructor to present procedural steps in the problem solution in a succinct yet fully engaging manner. By stepping through the PowerPoint animation of the problem solution, the students in a computer-based or online course such as the one described here get to understand more plainly the individual steps of the problem solution and how these steps relate to one another. For the example in Figure 1, the slide contents are displayed in multiple stages. The blue corresponds to the first stage of the solution and is displayed first. The orange corresponds to the second stage of the solution and is superimposed on the first. The dashed lines show the relationships between the cash flows at each stage of the solution. The functional relations at the bottom show how the actual computation is done.

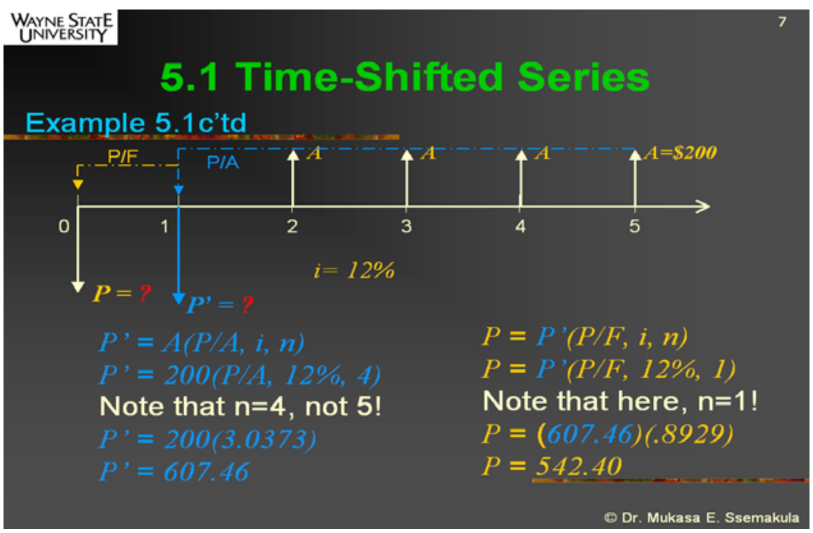
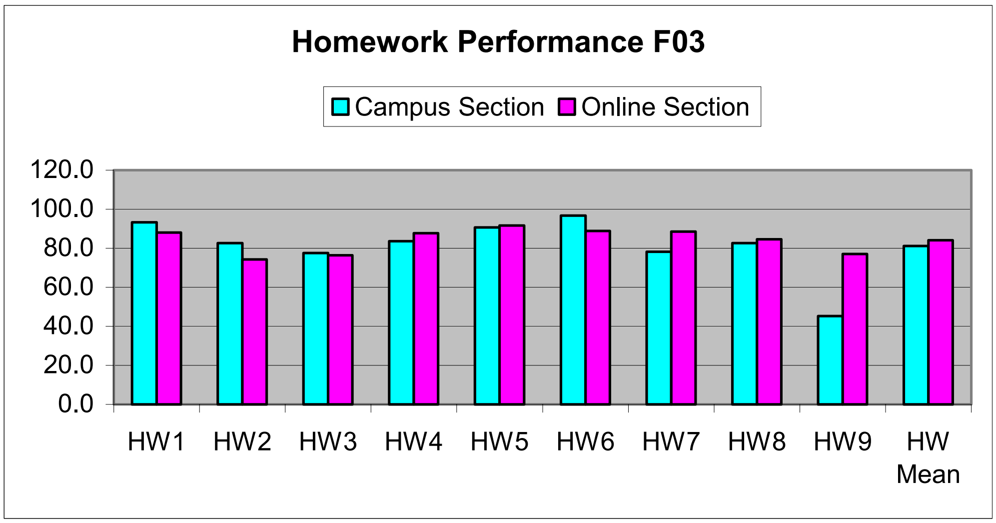


Figure 1: Animation of Multi-Step Problem Solution

4. Discussion

This course was offered in two parallel sections each semester during the 2003/2004 Academic Year – one online and one traditional. This proved to be an especially interesting experience because the sections were delivered simultaneously and were taught by the same instructor. This created the opportunity to make a direct comparison of the experiences of students in the parallel sections against each other. This also afforded a useful means of evaluating the teaching and learning effectiveness of the online course materials. The cohorts of students in the parallel sections were comparable because they were all drawn from the same pool of students who were already enrolled in our programs. Taking the online vs. traditional section was a matter of personal preference and so the two groups were self-selected. Figure 3 shows a comparison of student performance on homework assignments given to the parallel sections during two semesters. The homework was done under similar conditions with the students given one week to complete each assignment. The individual assignments were identical across sections within each semester. The online students had the added chore of typing up their solutions for online submission.



