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Laboratory-Based Experimental and Demonstration Initiatives in Teaching Undergraduate Economics

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Economics is characterized by well-developed predictive theories of human behavior. A wide variety of empirical tests of models based on those theories have been developed, as well as extensive and reliable data bases to test the theories. Thus, one can experiment with and simulate economic behavior. For these reasons, the conventional lecture-discussion format may be the least effective way to teach economics. Rather, the most effective teaching method may be as a laboratory science.

We report here on two efforts to adapt economic instruction to a laboratory format. The purpose of adapting the lecture-laboratory format to economics is to permit a more active learning environment in which students can be meaningfully engaged by the material, with other students, and with the instructor.

We report on two recent efforts to convert economics to a true, experimental, laboratory social science. The first, beginning in 1988, is a demonstration project conducted at Denison University for majors in economics. The second, beginning in 1993, is a true experiment conducted at Washington State University for all students taking introductory micro- and macroeconomics.

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I. The Demonstration Project for Economics Majors at Denison University

A. *Description of the Demonstration Project*

The project at Denison University is a demonstration since its design does not have a randomly assigned control group. All economics majors in the program at Denison took part in the project. Denison instituted a lecture-laboratory teaching format. The curriculum was reorganized, and laboratory courses were developed. With the institution of the laboratory format, economics majors must now take seven traditional economics courses and four laboratory courses. The four laboratory courses are intermediate micro, intermediate macro, and econometrics, plus one of the three advanced courses. The laboratory courses are the thread that connects all the courses. Research tools developed in one course are utilized repeatedly in other courses.

As noted above, in both this demonstration and in the experiment discussed below, the adaptation of the lecture-laboratory format from the sciences to economics allows for a more active learning environment. On-site supervision is important to provide students with feedback at the point in time when it is most effective. The economics laboratory and the materials taught therein provide economics students with the same pattern of feedback and analytical support experienced by students in the natural/life sciences. Finally, Denison emphasizes theoretical material in lecture sessions, with the difference being that students are able to place that material in the context of real-world situations that allow them to understand the applications and implications of theory in a contemporary setting.

*B. Impacts of Teaching Economics
as a Laboratory Science:
The Denison Demonstration*

Denison could not perform a comprehensive net impact evaluation of the incorporation of its lecture-laboratory curriculum. As an alternative, Denison examined intermediate-macroeconomics students from 10 years earlier and compared their performance to that of students in the lecture-laboratory sections during 1988–1989. This component of the overall study asked whether the addition of laboratory sections to the economics curriculum increased student comprehension of basic economic principles.

As with the experiment below, the Test of Understanding College Economics (TUCE; Philip E. Saunders, 1991) was used to measure cognitive development. To attempt to measure the net effect of the curriculum, the following characteristics were controlled for: mathematics and verbal Scholastic Aptitude Test (SAT) scores, GPA, previous economics courses, and previous mathematics courses taken by the 1979 and 1989 student cohorts.

Comparing the TUCE scores between the 1979 and the 1989 student cohorts, the improvement in total pre- and posttest scores progressed from 4.3 percent for the 1979 students to 10.8 percent for the 1989 students. The percentage change from pre- to posttest scores in recognition progressed from 7.9 percent in 1980 to 14.9 percent in 1990. The percentage change in implicit thinking progressed from 2.8 percent to 9.6 percent, and the change in explicit thinking was from 4.2 percent to 7.5 percent.

Ordinary least squares (OLS) was used to determine the correlates of improvement. In the case of overall scores, recognition, and explicit reasoning, students in the 1989 lecture-laboratory courses showed a rate of improvement exceeding that of students in the 1979 classes. The differences were significant at the 10 percent level. The correlations with SAT scores and gender were not statistically significant. The conclusion is that the lecture-laboratory format in intermediate macroeconomics does improve economic understanding and reasoning.

**II. The Experiment for Introductory Economics
at Washington State University (WSU)**

A. Description of The WSU Experiment

Using a classical random experimental design, Washington State University is testing the conversion of introductory micro- and macroeconomics courses from a standard lecture and discussion format to a lecture and laboratory format that integrates the principles of active learning with personal computers, data on actual economic behavior, and in-class economic experiments. The basic plan is accompanied by exercises and experiments amenable to operation on personal computers, and by thorough training and retraining of both instructors and teaching assistants. The control group is students enrolled in introductory classes that use a conventional lecture-discussion format.

