EFFECTS OF CLASSROOM EXPERIMENTS AND INTEGRATION ON STUDENT LEARNING AND SATISFACTION

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ABSTRACT

Student performance and course satisfaction measures are examined to evaluate the effectiveness of an integrated micro- and macro-economics principles course with a strong emphasis on classroom experiments. Student test scores are used to analyze performance for the microeconomics portion of the integrated class, relative to prior traditional microeconomics courses taught by the same instructor. Class evaluations are examined to gauge changes in student satisfaction. Student characteristics are included in the regression model to account for differences in performance due to ability or other factors.

INTRODUCTION

This paper examines the impact on student performance and satisfaction of an integrated micro- and macro-economics principles course, taught with a strong emphasis on classroom experiments and active learning. To explore the possible advantages of the pedagogical use of experimental economics, an experimental integrated micro- and macro-economics course was developed and taught to first-year students at the University. Students completing the course received six semester units of credit (3 units for Principles of Microeconomics and 3 units for Principles of Macroeconomics) and received separate grades for the two courses. The class met for 6 hours per week. Microeconomics was completed during the first half of the fourteen-week semester and macroeconomics was covered during the second half. The course was designed to include a number of classroom experiments. Economic experiments conducted during the semester, primarily in the microeconomics portion of the class, included a double oral auction, an ultimatum game, a public goods experiment, a production function experiment, a prisoner's dilemma game, and an experiment in international trade and comparative advantage.

Classroom experiments have grown in popularity and are claimed to improve student interest and learning (see Brock, 1991 and Neral and Ray, 1995, for example). The Journal of Economic Education has devoted an entire issue to classroom experiments (JEE, Fall 1993). Several resource books exist to assist instructors who wish to integrate economic experiments into the classroom as a pedagogy tool (Yandell, 2002; Bergstrom & Miller, 2000; Hazlett, 1998; Delemeester & Neral, 1995). Experiments can be time consuming, however, so there is concern that less material will covered in classes with a heavy experimental focus. The 6-unit integrated course was designed to allow more time for experiments without sacrificing the number of chapters covered by eliminating any overlap or review required when micro and macro courses are taught separately. The expected result was improved student learning without loss of content coverage. To test this hypothesis, student test scores and student evaluations are used to analyze performance and satisfaction for the Microeconomics portion of the integrated class, relative to traditional microeconomics courses taught by the same instructor. Student characteristics are included in the regression model to account for differences in performance due to ability or other factors.

BACKGROUND AND DATA

The University requires all entering freshmen to enroll in a preceptorial course in their first semester. Preceptorial courses are specially designated general education courses open only to entering freshmen. The preceptorial program was developed as a vehicle for academic advising. The professor teaches the course but also serves as the student's advisor for the first year, and often for an additional semester or two until the student declares a major. The classes are generally kept small, with enrollment limited to about eighteen students per course. Incoming students are given brief course descriptions and are asked to submit their preferences before registration. The Dean's office tries to accommodate these preferences when initial schedules are developed.

The experiments-based integrated six-unit course was offered as a preceptorial course, with two sections available. Each section met separately for 85 minutes on Tuesday and Thursday mornings, and both sections met in a combined three hour class on Wednesday afternoons. Most of the classroom experiments in the integrated course were run in the separate smaller classes during the morning sessions. The two classes had enrollments of 16 and 19, for a total enrollment of thirty-five students.

This paper compares test scores and course evaluations from the microeconomics portion of the integrated course to the scores and evaluations of students from a pair of preceptorials taught the prior year by the same instructor. The comparison courses were traditional 3-semester-unit microeconomics principles sections. The only experiments conducted in the earlier classes were a double oral auction and a production function experiment. Total traditional enrollment was 31, with sections of 19 and 12 students.

Students had very similar profiles in each year. Economics is taught within the School of Business Administration at the University, and approximately 88% of the students in each group reported that they intended to major within the School of Business Administration. The course therefore served as a prerequisite for the major in addition to fulfilling a general education requirement. Every student in each course was a first-semester freshman and had been registered in the course because of a listed preference for this preceptorial during summer advising.