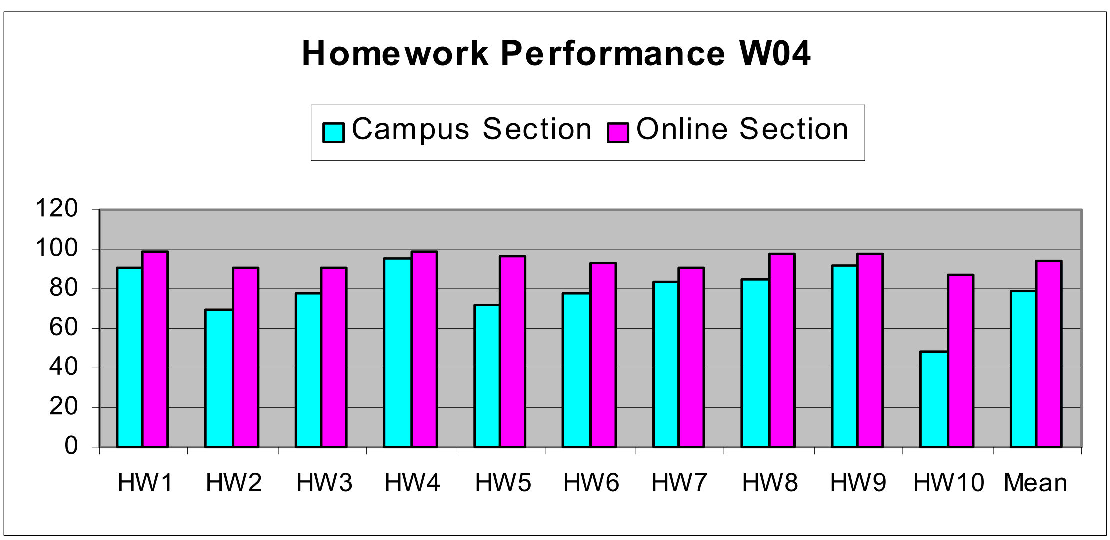
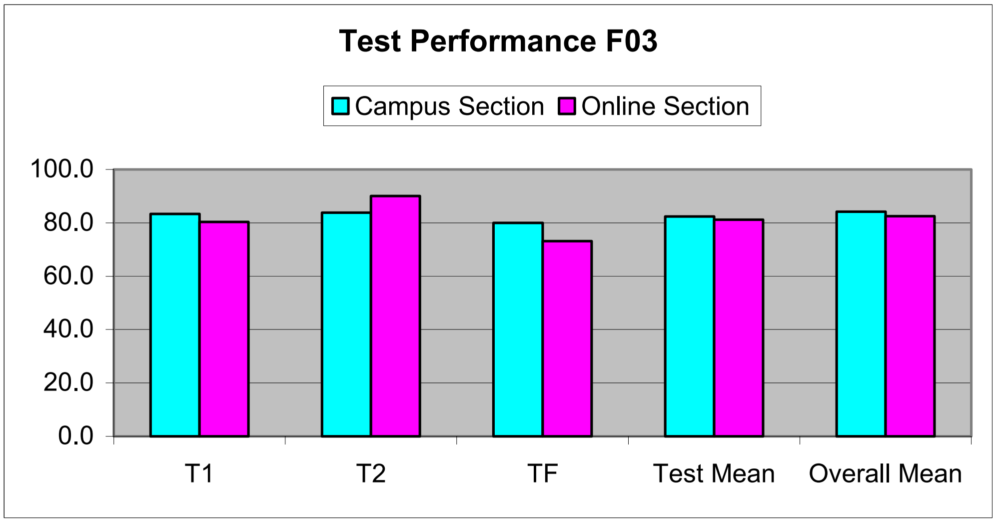


Figure 3: Homework Performance Comparison

As Figure 3 shows, in general there was no significant difference in performance between the online and traditional (on-campus) sections. The one exception to this was the last homework, which was given near the end of the semester. It is likely that the on-campus students who tend to be enrolled in more courses at a time, were facing extra pressures due to multiple assignments coming due at the same time. The performance on the tests was also compared and these results are shown in Figure 4.