The Nature of Randomization.—The experimental and control classes were paired as to common days and common time of day. A parallel-in-time control class with three discussion sections was offered, although the discussion sections did not necessarily meet at the same times as the laboratory sections. The two types of classes and their sections are not specifically identified in the time schedule. The students do not know, nor can they discover until they attend class, which classes have computer laboratories and which do not, nor do they know who the teachers or teaching assistants are.

To test for selection effects, we regressed pretest scores on a set of independent variables. For one model, an OLS regression of students' pretest scores on a standard set of their socioeconomic and schooling characteristics results in a statistically significant negative coefficient for the experimental categorical variable.¹ If selection is a function of the scheduled laboratory times, then selection is also likely to be systematically related to individual characteristics. As a crude test, the model was reestimated with the addition of

¹ All regression results are available from the authors upon request.

several interaction terms with the experimental variable. This specification eliminated the statistical significance on the main effect for the experimental variable. Only one of six interaction terms remained statistically significant—the interaction of “last attending a community college” with the experimental variable. This interaction is not statistically significant in the measures of the level-of-performance model or the value-added model discussed below (see Subsection B).

Crossovers and Dropouts.—Once students attend the first class of the semester and identify whether the class has a computer laboratory or a discussion group, they are tracked if they switch in either direction. Fewer than 20 students switched from the experimental group to the control group. Approximately 10 percent of the students enrolled in either the micro- or macroeconomics classes dropped out. The percentage of drops varied among the various experimental and control-group classes. Although none of these differences is significant, one cannot tell whether this behavior is random until the end of the experiment.²

The Instructional Treatment.—The control-class curricula reflect the experimental-class curricula as closely as possible with respect to instructional topics. A pilot semester was used to iron out problems in instructional technique, design of the syllabi, agreements on procedures for measuring attendance, and methods of collecting supplemental personal data from the students, including the design and administration of a time diary to measure study hours.

Microeconomics.—In the laboratory session, students engaged in several interactive market experiments. One was an oral negotiated-price market, in which students create supply and

demand schedules in markets generated by market interactions using bids and calls. Another was an oral double-auction market. In a third experiment, students investigated free-rider problems in the context of investment in public goods. Finally, the social well-being outcomes of changing the distribution of income were analyzed.

Students were exposed to a variety of tasks during the computer sessions. Spreadsheets were used to analyze data, such as that generated by the oral negotiated-price market. Real-world data on the baseball industry were used to develop production functions in baseball and information on the baseball labor market. Computer simulations were used to develop demand curves facing a pure monopolist and to analyze pricing strategies available to the monopolist given the monopolist’s demand curve. In addition to these activities, students were required to complete weekly assignments from a computerized study guide.

The control classes in microeconomics employed a standard lecture-discussion method. The issues discussed in the recitation period were left to the discretion of the instructor. No effort was made to parallel the various market experiments, with one exception, that of the auction-market simulation.

Macroeconomics.—The computer sections used two software programs developed by Richard Alston and Wan Fu Chi (1993) to illustrate the theory developed in the course. Laboratory books developed by faculty were keyed with this software. Students were required to turn in weekly assignments from these laboratory books in which they analyzed actual data and applied simple macroeconomic models to hypothetical economies. The control and experimental classes were essentially identical. Class syllabi were the same in terms of material covered and timing. Two of the instructors used similar, if not identical, problem sets across their control and experimental sections.