The microeconomics portion of the integrated course was structured with the same basic format as the traditional course from the prior year. Course requirements were identical, with a grade determined by performance on five quizzes, a midterm exam, a final exam, and regularly collected homework assignments. The same textbook, chapter sequence and content coverage was maintained. The same final exam was used and the same course evaluations were administered each year.

STUDENT PERFORMANCE

It was hypothesized that the economic experiments and active learning methods in the integrated course led to improved student learning and satisfaction. The combination of microeconomics and macroeconomics in the same semester eliminated the need to revisit the introductory foundation chapters and therefore allowed time for the experiments to be conducted without loss of content coverage. Performance on the microeconomics final exam was used as a measure of student learning. The same final exam was given in the traditional microeconomics classes in the first year and in the integrated course the following year. The final exam score is expected to be higher for the integrated experiments-based course, net of the effects of other relevant variables. For each student, data was gathered on the following variables:

FINALEXAM	the score (out of 100 possible) on the microeconomics final exam
SAT-V	the students' Scholastic Aptitude Test verbal score
SAT-M	the students' SAT mathematics score
HSGPA	the students' high school grade point average as calculated by the University's admissions office
FEMALE	a dummy variable for gender (= 1 if FEMALE; = 0 if male)
EXPERIMENT	a dummy variable to distinguish students in the experiments-based course from students in the earlier traditional course (= 1 if enrolled in the experiments-based course; = 0 for the traditional course)

The HSGPA variable represents the high school GPA as calculated by the University's admissions office. Academic grades were converted using a 4-point scale, but greater weight was given to honors or advanced placement courses. It counts only academic subjects (physical education grades are removed, for example). The total sample size was 66 students, with 31 observations from the first year and 35 from the experiments-based course in the second year. Table 1 summarizes the data.

Table 1: Summary statistics						
Variable	Traditional (n = 31)		Experiments-based (n = 35)		Combined (n = 66)	
	Mean (Std. Dev.)	Median (Range)	Mean (Std. Dev.)	Median (Range)	Mean (Std. Dev.)	Median (Range)
Final Exam	70.35 (13.10)	69 (51)	78.00 (11.79)	78 (50)	74.41 (12.91)	76 (57)
SAT - v	526.5 (76.2)	540 (330)	563.1 (71.3)	570 (290)	545.9 (75.37)	550 (380)
SAT - m	559.7 (66.5)	550 (280)	591.1 (69.7)	590 (280)	576.4 (69.54)	570 (340)
HSGPA	3.304 (0.397)	3.20 (1.32)	3.563 (0.522)	3.49 (2.25)	3.441 (0.482)	3.39 (2.25)
FEMALE	0.452		0.514		0.485	

Students in the traditional course received a mean score of 70.35 (out of 100) on the final exam, while the experiments-based students averaged 78.00. The higher-performing students, however, had stronger academic qualifications than in the prior year, averaging 20 points more on the verbal portion of the SAT and 30 points more on the SAT mathematics score. The mean high school GPA was also higher, 3.563 compared to 3.304 for those in the traditional course. To evaluate exam performance net of the effects of academic qualifications we estimated the following regression model, and the regression results are reported in Table 2.:

$$\text{FINALEXAM} = B_0 + B_1 \text{ SAT-V} + B_2 \text{ SAT-M} + B_3 \text{ HSGPA} + B_4 \text{ FEMALE} + B_5 \text{ EXPERIMENT}$$

Consistent with a priori expectations, both of the SAT variables and HSGPA are positively associated with the final exam score, although neither of the SAT variables are significant factors. Females, after accounting for academic qualifications, did worse on the exam, but the result is not significant at the .05 level. A student's high school GPA is the only statistically significant factor in explaining variation in the final exam score, with an approximate 14 point improvement on the exam associated with a 1-point increase in GPA. The coefficient for the EXPERIMENT variable is 3.761, suggesting that the integrated approach and focus on experimental economics increased student final exam scores by nearly 4 points, all else held constant. Although this positive coefficient is encouraging, it is not significant at the .05 level.