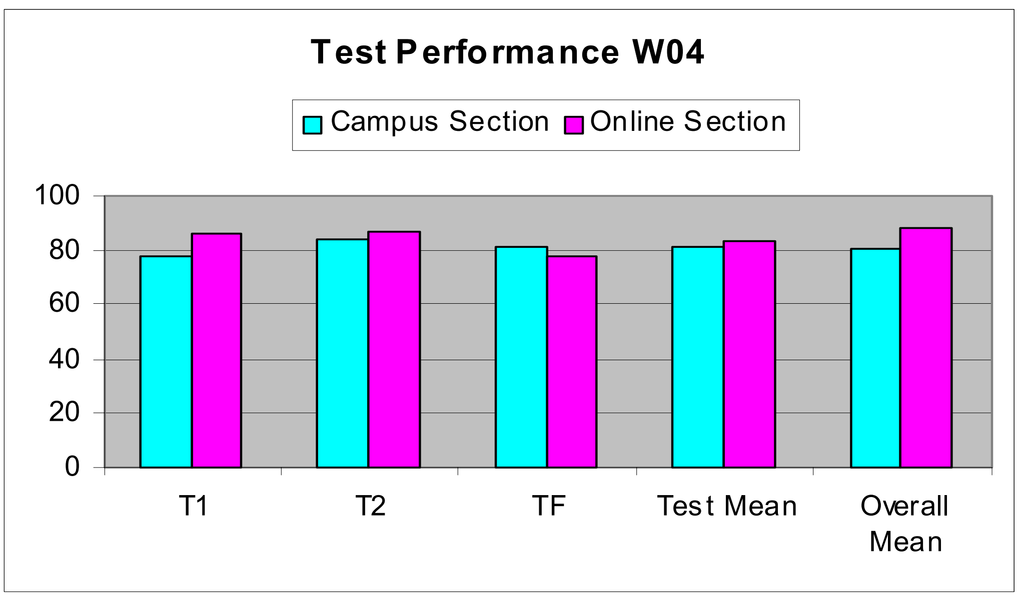


Figure 4: Test Performance Comparison

The performance in the tests was particularly interesting. Again, as Figure 4 shows, student performance was pretty comparable across sections. As a personal philosophy, the author does not give multiple-choice tests so as to be able to see the solution method used by students in arriving at an answer, and factor the method into the grading. This however leads to an issue of how to proctor the examinations for the online students. This was resolved by having the students appear in person for the final examination. For the online students, the mid-semester tests were treated as take-home tests. The students were given a specified time window within which to download the tests, solve the problems, type up the solutions, and submit them back via the internet. Despite this, there was no appreciable difference in performance between the online and on-campus students. The author believes this is largely attributable to the use of open-book tests even for in-class tests. This policy removes the relative advantage of a take-home test in comparison to an in-class test. This also has the advantage of reducing the motivation to cheat because the notes and textbook are readily available to the student during a test. Of course the tests have to be structured in such a way that answers cannot be copied directly from the notes or textbook. It is not a perfect solution but it worked well in this case.

Another basis of comparing the performance of students in the online and traditional sections was the attrition rate. For the traditional section in the Fall 2003 semester, the attrition rate (students who started but never finished the course) was 14.3% while in the online section; the attrition rate was 15.4%. For the Winter 2004 semester, the attrition rates were 11.8% in the traditional section and 10.5% in the online section. Clearly, the rates were comparable both within and across semesters. This was an encouraging result.

Finally, a comparison was made on the basis of how the students themselves perceived the learning experiences. The University's standard end-of-semester course evaluation instrument was used. The rating scale is from 1 (worst) to 5 (best) and a score above 3 is generally considered to be good. The three key questions for comparison purposes and the comparison results are shown in Figure 5.