Controls for Work Effort and Target Grades.—Students adjust their work effort to conform with their taste for a particular target grade in their economics classes and for their

² At this point the study cannot control for the effects of individual instructors and teaching assistants because the model is not identifiable. As the experiment operates in its steady state during the final year, most instructors and teaching assistants will switch from a control to an experimental class and vice versa. This design feature will help control for instructor and teaching-assistant behavior.

overall college grade-point average.³ We adjust for this phenomenon in two ways. First, we take daily attendance, which yields points as part of the final grade. Second, we collect data on study habits. Buried in a list of conceivable daily time-diary activities is a request for data on overall study hours and for study hours in economics on that given day. The diary is administered randomly across students during the semester and across all days in the semester, including weekends and holidays, except for the extended periods of the Thanksgiving and Spring breaks.⁴

B. *The Measure of Net Instructional Impact*

As with the Denison demonstration, we use the TUCE as the measure of instructional effectiveness.⁵ To help maintain consistent effort while taking these tests, students were also given extra credit for taking the pretest. The posttest was part of the final exam. These test data are complemented by each student's full college transcript, supplemental personal information collected in class, and the self-reported data on study habits noted above.

The Sample.—As noted, the experiment has operated for one pilot semester in the fall of 1994 and one steady-state semester in the spring of 1995. It began a full year of steady-state operation in the fall of 1995. The experiment ends at the end of the 1996 spring semester. Thus far, about 1,800 observations have been collected, split approximately as 43 percent experimental and 57 percent control subjects.

In looking at the sample characteristics, several points should be noted:

- (i) The most recent GPA is about 2.78 on a 4.0 scale.
- (ii) Demographic characteristics are similar

³ William E. Becker (1983a, b) has written the most careful discussion of this issue of student behavior.

⁴ We are indebted to Frank Stafford for assistance in designing the time diary and its administration.

⁵ See Philip E. Saunders (1991) for a conceptual discussion of the design of the TUCE.

for the two groups. Males comprise 62.2 percent of the total sample. The average age is 20.3 years.

- (iii) The experimental and control groups are similar on all three ability measures: SAT mathematics and verbal scores and ACT scores. The average SAT mathematics score is approximately 500 points, and the average SAT verbal score is approximately 425 points. The sample's ACT scores average 21.8 points.
- (iv) The students in the sample studied an average of 12.8 hours per week in their previous semester, whether it be college or high school.
- (v) Students attended an average of 80 percent of classes across both control and experimental groups.
- (vi) Fifty-two percent of the students in the control group have taken a previous economics course, compared to 46 percent in the experimental group.
- (vii) Only about 36 percent of the total sample has been exposed to introductory calculus or higher. On average, students have 5.8 credit hours in mathematics at WSU. The average math GPA was about 2.62 on a base of 4.0. Approximately 20 percent of the sample has no college-level mathematics.

Net-Impact Estimation.—OLS is used to estimate net experimental impacts. At this point no corrections have been made for cross-over behavior, potential selection into the experimental and control groups, or selection out of a class by dropping it. Final estimations will adjust for these potential selection problems.

A value-added model regresses the *difference* between the TUCE posttest and the pretest against the set of independent variables. Table 1 shows selected results. Value added is used as the dependent variable because the coefficient estimates are unbiased and efficient. If the level of performance achieved (posttest score) is used as the dependent variable, the coefficient estimates are biased.⁶

⁶ The proof is available from the authors upon request.

TABLE 1—NET EXPERIMENTAL IMPACT OF THE WSU
CONVERSION OF INTRODUCTORY MICRO- AND
MACROECONOMICS COURSES TO LECTURE AND
LABORATORY FORMAT, POSTTEST
TUCE MINUS PRETEST TUCE

Independent variable	Estimated regression coefficients		
	(1)	(2)	(3)
EXPER	0.211 (0.212)	0.250 (0.212)	0.230 (0.211)
MALE	0.480* (0.226)	0.315 (0.230)	0.269 (0.231)
GPA	1.460** (0.228)	1.454** (0.231)	1.453** (0.230)
PREV ECON	-0.273 (0.215)	-0.283 (0.215)	-0.268 (0.214)
MICRO	1.099** (0.211)	1.128** (0.211)	1.161** (0.211)
ATTEND	0.012 (0.008)	0.015 [†] (0.008)	0.016* (0.008)
SAT-M	—	0.003 [†] (0.002)	0.003 [†] (0.002)
SAT-V	—	0.002 (0.002)	0.002 (0.002)
Adjusted R ² :	0.092	0.101	0.106
d.f.:	1,472	1,463	1,463

Independent variable	Estimated regression coefficients	
	(4)	(5)
EXPER	0.230 (0.211)	0.285 (0.515)
MALE	0.287 (0.231)	0.098 (0.298)
GPA	1.471** (0.231)	1.516** (0.231)
PREV ECON	-0.287 (0.215)	-0.200 (0.285)
MICRO	1.163** (0.211)	1.144** (0.211)
ATTEND	0.016* (0.008)	0.015 [†] (0.008)
SAT-M	0.003 [†] (0.002)	0.003 [†] (0.002)

TABLE 1—Continued.