Table 2: Regression results for student performance
(Dependent variable = score on microeconomics final exam)

Variable	Coefficient	T-Statistic	p-value
Constant	18.120	1.29	0.201
SAT-V	0.01034	0.50	0.619
SAT-M	0.00311	0.13	0.897
HSGPA	14.235	3.86	0.000
FEMALE	-4.394	-1.40	0.167
EXPERIMENT	3.761	1.30	0.197
R^2 (adj) = .269	F= 5.79	S = 11.04	n = 66

High correlation between the SAT variables and HSGPA was suspected, but the correlation matrix (shown in Table 3) shows that multicollinearity is not a problem. Alternate models were estimated without the SAT variables a with a single combined SAT score, but the remaining coefficients did not change appreciably in magnitude or significance. Estimating the model in log and semi-log forms did not change the results.

Table 3: Correlation between independent variables

SAT-V	SAT-M	HSGPA	
SAT-M	0.446		
HSGPA	0.262	0.421	
FEMALE	-0.028	0.003	0.450

Although the coefficient for EXPERIMENT is not statistically different from zero in the pooled data, a Chow test can be used with the data, separated by year, to test for more general differences between the two years.

The Chow test F-statistic is 0.67, which is not greater than the critical value $F_{.05,5,60} = 2.37$, so the null hypothesis that the slope coefficients are the same in the two samples cannot be rejected.

STUDENT SATISFACTION

To test student satisfaction, student evaluation responses were evaluated. The same standardized assessment form was used each semester. The first twenty-two questions refer to the course and the instructor's performance, and the remaining five questions reflect the student's efforts in the course. A two-sample t-test was performed with the raw evaluation responses from the two years for each question and for groups of questions to test for significant differences. For the first 22 questions, students rated the course and the instructor's contribution to the course with a response in one of six categories (Excellent, Very Good, Good, Fair, Poor, Very Poor) which are quantified using a 5 - 0 numeric scale. The last five questions offered seven options (ranging from Much Higher to Much Lower), which are coded from 7 to 1. Table 4 provides a summary of the mean responses to each question for the two years.

Overall, the student evaluations significantly improved in the experiments-based course. Both the combined items 1-22 and items 1-27 showed an improvement that was significant at the 1% level. For individual questions within the first 22 items, three showed a significant improvement and none were significantly worse. The three significant improvements were for question 4, "The instructor's effectiveness in teaching the subject" (p-value = 0.096); question 10, "Instructor's enhancement of student interest in material" (p-value = 0.0013); and question 14, "Interest level of class session" (p-value = 0.046). These suggest that the experimental focus did improve student interest in the material and teaching effectiveness.

It is interesting to note that lower scores were received in the experiments-based classes on questions 5, 8, and 16: "Course organization," "Instructor's ability to present alternatives," and "Use of class time." Although the reductions were not significant, these three questions may reflect the opportunity costs of using classroom experiments. The student perception that the course is less organized may be due to the unpredictable nature of classroom experiments, since actual experimental outcomes are uncertain. Experiments also take time to explain, administer, and debrief, so students may see class time being used less intensively than in a lecture-dominated course. More time with experiments also means less time to develop alternatives or present additional examples.

Table 4: Student course evaluation summary

	Traditional		Experiments-Based		Improvement	p-value
	Count	Mean	Count	Mean	(Exper.-Trad.)	(Ho:Diff. = 0)
1. The course as a whole was:	27	4.000	33	4.182	0.182	0.35
2. The course content was:	27	3.926	33	3.848	-0.077	0.68
3. The instructor's contribution to the course was:	27	4.519	32	4.719	0.200	0.25
4. The instructor's effectiveness in teaching the subject was:	27	4.185	33	4.545	0.360	0.096 *
COMBINED ITEMS 1-4:	108	4.157	131	4.321	0.163	0.11
5. Course organization was:	27	4.481	33	4.303	-0.178	0.27
6. Sequential presentation of concept was:	27	4.037	33	4.152	0.114	0.58
7. Explanations by instructor were:	27	4.185	33	4.303	0.118	0.59
8. Instructor's ability to present alternatives was:	27	4.259	33	3.939	-0.320	0.16
9. Instructor's use of examples/illustrations was:	27	4.407	33	4.667	0.259	0.19
10. Instructor's enhancement of student interest in material was:	27	3.333	33	4.182	0.848	0.0013***
11. Student confidence in instructors knowledge was:	27	4.667	33	4.697	0.030	0.83
12. Instructor's enthusiasm was:	26	3.692	33	4.091	0.399	0.15
13. Clarity of course objective was:	27	3.926	33	4.242	0.316	0.29
14. Interest level of class session was:	27	3.148	33	3.636	0.488	0.046 **