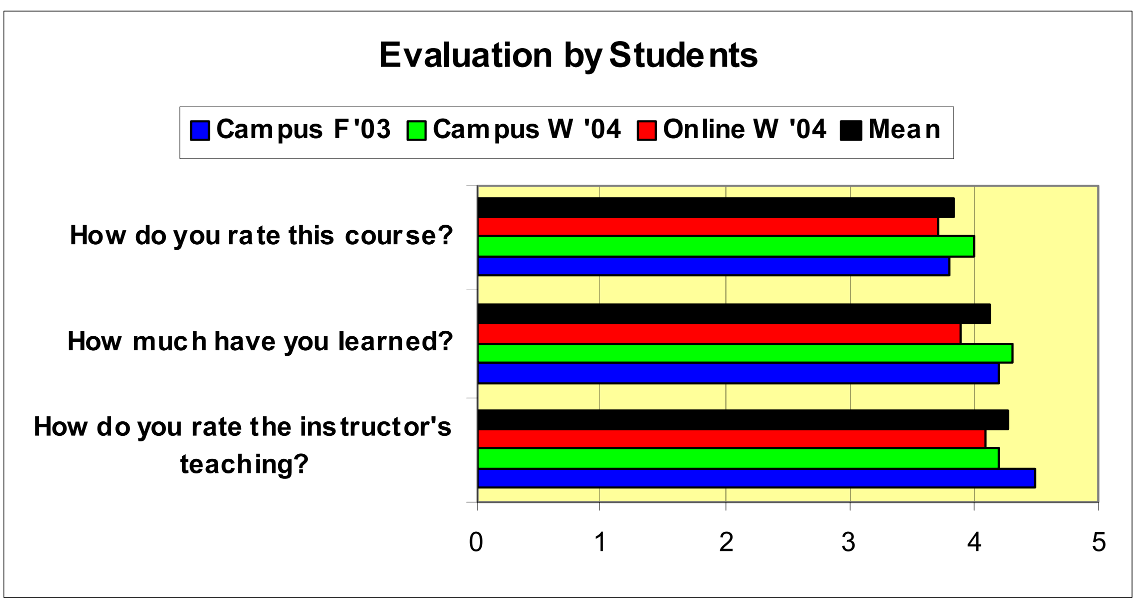


Figure 5: Student Evaluation of Learning Experience

Unfortunately, the data for the Fall ’03 online section was not available as we had not yet implemented a method of collecting the student evaluations for the online section. Nevertheless, the available student evaluations were very encouraging as they showed that the students were very happy with both the online and the traditional (on-campus) offerings of the course. These evaluation results, taken together with the actual student performances, lead us to the conclusion that the online course offering was at least as good as the traditional offering. The results were so compelling that simultaneous offering of online and traditional sections has now been eliminated. Starting Fall 2004, the course is being offered online only during the regular academic year. One traditional in-class section is offered during the Spring/Summer to accommodate those students who strongly prefer taking a traditional rather than online course.

5. Conclusion

The experience gained in adapting this course for delivery as an online course was quite valuable. The nature of the materials used in the classroom had to be adapted to meet the needs of an online course. The move to a largely computer based delivery made possible the use of simulations and animations in a manner that had not been tried before in this course and students were able to learn more effectively as a result. In particular, the use of the Blackboard online course delivery system proved beneficial for both the instructor and the students. The student performance throughout the semester, on homework assignments as well as tests showed that the students in the online course performed comparably well to those in the traditional course. The results gave us the confidence to eliminate some of the traditional course sections at substantial cost savings to the department. The results were encouraging enough that we will continue our drive to diversify the modes of course offerings we use and we expect to expand these efforts.

7. References

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Biographical Sketch

MUKASA E. SSEMAKULA graduated from the University of Manchester Institute of Science and Technology, UK, with a Ph.D. in Mechanical Engineering in 1984. He joined the Wayne State University in 1993 and is currently teaching courses in Manufacturing/Industrial Engineering Technology. He has research interests and has published widely in the areas of Manufacturing Systems and Computer Aided/Distance Education.