Can Web Courses Replace the Classroom in Principles of Microeconomics?

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The proliferation of economics courses offered partly or completely on-line (Katz and Becker, 1999) raises important questions about the effects of the new technologies on student learning. Do students enrolled in on-line courses learn more or less than students taught face-to-face? Can we identify any student characteristics, such as gender, race, ACT scores, or grade averages, that are associated with better outcomes in one technology or another? How would the on-line (or face-to-face) students fare if they had taken the course using the alternative technology? This paper addresses these questions using student data from our principles of microeconomics courses at Michigan State University.

I. The Courses

This study analyzes examination performance of students in three different modes or technologies of instruction in principles of microeconomics. We call the modes of instruction live, hybrid (for reasons that will become clear), and virtual.
Each of these modes of instruction employs different instructional materials, but they all have some features in common, such as the same textbook, Mankiw (2001), use of multiple-choice examinations, and e-mail and course web sites for communication.

The live course, taught in two sections by Liedholm in Fall 2000, met face-to-face for three class hours per week. Although the classes were large, the instructor directly engaged them in the learning process by using animated PowerPoint slides, videos, and group demonstrations, and by calling on individual students.

Brown taught the hybrid course in Fall 2000. It supplemented face-to-face lectures of *two* class hours per week with a variety of on-line materials. Most important of these on-line materials was an extensive collection of interactive, collaborative practice materials called *Problems in Microeconomics* (http://www.msu.edu/course/ec/201/brown/pim). In these problems the parameters in the relevant functions are pseudo-randomized so each student receives a unique version of each problem set, and students were encouraged to work together on the problems. Completing the problem sets was a course requirement. The remaining on-line materials included an extensive set of PowerPoint slides available on-line as a supplement to the textbook, and extensive files of repeatable practice quizzes.

The virtual course, offered in Fall 2000 and Spring 2001, was the product of a staff of professional web course producers, designers, programmers, and pedagogical experts operating under the direction of the authors. What makes the comparison of the live and virtual courses especially interesting is that we were able to incorporate streaming video of Liedholm's lectures in an on-line format that included synchronous viewing of textual material. Thus the students taking the course completely on-line got to enjoy as nearly as possible what the live students got in class. The virtual course also included *Problems in Microeconomics*, and the other on-line materials available to students in the hybrid course, including the repeatable practice quizzes.

II. The data and model

Our data set consists of information on the test scores and personal data from official university records from 363 students in Liedholm's live course sections, 258 students from Brown's hybrid course, and 89 students from two semesters in the virtual,

on-line course. Table 1 shows the basic statistics on most of the variables. The students in this study we believe were, in most respects, typical of students in the principles course in general. Overall, forty-eight percent of the students were women, about thirty percent were majors in business, eighteen percent were from social science, and seven percent from engineering. The live classes had a significantly higher percentage of Black students, and athletes. The virtual sections had significantly higher ACT comprehensive scores, and had completed significantly more credits towards graduation then either the live or hybrid sections.

The dependent variable, total score, is the percentage of the total number of questions answered correctly from thirty-seven questions that were included on all of the students' examinations. The questions are available at http://www.msu.edu/~brownb/vstudy.htm. In order to analyze depth of understanding, we divided the pool of questions into three groups according to the degree of sophistication in using economic concepts we believed a student would need to answer each question. The first group, subscore 1, included sixteen questions that were either straightforward definitions or concept identification. An example would be recognition of the definition of elasticity of demand. The second group, subscore 2, consisted of eleven questions that required a simple application or extension of a microeconomic concept or tool. An example would be the calculation of elasticity of demand from data. Subscore 3 consisted of questions requiring a more complex application of a concept. An example would be a question that asks about the implications for total spending on a good when price changes under specific assumptions about elasticity of demand. While the overall percent correct falls as we move up the groups from 1 to 3, this grouping does

not correspond exactly to one based simply on question difficulty, an alternative we also explored.