Table 4: Student course evaluation summary

	Traditional		Experiments-Based		Improvement	p-value
	Count	Mean	Count	Mean	(Exper.-Trad.)	(Ho:Diff. = 0)
15. Availability of extra help when needed was:	26	4.192	33	4.333	0.141	0.52
16. Use of class time was:	27	4.481	33	4.212	-0.269	0.13
17. Instructor's interest in whether students learned was:	27	3.963	33	4.212	0.249	0.35
18. Amount you learned in this course was:	27	3.963	33	4.242	0.279	0.17
19. Relevance and usefulness of course content were:	27	3.926	33	4.152	0.226	0.34
20. Evaluative and grading techniques (tests, papers, etc.) were:	26	4.000	33	3.788	-0.212	0.39
21. Reasonableness of assigned work was:	26	4.038	33	4.212	0.174	0.43
22. Clarity of student responsibilities and requirements was:	27	4.259	33	4.273	0.013	0.94
COMBINED ITEMS 5-22:	482	4.054	594	4.199	0.145	0.0076***
COMBINED ITEMS 1-22:	590	4.073	725	4.221	0.148	0.0021***
Relative to other college courses you have taken:						
23. Do you expect your grade in this course to be:	27	4.778	33	4.848	0.071	0.81
24. The intellectual challenge presented was:	27	5.556	33	5.455	-0.101	0.62
25. The amount of effort you put in this course was:	27	5.074	33	5.758	0.684	0.020**
26. The amount of effort to succeed in this course was:	27	5.519	33	5.576	0.057	0.83
27. Your involvement in course was:	27	5.519	33	5.818	0.300	0.34
COMBINED ITEMS 23-27:	135	5.290	165	5.490	0.200	0.11
COMBINED ITEMS 1-27:	725	4.301	890	4.456	0.155	0.0024***

* = signif. at 10%
** = signif. at 5%
*** = signif. at 1%

In addition to the questions summarized in Table 4, students have the opportunity to provide handwritten comments on a separate page. Students are prompted on the comment sheet with the following questions:

1.	Do you find this class to be intellectually challenging?
2.	What aspects of this class contributed most to your learning?
3.	What aspects of this class detracted from your learning?
4.	What suggestions do you have for improving this course?

There were 27 comment sheets returned in the traditional course and 33 in the experimental course. Each was examined for evidence that the classroom experiments contributed to student interest or satisfaction. Frequent comments under question 2 were that the class activities, examples, and experiments were interesting and useful. Seven (26%) of traditional course forms contained such comments, compared to 23 (70%) of the experiments-based forms. These proportions are statistically different at the 1% level (p-value = 0.000).

For question 4, seven students in the traditional course (26%) suggested that more interactive learning, student involvement, and experiments would have improved the course. Interestingly, six students in the experiments-based course (18%) made the same comment, even though the experimental focus was much more pronounced that year. No student in either year said that the class activities or experiments detracted from learning or that fewer experiments should be done.

CONCLUSION

The impact of classroom experiments on student learning and satisfaction was examined. Student evaluations show that the experiments were memorable, and thus potentially contributed positively to the students' learning experience. This study also supports the claim that classroom experiments improve overall student satisfaction and interest. The impact on student performance is less dramatic. The key factor explaining performance on the final exam was found to be the students' high school GPA. After accounting for other factors, students in the experiments-based course scored almost four points higher on the final exam, but the regression coefficient was only statistically significant at the 20% level.

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