Independent variable	Estimated regression coefficients	
	(4)	(5)
SAT-V	0.002 (0.002)	0.002 (0.002)
Adjusted R ² :	0.107	0.109
d.f.:	1,458	1,450

Notes: The numbers in the column headings refer to the following estimated models:

- (1) Pretest minus posttest with no spline for age, no ability controls, no opportunity costs, no high school or graduate student controls, and no interactions with the experiment.
- (2) Pretest minus posttest with ability controls, and graduate or high school student controls.
- (3) Pretest minus posttest with ability controls.
- (4) Pretest minus posttest with ability controls and opportunity costs (other activities).
- (5) Pretest minus posttest with ability controls, opportunity costs, and interactions.

Variable definitions: EXPER, dummy variable = 1 if experimental group; MALE, dummy variable = 1 if male; GPA, most recent GPA; PREV ECON, dummy variable = 1 if individual has taken a previous economics course; MICRO, dummy variable = 1 if taking microeconomics; ATTEND, percentage classes attended; SAT-M and SAT-V, math and verbal SAT scores. Other variables included are: age, ethnicity, class standing, dummy variables for most recent GPA being high school, community college, or missing, study hours, dummy variables for SAT score or ACT score missing, highest attained mathematics course, and extracurricular activities.

[†] Statistically significant at the 10-percent level.

* Statistically significant at the 5-percent level.

** Statistically significant at the 1-percent level.

Statistical Results.—These results are preliminary for two major reasons. First, there is no direct control for the selection issues noted above. Second, we cannot fully control for variations in the behavioral impact of instructors and teaching assistants until the experiment is completed. Given these qualifications, we have the following initial findings:

- (i) For the present models and sample size, there is no net positive statistical impact of the laboratory experiment.
- (ii) Models that use value added as the de-

- pendent variable explain from 9.18 percent to 10.88 percent of the variance.
- (iii) For models using value added as the dependent variable, a 10-percent increase in class attendance results in a net score increase of about 0.15 point.
 - (iv) Having taken trigonometry or the second semester in the calculus sequence raises the net TUCE score by about one point.
 - (v) A one-point increase in the most recent GPA results corresponds to about a 1.5-point increase in the net posttest TUCE score.
 - (vi) There are no significant effects of sex.
 - (vii) Asian-Americans perform at a statistically significant lower level than other ethnic groups for all value-added models. African-Americans perform at a statistically significantly lower level in two of the five value-added models.

Almost all statistical tests indicate that the chosen measures of student performance and achievement are appropriate to the estimated models. In particular, the measures of academic performance, ability, and mathematics background are consistently statistically significant.

Additional models have been estimated to test for potential sample bias arising from sample attrition. A Heckman two-step procedure is estimated. The first stage consists of estimating a logit model that uses exogenous variables, including the the variables of previous semester-hours attempted, time of afternoon Friday laboratories, and the number of

classes each week meeting before 10:00 A.M. The second stage includes the selection variable and is estimated by OLS. The estimates use the corrected asymptotic covariance matrix.

At this time the selection coefficient is not significant. This result is preliminary, but it is encouraging. Also note that we controlled for whether a student switched from a control to an experimental class and vice versa. The results indicate that those individuals selecting into the control class performed significantly better in terms of value added. These results should be taken with caution due to the limited number of observations of students switching from the experimental group to the control or vice versa. The correction for sample attrition results in an estimate of the experimental treatment of 0.33, which is consistent with previous findings.

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[Footnotes]

³ **Economic Education Research: Part II, New Directions in Theoretical Model Building**

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