Our empirical specification is that the students' scores depend on the students' characteristics, and in which section of the course they found themselves, live, hybrid, or virtual.

III. Results

Table 2 reports results of OLS estimation for most of the important variables. We explored a large number of non-linearities, and interactions and found that none of these made any meaningful difference to the results. Significant censoring or ceiling effects were present in the data for the subscore 2 and subscore 3 subgroups. We used Tobit estimation to account for this, but there were no important differences from the OLS results.

A Chow test of the differences in coefficients among the three modes of instruction shows that the live and virtual methods differ significantly ($p=.01$). The other pair wise comparisons show no significant difference in the sets of coefficients.

The results strongly suggest that the virtual course represents an inferior technology compared to the live sections. Table 3 shows the predicted mean scores of students from each mode using their own characteristics and the coefficients of the other modes of instruction. Reading down each column of the table shows how students who had chosen a particular mode of instruction, say virtual, would score if they had taken the course in each of the other modes of instruction. For example, if the students who actually enrolled in the virtual course were placed, hypothetically, in the live course, their scores would have risen by a significant 5.79 (= 66.98 – 61.19) percentage points

(t=3.24). And because of their superior characteristics, they would actually have scored slightly higher than the students who chose to enroll in the live section. The virtual students, if put in the hybrid section, would gain a significant 4.83 (= 66.02 – 61.19) percentage points (t=2.87). When the live students were put in a virtual section they lost 5.77 points (t=6.08). Interestingly, students from the hybrid section, when transplanted to a virtual section, would have had their scores drop by only .71 (t=.70), and when put in a live section lose only 1.25 percentage points (t=1.32).

An analysis of scores for the subsets of questions provides some of the most persuasive evidence for significant differences between live and on-line sections. The sixteen definition and recognition questions, subscore 1, showed no significant difference in predicted scores across the three modes of instruction. But Table 1 shows that as we move to more difficult subject matter, the scores of the virtual students fall relative to the live and hybrid sections, and by the time we come to the questions requiring the deepest understanding, the difference between the virtual and live students is significant. The live students do significantly better than the virtual students on the most complex material, while there is no difference at all in learning the most basic concepts.

These results may reflect the benefits and importance of the direct student – teacher interactions that occur in live classes. The performance of the live students could also be due, at least in part, to differences in student effort. Approximately fifty-one percent of the students in the virtual class, for example, reported in an end-of-course survey that they ordinarily spent less than three hours per week on the course, and none claimed to have devoted more than seven hours per week. In the live class, attendance was recorded electronically every day and averaged over eighty percent over the entire

term. Fifty-two percent of the students in the live sections attended every class, and consequently put in a minimum of three hours per week. So there is some evidence that the live students spent more time on the course than their virtual counterparts, and it is possible that this added effort contributed to their superior performance.

The effect of gender varies across learning technologies in ways that are suggestive of some of the possibilities of on-line learning. In live instruction, women students score 5.70 percentage points less than men in total score, a significant effect ($p<.01$). This result is consistent with other studies of the effect of gender on learning in economics (M.A. Ferber, 1995). In both the hybrid and virtual courses the effect on test performance of the female variable is negative, but small and not statistically significant. Recall that the unifying link between the virtual and hybrid courses is their use of the web-based *Problems in Microeconomics*, while the live section does not use these materials. Brown (1998) compared grades in two courses that differed only in whether they used *Problems in Microeconomics.* He found that a significant difference favoring men in the control section virtually disappeared in the section that used the on-line problems. What the problems do is provide an opportunity to explore the theoretical concepts of the course in an atmosphere free of time pressure, or the pressure to come up with the correct answer right away. Thus in all sections we studied that have used the *Problems*, the gender effects, became insignificant. This is consistent with the work of Shea, *et al.* (2001), who report that females experience a more favorable learning environment on-line compared to the traditional classroom. In our case it remains for further study whether this effect is real or only an artifact.

Black students score significantly lower in the live sections, and while they have lower scores in the other sections as well, the coefficients are not significant.

The most obvious result across all sections is the importance of GPA and ACT score. An increase in one point in GPA is associated with an additional 15 percentage points in the total examination score. The effects on scores of having more math courses (technical skills) and of having accumulated more course credits (experience) are hypothesized to be positive. Yet the credits variable seems to have no significant effect, and having more math courses has a significant, positive effect only in the live sections. Indeed, the coefficient on the math courses variable is quite large and significantly negative in the virtual sections.

IV. Conclusions

We find that the students in the virtual classes, while having better characteristics, performed significantly worse on the examinations than the live students. This difference was most pronounced for exam questions that tapped the students' ability to apply basic concepts in more sophisticated ways, and least pronounced for basic learning tasks such as knowing definitions or recognizing important concepts.

Women students were at a significant disadvantage in the live sections, where they scored almost six percentage points lower on the test, and showed no significant disadvantage in the hybrid and virtual courses. We speculate that this may be due to the ways the students can interact with the *Problems in Microeconomics* and other on-line materials.

So what can we advise prospective on-line students to do? Choosing a completely on-line course carries a penalty that would need to be offset by significant

advantages in convenience or other factors important to the student. Women, on average, suffer less of a disadvantage in the virtual course. But this relative gain is not enough to offset completely the loss they incur in choosing an on-line course. Doing as well in an on-line course as in the live alternative seems to require extra work or discipline beyond that demonstrated by our students, especially when it comes to learning the more difficult concepts.

Table 1
Variable means and (standard deviations) for raw data

Variable	Live	Hybrid	Virtual
Total score (percent)	65.49 (16.13)	64.51 (14.98)	61.19 (17.14)
Subscore 1 (percent)	72.23 (17.07)	73.06 (16.69)	71.84 (17.66)
Subscore 2 (percent)	62.48 (21.14)	58.77 (17.72)	55.57 (23.15)
Subscore 3 (percent)	58.02 (20.92)	57.13 (18.95)	50.34 (21.29)
Female (=1)	.52 (.50)	.46 (.50)	.42 (.50)
Black (=1)	.17 (.37)	.05 (.22)	.03 (.18)
Math courses	1.53 (1.03)	1.17 (.96)	1.62 (1.12)
ACT	22.84 (4.04)	23.52 (3.57)	24.46 (3.35)
GPA (Max. poss. = 4.00)	2.86 (.56)	2.84 (.60)	2.80 (.58)
Credits	51.48 (21.84)	39.95 (19.24)	56.42 (28.8)
N	363	258	89

Note: The data set also includes dummy variables for college major (a potential measure of differences in learning style), more extensive racial and ethnic variables, and whether a student is in the Honors College or an athlete. See text for a full description of the sections and variable definitions.

Table 2
Selected OLS regression results for total score

Variable	Live	Hybrid	Virtual
Female	-5.70* (-4.41)	-1.08 (-0.67)	-2.03 (-0.60)
Black	-4.70* (-2.43)	.-5.94 (-1.59)	-4.93 (-.45)
Math courses	1.65* (2.18)	.69 (.67)	-3.74* (-1.65)
ACT	.63* (3.10)	.74* (3.20)	1.15* (2.02)
GPA (max. poss. = 4.00)	15.93* (11.99)	12.72* (9.16)	15.06* (4.96)
Credits	.030 (.86)	.044 (.89)	-.052 (-0.68)
Adj. R-squared	.50	.37	.36

Note: t-values are in parentheses. See Table 1 for the list of other included variables.
* = significant at the 5 percent level.

Table 3
Predicted sample means and (standard deviations) of scores of students if they enrolled in their chosen or an alternative mode of instruction

	Students:		
Mode of instruction:	Live	Hybrid	Virtual
Live	65.49 (11.78)	65.76 (11.65)	66.98 (11.58)
Hybrid	64.20 (10.65)	64.51 (9.76)	66.03 (10.10)
Virtual	59.72 (13.70)	63.80 (13.04)	61.19 (12.29)

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Footnotes

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